## ALIS

### Project Identification

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| **Project name** | **ALIS** |
| **Acronym** | Advanced Landmine Imaging System |
| **Participation Level** | National (Japanese) |
| **Financed by** | JST(Japan Science and Technology Agency) |
| **Budget** | N/A |
| **Project Type** | System/subsystem development |
| **Start date** | September2002 |
| **End date** | March 2006 |

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| **Technology type** | Metal detector, Ground Penetrating Radar |
| **Readiness level** | 7 |
| **Development Status** | Completed |
| **Company/Institution** | **Tohoku University** |

### Project Description

ALIS (Advanced Landmine Detection System) is a hand-held dual sensor for Anti-Personnel landmine detection, which can visualize the MD and GPR signals for the benefit of deminers. The visualized metal detector signal image provides a direct information about the location of metallic objects, and then GPR gives the radar image of the buried objects, which can be used to detect landmines. According to the developer, the visualization system increases the reliability of operation. The locus (position in space) of the sensor head scanned by the deminer can also be recorded in real time. This record can be used for the quality control of the operation, and also for the training of operators.

### Detailed Description of the prototype/product

The sensor signals from the metal detector and GPR are stored in a PC, which provides both detection and sensor position information. The entire system is controlled by a PC which is carried inside a backpack worn by the deminer. The deminer monitors the metal detector signal displayed on a hand-held display or PDA and scans the ALIS sensor as shown in Fig.1. The same image which the deminer is looking at is transmitted by wireless LAN to a handheld PC display, allowing several operators to monitor the operation as well. For the normal operation of ALIS, one operator who scans the sensor and another operator who controls and monitors the sensor signals are needed.

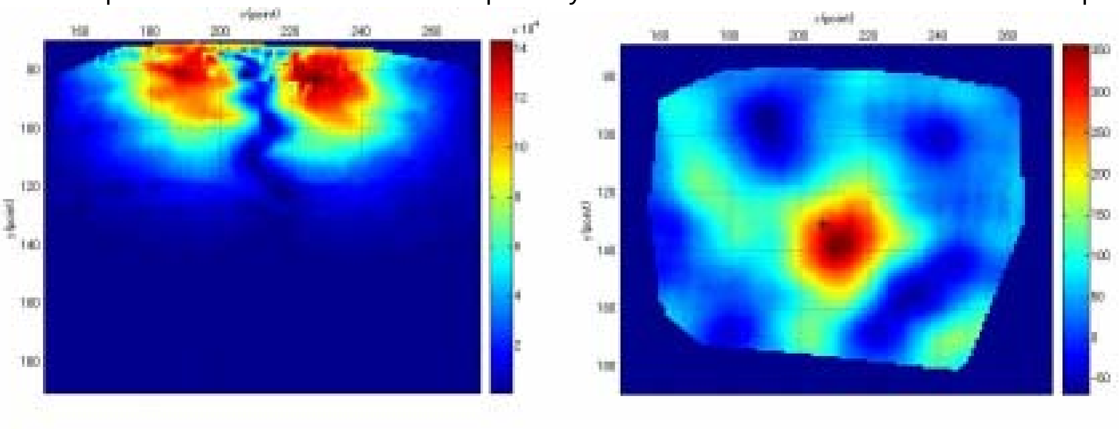
The scanning by ALIS follows exactly the same procedure as for the normal hand-held metal detector. A deminer stands at the front of the boundary of a safe zone, and scans an area of about 1 m by 1 m. Continuous scanning is recommended, even if the deminer detects an anomalous signal from the metal detector. One set of data acquisition by ALIS takes several minutes, which is almost equivalent to the time required for normal scanning operation of a conventional MD.

**Fig.1 ALIS**

After scanning the area, the acquired data sets are processed using the same PC mentioned above. First, all the acquired data sets are transformed to a regular grid of points. An interpolation algorithm is used for this process. The full processing does usually require one to a few minutes until all the data sets are displayed. Subsequently, ALIS provides a horizontal (plan) visual image of the metal detector signal (Fig. 2a), and 3-D GPR information. The 3-D GPR information is however usually too detailed and cluttered for interpretation on site, so that the displays of horizontal time slices (C-scans) of the GPR signal (Fig. 2b) is preferred instead. In the developer’s experience the detection of buried landmines with the horizontal time slice image is the most reliable.

After processing and generating the signal images, one can locate/designate the suspect position on the display. Currently, the data is interpreted manually. First, anomalies appearing in the metal detector image are detected. Normally this is quite easy, but it includes many signals due to metal fragments and other objects (i.e., false alarms). After marking the location of these anomalous points on the GPR horizontal slice image, the operator can move the depth of the horizontal slice images trying to find a continuous image that can correspond to a GPR image of buried landmines. A semi-automatic detection algorithm can be used to get advice during the manual interpretation procedure.

Another unique feature of ALIS is its compatibility with conventional landmine detection operations, as it requires,

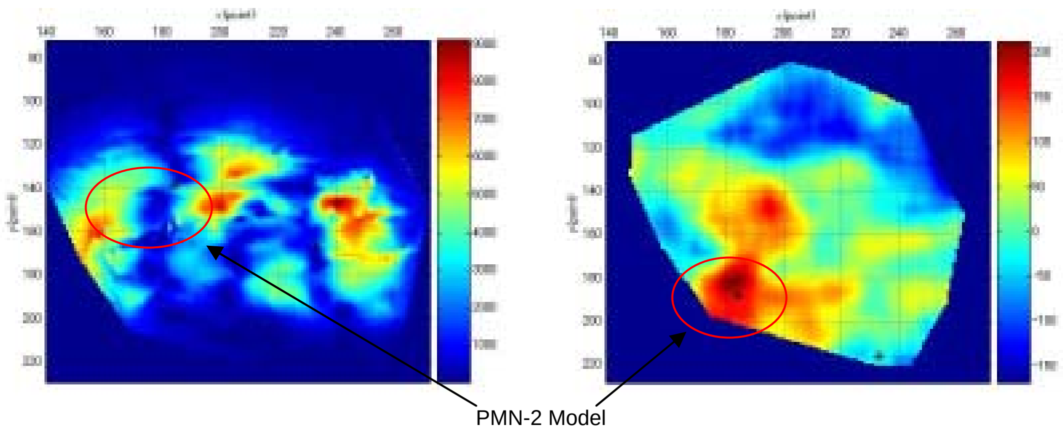


(a) Metal detector image (b) GPR image

**Fig.2 Typical ALIS output image of buried AP landmine. (PMN-2, 10cm depth)**

according to the developer, minimum modification of the operational procedures. The ALIS is an add-on system that can be attached to an existing commercial metal detector (e.g., CEIA MIL-D1). The performance of the metal detector is not altered by adding the ALIS system[1]: the operator still hears the audio tone signal from the metal detector, and can detect anomalies using its own experience.

## Test & Evaluation




(a) Metal Detector image (b) GPR image

**Fig.3 ALIS output at Bibi Mahro Hill in Kabul, Afghanistan**

ALIS was evaluated at several different locations, including tests in Kabul City, Afghanistan, in December 2004. The field tests were conducted at two locations. The first site (CDS: Central Demolition Site) was a controlled flat test site, prepared for the evaluation of landmine sensors. The second site (Bibi Mahro Hill) is a small hill inside Kabul City, which is a real minefield where a demining operation was being carried out.

[1] Note: a priori this does not apply to all metal detectors.

At the CDS site, the operation of the ALIS for known targets could be validated under various conditions. The soil in the CDS site was relatively homogeneous, although much clutter was found in the raw GPR profile. Metal fragments had basically been removed from the soil before the evaluation was carried out. After migration processing[2] of the GPR data, in most cases clear images of buried landmines could be found. The climatic conditions during the field tests were partly rainy, and water content of the soil at the CDS site was about 10%, corresponding to a dielectric constant of 5.3. Real PMN-2 and Type 72 landmines without boosters were buried at the CDS site at different depths between 0 and 20 cm. The metal detector could only detect landmines buried shallower than 15 cm, whereas GPR could show clear images of landmines which were buried up to a depth of 20 cm. Metal fragments do not show clearly on the GPR images, and could therefore be discriminated from landmines using ALIS. Figure 2 shows an example of the ALIS output for an inert PMN-2 mine, which was buried at 10 cm. Both MD and GPR images are clear in this case.

Bibi Mahro Hill is a small hill near the Kabul airport. The soil in this site is very non-homogeneous, and contains many small objects such as gravel, pieces of wood and metal fragments. At the calibration site in Bibi Mahro Hill, a PMN-2 plastic shell model filled with TNT explosive was buried; it also contained a small metal pin imitating the metallic part of a booster in a real landmine. In addition, a small metal fragment was added at about 15 cm from the landmine model. Figure 3 shows the corresponding ALIS visualization output. Figure 3(a) is the MD image, which features two separated metal objects[3]. Figure 3(b) shows the GPR image, in which only one clear image could be found that corresponds to the landmine model. (The images in Fig. 2and 3 have a 20 cm offset between MD and GPR.)

**Fig. 4 ALIS mounted on a vehicle**

**Other applications (non demining):**
The ALIS stepped-frequency GPR is capable of operating in the 100MHz-4GHz frequency range. The operational frequency range can be adaptively selected as a function of the soil conditions, mainly its moisture. This unique feature is useful not only for landmine detection, but also for other applications. Especially its capability in the lower frequency range allows using ALIS for environmental studies including ground water monitoring and detection of buried utilities, e.g. pipes.

The sensor head of the ALIS is small, and is also suitable also as a sensor unit for a robot arm mounted on a vehicle as shown in Fig.4. In this case the scanning speed can be increased due to higher accuracy of the sensor positioning.

## Related Publications


1. M. Sato, J. Fujiwara, X. Feng and T. Kobayashi, “Dual Sensor ALIS evaluation in Afghanistan,” IEEE Geoscience and Remote Sensing Society Newsletter, pp. 22-27, September 2005.
2. X. Feng and M. Sato, “Pre-stack migration applied to GPR for landmine detection,” Inverse problems, 20, pp. 1-17, 2004.
3. X. Feng, J. Fujiwara , Z. Zhou., T. Kobayashi and M. Sato, Imaging algorithm of a Hand-held GPR MD sensor (ALIS), Proc. Detection and Remediation Technologies for Mines and Minelike Targets X, March 2005.
4. Final Report (Summary) for Humanitarian Mine Clearance Equipment in Afghanistan, Japan International Cooperation System, March 31, 2005, http://www.mineaction.org/doc.asp?d=452


[2] Software refocusing of the GPR data after data acquisition.

[3] The CEIA MIL-D1 has a differential signal output. A single metal object shows therefore a symmetric response with a null point at the centre, right above the object.

**Technical Specifications [Tohoku University, ALIS]**

1. Used detection technology: Metal Detector and GPR Visualization
2. Mobility: Hand-held (vehicle based possible)
3. Mine property the detector responds to: Physical properties
4. Detectors/systems in use/tested to date: Two prototypes
5. Working length:
6. Search head:
   - size: 30cm Diameter, 20cm Height
   - weight: ca. 2kg
   - shape: Round (CEIA MIL-D1)
7. Weight, hand-held unit, carrying (operational detection set) / Total weight, vehicle based unit: ca. 6kg
8. Environmental limitations (temperature, humidity, shock/vibration, etc.):
9. Detection sensitivity:
10. Claimed detection performance:
    - low-metal-content mines: Max 20cm depth (PMN-2)
    - anti-vehicle mines: Not applicable
    - UXO: Not applicable
11. Measuring time per position (dwell time)/ optimal sweep speed: 2-3 min/$m^2$ / 30cm/sec
12. Output indicator: PDA Display
13. Soil limitations and soil compensation capability: Equivalent to CEIA MIL-D1
14. Other limitations:
15. Power consumption:
16. Power supply/source: DC12V car battery
17. Projected price:
18. Active/Passive: Active
19. Transmitter characteristics: 100MHz-4GHz Stepped Frequency
20. Receiver characteristics: Synchronized to Transmitter
21. Safety issues:
22. Other sensor specifications:

**Remarks**

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