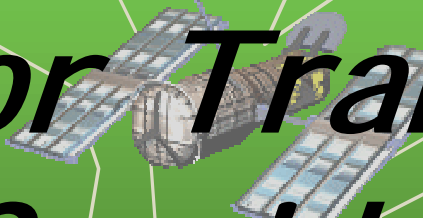# Can Power Companies use Space Patrols to Monitor Transmission Corridors?

ESRI User Group Conference 2004

San Diego   Paper 1591

Keith Beck

Dr Renaud Mathieu

Dunedin, New Zealand

Background

- **This research is being undertaken as a Master of Science thesis by Otago University**

- **A major part of electrical asset management is devoted to risk assessment and where possible, risk avoidance.**

- **Risk assessment involves identifying places in the electrical network where faults may occur and estimating the chances of a fault occurring at that site, compared to faults elsewhere on the network.**

- **Maintenance of distributed electrical assets requires the corridor of land in which the assets are located to be monitored for vegetation; these assets may be substations, poles or power lines.**

- **Utility companies ensure that these corridors are clear of any objects that may cause line faults.**
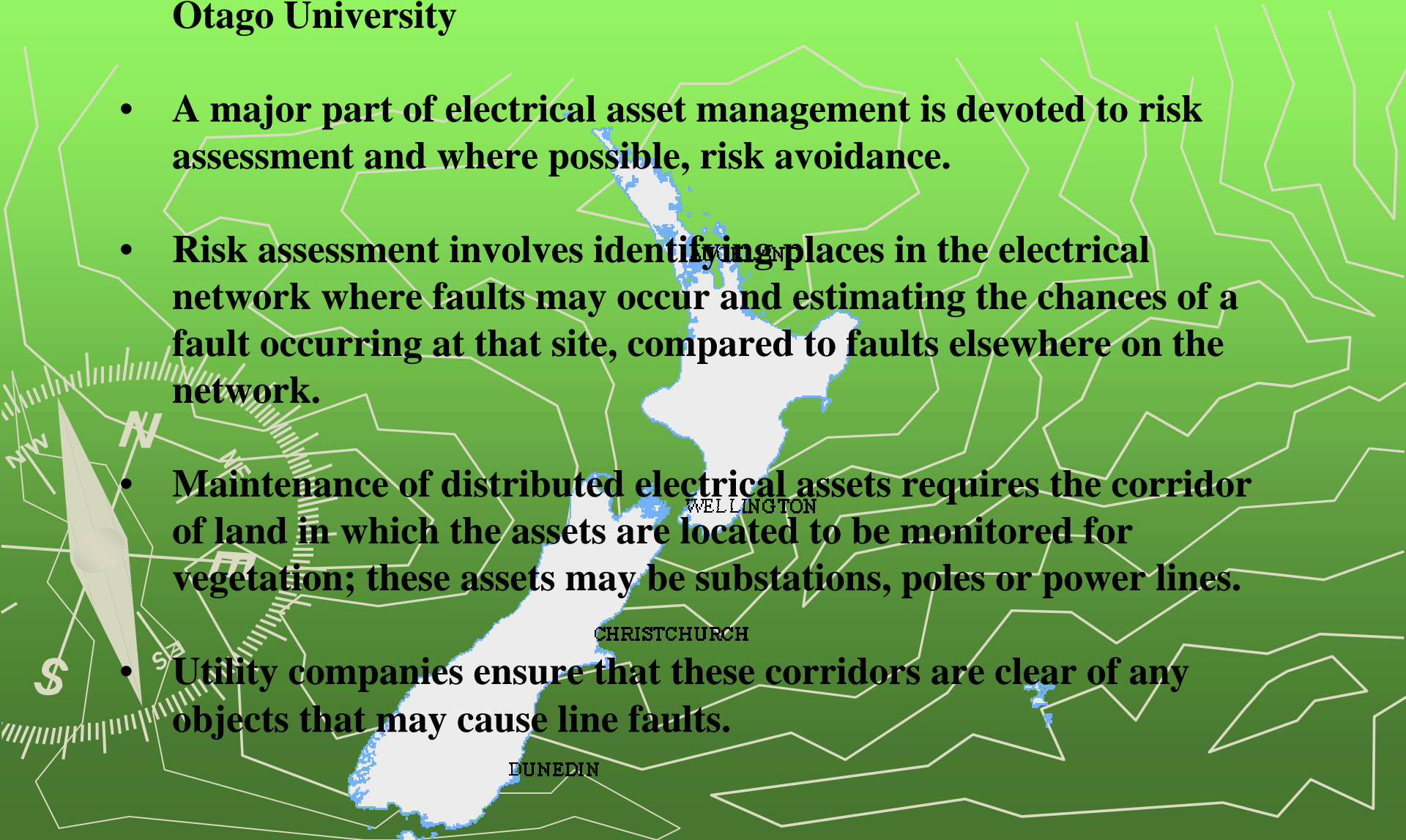
Utility Vegetation Management is a Worldwide Problem

Trees contribute to power disruptions worldwide.

Two of the biggest disruptions in recent years happened in different continents.

14th August 2003 A large tract of Canada & the USA blacked out

The cause of the blackout was determined as initiating in Ohio when three high-voltage transmission lines short circuited when they came into contact with trees.

While there were a number of complicating factors 50 million people were plunged into blackouts due to tree trimming problems.

28th September 2003 – 57 million people in Europe were without power

Investigators found it was triggered by a flash-over between a 380kv conductor and a tree on a line in Switzerland.
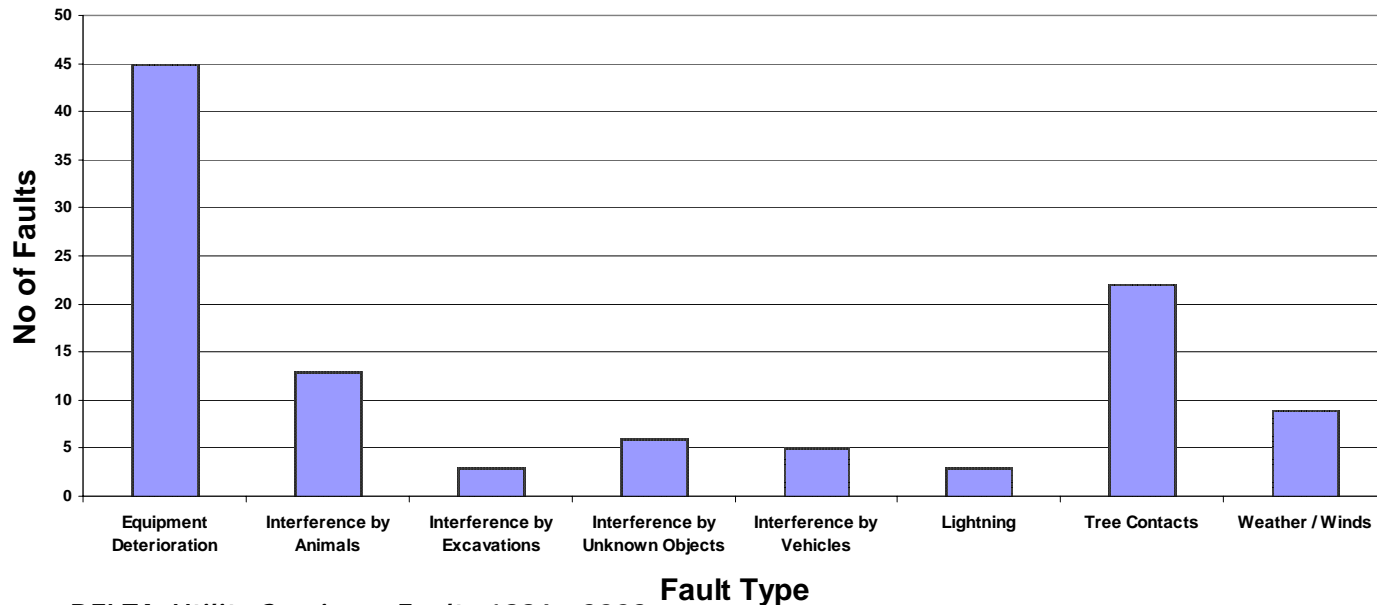
Putting the Problem in Perspective

Approx 30% of faults on electrical transmission lines are caused by trees.

This problem is more common on distribution lines but transmission tree-related outages are also experienced on all utilities' lines on a regular basis.

Utilities spend a significant amount of money maintaining a clear distance between the lines and vegetation.

Taieri Plains Fault Data

Data Source: DELTA Utility Services : Faults 1996 - 2003

Spatially Related Asset Histories

Equipment Deterioration

Tree Contacts Tree Contacts

Tree Contacts

Equipment Deterioration Unknown

Equipment Deterioration

Equipment Deterioration

Foreign Interference Animals

Foreign Interference Excavations

Foreign Interference Animals

Foreign Interference Animals

Foreign Interference Animals

Equipment Deterioration

Equipment Deterioration

Tree Contacts

DELTA has collected 10 years of spatially related asset management data.

Equipment reports 1996 – 2003 were used to locate tree interference in the Taieri Plains area.

Weather Winds

Unknown Unknown
Tree Contacts

Space Imaging®

Why not use space patrols to check tree growth?

- Many organizations calculate the rate of tree growth based on soil type, water and tree type then use this growth rate to schedule cutting programs.

- Others use ground patrols to assess which trees are close to power lines, then schedule their cutting programs.

- Why not detect the type of trees and their height using remote sensing techniques? High resolution satellites pass over power lines more regularly than any ground patrol can and have a ground resolution of 1 meter.

A new Perspective on Determining the Risk Trees Pose to Power Lines

- **The goal of my research is to reduce the number of ground patrols needed to determine where vegetation interfered with power lines and to produce a tree risk layer on the GIS to identify where the lines are most at risk.**

- **The questions are can satellite images and remote sensing techniques be used and can the results be applied to a GIS to detect problem areas?**

- **In July 2002 we took the first steps to produce a process to achieve our goal.**
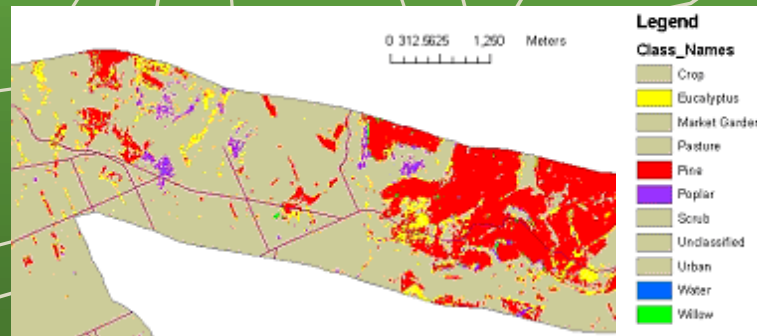

Data Source: Delta Utility Services

Why use Remote Sensing?

To use remote sensing as a successful solution for patrolling trees it has to:

- Be relatively simple to extract data (does not require remote sensing specialists to operate it).

- Use the existing GIS products where possible.

- Have lower ongoing costs by associating maps produced from satellite images rather than the existing manually based system.
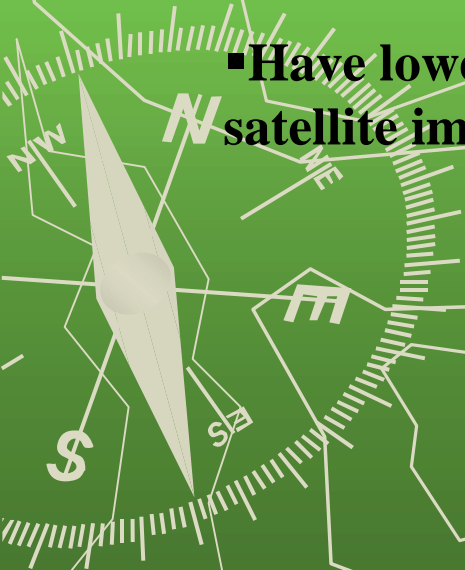
Power Lines Visible from Space

In June 2003 Dr Renaud Mathieu contacted me. During a remote sensing project to monitor a species of endangered birds, he found power lines running through one of his satellite images. The image showed several 220Kv power lines and towers, however the image was non typical for several reasons:

- **It was an arid region with very clear dry air**
- **There were few trees in the area**
- **Each line was a bundle of 4 wires**

Space Imaging®
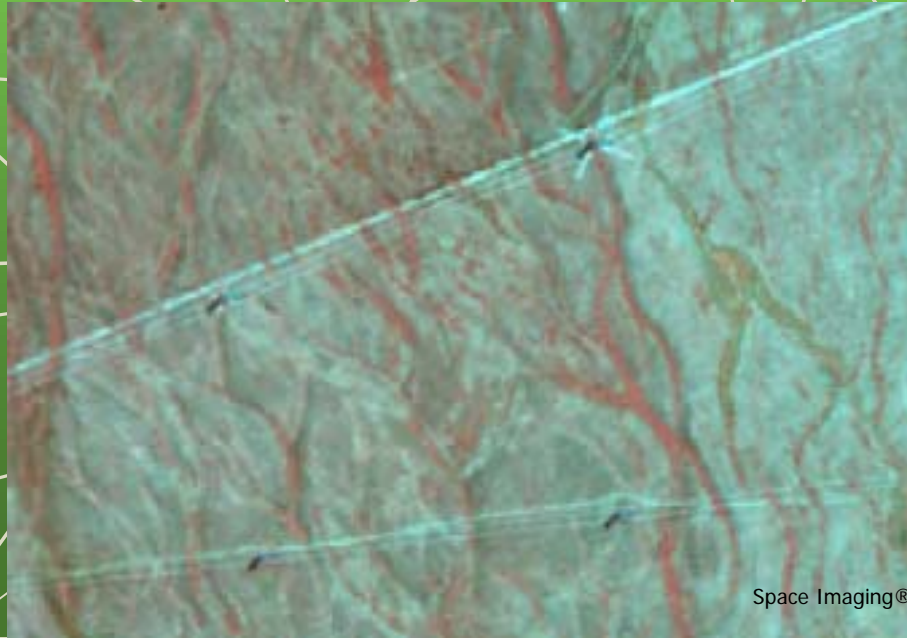
What about distribution lines?

- **Even distribution power poles are 'visible' in 1m satellite panchromatic images by virtue of the shadow they cast.**

- **Distribution lines aren't visible in the image but not necessary as the GIS contains line information.**

Space Imaging®

Risk Assessment

Risk assessment needs to be based on:

- detection of tree clusters having proximity to power lines.

- approximate height and tree species.

- a set of rules to automatically determine the risk that classes of trees pose to assets.

Devising Rules for Assessing Risk

Rules have been designed to be applied to tree heights and distance from power lines. This determines the risk of the trees touching the power lines. These rules are based on the field experience of network inspectors.

Sample Low Voltage Pole Rules
Tree height is more than 2 meters lower than the adjacent power line = no tree hazard. Trees are far enough below power lines to pose no risk.

Tree height is within 2 meters of the adjacent power line = reasonable risk the height of trees is similar to power lines and may cause problems in the near future.

Tree height over the height of the power line = high tree risk. The trees are the same height or higher than the power lines and therefore pose a significant risk.

These rules are being applied in the GIS by using selections. Tree shadows being sorted into the three new shapefile layers, dependent on risk.

Devising Rules for Assessing Risk

For the purposes of identifying which trees are likely to cause damage to the transmission lines, it will be important to identify ways in which various tree types cause damage to power lines. This will include the development of a risk index based on the distance of trees from transmission lines, tree type and tree height, the result being a map showing hot spots in terms of risk damage to power lines

Tree type, water and weather conditions dictate the speed of growth and how well the tree will withstand weather conditions. Some types of trees grow very rapidly and develop hollow centres which cause the trees to fall into power lines. Other types grow slower with strong dense branches however these branches break off in strong winds and flick into the power lines.

The rules have been designed to be applied to tree heights and distances from the power line to determine the risk to the power line tree contact. These rules are based on the field experience of network inspectors.

Converting Shadows from Raster Images

- **Shadows are extracted from the raster image using a texture filter to produce a black & white raster image containing only the shadow edges. The image is further filtered to remove the less significant shadows.**

Image Processing

To extract information from the satellite images in several simple steps:

- **1 meter panchromatic image**

- **Power lines added**

- **50 Meter buffer around power lines**

- **Classified supervision of multi-spectral image**

- **Shadow extracted from panchromatic image**

Space Imaging®
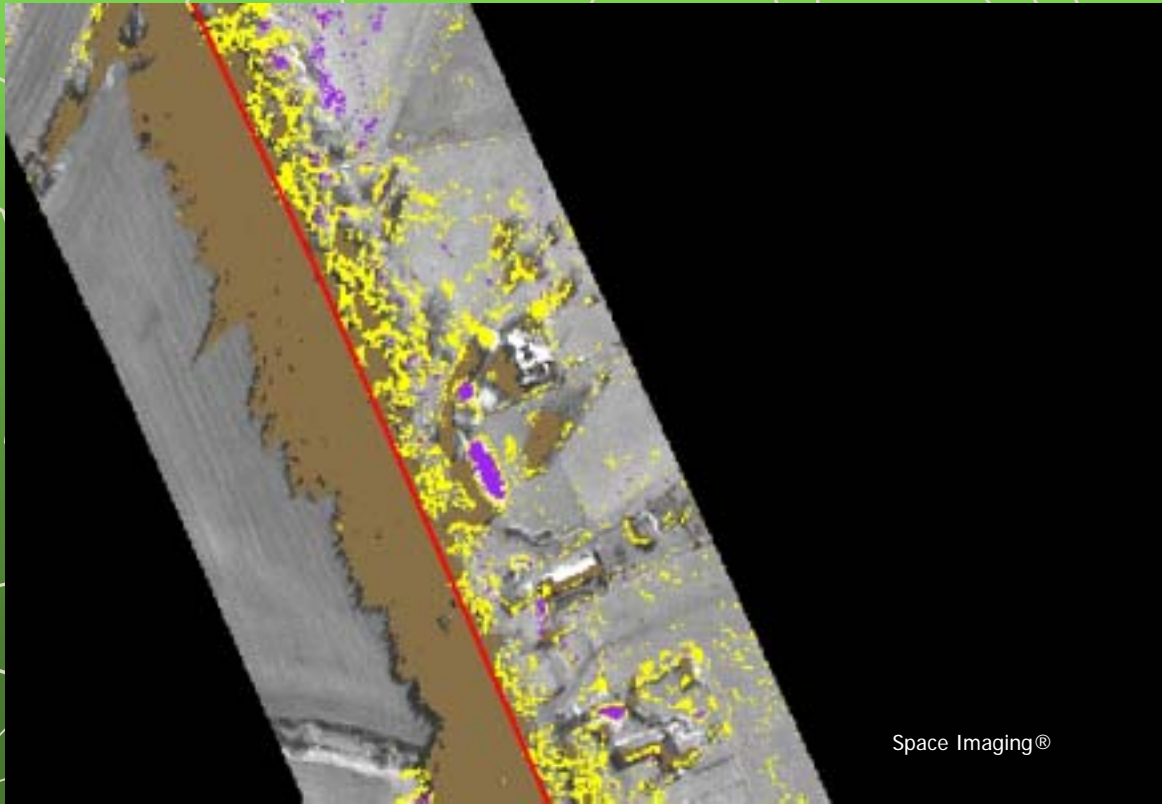
Adding Vectors

- **Vectorise the raster shadow image**

- **Vectorise the tree image and extract the tree types from the image**

- **Classified supervision of multi-spectral image**

- **Shadow extracted from panchromatic image**

Space Imaging®
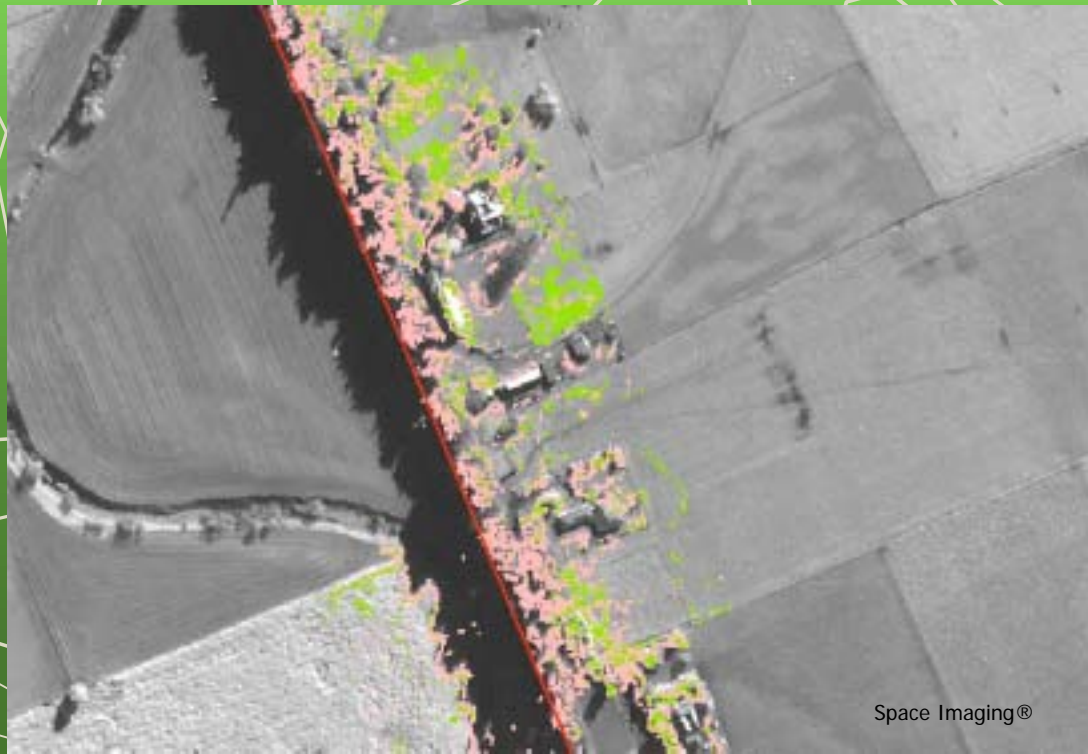
Assessing Tree Heights from Shadows

All trees being assessed for height are close to poles or towers
All poles have their height recorded on installation
Therefore it is possible to calculate the height of the trees.

48492
48493
48494
48491
48498
48495
48496
48397
48497
48398
48400
48399

Pole Shadows
**Tree Shadows**

Space Imaging®

Zones of Risk

Once the height of the trees is known it is possible to develop zones of risk around the power lines based on height and tree species.

Space Imaging®
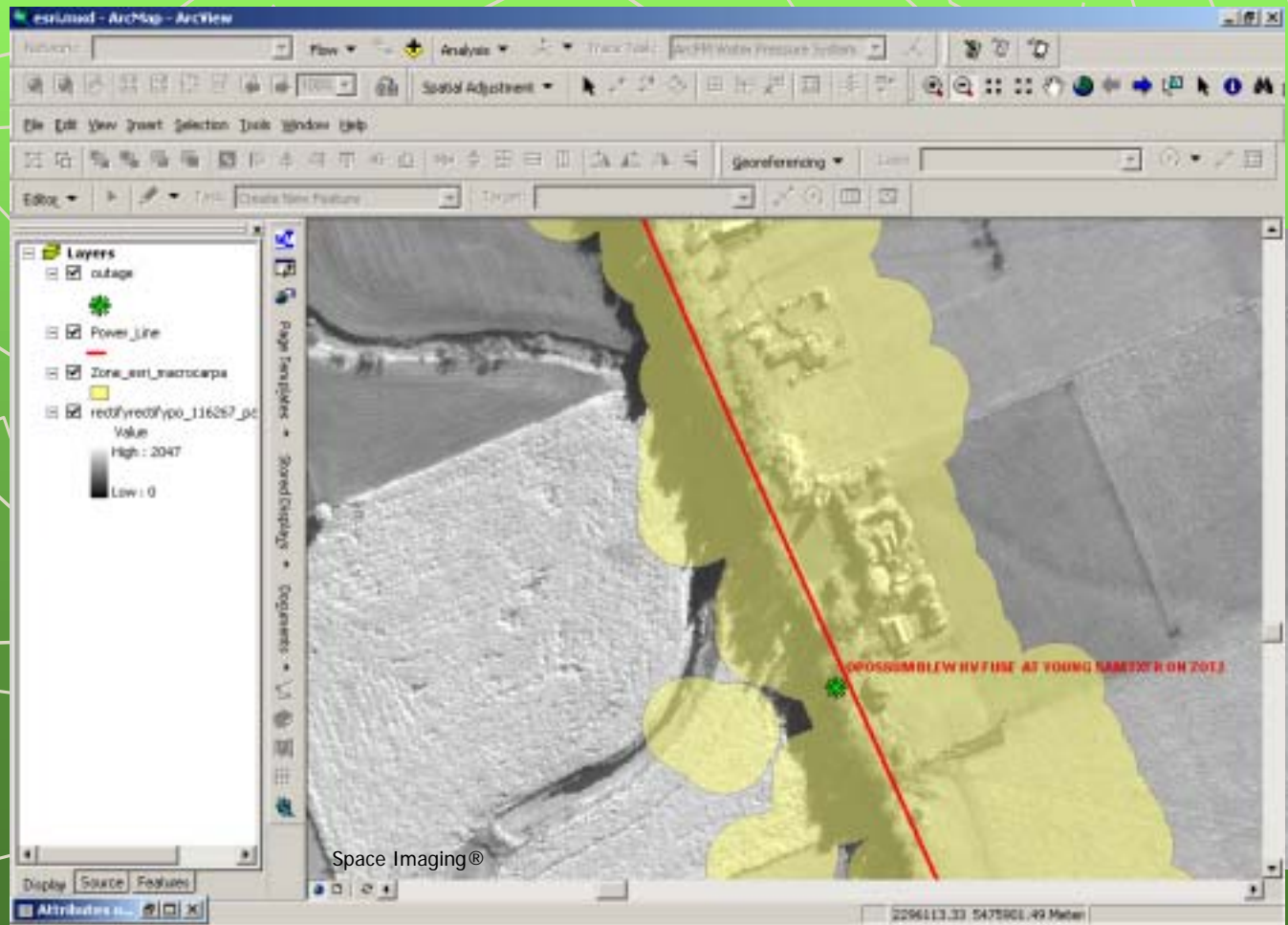
Conclusions

- **Remote sensing is suitable for detecting tree types near lines.**

- **Initial tests show that tree heights can be determined from satellite images.**

- **Rules can be devised to determine zones of risk around power lines.**

- **The remote sensing techniques used in these tests are suitable for use by GIS operators.**
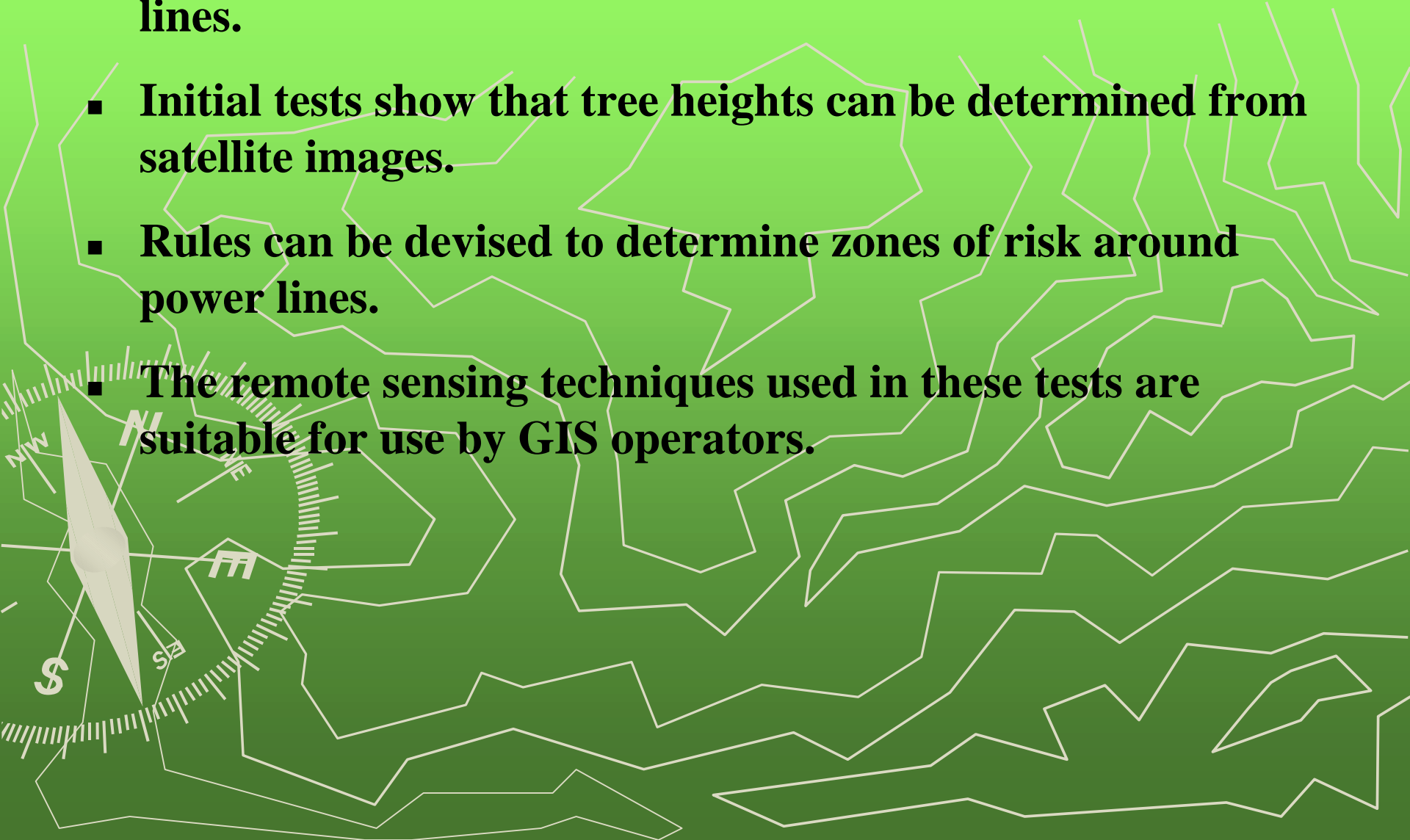
Thank You

Any Questions ?

Acknowledgements

The satellite images are licensed from Space Imaging to the School of Surveying of the University of Otago for research purposes.

The GIS data was supplied by Delta Utility Services Ltd and is a subset of their GIS system. The subset depicts the Taieri Plains area of Otago New Zealand

Profile

Keith Beck Pg Dip Sci Otago , TIPENZ, Dip Bus Stud Massey**.** DELTA Utility Services, Dunedin, New Zealand

Email: keith.beck@4delta.co.nz

· Keith Beck has PGDipSci (Spatial Information) from University of Otago, Diploma Business Studies (Info) from Massey University and is a Technical Member of the Institute of Professional Engineers New Zealand. He is currently completing a MSc (Land and Spatial Data) at University of Otago

· Keith has worked in the electricity distribution industry since 1969 he is currently the Information Services Manager for DELTA Utility Services, Dunedin New Zealand where one of his responsibilities is the development of Delta's GIS systems. Keith has had 15 years experience in GIS, managing a range of GIS systems; he is currently managing an ArcFM Energy system.

· Keith's research interests are related to the application of remote sensing and GIS technologies in the management of distributed assets. His current research is oriented to the remote identification of asset risks.

Dr Renaud Mathieu BSc Ag (Toulouse), MSc (Cranfield), PhD (Marne-la-Valée). University of Otago, Dunedin New Zealand

Email: renaud.mathieu@stonebow.otago.ac.nz

· Renaud grew up in Africa before obtaining a BSc in agronomy (Toulouse - France). He then completed a MSc in Applied Remote Sensing at Cranfield University (UK) in 1992. During the next four years he worked in Chile with an institute of French co-operation and the University of Chile. He completed a PhD in Geographic Information Science from the Marne-la-Vallée in Paris, France in 1998. Before joining our Department in 2000, Renaud spent one year as Post-Doctoral fellow at a Research Center for Geomatics in Laval University, Canada.

· Renaud's expertise and research interests are related to the application of remote sensing technologies to agriculture as well as to natural resource management and conservation. Most of his recent research works are orientated to the retrieval of earth surface biophysical parameters from radar and optical remote sensing data at both large and medium scale.

Web sites:-

DELTA Utility Services –   www.4delta.co.nz

Aurora Energy   -   www.electricity.co.nz

Otago University   -   www.otago.ac.nz