A New Zealand Perspective –

Research, development and collaborative work with Fraunhofer ENAS

Ian Woodhead and Adrian Tan

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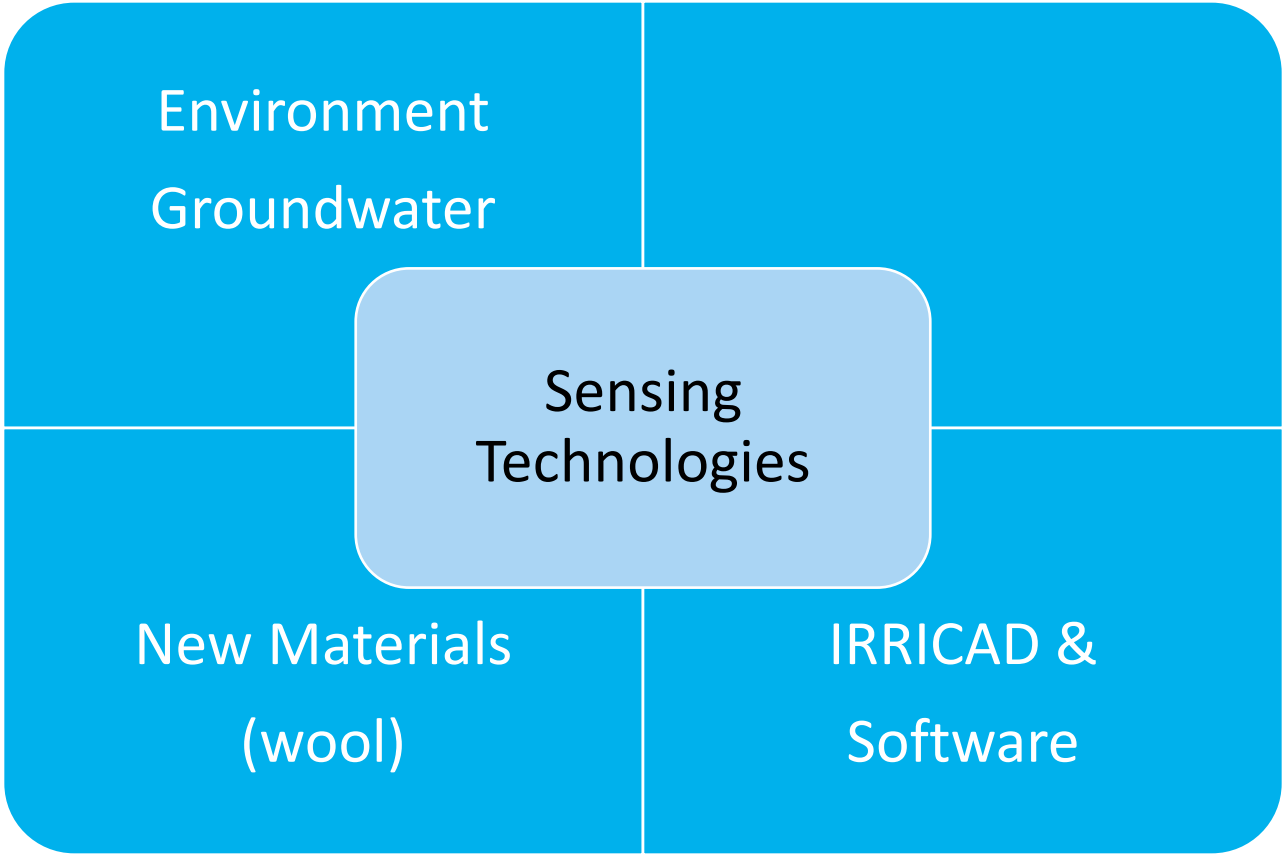
Outline

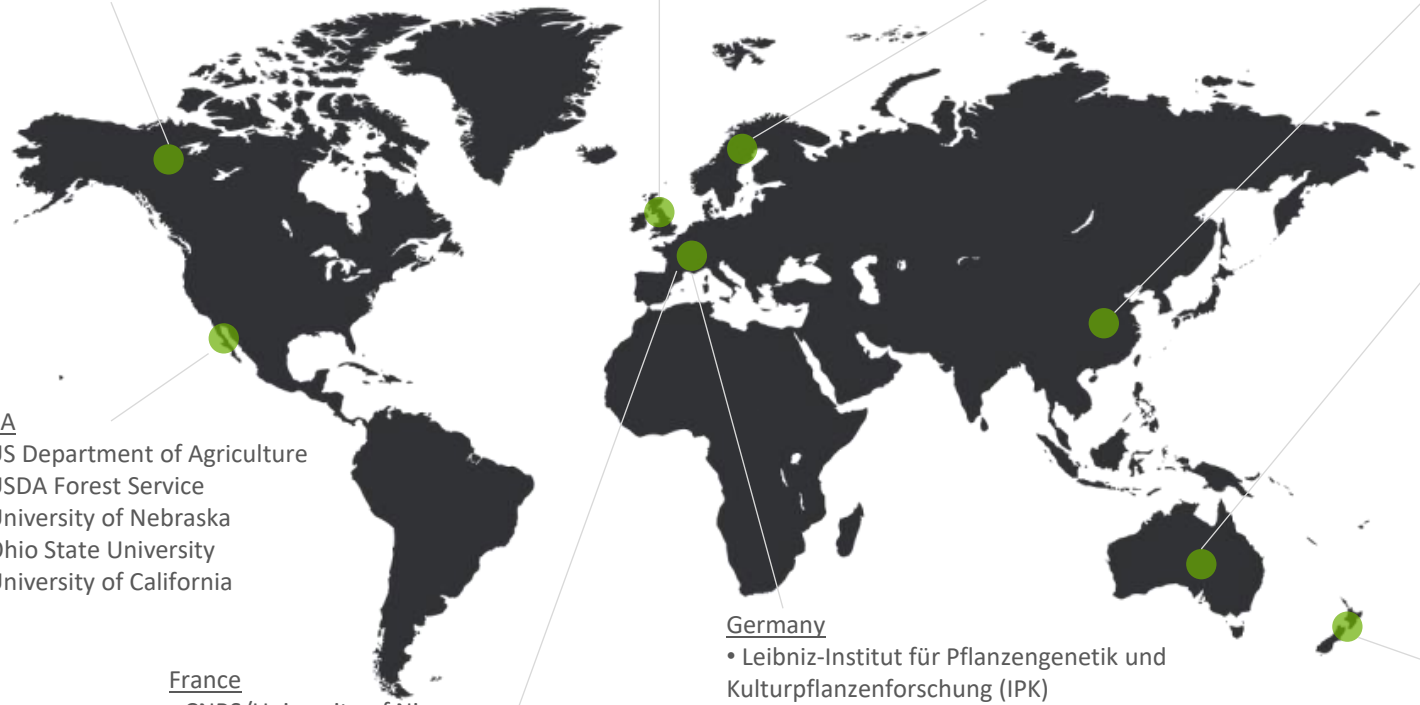
- Lincoln Agritech – Structure
- R&D examples
- Product examples
- New Zealand science sector
- National Science Challenges
- Collaboration ENAS – LAL
- Microwave Sensors

Overview

- Independent R&D provider to the private sector and government
- 47 Research Scientists and Engineers
- 50 year history in Ag Engineering
- 100% owned by Lincoln University, independent board
- Offices in Lincoln and Hamilton



COLLABORATIONS



Canada
- Department of Agriculture
- Pesticide & Vet Medicines Group

UK
- City University London

Sweden
- Lund University

China
- China Agricultural University
- National Engineering Research Centre for Information Technology
- Ministry of Agriculture

Australia
- University of Queensland
- University of New England
- University of Sydney and Australian Centre for Field Robotics

USA
- US Department of Agriculture
- USDA Forest Service
- University of Nebraska
- Ohio State University
- University of California

France
- CNRS/University of Nice
- Rennes 1 Université
- École Nationale Supérieure de Chimie et de Physique de Bordeaux
- Aix-Marseille Université
- Institut National Superieur des Sciences Agronomique

Belgium
- Catholic University, Leuven

Germany
- Leibniz-Institut für Pflanzengenetik und Kulturpflanzenforschung (IPK)
- Bochum University
- Tübingen University
- Water and Earth Science Competence Cluster (WESS)
- University of Mannheim
- University of Göttingen
- Fraunhofer ENAS
- Technical University of Munich

Austria
- BOKU University

New Zealand
- Lincoln University
- University of Canterbury
- University of Auckland
- University of Otago
- Massey University
- Scion Ltd
- Cawthron
- ESR
- AgResearch
- Aqualinc Research Ltd
- PPCNZ
- Landcare Research
- Plant and Food Research
- NIWA
- Environment Canterbury
- Waikato Regional Council
- Taranaki Regional Council

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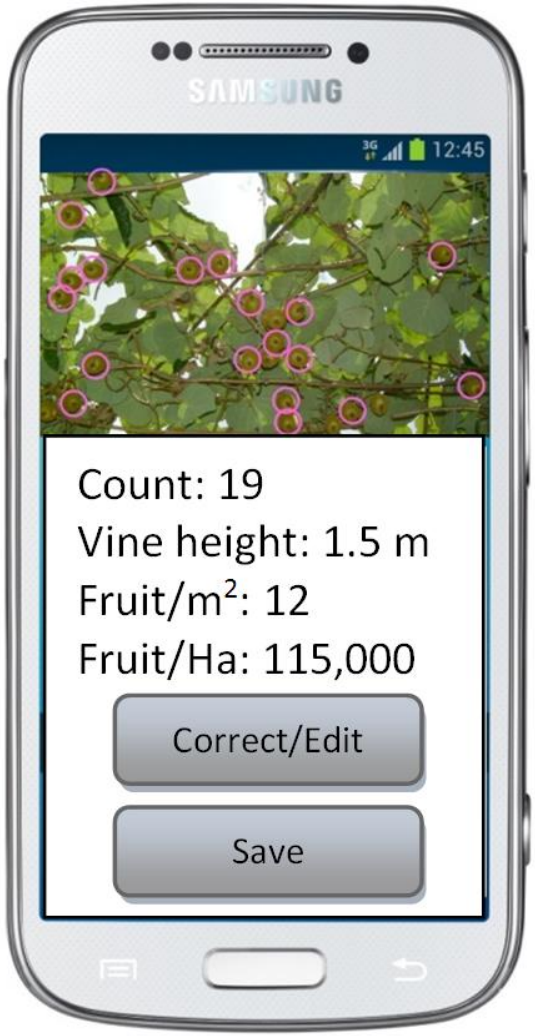
Kiwifruit yield

SMARTPHONE GROWER PROJECT:

- Use smartphone camera to capture images and mobile app to process images and interpret results
- Use machine vision to identify and count fruit in the canopy from captured images
- Augment the phone's hardware with a small Bluetooth enabled sensor pod
- Sensor pod sends back canopy height and light intensity data to the mobile app



On-farm sensors

OPTIMUM-N

Optimising amount of nitrogen fertilizer applied to intensively grazed pasture.

Developing new sensors, methods and tools to balance demand with application rate.

Enables smarter and more responsible application of fertilizers.

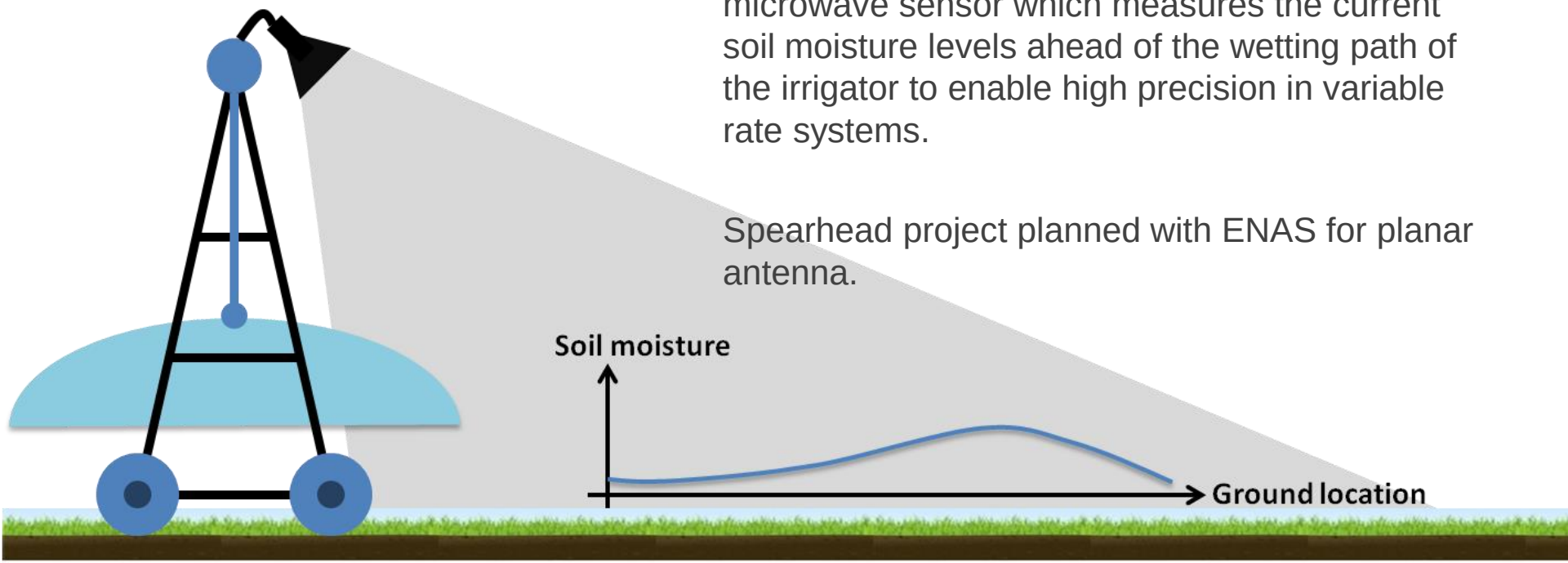
Soil Moisture Radar

SMARTER IRRIGATION

Centre pivot irrigators provide a sensor platform to collect on-farm data with high spatial / temporal frequency.

Lincoln Agritech has developed a radar-like microwave sensor which measures the current soil moisture levels ahead of the wetting path of the irrigator to enable high precision in variable rate systems.

Spearhead project planned with ENAS for planar antenna.



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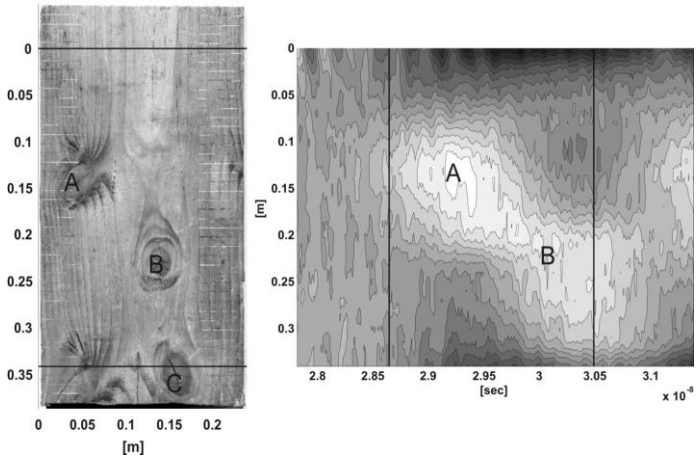
Sub-surface Moisture

TIMBER IMAGING



Detection of subsurface knots and defects.

Visual image of wood features (left), compared with sub-surface measurement via TDR (right). TDR correctly positions knots and related wood characteristics.

SUBSURFACE MOISTURE IN ROADS

Non-invasive measurement of subsurface moisture and distribution profiles.

Evolution of microwave technologies to allow profile measurements with multiple transmission lines (patented). Process speed measurement (pico-second resolution sampler).

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Animal detection & ID

CHALLENGE:

1. Monitoring and trapping pests and endangered species is expensive, inaccurate.

Ink pads, muddy paws, labour intensive.

SOLUTION:

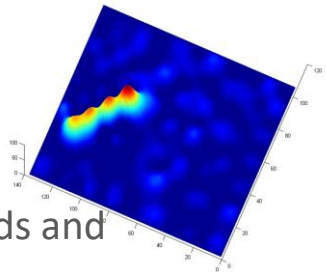
Electronic capacitive sensor pad.

Accurately targeting pests: stoats, ferrets, possums, cats, rats and mice.

Endangered: NZ native (ground) birds, skinks/lizards,

EXTENSION OPPORTUNITIES:

- Small crawling insect detection
- E.g. 0.1g millipede



Collaboration:

How to mass-manufacture sensor pads and integrate electronics.

Fat depth

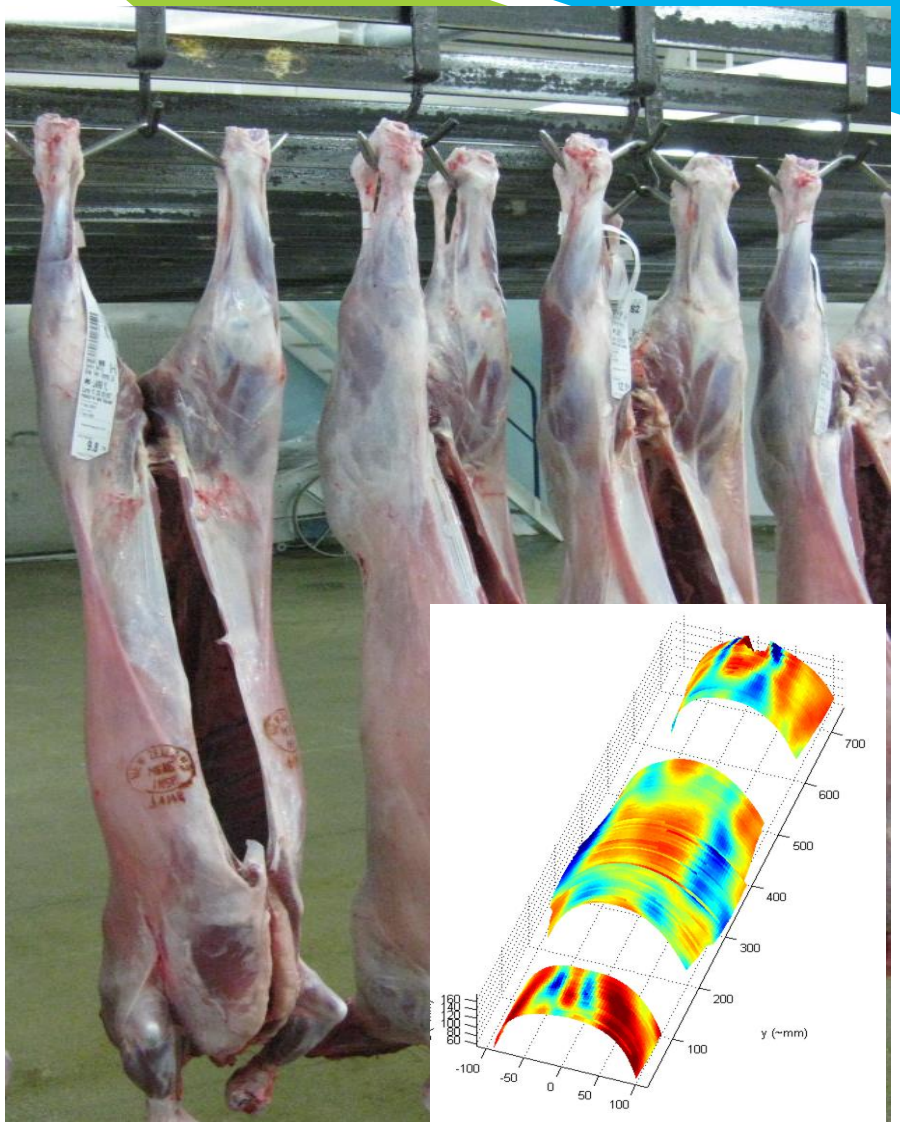
Objective measurement of carcass quality. Prototype developed and trialled successfully, commercialisation discussions in progress.

CHALLENGE

High-speed, non-invasive, non-contact analysis of carcass quality on the processing line.

SOLUTION

A microwave-based system for measuring fat and muscle distribution of whole carcasses.



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Engineering wool

- Mix of providers working across discovery and functional properties characterisation:
  - Lincoln Agritech
  - AgResearch
  - Centre for Industrial Rheology (UK)
  - Hosokawa Micron (UK)
  - Dermatest (Germany and Aust.)
  - University of Wollongong (Aust.)

- New discovery in processes for insoluble and soluble keratin derivatives are being created.

Irrigation Design Software

- Sold internationally since 1988
- Owned by Lincoln Agritech
- Distributed by:
  - Nelson Irrigation (USA)
  - Netafim (Israel)
  - >1600 users in over 60 countries
- Current opportunity in China.

IRRICAD

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Aquaflex

CHALLENGE

Integrated, accurate measurement of soil moisture with cost effective and robust equipment.

SOLUTION

Measures propagation time of pulse on a 3m buried transmission line. Commercialised by Streat Instruments Ltd.

“Aquaflex soil moisture meters overcome the problems associated with measuring the soil moisture content at one point only and in a relatively small amount of soil”

(Streat Instruments)

Subsidiary

- Certus Bio – LAL owns 20%

- Rapid BOD_5 detection – LAL developed
- At line Lactose detection – LAL developed

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Colour Grading

CHALLENGE:

- Accurate, low cost colour measurement of kiwifruit, across a variable wet surface.
- Robust technology for pack house use
- Intuitive operator use.

SOLUTION:

Handheld colour sensor provides an objective measure of the flesh colour, integrated lighting overcomes specular reflection.

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NZ Science Funding

NZ Government science funding schemes:

- Marsden Fund – blue skies, exploration research
- Smart Ideas – test novel concept, 2-3 years, $1M (~€0,65M) total
- Research Programme – stretch science for industry, 4-6 years, ~$1M p.a.
- National Science Challenges (NSC) – small seed projects + larger strongly collaborative projects
- For-industry funding – may involve research institutes

- NZ: 8 Universities, 7 sector-oriented Crown Research Institutes

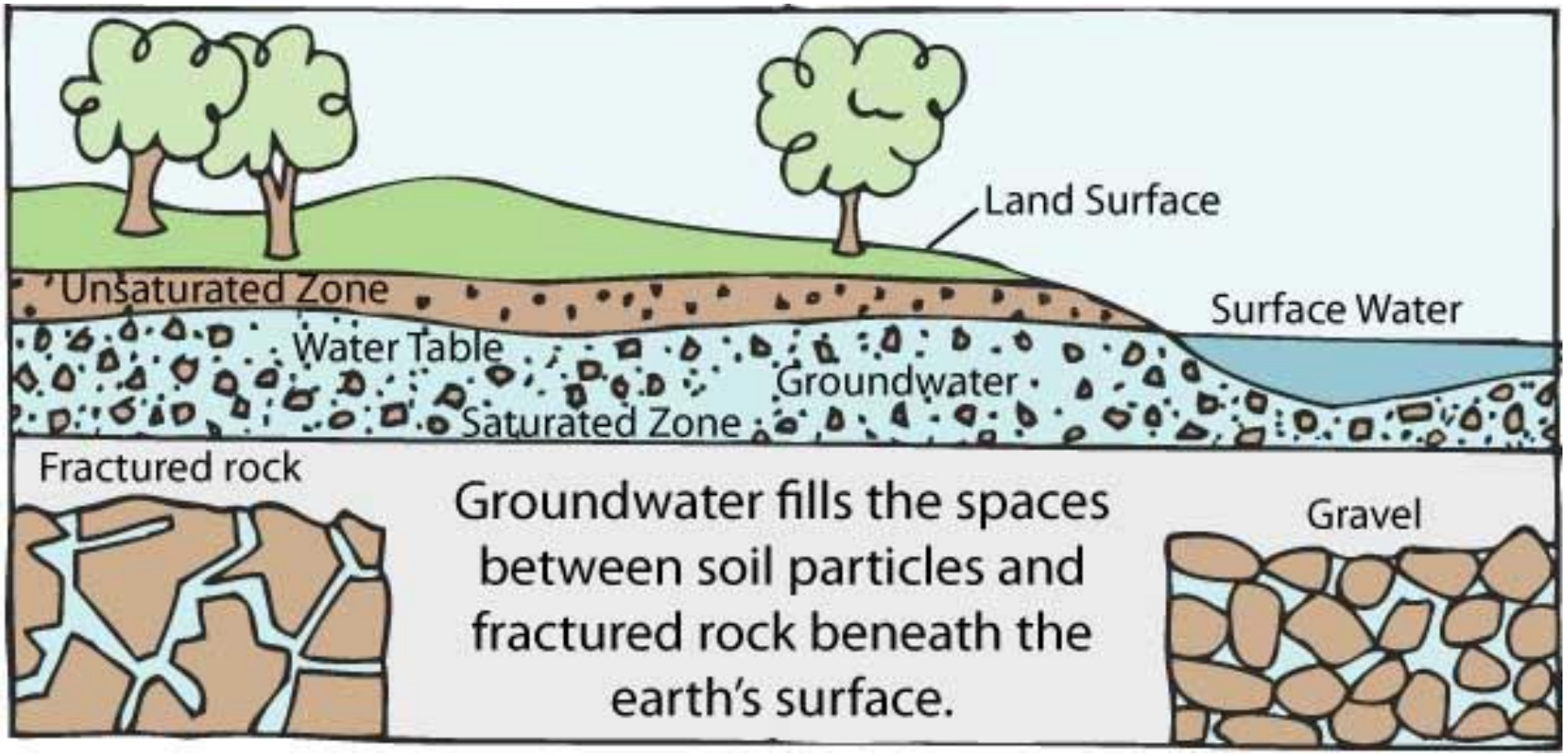
NSC: Science for Tech Innovation

Portfolios:

1. Understanding the research and innovation process
2. Agricultural and Environmental Technologies – focus: groundwater flow
3. Medtech – focus: needle-free sensing and treatment
4. Data Analytics – focus: business models and optimisation
5. Materials and manufacturing – focus: additive manufacturing of biomaterials

SfTI objective: *Enhance the capacity of New Zealand to use physical and engineering sciences for economic growth.*

Portfolio 2



Aims to measure flow from source to stream and lake beds (water is the vector for contaminants but also refreshes at-risk water bodies).

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Portfolio 2

- Physics of large-scale, sub-surface electromagnetic sensing
- Measure groundwater velocity from the surface, averaging the heterogeneity
- Aims for informed management of water quality in primary production environments
- Will deliver to national and indigenous environmental objectives
- A new team involving researchers from 4 universities and 2 research institutes
- Engagement with companies and end-users including iwi and government

Collaboration ENAS – LAL

- BMBF and RSNZ bilateral funding to establish collaboration
- Frank Roscher and colleagues from ENAS
- Initial visit last year to launch collaboration and initiate dialogue

- Follow up visits this week and to NZ in November
- Initial project: printed antennas for automatic control of irrigation
- Possible second project: light weight drone antennas for current project for mapping snow-depth over sea ice in Antarctica.

Projektträger Jülich Forschungszentrum Jülich

Federal Ministry of Education and Research

the Royal Society of New Zealand Te Apārangi

Microwave sensors

Lincoln Agritech are actively involved in several research projects, predominantly using the microwave part of the electromagnetic spectrum.

The next slides describe the scope of these sensors.

Sensor Types

Near-field Sensors	• Fringing fields (capacitive, inductive, time domain) • Localised, high spatial resolution • 'Short range'
Far-field Sensors	• Transverse electromagnetic fields (radiated) • Propagated fields, lower spatial resolution • 'Long range'

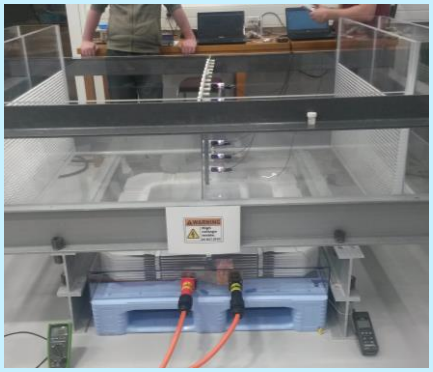
Sensor Types

Near-field Sensors	TDR 		
Far-field Sensors			

Sensor Types

Near-field Sensors	**TDR** • Electrical pulse running down twin-conductor • Moisture profile layers useful for road checking and soil moisture map • Compaction ratio of road base-course		
Far-field Sensors			

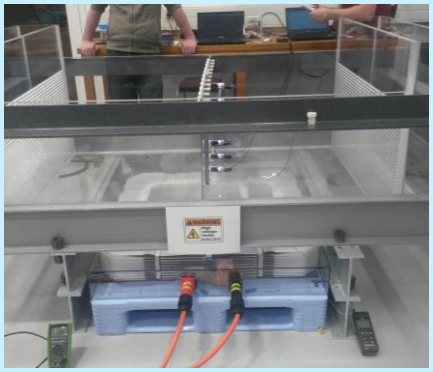
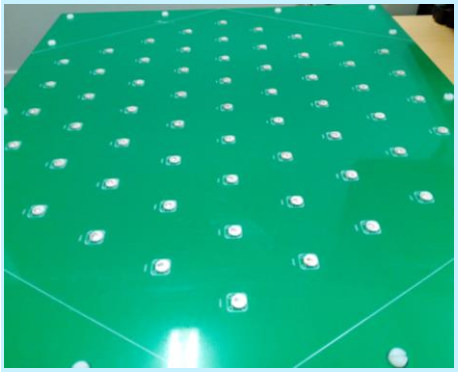
Sensor Types

	TDR	Inductive sensors	
Near-field Sensors			
Far-field Sensors			

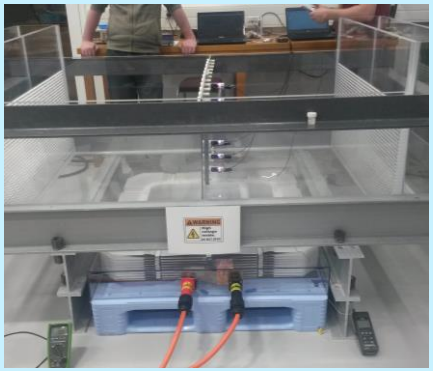
Sensor Types

Near-field Sensors	**TDR** 	**Inductive sensors** • Interaction between moving charges in water and magnetic field • Underground water flow is in the region of 10 mm per hour • Proof-of-concept stage	
Far-field Sensors			

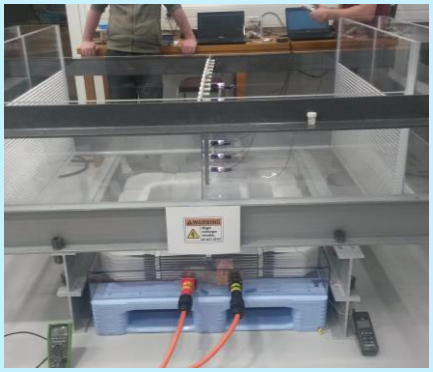
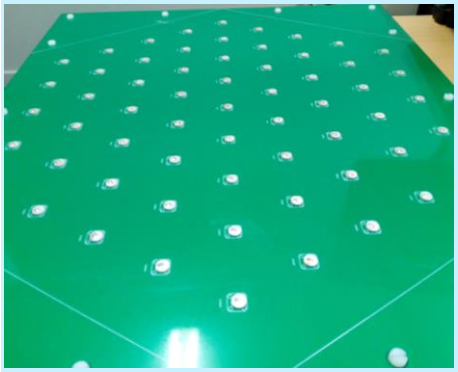
Sensor Types

	TDR	Inductive sensors	Bessel beam
Near-field Sensors			
Far-field Sensors			

Sensor Types

	TDR	Inductive sensors	Bessel beam
Near-field Sensors			• Non-diffracting column of beam of E/H fields • Measures fat profile of sheep to determine stock conditions • In development
Far-field Sensors			

Sensor Types

Near-field Sensors	**TDR** 	**Inductive sensors** 	**Bessel beam** 
Far-field Sensors	**Soil moisture sensor** 		

Sensor Types

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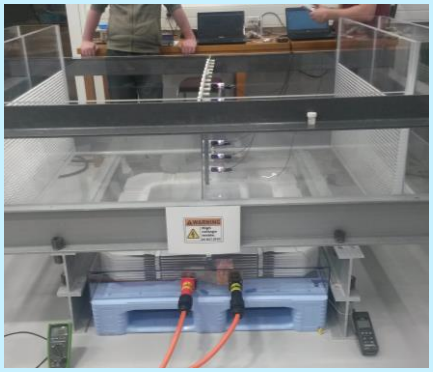
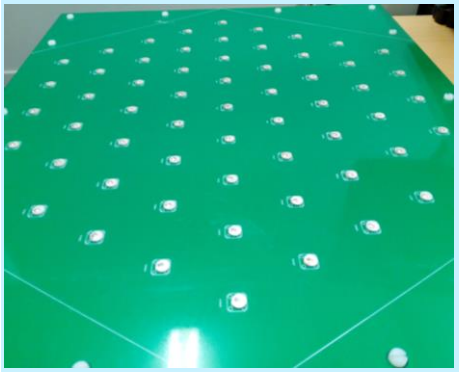
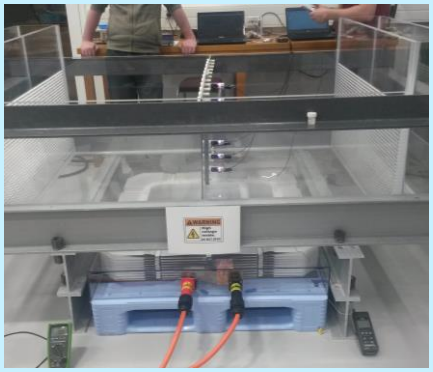
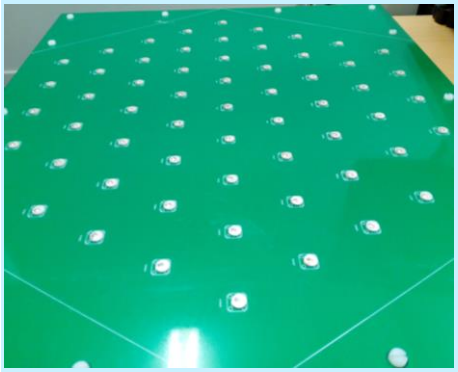
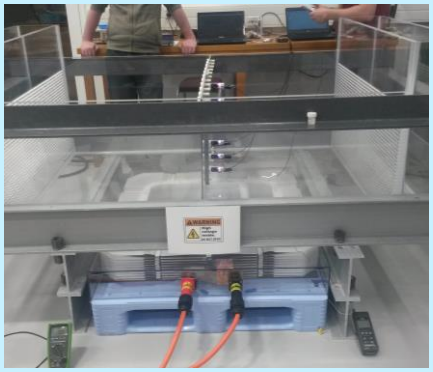
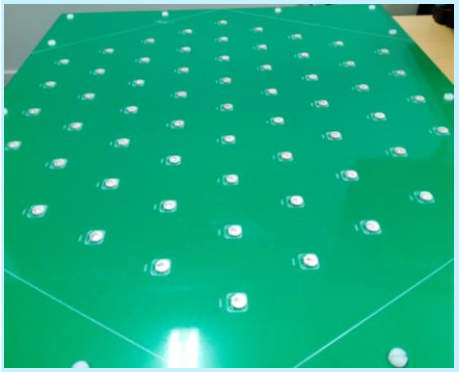
Near-field Sensors			
Far-field Sensors	**Soil moisture sensor** • Scattered fields from pasture measured by high gain antenna • Placement of sensors at centre-pivot irrigators • Able to differentiate soil moisture at field test		

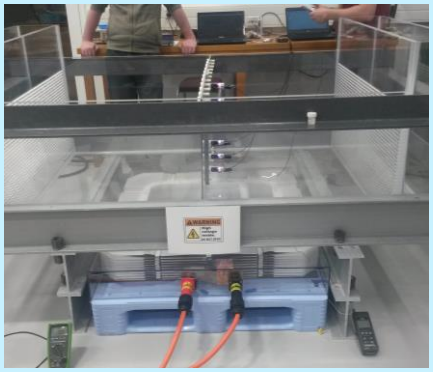
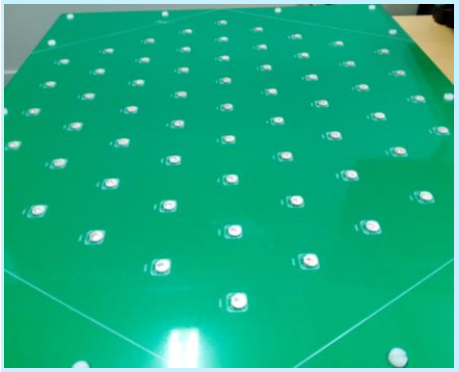
Sensor Types

Near-field Sensors	**TDR** 	**Inductive sensors** 	**Bessel beam** 
Far-field Sensors	**Soil moisture sensor** 	**Material moisture** 	

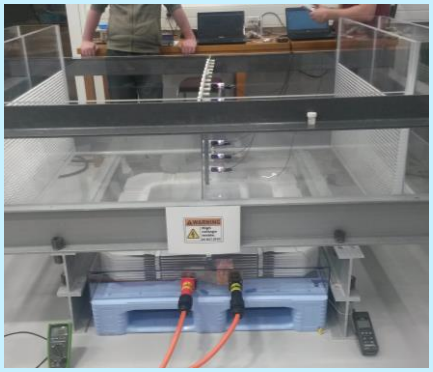
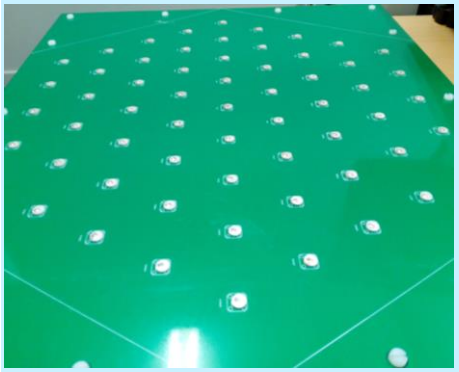
Sensor Types

Near-field Sensors	**TDR** 	**Inductive sensors** 	**Bessel beam** 
Far-field Sensors	**Soil moisture sensor** 	**Material moisture** • Material properties determined from wave reflections • Tight moisture tolerance of material required • Demonstrated for VMC between 0.05 to 0.4	

Sensor Types

Near-field Sensors	**TDR** 	**Inductive sensors** 	**Bessel beam** 
Far-field Sensors	**Soil moisture sensor** 	**Material moisture** 	**Snow radar** 

Sensor Types

Near-field Sensors	**TDR** 	**Inductive sensors** 	**Bessel beam** 
Far-field Sensors	**Soil moisture sensor** 	**Material moisture** 	**Snow radar** • Estimation of snow thickness on sea ice • Collaboration with UC Deep South project • Snow thickness radar on UAV development

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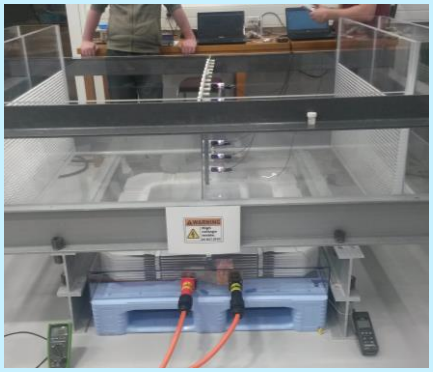
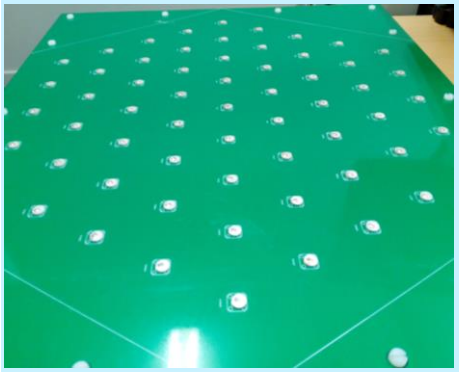
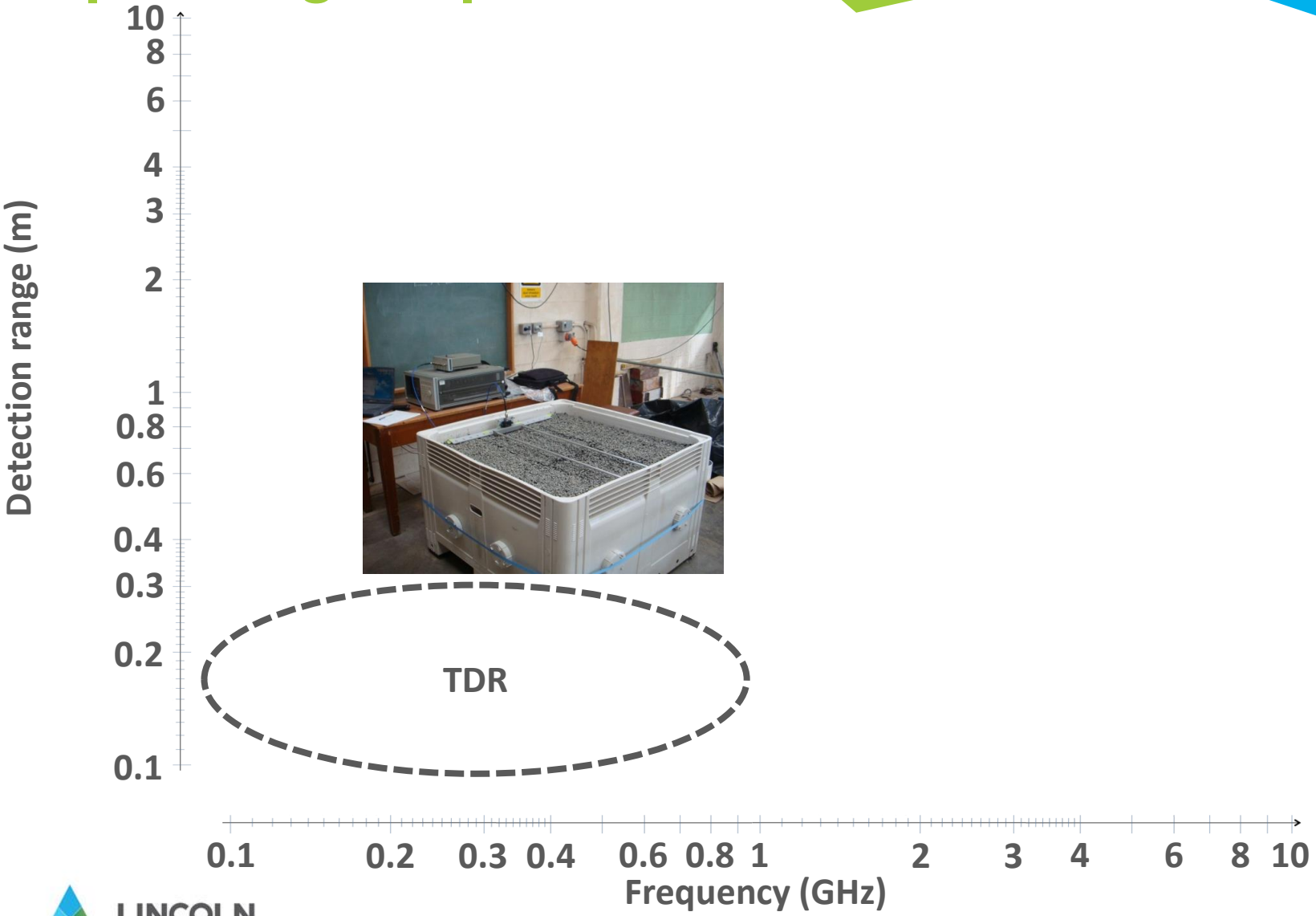
Sensor Types

Near-field Sensors	**TDR** 	**Inductive sensors** 	**Bessel beam** 
Far-field Sensors	**Soil moisture sensor** 	**Material moisture** 	**Snow radar** 

Operating frequencies



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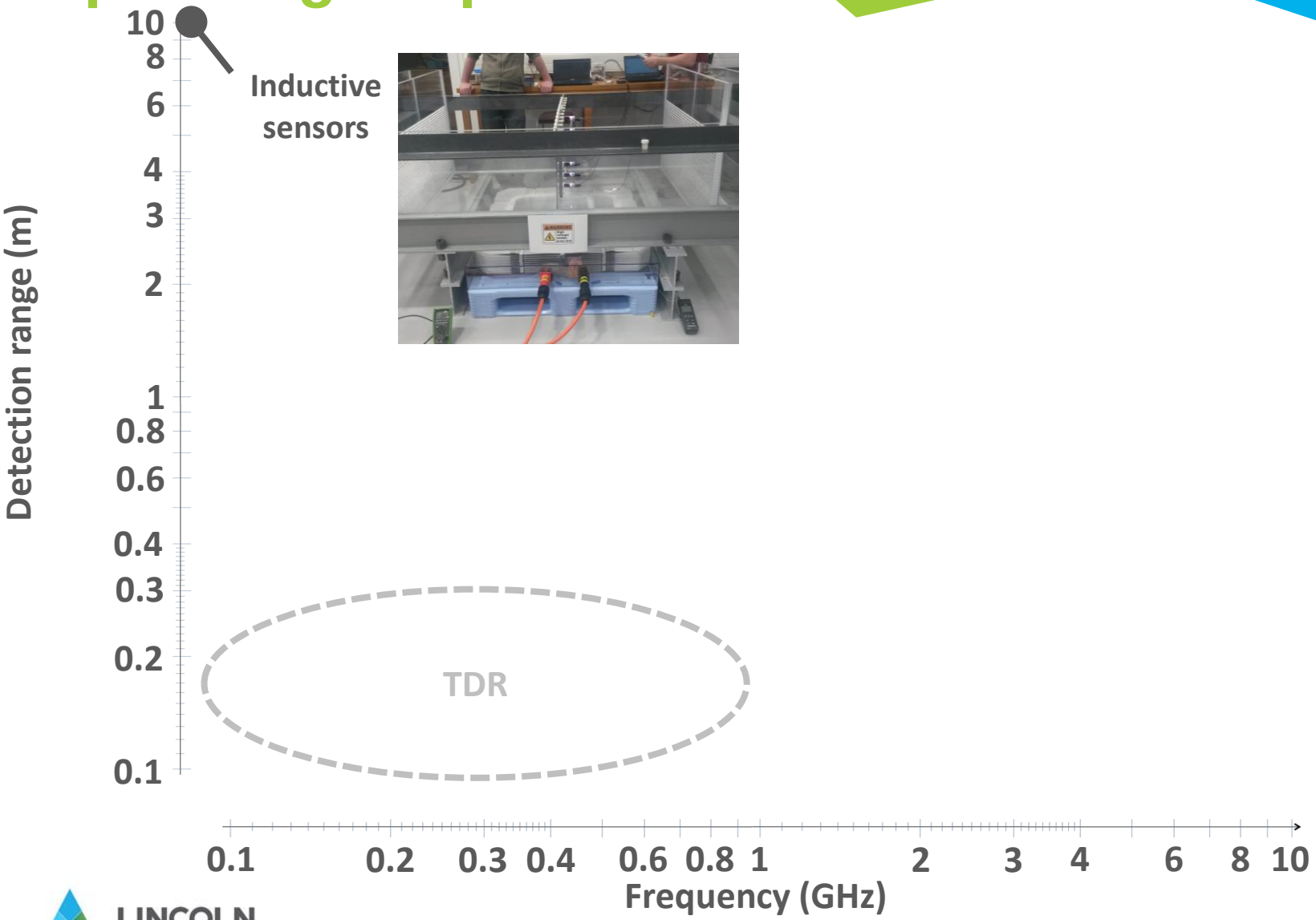

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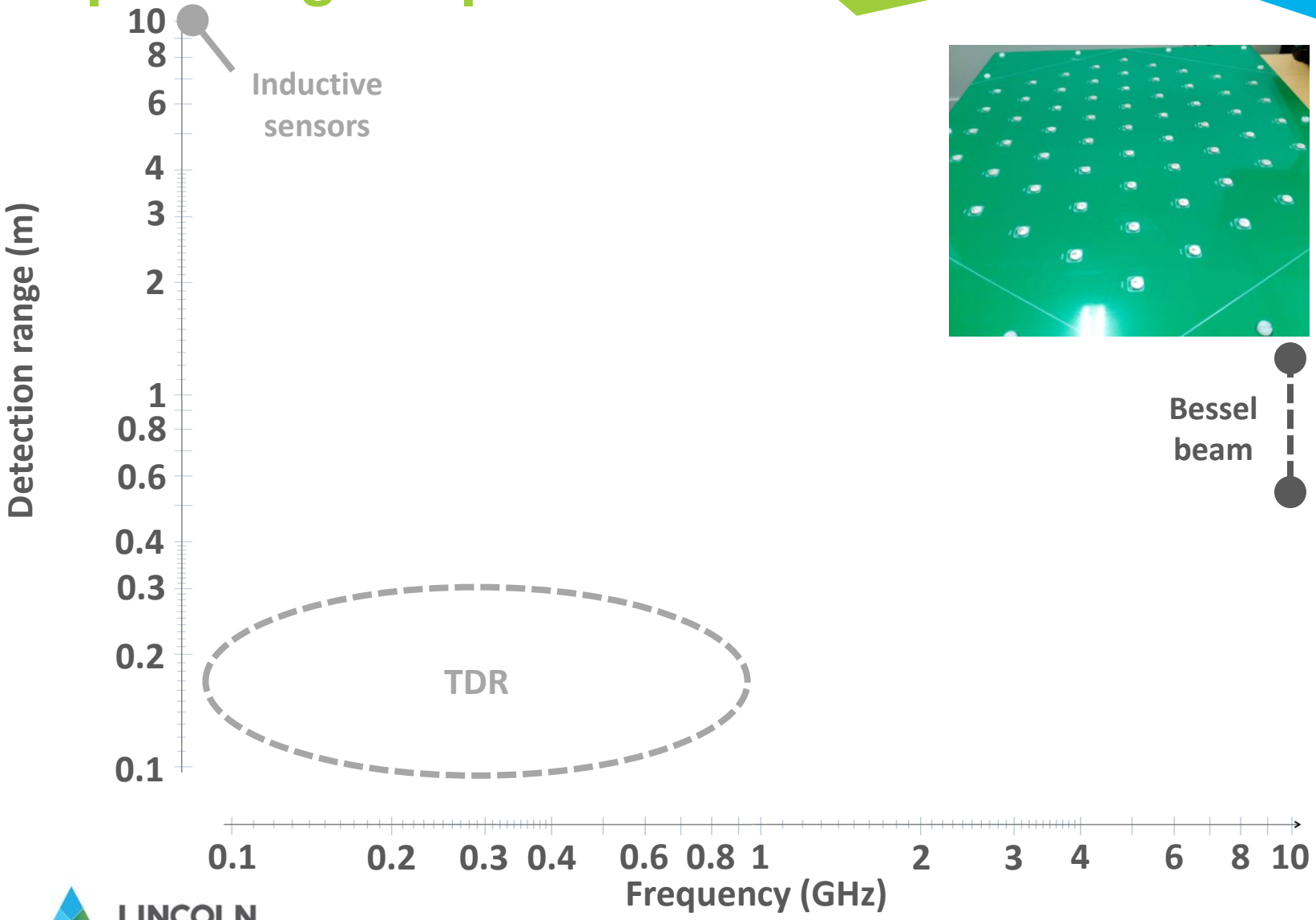

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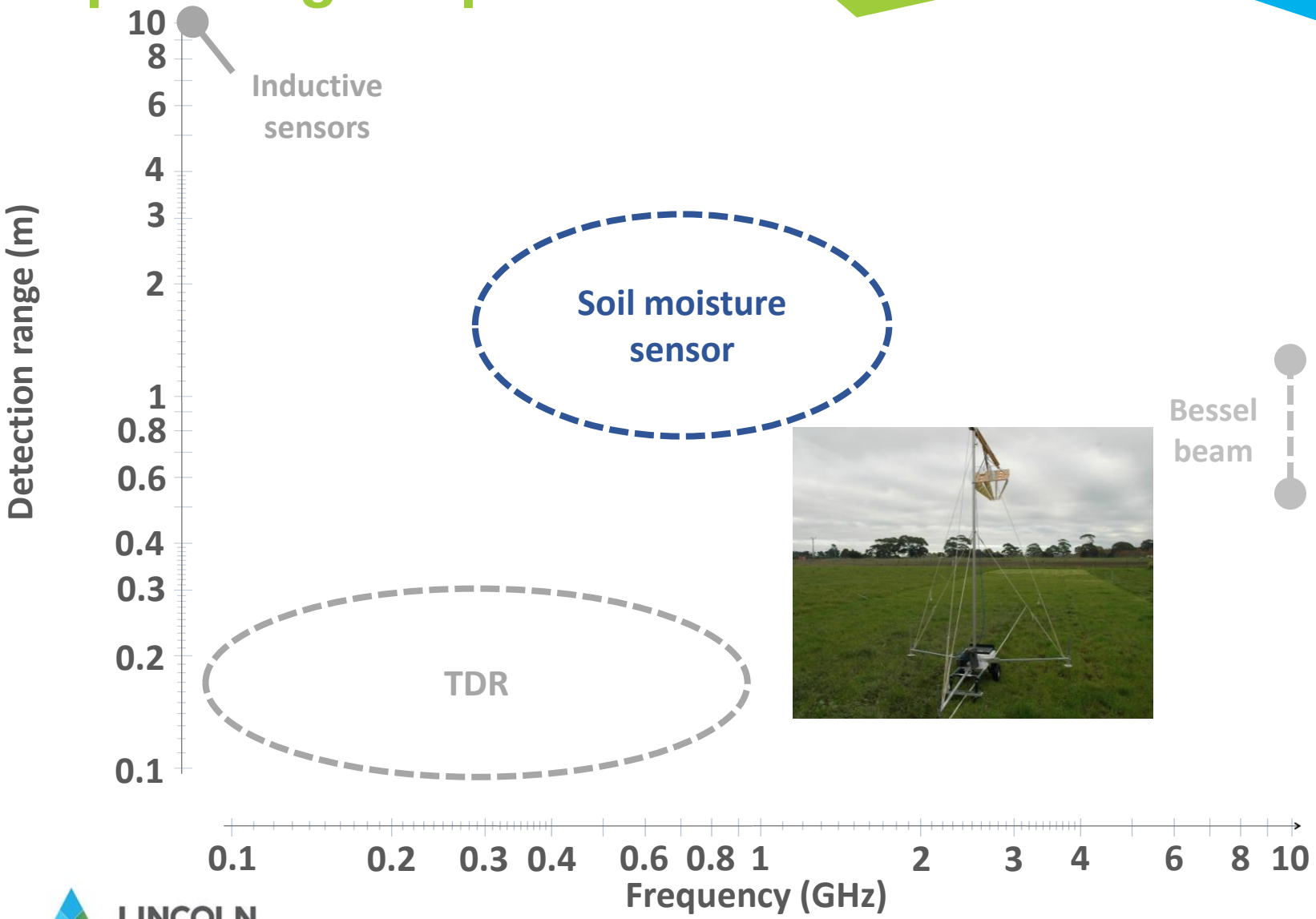

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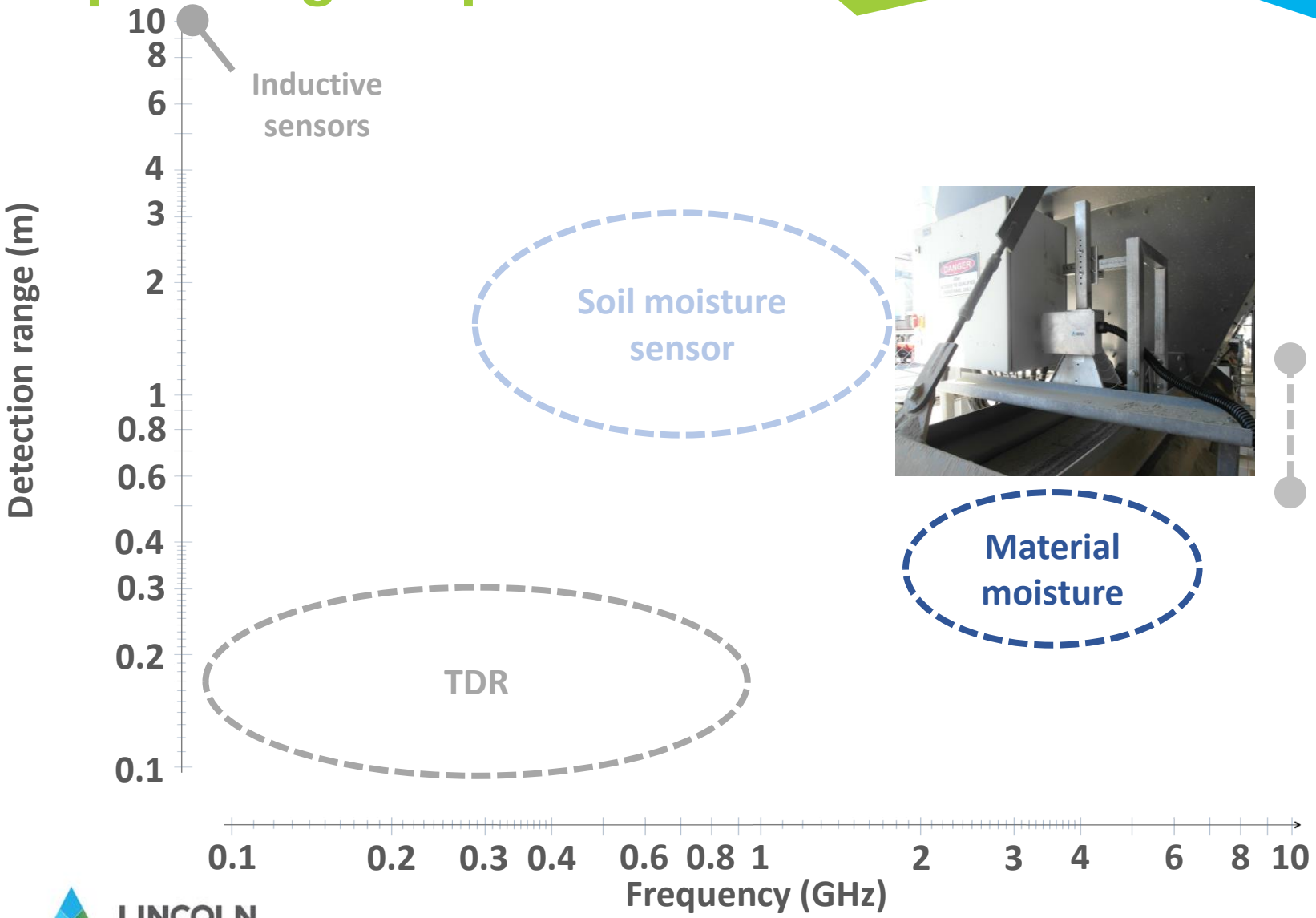

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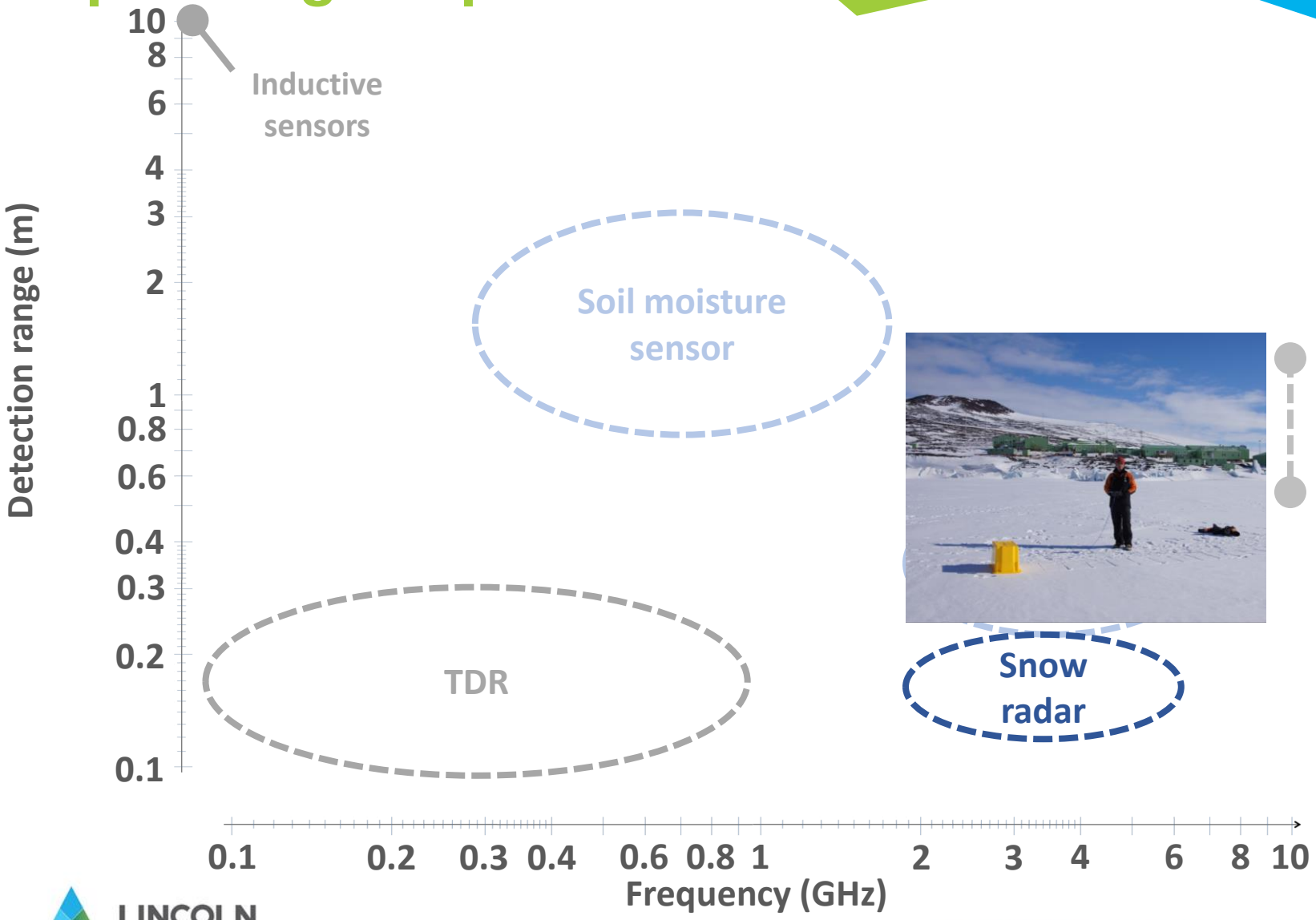

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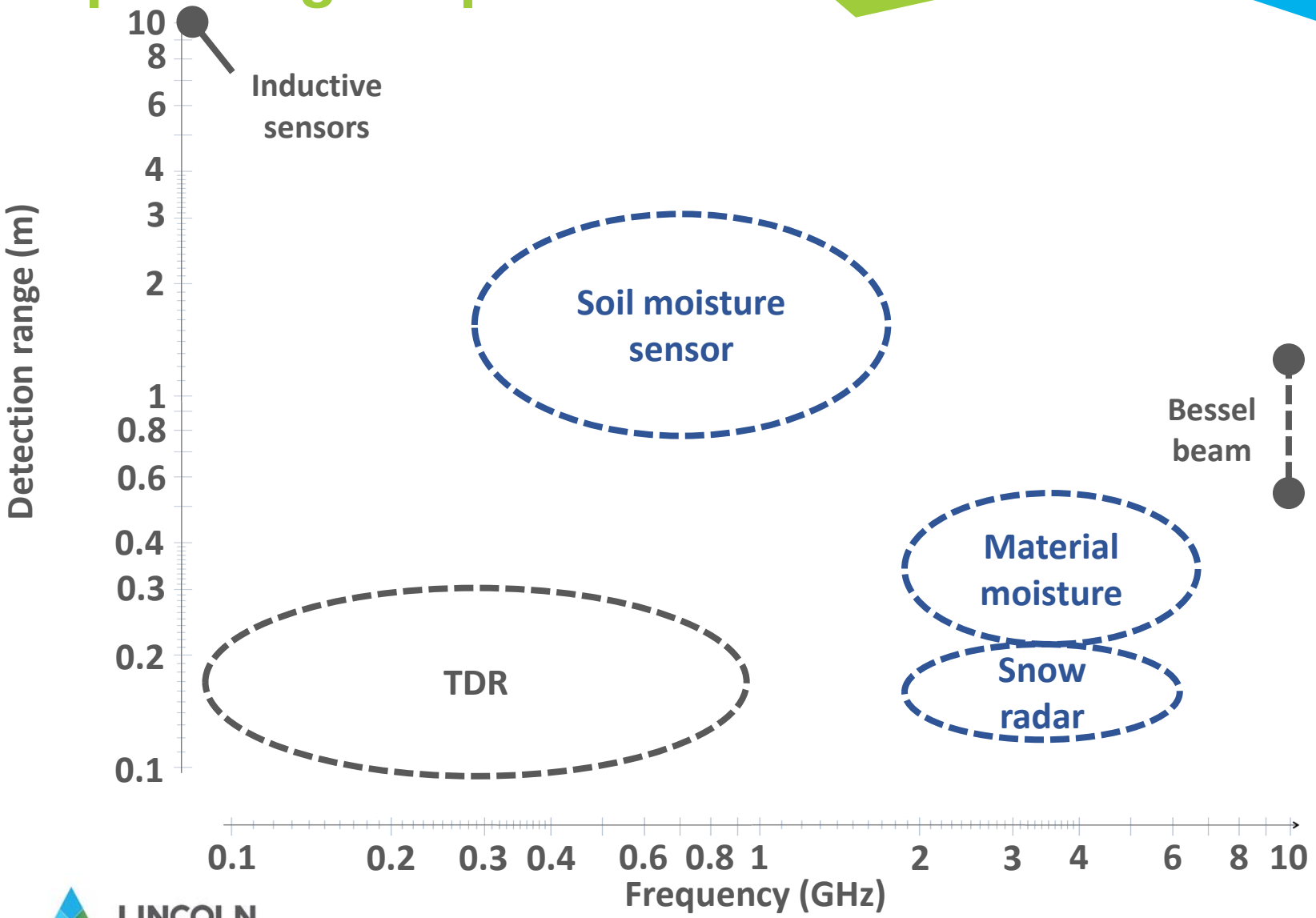

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Thank you