

# Area 2 – Electromagnetics

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Prof. Piero Triverio

Information session for 2<sup>nd</sup> year students

October 1<sup>st</sup>, 2014

University of Toronto



# Electromagnetics: theory and application of electromagnetic waves



Photo credit: ESO/José Francisco Salgado ([josefrancisco.org](http://josefrancisco.org))



# Wireless communication



Photo credit: LG Source: Flickr

# High-frequency circuits (RF)

Parts that rely on electromagnetics:

- Antenna
- Wi-Fi chip
- LTE/EDGE/GSM transmitter
- GPS
- Bluetooth chip
- Digital compass
- ...



iPhone 5 teardown **Source:** ifixit.com



# Radar (defense, weather forecast)

A person wearing a headset is seen from behind, operating a radar console. The console features a large circular display with orange and yellow radar returns. Above the circular display is a rectangular screen showing green text and data. The entire scene is dimly lit, with the primary light sources being the screens and the circular radar display. The person is wearing a dark blue uniform.

USS Shiloh - Radar console in the Combat Information Center



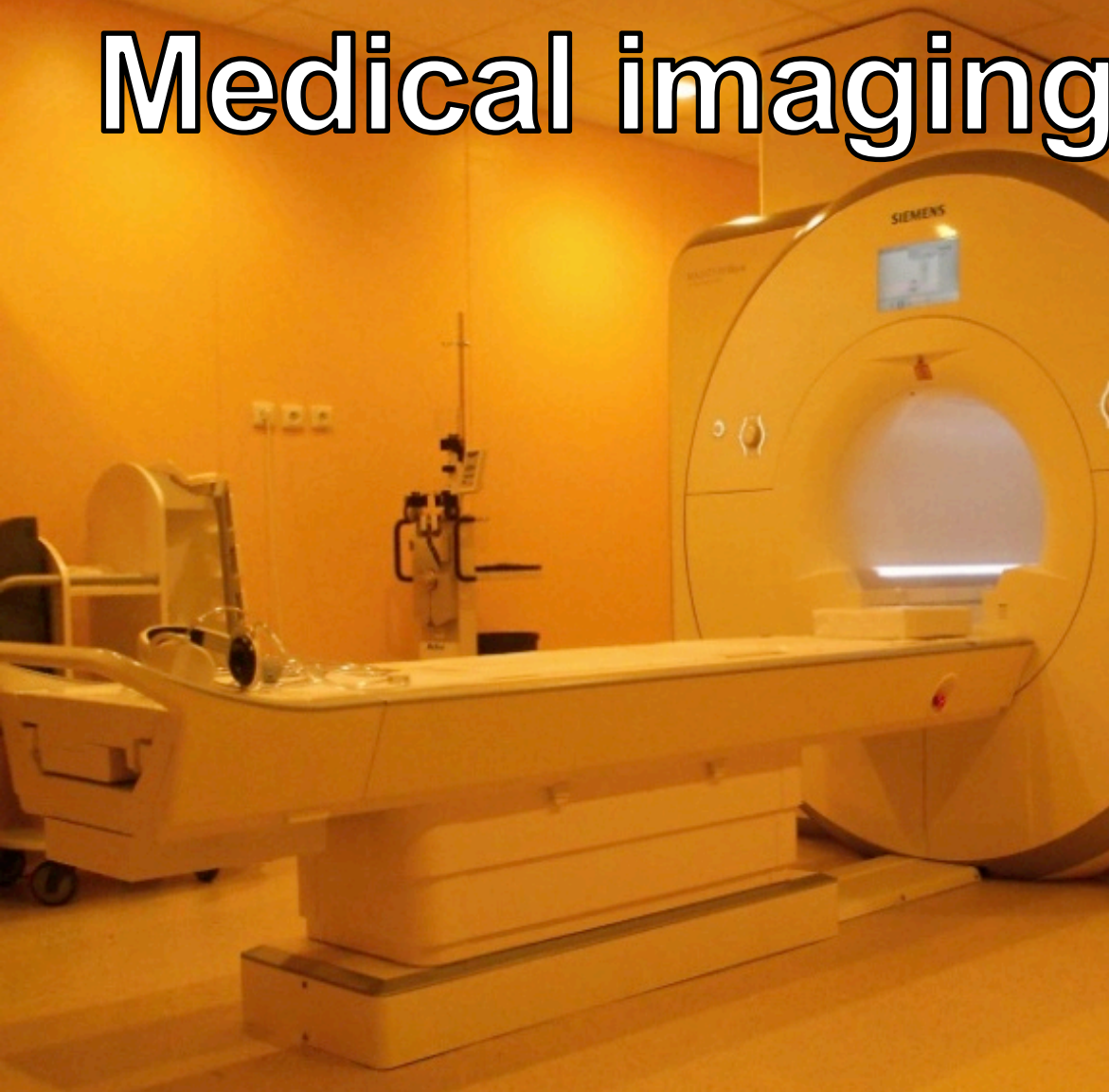
# Space Missions



Photo credit: MDA / ESA



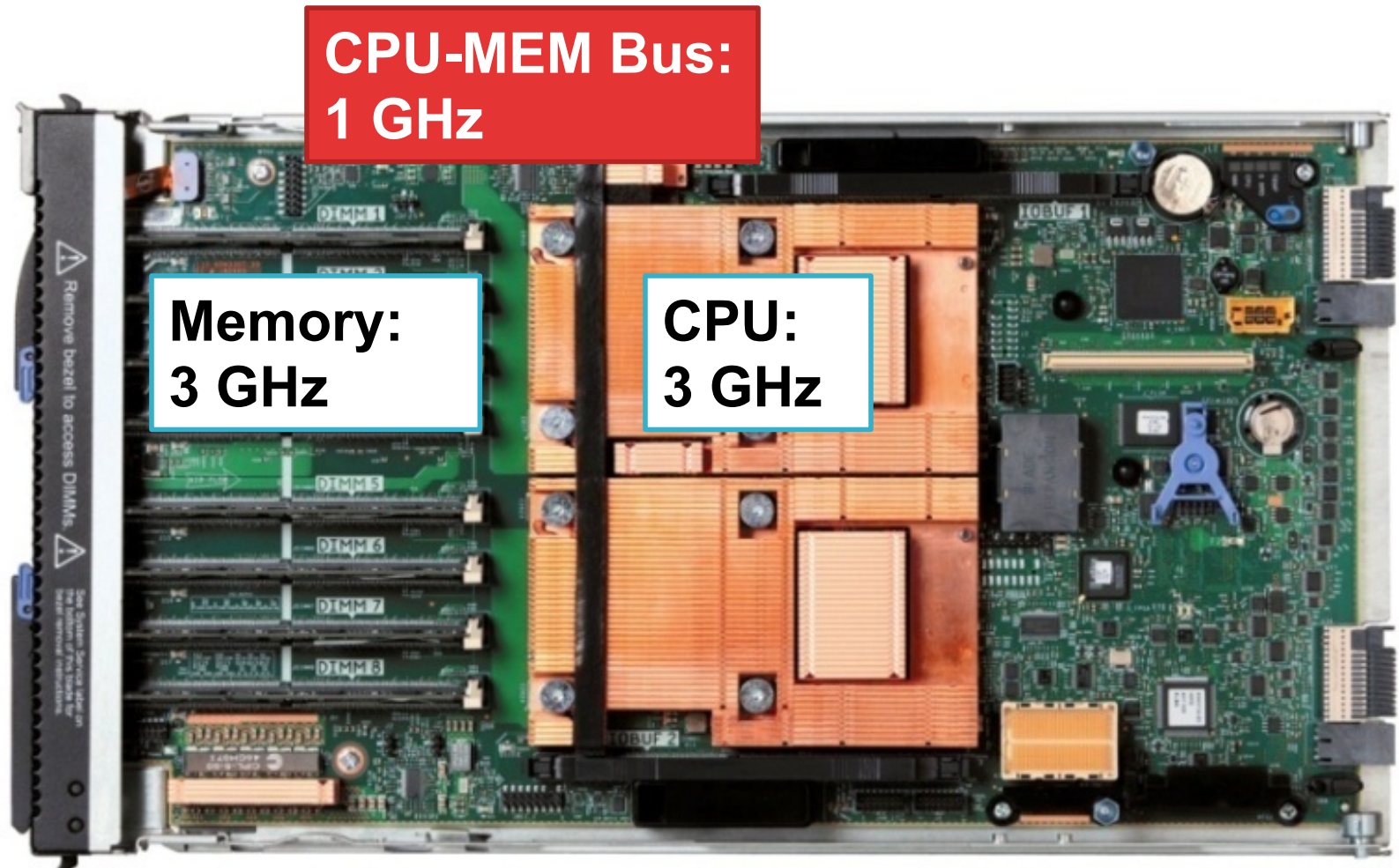
# Medical imaging



Real-time MRI of a human heart



# Digital systems

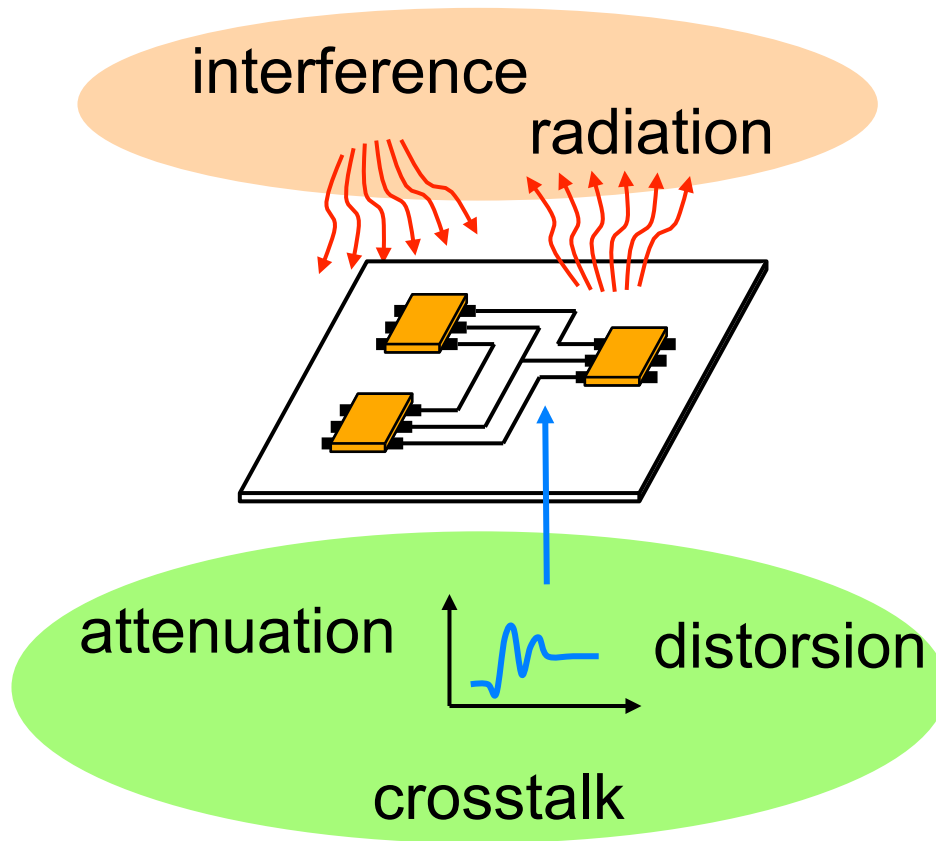


IBM Blade server (Courtesy of IBM)



# Digital systems

## Electromagnetic Compatibility (EMC)



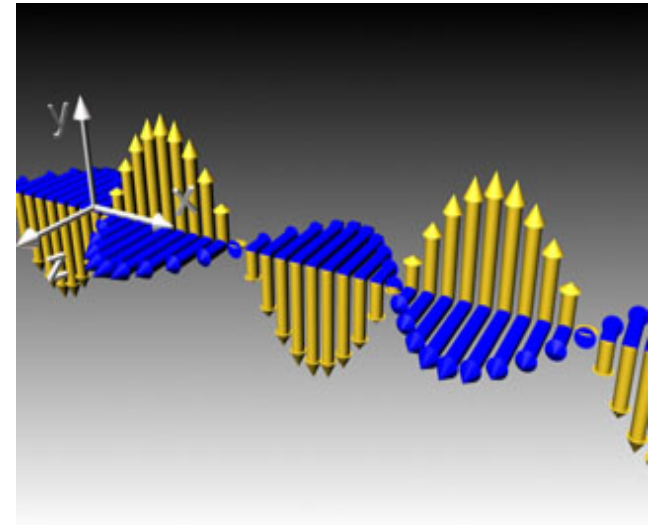
## Signal Integrity (SI)

Electromagnetic phenomena play nowadays a **crucial** role in digital design (servers, graphic cards, smartphones)

# Course offering

## ***Kernel Course: ECE320 – Fields & Waves***

- Transmission Lines
- Maxwell's Equations
- The Wave Equation
- Plane Waves
- Waveguides
- Coaxial cables, optical fibers
- Elementary Antenna Theory
- ***Strong Lab Component***





# Course offering

## ***ECE524 - Microwave Circuits***

- Planar Transmission Lines
- Design with Scattering Parameters
- Microwave Passive Devices, Integrated Circuits, Amplifiers & Mixers
- RF Receivers

**Laboratories on  
passive  
and active devices  
use of VNAs**



Image credit: Susanlea

# Course offering

## ***ECE422 - Radio & Microwave Wireless Systems***

- Antennas
- Diffraction, refraction and reflection
- Antenna system noise and radio link budgets
- Satellite and mobile communications.
- Radar systems and radio astronomy.

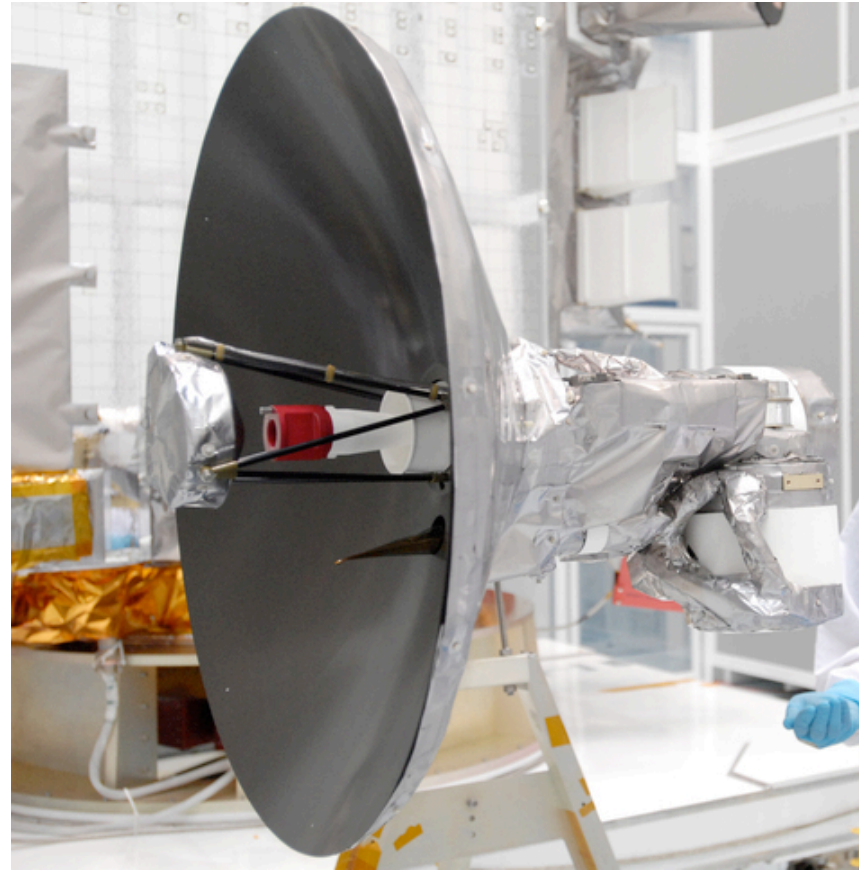


Image credits: Range of Motion Antenna Tests for LRO (NASA, Moon, 6/17/09)



# Curriculum: RF/Wireless Hardware Engineering

- Kernel A: Fields and Waves
- Kernel B: Analog Electronics
- Kernel C: Communication Systems
- Kernel D: Introduction to Electronic Devices
- Depth A1: RF/Microwave Circuits I
- Depth A2: Radio & Microwave Wireless Systems
- Depth B1: Analog integrated circuits
- Depth B2: Digital electronics
- Science/Math Elective:  
Complex Variables
- Design project: one term
- Technical Elective 1: Analog Signal Processing Circuits
- Technical Elective 2: Digital Hardware
- Technical Elective 3: VLSI Systems and Design
- Technical Elective 4: Semiconductor & device physics
- Free Elective 1: Partial Differential Equations
- Free Elective 2: at your choice

# Curriculum: RF/Wireless Systems Engineering

- Kernel A: Fields and Waves
- Kernel B: Communication Systems
- Kernel C: Digital Electronics
- Kernel D: Computer Networks I
- Depth A1: RF/Microwave Circuits I
- Depth A2: Radio & Microwave Wireless Systems
- Depth B1: Probability & Random Processes
- Depth B2: Wireless Communication
- Science/Math Elective: Complex Variables or Partial Differential Equations
- Design project: one term
- Technical Elective 1: Digital Signal Processing
- Technical Elective 2: Optical Communication Systems
- Technical Elective 3: Dynamic Systems & Control
- Technical Elective 4: Digital Communication
- Free Elective I: Optical Networks
- Free Elective II: at your choice

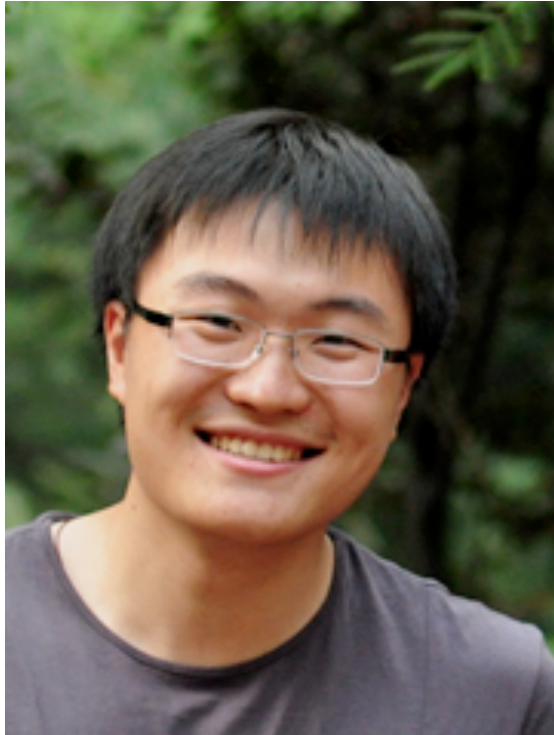


# Potential Careers

- Wireless communications **link design** (Bell, Rogers, etc.).
- **Antenna designer** (Huawei, Samsung, several smaller companies).
- **RF front-end designer** for wireless devices and base stations (Apple, Comdev).
- **Medical imaging** (Agilent, Toshiba).
- **Electromagnetic compatibility & interference** groups in almost any high-tech company (AMD, Bombardier, Honeywell).
- **Government labs** (CRC Ottawa) or **defense** (DRDC).

Knowing field theory is a sound basis for work in **photonics** and **power** industry (high and low frequency limits of electromagnetics).

# Careers: industry



**Yu Zhou**  
RF Engineer  
(Ottawa)



**Natalie Jones**  
Hardware Developer  
(Ottawa)



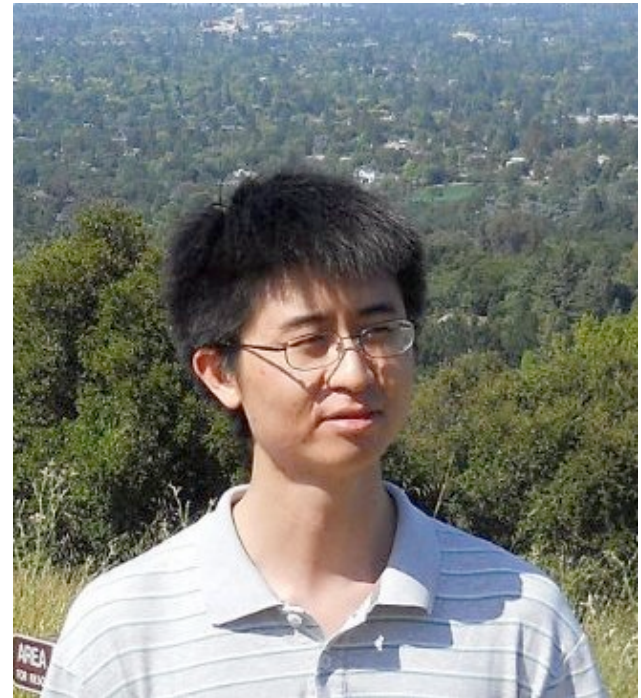
**ERICSSON**

# Careers: industry



**Sherry Yu**

IC R&D  
Engineer



**Chang Liu**

Signal Integrity  
Engineer





# Careers: industry



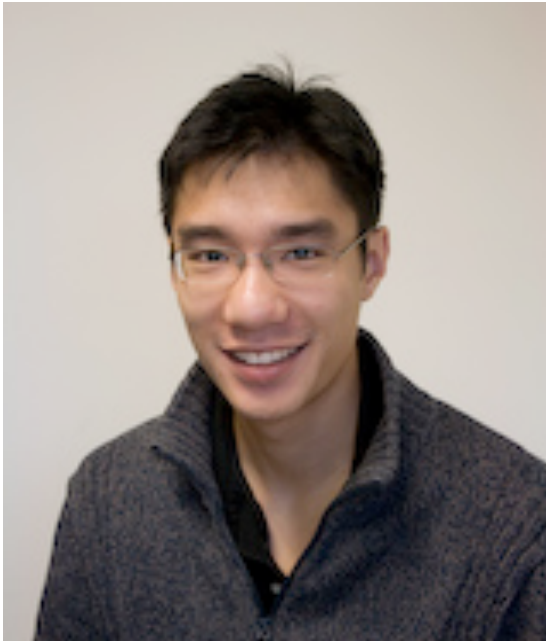
**Alvin Ho**

Antenna Engineer  
*MDA Space missions*  
*(Quebec)*



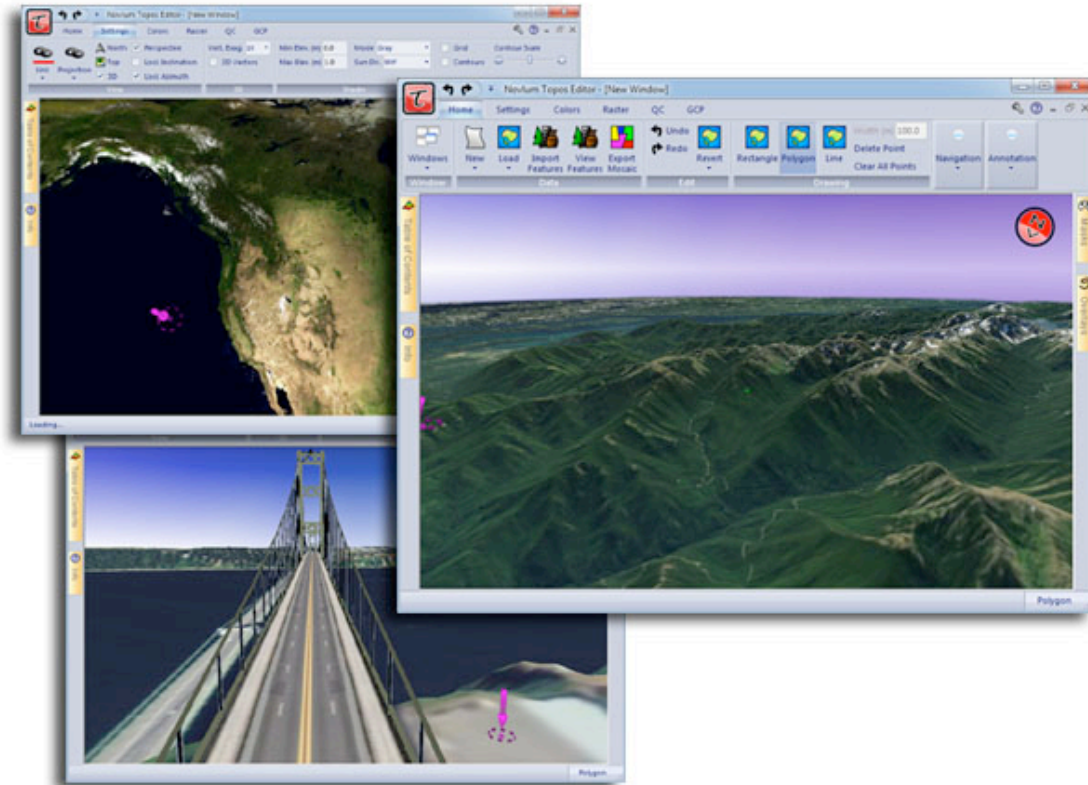
MDA's Canadarm2

# Careers: entrepreneur



**Jonathan Lau**

Co-founder



*Geospatial software for Oil, Gas  
and Aerospace industries*

# Careers: scientific research

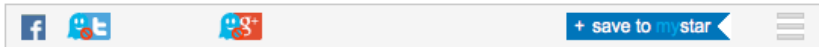
Apr 24, 2014

thestar.com  
GTA

News / GTA

## U of T researchers create a homemade 'invisibility cloak'

The device made by professor George Eleftheriades and grad student Michael Selvanayagam uses radio waves to cancel out incoming waves.



NATURE WORLD NEWS

Daily  Mail

**Michael Selvanayagam**  
PhD student, UofT



# Careers: scientific research



**Anthony Grbic**  
Associate professor



**President Barack Obama** talks with the Presidential [Early Career Award for Scientists and Engineers winners](#) in the East Room of the White House, Jan. 13, 2010. January 13, 2010. (*Official White House Photo by Lawrence Jackson*)



# Questions?

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Photo credit: ESO/José Francisco Salgado ([josefrancisco.org](http://josefrancisco.org))