Technology Work Session for the South African Army; Hosted by the CSIR

Battle Space Awareness and Sensors

Introduction

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Date: 19 August 2012

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Overview

- Discuss needs and trends in **Battlespace Awareness** focussing on **Radar and Optical Sensors**
  - Introduction – **F Anderson**
  - **Radar - F Anderson**, W Nel and A le Roux
  - **Optics – M Lysko,** B Duvenhage, J Baumbach, M Lubbe, D Aucamp and D Bezuidenhout
  - Conclusions: so what? **- F Anderson**
- Note: Specific products are shown to illustrate trends; **we do not necessarily endorse them**

Introduction: SA Army Challenges & Perspectives

- SA Army Philosophy and Critical Success Factors 2008:

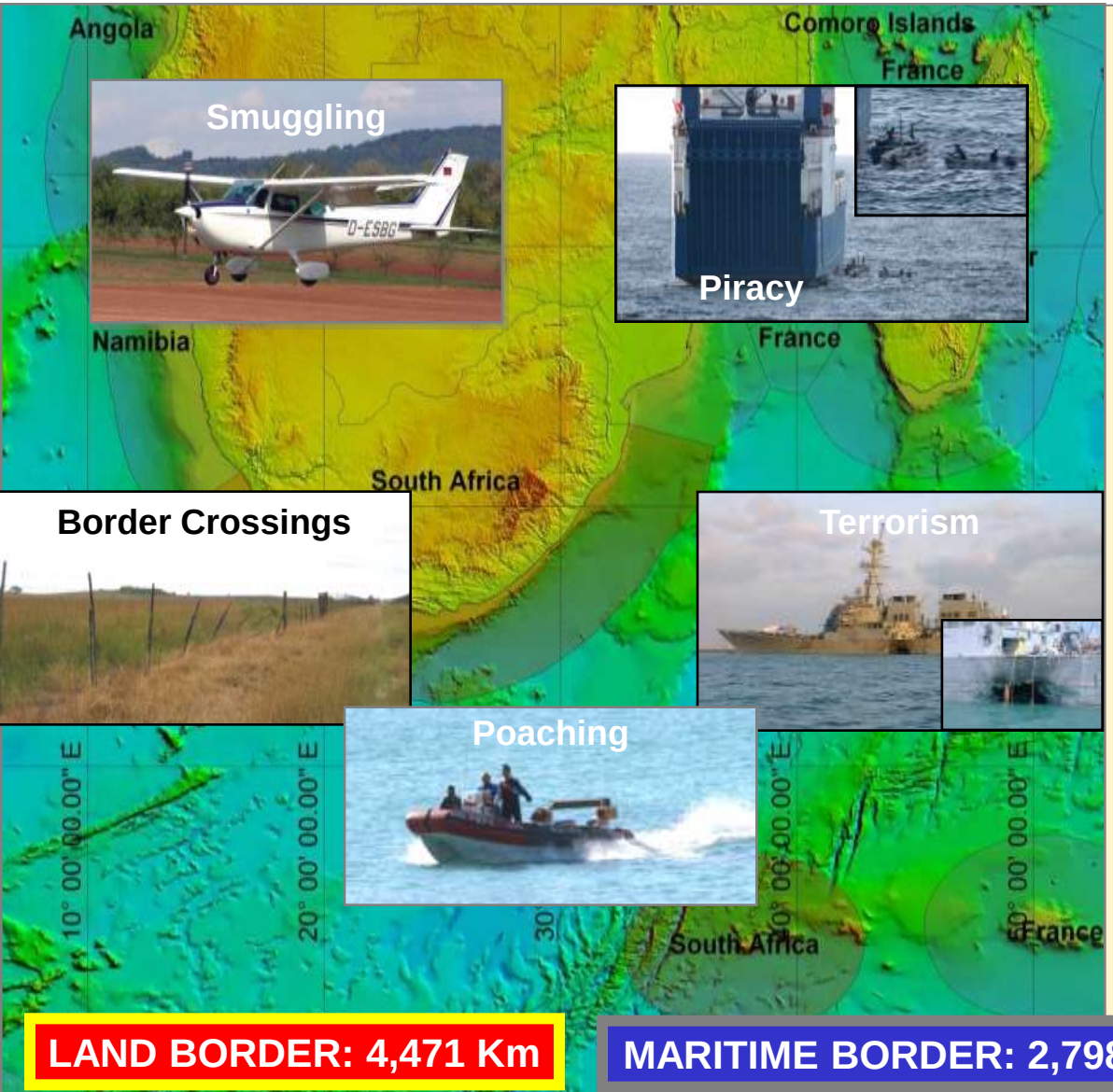
> *"**Superior C^4I^3RS** systems are **top priorities** and must enhance high mobility, firepower, protection and superior **situational awareness**."*
>
> *"This focuses on **technology** and the **human dimension** in order to provide **superior situational awareness** that will, in turn, create **decision superiority**."*

- Since 2008:
  - **FIFA Soccer World Cup**
  - **Border Safeguarding & Counter Poaching**
  - **Thutlwa deployed to South Sudan July 2011**
  - **SAAF, SAN deployed to Pemba**

Introduction: SA Army Challenges & Perspectives

- **Protection required**:
  - Mines, IEDs, RPGs
  - 360° Situation awareness essential for survival
- **Weapons Guidance required**: GBADS, Artillery
- **Overcome "surprise"**
  - Be **flexible, modular, integrated, mobile**
  - Increased use of **robots** (*including those that help provide an "**all seeing God's eye view**"?*)
  - **Thermal imagers** becoming ubiquitous: self and adversaries
  - Adversaries use conventional **military and civilian** equipment **unconventionally**; apply **modifications & upgrades**; *we too?*
  - Adversaries **hide amongst civilians**: *how can we overcome this?*

South African Border Safeguarding and PSO Requirements



- **Adversaries** have **initiative**: They choose place, time and method
- **Difficult to detect and track**: Fly low, use small craft, operate in low visibility conditions, move stealthily
- **Difficult to recognize:** Operate amongst **similar non-threatening** entities
- They plan to **beat the reaction time** of State security forces
- **They have the advantage**, when **force-to-space ratios** are low

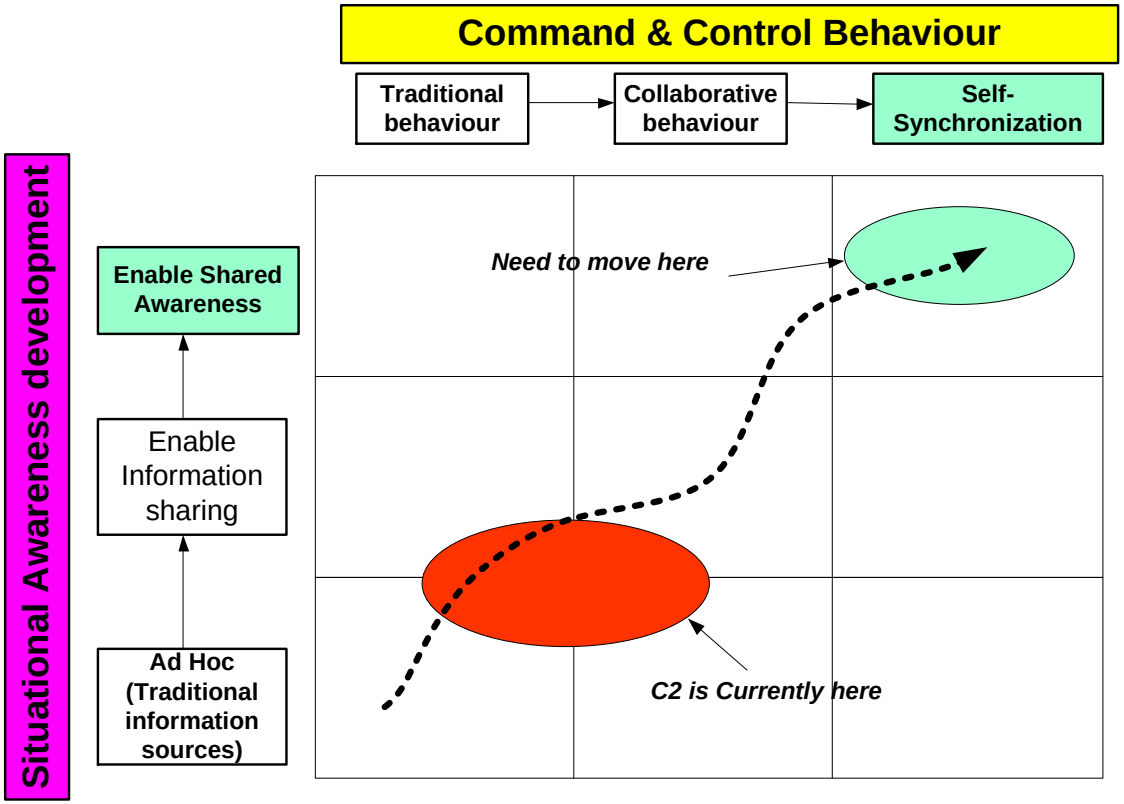
LAND BORDER: 4,471 Km

MARITIME BORDER: 2,798 Km

AIR BORDER: 7,660 Km

Moving towards for Joint, Interdepartmental and Multi-national Operations

Need to establish the ability of RSA Departments, Agencies and their International Allies to dynamically synchronise their actions; achieve Command & Control (C2) agility; and increase the speed of command over a robust, networked grid.



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(Source: Maturity model from :" Power to the edge")

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Radar Sensors for SA Army Applications

Francois Anderson
With Willie Nel and Andre le Roux

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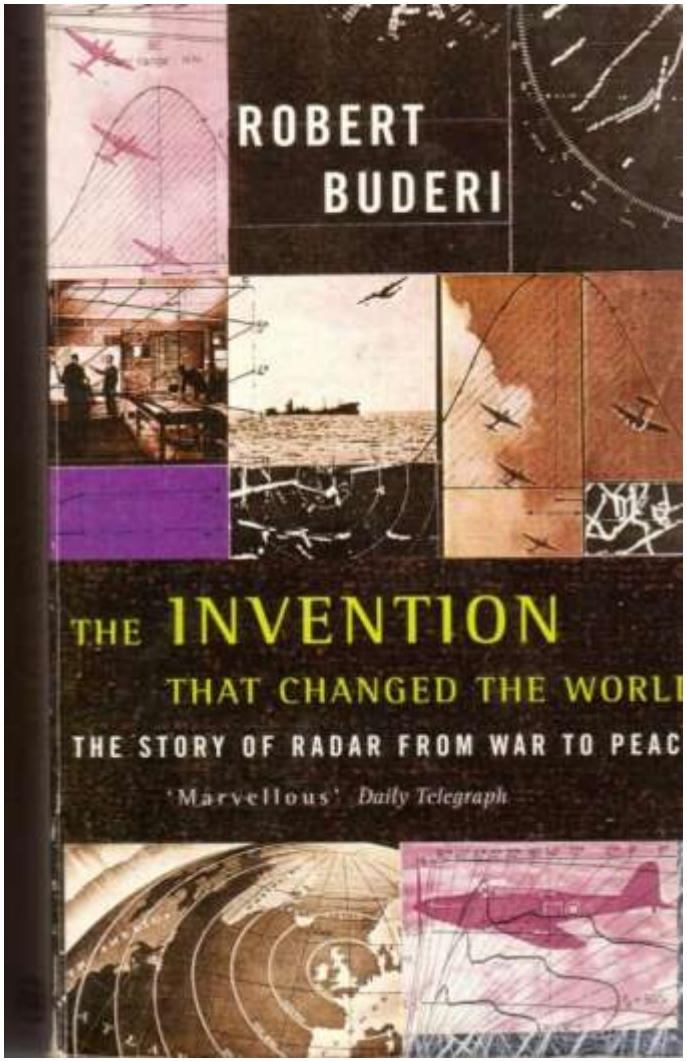
Outline of presentation

- Introduction to Radar: History, benefits, radar in SA
- Potential SANDF Battlespace Applications of Radar
- International Radar Market and Radar Solutions
- Some Radar Technology Trends

History of Radar



- **"Invented" during 1930s** by several countries independently, utmost **secrecy**
- Played **decisive role in WW2**
  - Chain Home Air Defence C2 system
  - Submarine hunting
  - ….
- **SSS in SA Army** developed, deployed, trained, operated in South Africa
- Radar at **CSIR since 1946**
- Radar in **SA industry since 1987**

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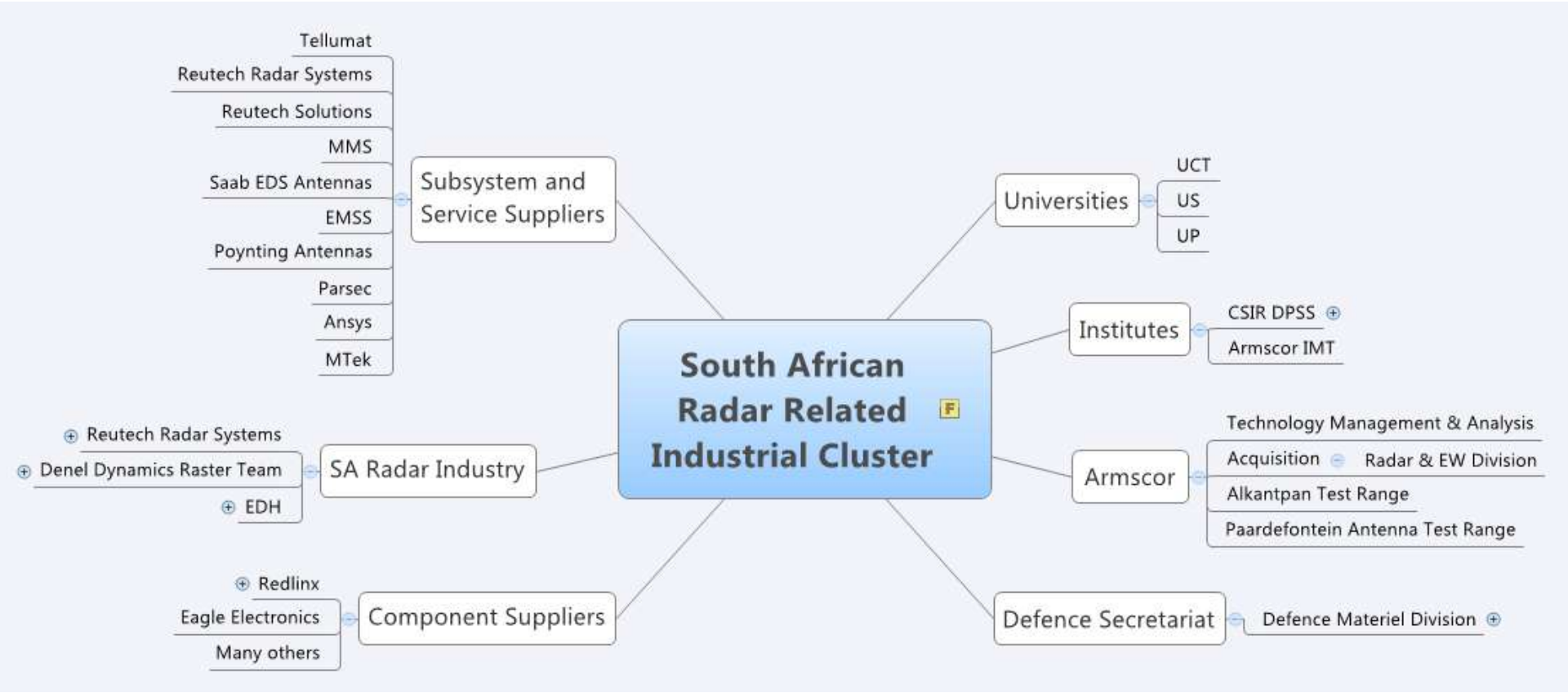
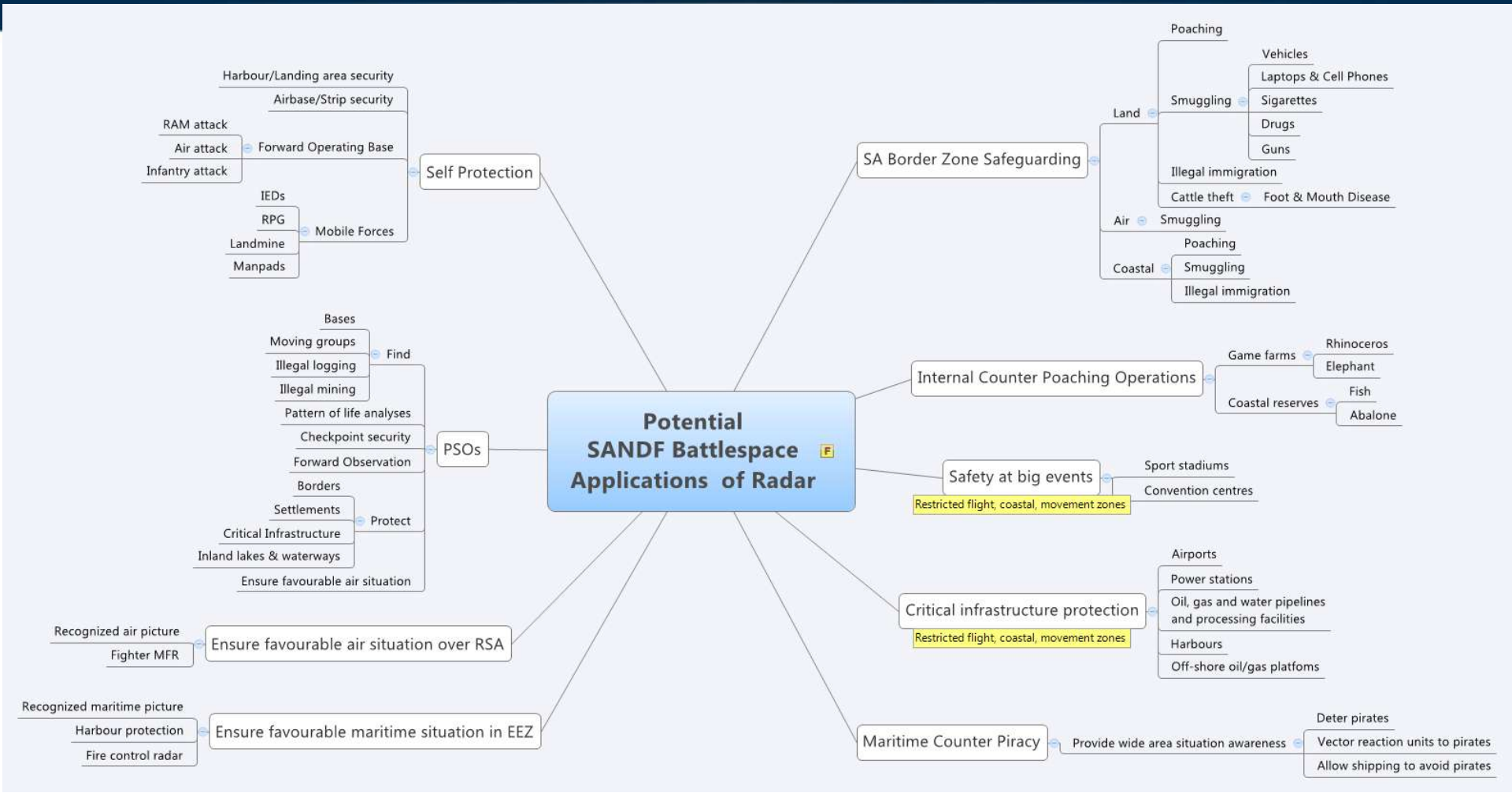
Why Radar?

- Physics: Can sense **5 quantities vs time**
  - EM energy **propagates through atmosphere, dust, rain with low loss**
  - EM energy reflects off objects of interest – delay allows **range measurement**
  - Antenna focusses EM energy in beam – allows **measurement of azimuth and elevation angles**
  - Moving reflector causes Doppler shift – allows measurement of **radial velocity**
  - Can also sense **polarization**
- Can **discriminate targets from clutter** in any of these dimensions
- **Detection, tracking, measurement** at **long range** on **small targets**
- **Day/night, all weather, wide area, large volume sensor**
- **Imaging**
- **Non-cooperative Classification**

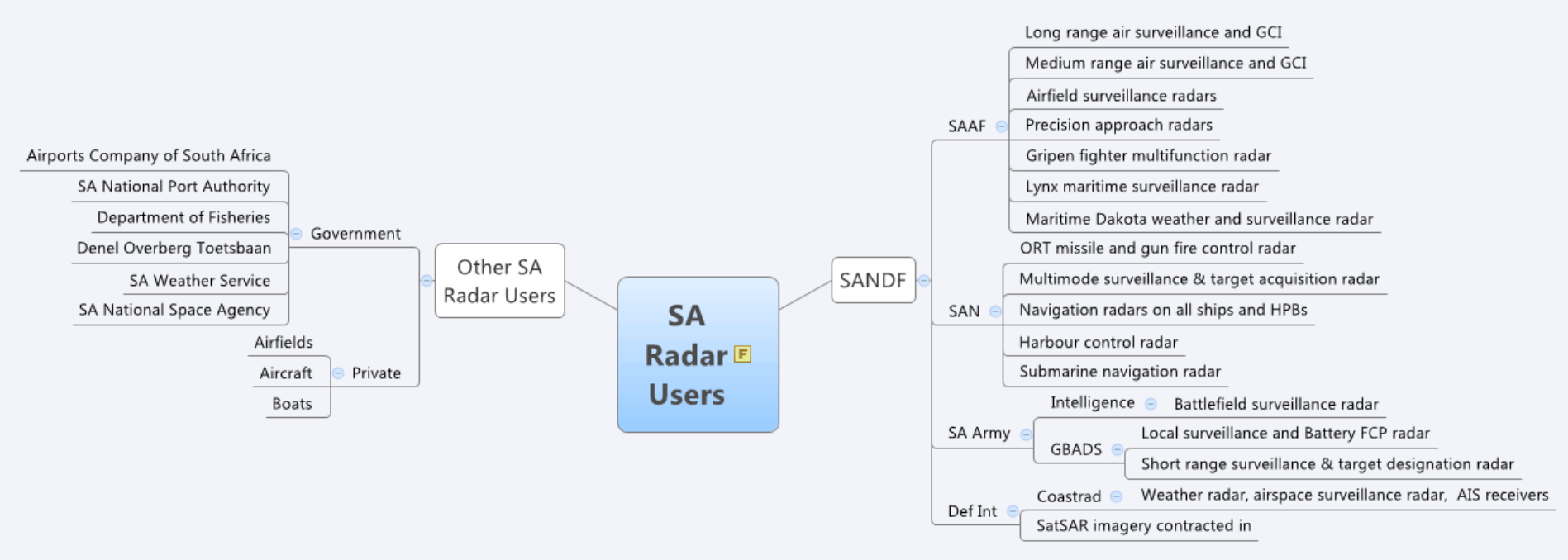
Radar Related Industrial Cluster in South Africa



Potential SANDF Applications of Radar



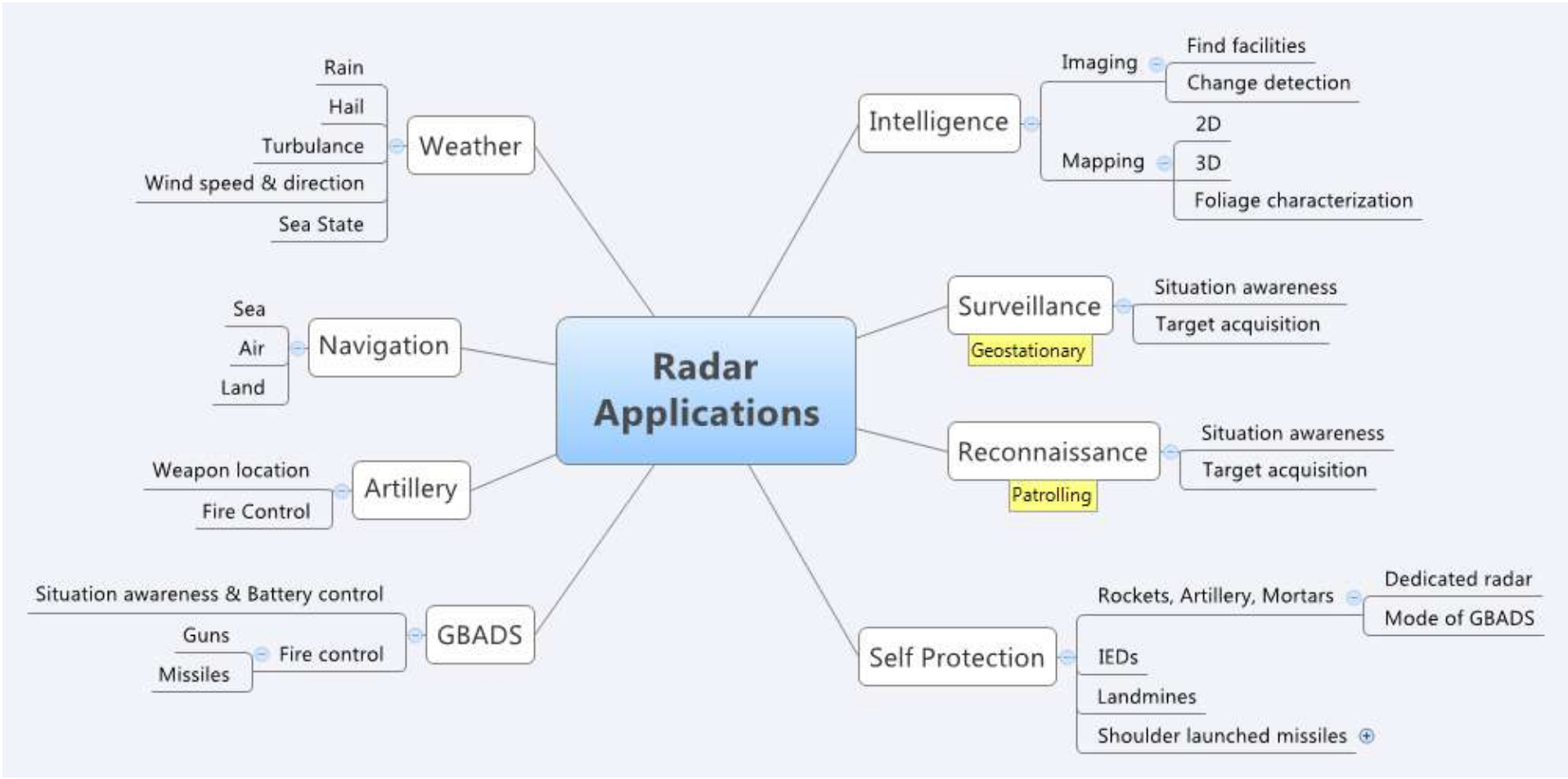
Current Radar Users in South Africa



International Radar Market and Applications

- Global Radar Market estimated as **$9.16 bn in 2011**
- Radars identified as **governments' investment priority**
  - **Intelligence gathering and protective** capabilities
  - **Acquire or upgrade**
  - **Standardization, modularization**
  - Surge in **developing** and **high growth markets**

International Radar Market and Applications



Intelligence: SAR on Satellites

Space

"a) A complete transformation has taken place over the last two years with the launch and entry into service of numerous space borne SAR imagers providing all-weather and day/night imaging capabilities.

(b) In 2005/2006 , only 3 civilian space borne SAR in operation. By the end of 2008, 18 civilian, military & dual-use SARs will be in orbit in space. 16 more spacecraft equipped with SAR imagers are under construction.

(c) One may expect much more use of space borne SAR imagery in the future by a wide spectrum of users. "

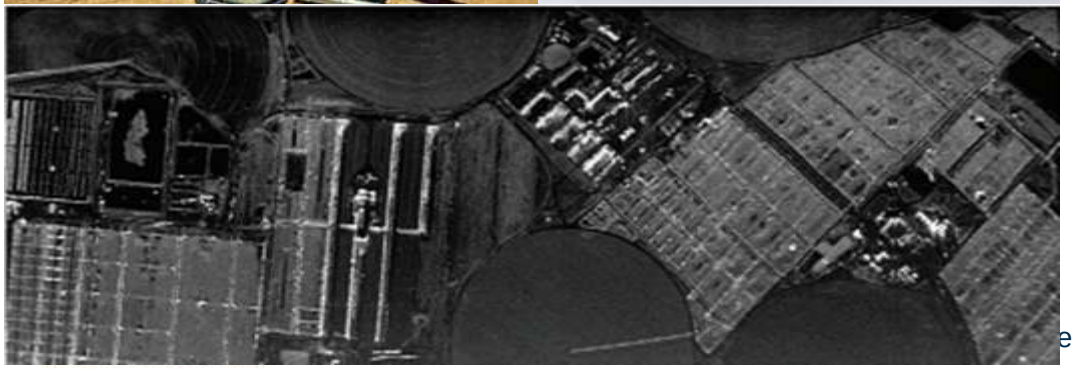
Gordon Petrie, "Current & Future Spaceborne SAR Systems," in *VIII International Scientific & Technical Conference "From Imagery to Map: Digital Photogrammetric Technologies"*, Porec, Croatia, 2008, p. 20.

Aircraft/UAS SAR

Short range, high resolution FMCW SAR on a/c or UAS

Aircraft	Cessna 172/182/206 or similar, UAVs
Frequency	X band (9 – 10.5 GHz)
Receiving channels	2
Polarization	VV-VH/HH-HV
Azimuth resolution	15 cm, single look
Slant range resolution	up to 15 cm
Maximum range	up to 6 km
look angle	From 20º to 70º
Quantization	16 bits

SAR on ScanEagle UAS: 10 km range



Specifications

Operating Mode	Strip map
Processing	Onboard, near real-time
Output	NTSC analog video downlink NITF-formatted still imagery
Communications	C2 via turret serial link
Size	6.2" x 7.5" x 4.5"
Resolution	Typical: 1 m; Max: 0.3 m
Swath Range	Typical: 2 km; Max: 4 km
Power	15 Watts
Transmit Frequency	X-band

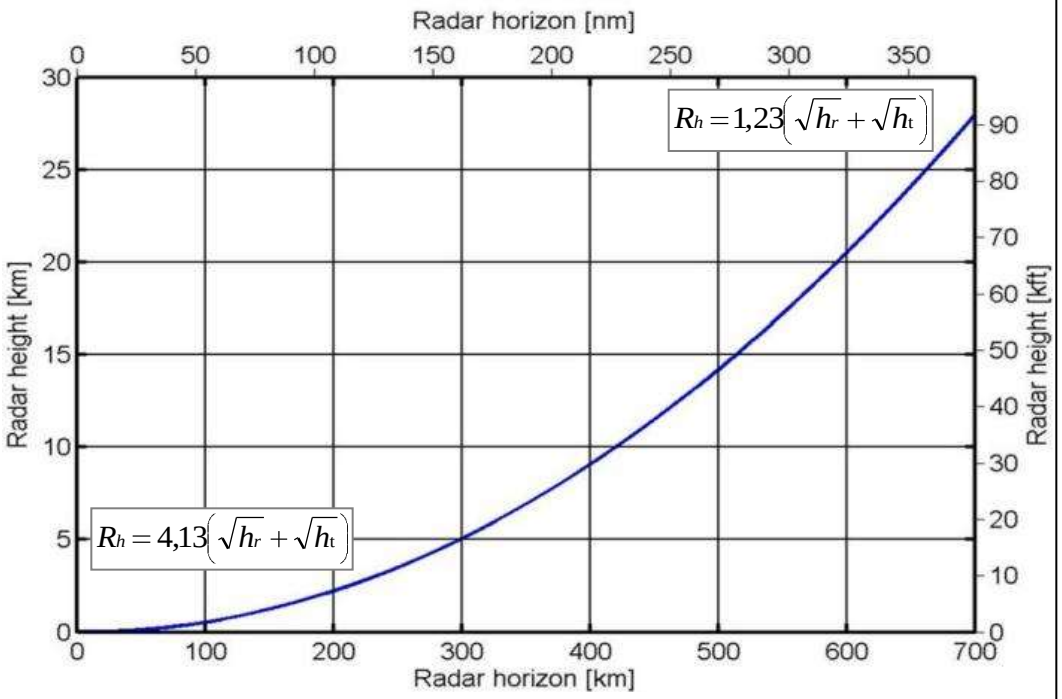
Credit: Insitu, USA

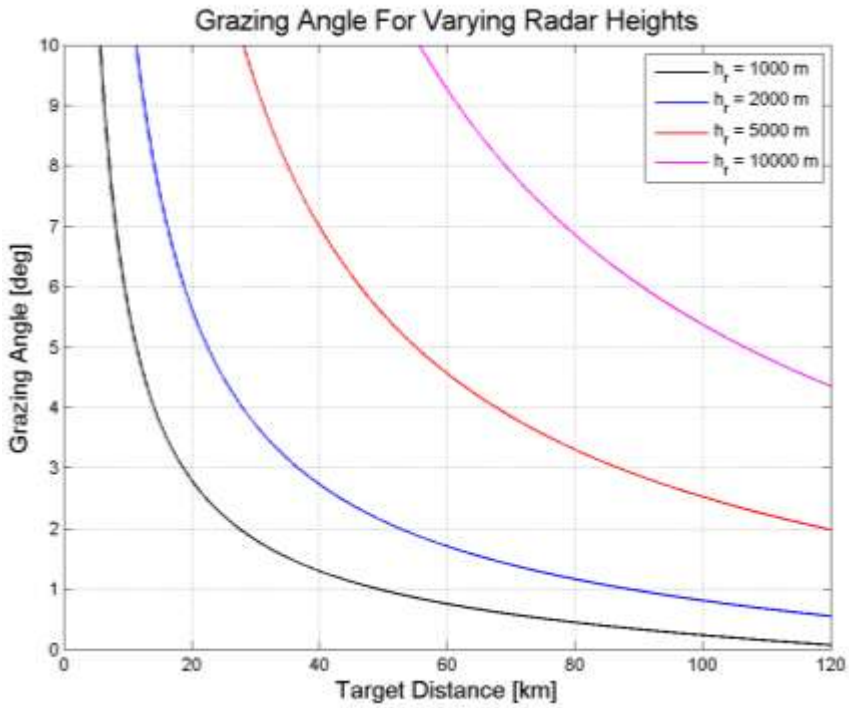
Persistent, Ubiquitous Surveillance: GMTI

- **JSTARS** and PTDS in Iraq since 1990
- **Detect, Track, Classify non-cooperative ground movers**
- Provide **asymmetric advantage**
- **Rich information** is causing a **transformation in operations**
  - Time and mass
  - Faster manoeuvre
  - More effective fires
  - Better and faster decisions
  - Faster lower level integration

Bingham Price T., Fowler Charles A. Dunn Richard J. (2004, February) Ground Moving Target Indicator Radar and the Transformation of U.S. Warfighting. [Online]. www.capitol.northgrum.com

Line of Sight Sensors & Communications Require an Elevated Platform for Wide Area Coverage





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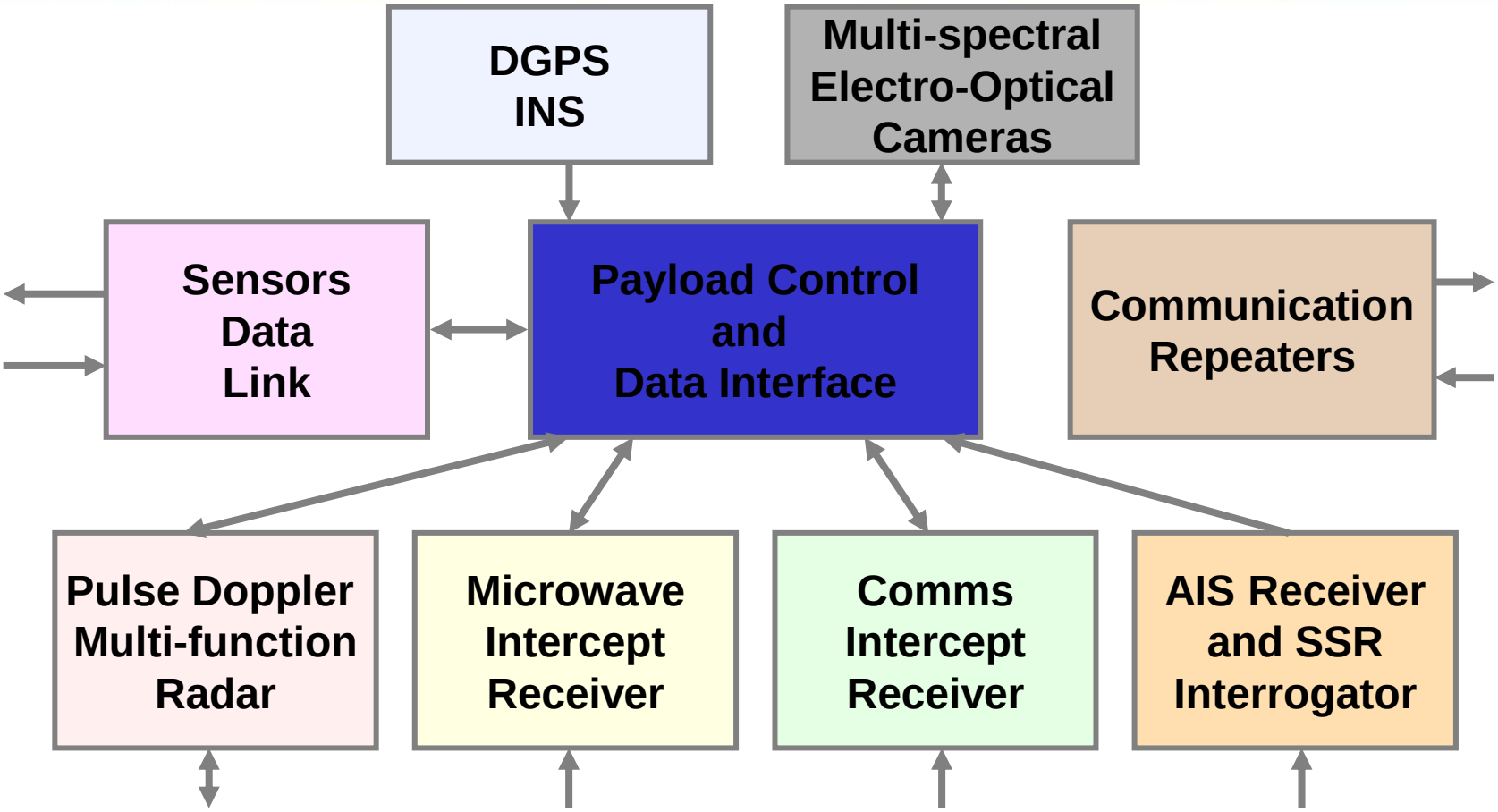
Persistent Ubiquitous Surveillance Platforms (in addition to mountain top, Predator, Global Hawk, JSTARS, AWACS)

2012

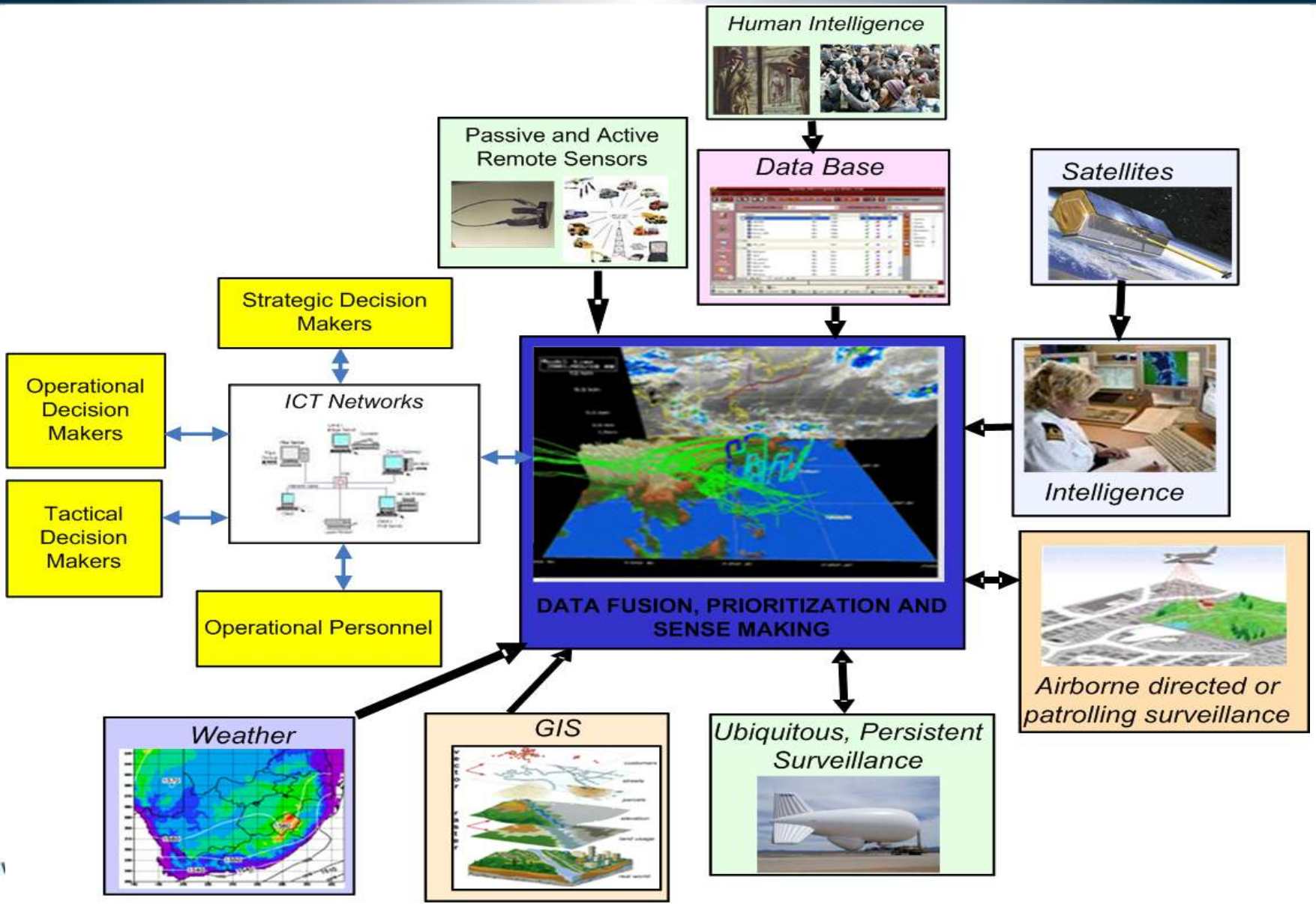
Airborne Sensors and Communication Repeaters



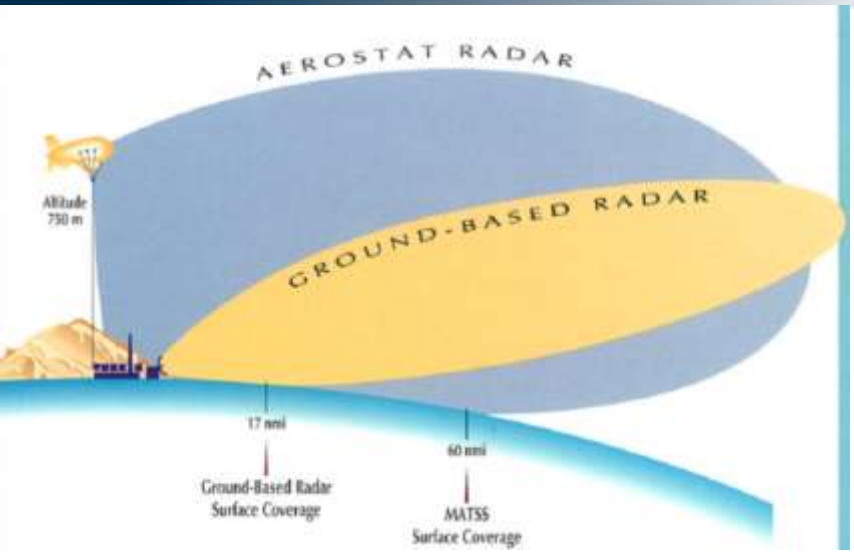
DGPS: Differential GPS
INS: Inertial Navigation System

GPS: Global Positioning System
AIS: Automatic Identification System
SSR: Secondary Surveillance Radar

Data Fusion, Analysis, Display & Distribution



Benefits of Radar on an Aerostat



- Radar is **elevated above terrain**
  - Over the horizon – coverage area dramatically increases
  - Reduced height of multipath null – no “Flying below the Radar”
  - Reduce effect of terrain shadowing
- Radar is **geo-stationary**
  - Allows persistent surveillance with high enough update rate
  - Side-lobe clutter is not spread in Doppler
  - It is possible to detect targets close to the clutter (low minimum detectable velocity)
  - Doesn’t require complex techniques / architectures such as STAP
- **Platform environment**
  - More space for sensor, operating environment relatively benign
  - Re-deployable on trucks or ships
- **Much lower operating cost than on aircraft or UAVs**

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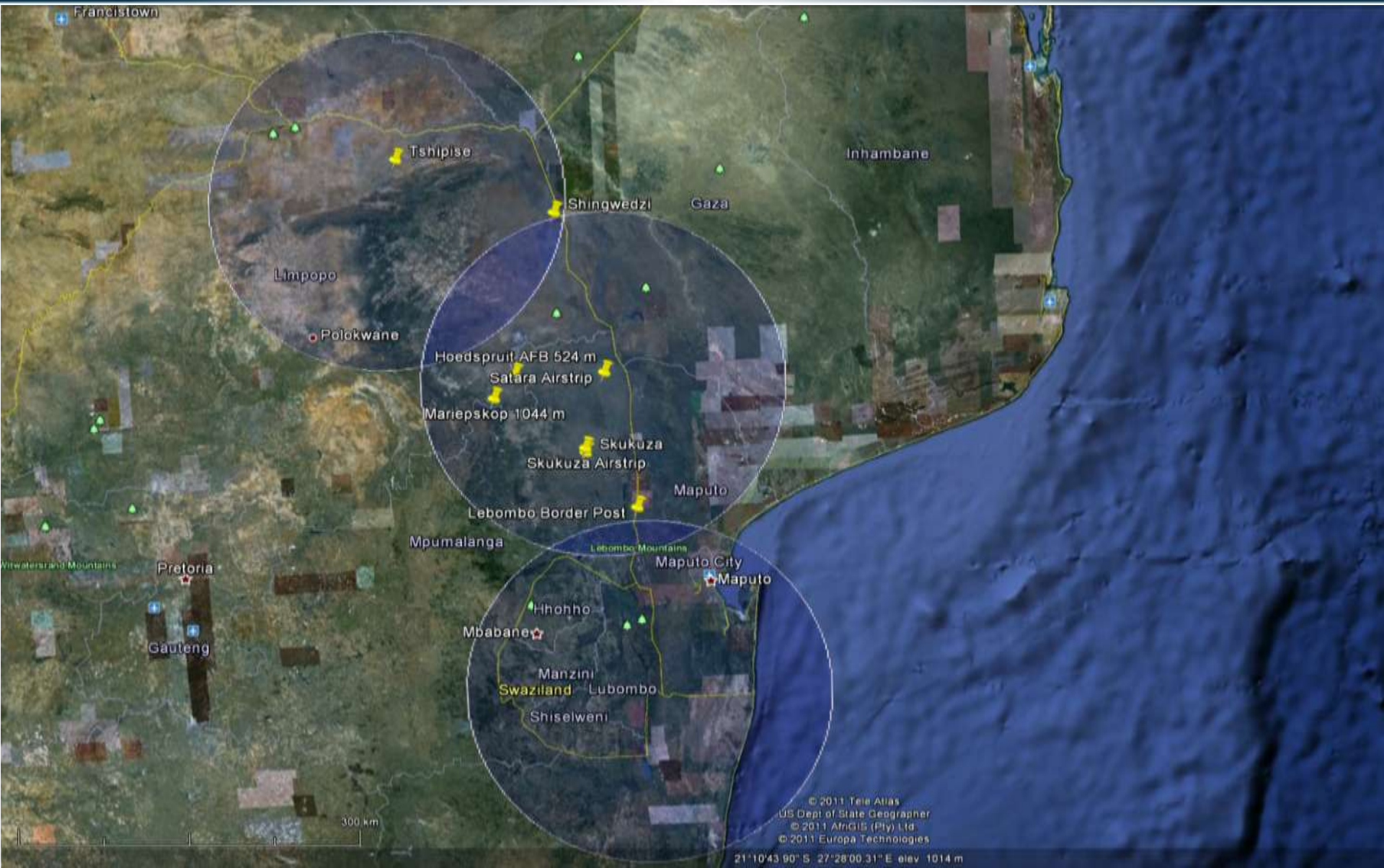
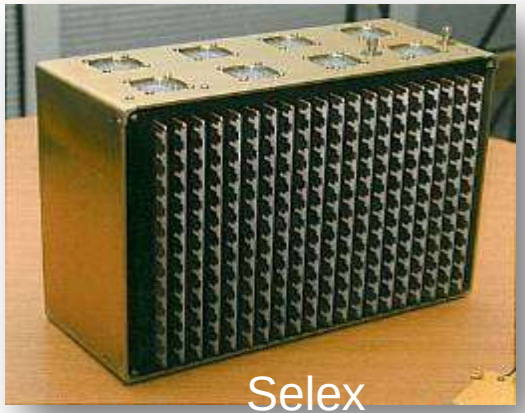
South Africa's North-Eastern Borders



Radar Technology Trends: Active Electronically Scanned Antenna (AESA)



Selex PicoSAR

- Tens of solid state amplifiers
  - Reliability – 3000 hrs MTBCF
- Instantaneously move beam
  - Step scan – lower MDV
  - Confirmation dwells – better sensitivity
  - Concentrate in areas of interest
  - Multi-functions – search, track, classify
  - Irregular scan – good ECCM
- No physical movement
  - Easy to install on mast
  - Easier to camouflage

Radar Technology: FMCW Transmitter/Receiver

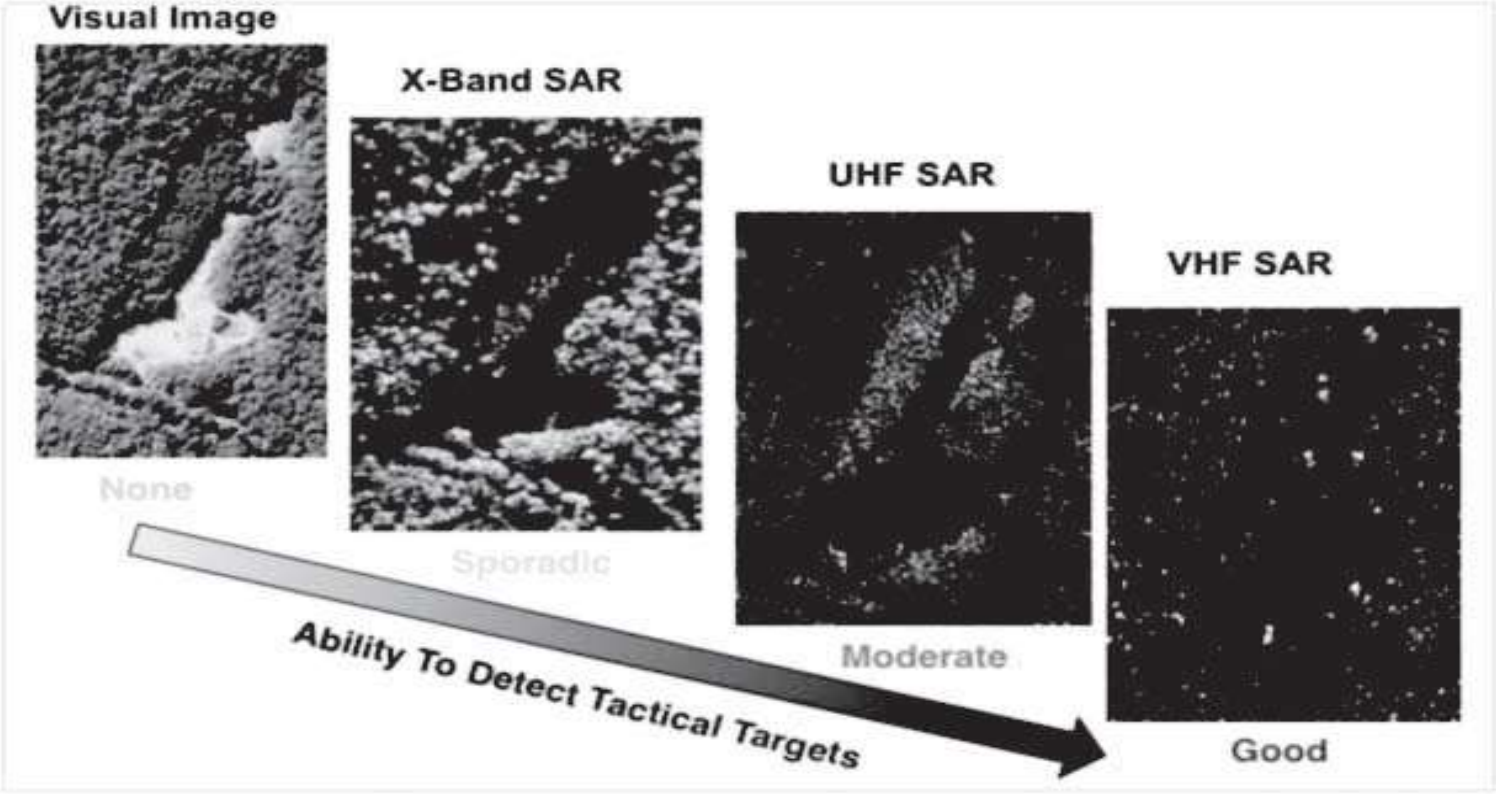

RSR 940 Spider

- Low cost
- Light weight
- Reliable
- Low probability of intercept

Time = 0 RPG Launch	Time = 5.2 ms First Detection (worst case)	Time = 14.3 ms Confirmed track
		

Radar Technology: Foliage Penetration

- Low frequencies allow propagation through foliage (FOPEN)
- Need large antennas to obtain reasonable resolution
- SAR and GMTI are main modes: Intelligence and Surveillance



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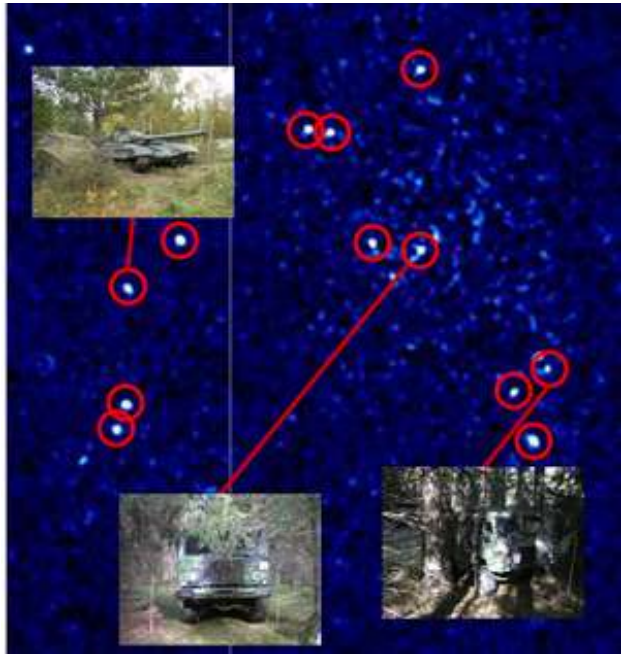
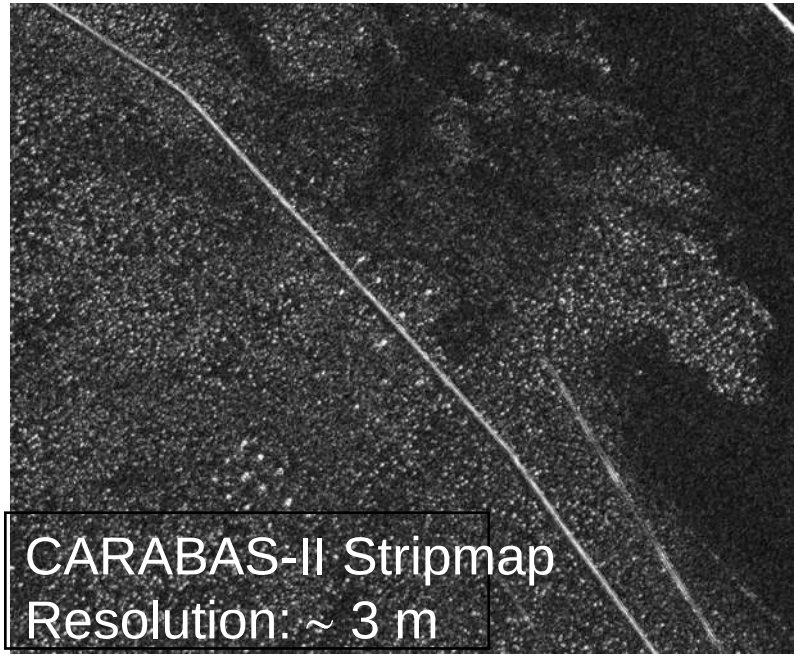
Radar Technology: Foliage Penetration

- Sweden and USA
- Saab EDS: Carabas II
- Forms SAR stripmap image over large areas
- Performs change detection to find vehicles





CARABAS-II Stripmap
Resolution: ~ 3 m

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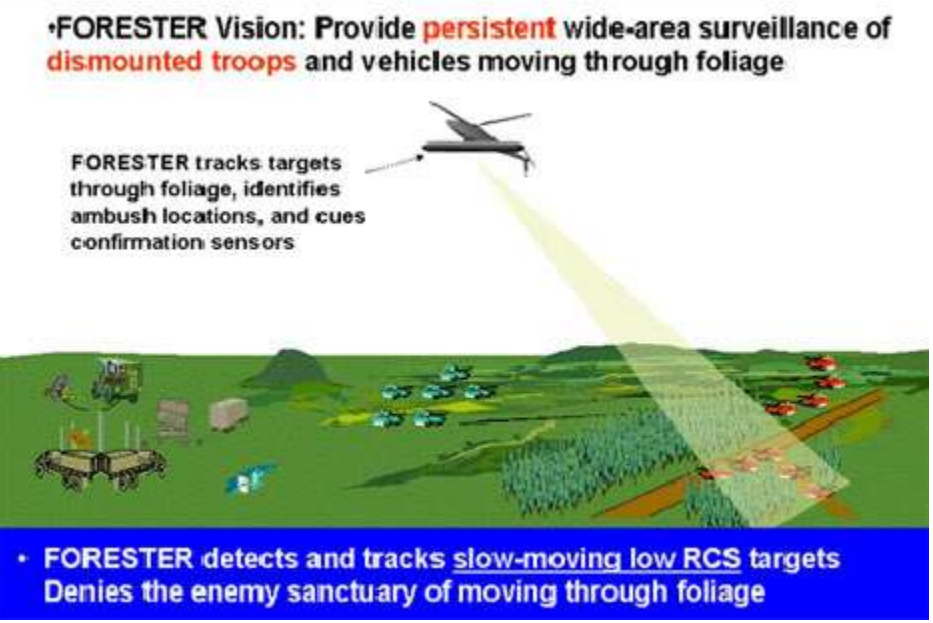
Radar Technology: Foliage Penetration



- DARPA FORESTER
- UHF GMTI radar:
- Detects dismounts under foliage at 19 km, vehicles at 32 km
- Updates every 20 to 80 sec, covering 400 sq km
- 6 m resolution
- Antenna width: 6.6 m
- USD2.5 m, later USD1 m

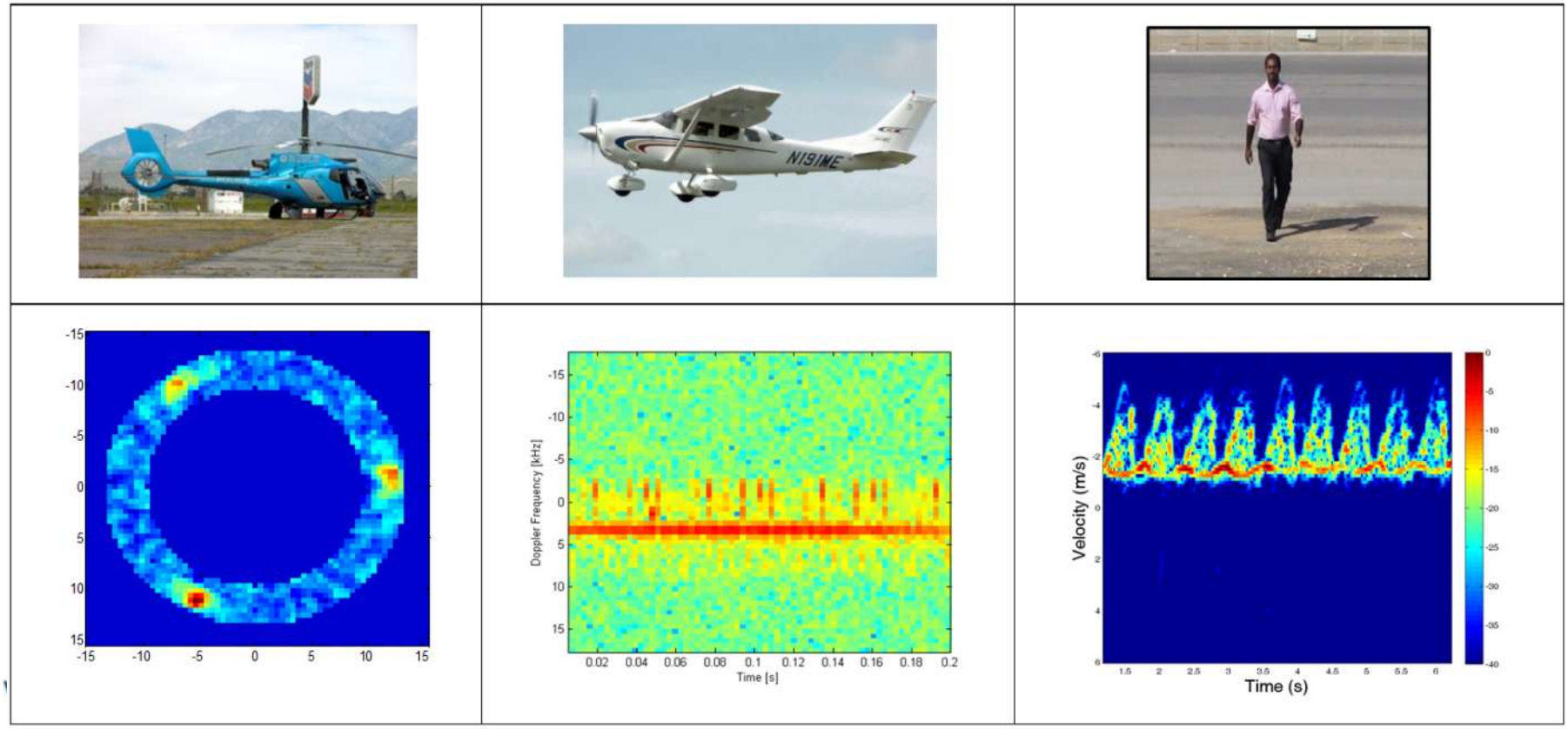
Target Classification & Identification

- **Required to:**
  - Shorten TEWA reaction time
  - Avoid fratricide
  - Especially important in Peace Support Operations
  - ROE may demand it

- **Cooperative**
  - IFF
  - AIS
  - Combat ID
  - RFID, …
- **Non-cooperative**
  - Feature extraction
  - Pattern recognition
  - Sensor data fusion

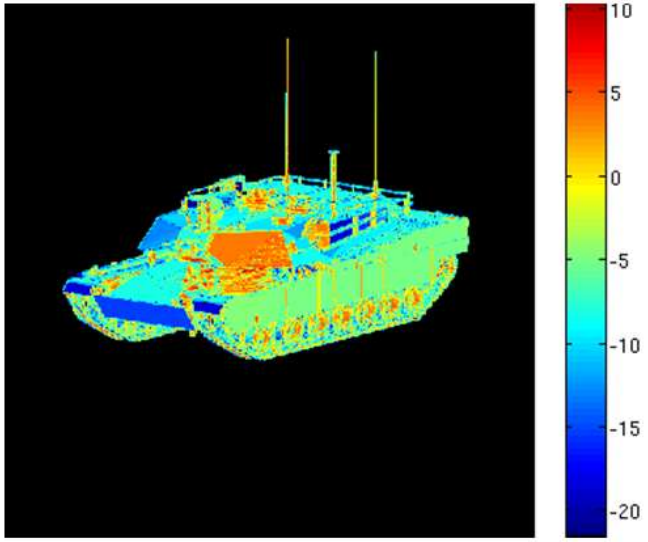
Non-Cooperative Radar Target Classification

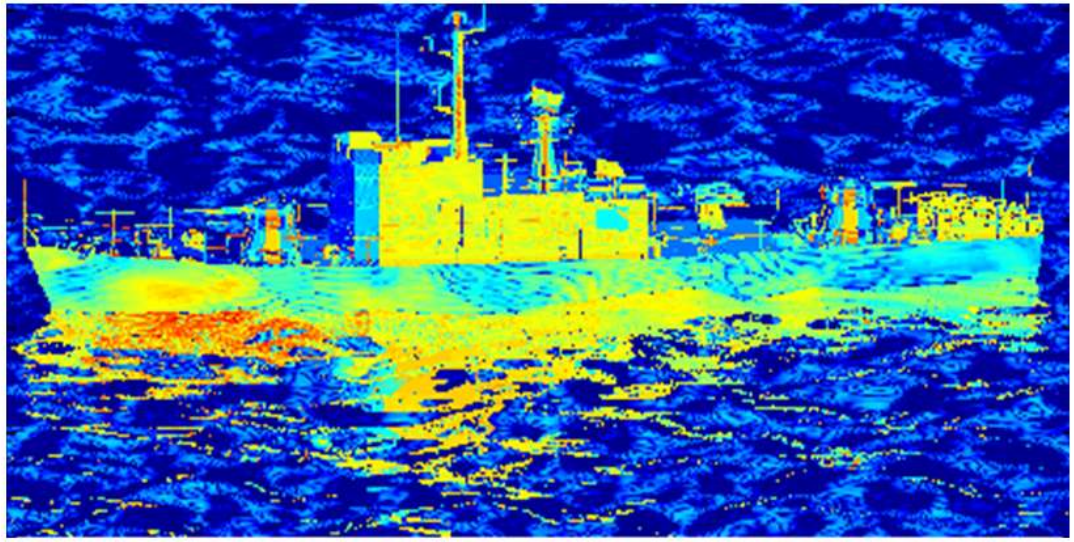
- **Use high resolution sensing of target signature**
  - Range
  - Doppler
- Active field of R&D: **Applications as sensitive as ECCM**



Radar, Target and Environment Modelling

- Reflectivity of targets and clutter
- Propagation
- Radar physics and signal/data processing
- Allows performance estimation, design validation, doctrine development
- Help develop understanding of phenomena not seen by humans





The Future of Radar

- Radar remains the only **long range, day/night, all weather** sensor against **non-cooperative, non-radiating targets**
- Remains important for **military and civil users**
- New **component and subsystem technologies** contribute to making radar more:
  - Affordable
  - Reliable
  - Maintainable
  - User friendly
  - Modular
  - Flexible
  - Adaptable
  - **Multi-function**
  - Upgradeable
- This combines to **proliferating the types and numbers of radars** used world wide

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Optics

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Conclusions

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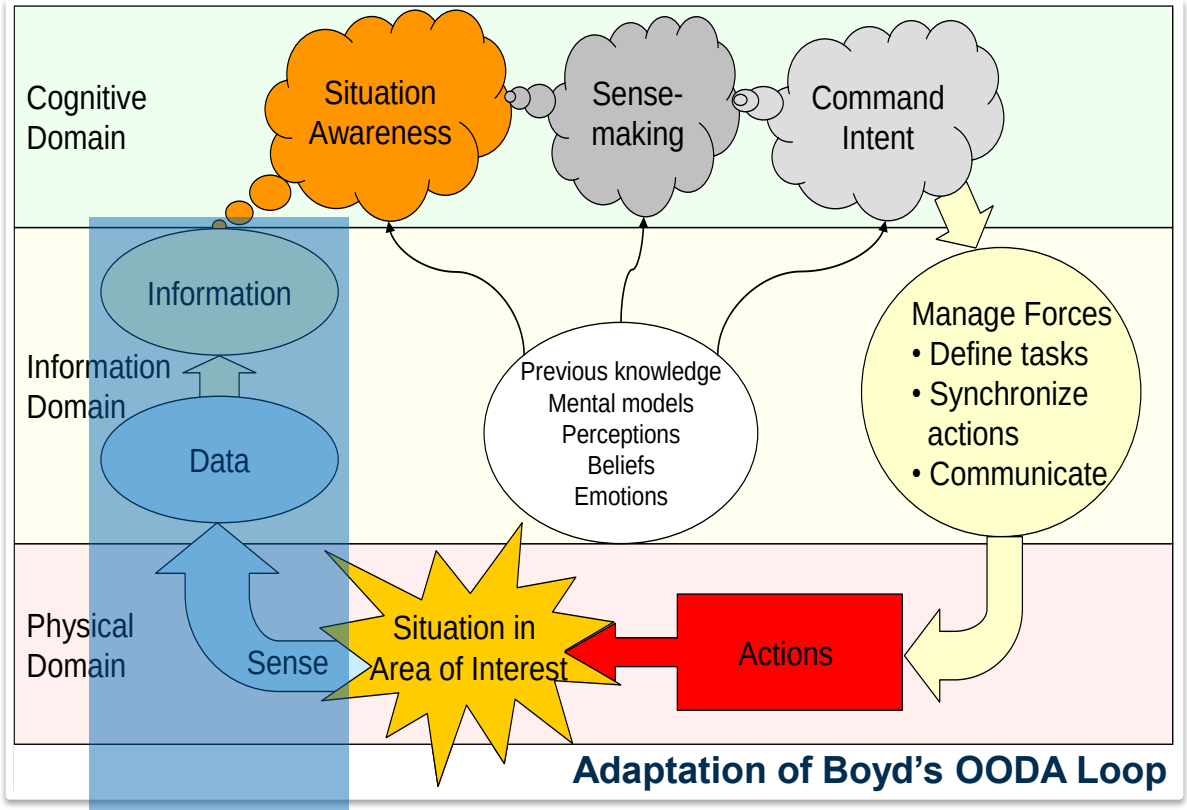
Conclusion (1): Modern ISR can be a game changer

Modern ISR systems, radars and EO/IR sensors provide **increasing functions and performance**, thereby offering potentially impressive degrees of **force multiplication**. This can become a **game changer if properly utilized**

Technological Force Multiplier

Provide an **asymmetric advantage** to **commanders** of our **security forces**



Modern ISR

Provide information regarding an adversary's:

- **Presence** (Detection)
- **Course & speed** (i.e. behaviour over time – requires continuous tracking)
- **Relative movement** (multiple target tracking)
- **Classification & Identity** (Non-cooperative target recognition)
- **Threat level** (Intent estimation in context of resources and intelligence)

Conclusion (2): New, creative CONOPS required

To gain maximum value from the more capable types of **ISR systems** including their integrated **radar and EO/IR sensors**, new **concepts of operation** that make full use of their capabilities need to be developed. This requires an **open and creative mind-set** followed by **joint experimentation** by **specialized teams** consisting of both **military and technology experts**

Conclusion (3): New acquisition approach needed

- ISR systems, radars and EO/IR sensors acquired as a result of such new CONOPS being formulated need to be acquired using an **incremental acquisition model** to avoid **expensive mistakes**
  - "Try before you buy"
  - "Buy a little, test a little"
- **Insist on suppliers** who offer:
  - Continuous improvement & adaptation to emerging requirements (at reasonable cost) & Counter obsolescence plan
  - Standardized interfaces with sufficient capability, cyber security
  - Integration with existing equipment
  - Access to internal signals to allow performance measurements

Conclusion (4): Changes to DOD, Armscor, DERI processes required

ISR systems, radars and EO/IR sensors are increasingly based on **COTS hardware**. They need to be:

- **Continuously upgraded** to avoid obsolescence
- **Adapted** to optimally overcome shortcomings, satisfy new requirements, and exploit new opportunities for creative solutions

This requires **changes to the traditional acquisition, test and evaluation, maintenance and upgrade** processes and capabilities in the DOD, Armscor, the DERIs and the industry.

Conclusion (5): JIM applications require sensor strategy & plan and funding mechanism

Modern ISR systems, radars and EO/IR sensors can deliver value over a wide range of applications typically encountered in **joint, interdepartmental and international operations**. To realize this potential it is essential to develop a **national level sensor strategy and plan** followed by a mechanism to **fund the acquisition and use** of the planned assets from a **central budget**.

Conclusion (6): Local capability exists to support acquisition, maintenance and upgrade requirements

For a developing country of its size, South Africa has an **unusually well developed radar related industrial cluster**. These assets should be used to **acquire and/or adapt and upgrade** modern radars locally. This could help ensure that the radars are optimized for **local conditions and applications** while stimulating the **local economy** and **creating jobs** for South Africans.

Conclusion (7): New structure and methods required in SANDF to manage and own complex ISR systems

- No **permanent structure** currently exists in the SANDF that is designed and mandated to **develop philosophy, policy, strategy and plans** for ISR systems and sensors that are not dedicated to specific weapons systems and platforms. These are generally **complex systems** and need to be acquired, deployed, used and maintained by **knowledgeable people working in specialized organizations**.
- **Such a structure is needed** to derive maximum benefit for the **DOD and its partners** from modern ISR systems and sensors. It may find a **natural home in the SA Army**
- Affordability?
  - Don’t go alone. Utilize **National System of Innovation**,
  - Attract **National R&D funding**
  - Enter into **international partnerships**
  - Use **mature building blocks, appropriate performance & interfaces**

Conclusion (8): Final

- ISR and sensor technologies offer **force multipliers, can change game** – exciting, but also threatening
- **Training, education and experience critical for planners, maintainers and operators**: Critical thought, enthusiasm, open to benchmarking, learn and adapt equipment and processes
- These are **professional careers**: need **organizational home**
- Need **special acquisition** model to conceptualize, define requirements, experiment, acquire, use, adapt, maintain & upgrade
- We have **local knowledge and skills – use these**!

Thank You

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