Panel on Networking and Systems

Theme: Cyber-systems: From Deep-Space to Deep-Waters

Moderator:

Timothy Pham, Jet Propulsion Laboratory - NASA, USA

Panelists:

Paul Labbé, Defence Research and Development Canada, Canada

Christopher Graves, NIWC Pacific, U.S. Department of Defense, USA

José Manuel Fonseca, UNINOVA, Portugal

Timothy Pham, Jet Propulsion Laboratory - NASA, USA

Topics

Paul Labbé - Vulnerabilities to cyber attacks are become serious issues to consider

Christopher Graves – TBA

José Manuel Fonseca - Are cyber systems contributing for a better quality of life? Is true privacy possible in the Digital Age?

Timothy Pham – Cybersecurity Challenges in Ground Communications Network

Cybersecurity Challenges in Deep Space Communications

Timothy Pham

Jet Propulsion Laboratory

California Institute of Technology

Cybersecurity Considerations

- Global multi-user system
  - Diversely located across the globe
  - Multinational operational teams
    - Role-based access credential
    - Credential vetting
- Long lifecycle equipment
  - Cost of upgrading applications with obsolete OS
    - Some equipment last over 20 years
- Security-conscious software development
  - Domain knowledge - Application specific vs. cybersecurity
  - Network layer security vs. application layer security
- Tradeoffs
  - Strong security posture vs fast/timely deployment

SPAWAR Systems Center PACIFIC

TIPPERS: Bringing IoT to the Navy

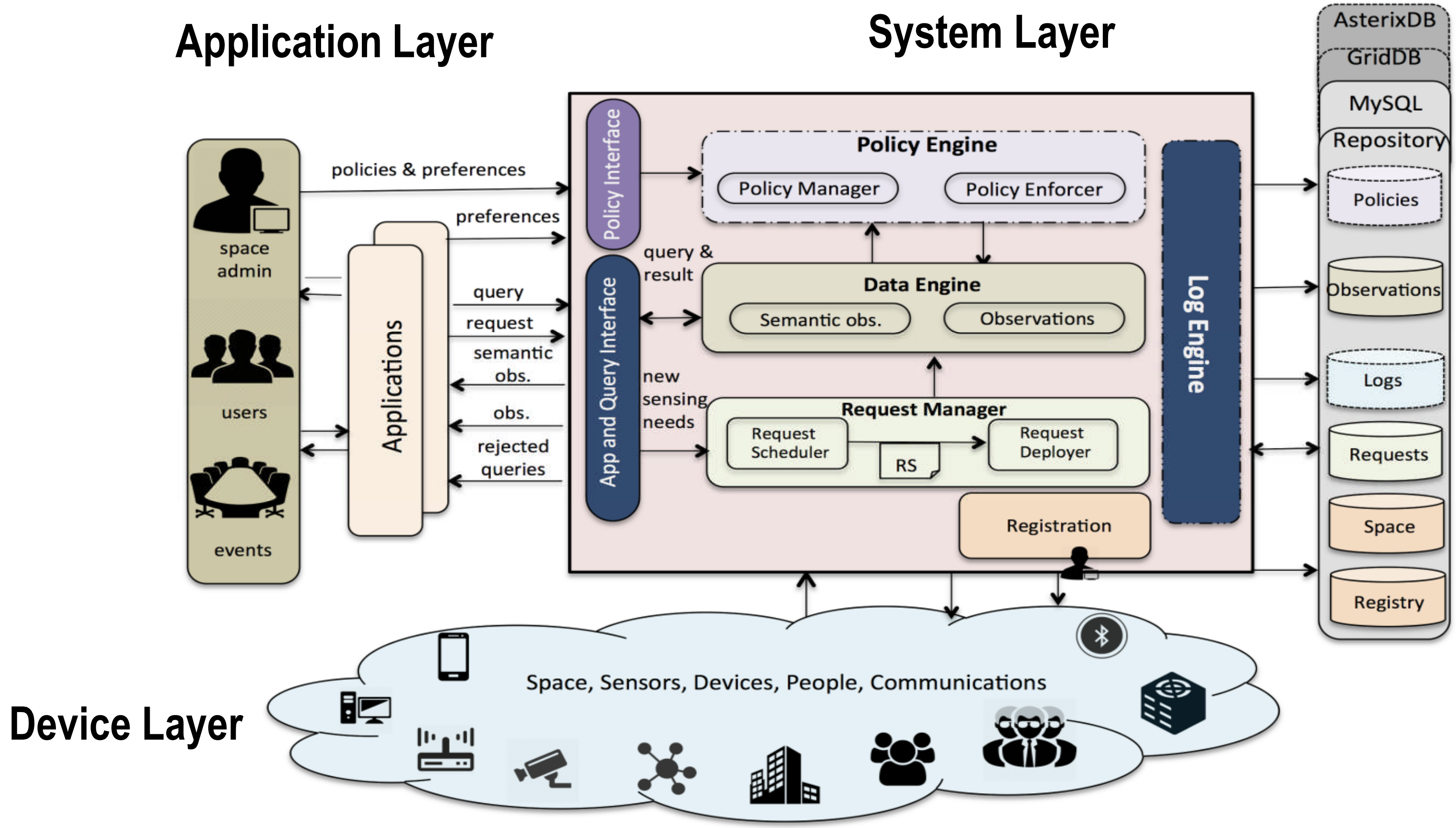
Christopher T. Graves

Naval Information Warfare Center Pacific, DoD

DARPA Brandeis Program

- **Program Manager**: Dr. Joshua Baron
- **Objectives: *The Brandeis program seeks to develop the technical means to protect the private and proprietary information of individuals and enterprises.***
- **Four Technical Areas**:
  - TA1: Privacy Preserving Computation
  - TA2: Human Data Interaction
  - TA3: Experimental Systems
  - TA4: Metrics and Analysis
- **Three Focus Areas**:
  - Internet of Things (IoT) - TIPPERS
  - Mobility
  - Coalition Information Sharing

TIPPERS Overview



Privacy-by-Design Approach: Level 1 (Secure Computing), Level 2 (Differential Privacy)

TIPPERS Overview: 9 Performers From Academia and Industry

Technologies	Performers
TIPPERS Platform: Enables management of sensors in an IoT environment. Enables development of services based on inferences made on sensor data. Incorporates privacy technologies applied to different phases of data flow.	UCI Honeywell
Privacy Policy Management: Enables communication of policies to users and capture of their preferences.	Carnegie Mellon University
Secure Computing: Enables computation to be performed on the encrypted data. Protects data at rest and in processing, including the queries.	Galois Stealth
Differential Privacy: Enables protection of privacy of individual records. Incorporates noise to aggregate query responses.	U. of Massachusetts Duke University Colgate University
Metrics and Evaluation: Privacy vs. Utility Analysis and Privacy Leakage Analysis	Galois Cybernetica

TIPPERS Evaluation & Transition

▼ Phase 1: TIPPERS Deployment at NIWC Pacific

- Mobility Center of Excellence (MCoE)
- Navy Advanced Cyber Security (NACS) Lab

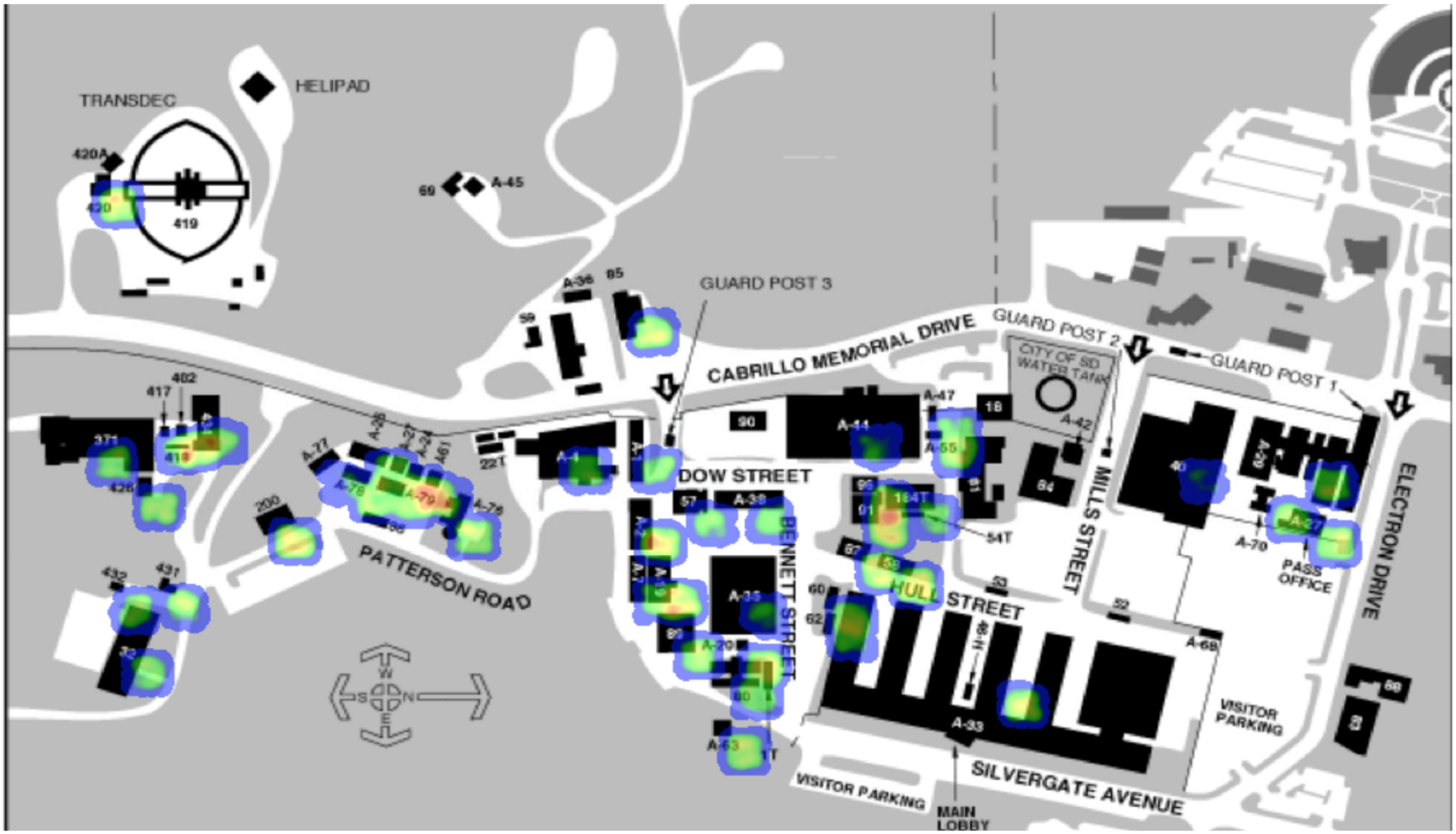
▼ Phase 2: TIPPERS Deployment in a Shipboard Environment

- Develop applications specific to the ship
- Participate in Trident Warrior 2019 (TW19)
- Participate in Trident Warrior 2020 (TW20)

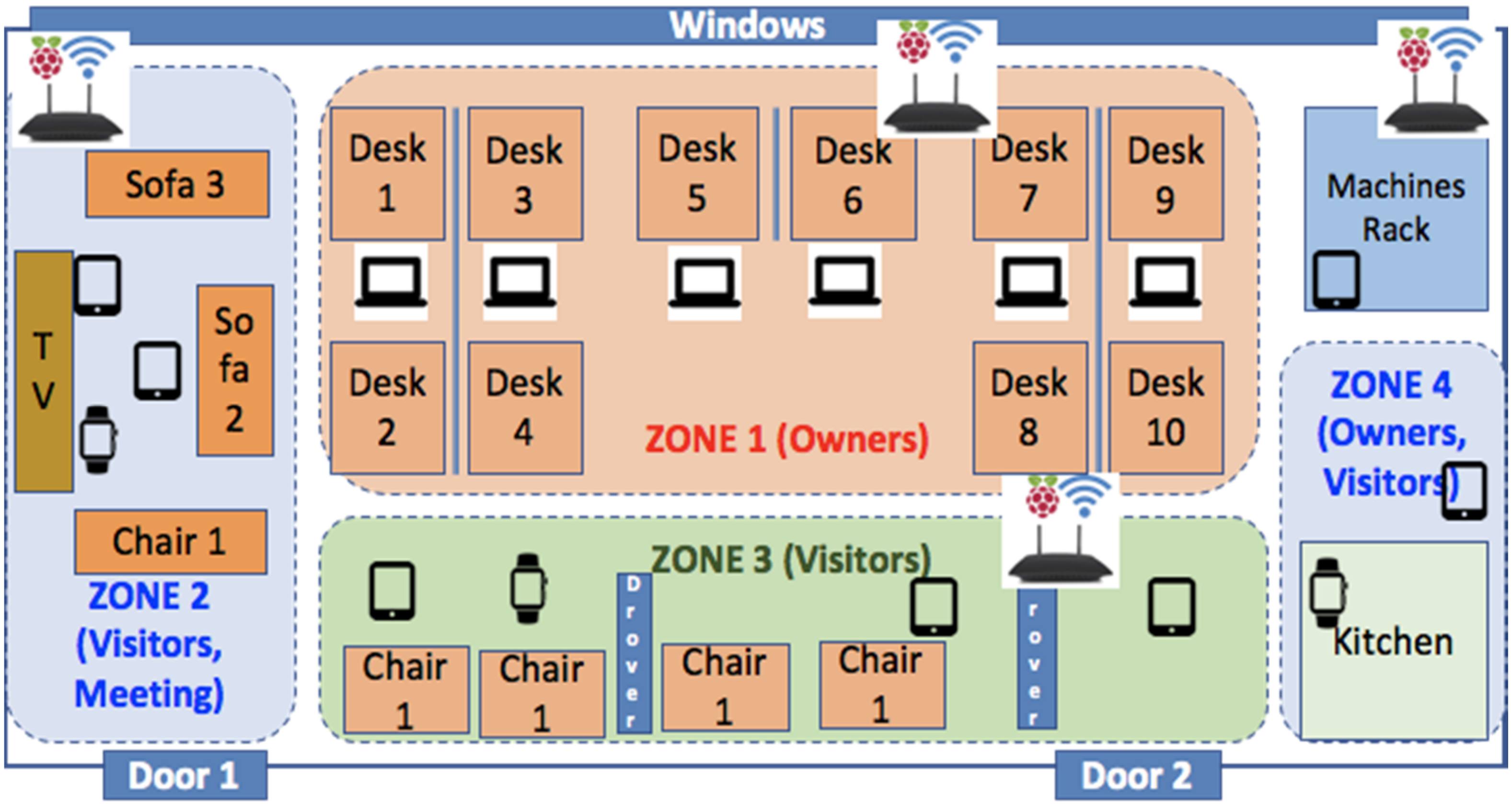
Identify Navy Applications and Navy Customers

Security Surveillance App

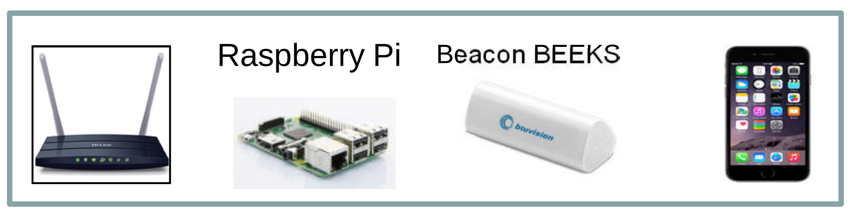
Heatmap of NIWC Pacific: Presence and Occupancy Monitoring



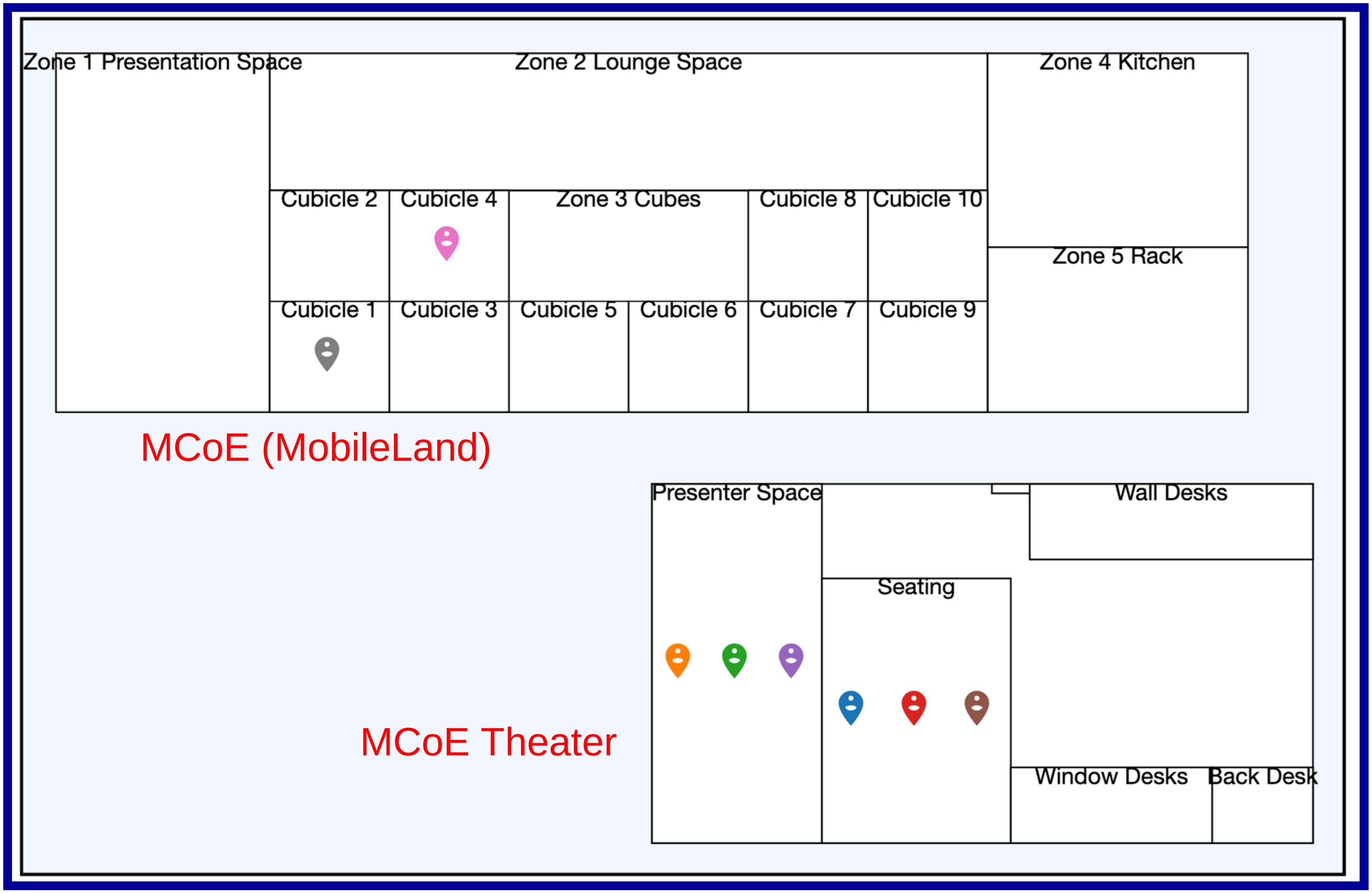
Security Surveillance App



Sensors used for location



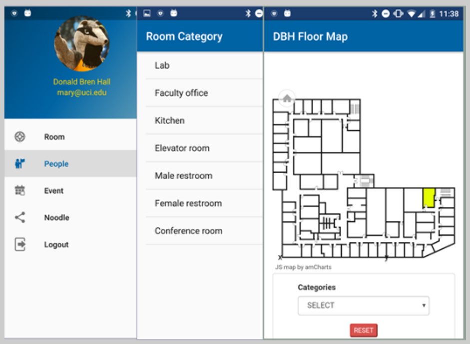
Security Surveillance App



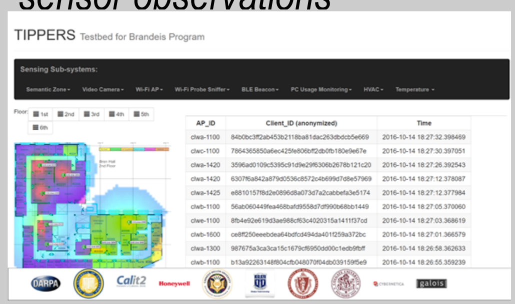
TIPPERS Applications

Presence-Based Applications	Analytics Applications	Energy-Based Applications

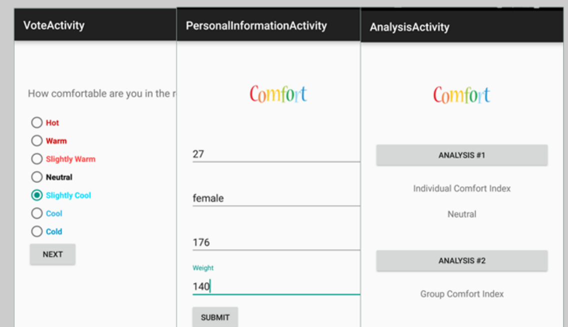
Concierge: smart building assistant



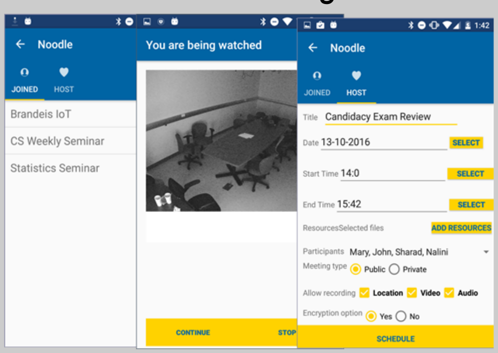
T-Panel: analytics toolkit for sensor observations

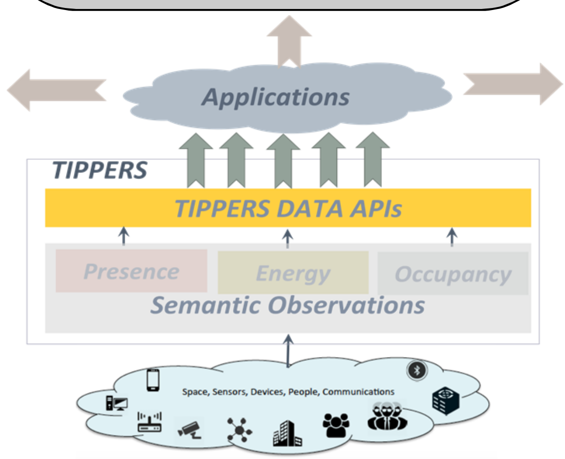


GCC: smart thermal comfort controller



Noodle: smart meeting assistant





Open APIs will lead to more applications.

Semantic Observations

Presence Table

Person	confidence	Location	timestamp
56abe58 4a4caa1 71fc8c9 681	0.85	2099	2016-01-29-14:20:10
56abef3 0b4cdc3 15ae698 19a	0.8	2085	2016-01-29-08:20:10
…	…	…	

Occupancy Table

Id	confidence	resource	usage	time
56abe 584a4 c9681	0.85	Room 2099	10kw	2016-01-29-14:20:10
56abe f30b4 cdc31	0.8	Room 2085	12Ks	2016-01-29-08:20:10
…	…	…		

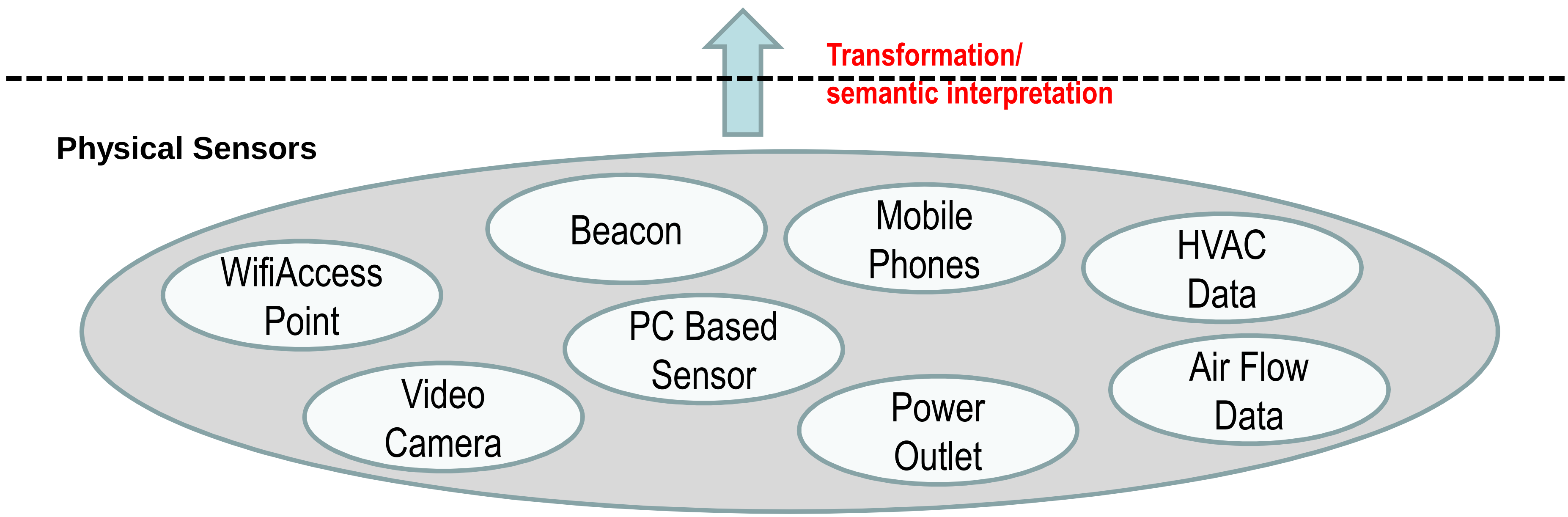
Energy Usage Table

Id	confidence	resource	usage	time
56ab e584 a4c9 681	0.85	Room 2099	10kw	2016-01-29-14:20:10
56ab ef30b 4cdc 31	0.8	Room 2085	12Ks	2016-01-29-08:20:10
…	…	…		

Using: Wi-Fi AP, BLE Beacon

Using: Wi-Fi AP, BLE Beacon

Using: HVAC System, Power Outlet Meter



TW20 Applications

- Emergency Response
  - Fall Detection
  - Fire Damage Control Locker
- Mustering
  - General Quarters
  - Onboarding
- Maintenance
  - Inventory Management

TW20 Applications

- Training/Exercise
  - Active Shooter
- Communication
  - Sailor-to-Sailor Messaging

Panel on Networking and Systems
Theme: Cyber-systems: From Deep-Space to Deep-Waters

Are cyber systems contributing for a better quality of life?

Is true privacy possible in the Digital Age?

José Manuel Fonseca
NOVA University of Lisbon / UNINOVA

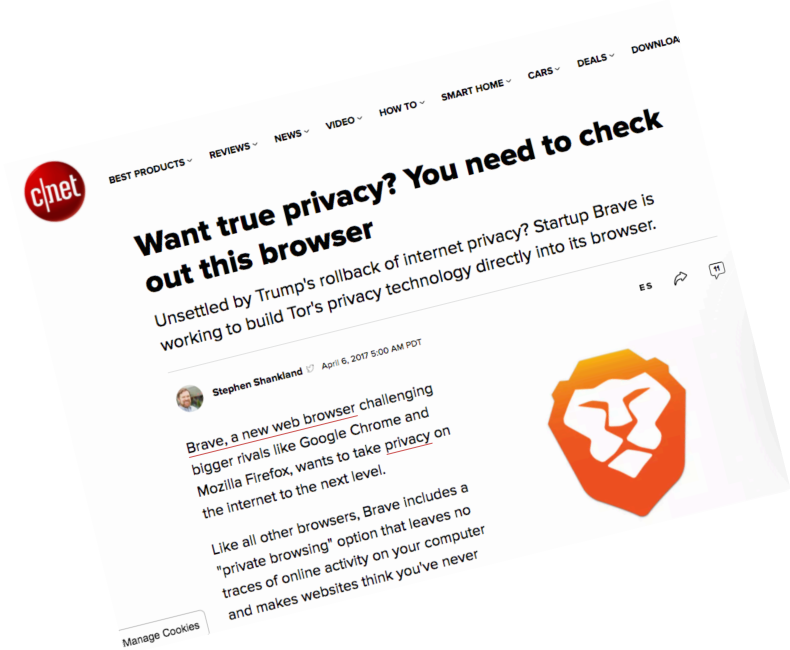
SPACOMM 2020 - The Twelfth International Conference on Advances in Satellite and Space Communications
February 23, 2020 to February 27, 2020 - Lisbon, Portugal

Cyber-systems: are they contributing for a better quality of life?

A cyber-system is a system in which a mechanism is controlled or monitored by computer-based algorithms.

Examples: smart grids, autonomous automobile systems, medical monitoring, industrial control systems, robotics systems, and automatic pilot avionics

True privacy – is it possible in the digital age?



BEST PRODUCTS REVIEWS NEWS VIDEO HOW TO SMART HOME CARS DEALS DOWNLOA

Want true privacy? You need to check out this browser

Unsettled by Trump's rollback of internet privacy? Startup Brave is working to build Tor's privacy technology directly into its browser.

Stephen Shankland April 6, 2017 5:00 AM PDT

Brave, a new web browser challenging bigger rivals like Google Chrome and Mozilla Firefox, wants to take privacy on the internet to the next level.

Like all other browsers, Brave includes a "private browsing" option that leaves no traces of online activity on your computer and makes websites think you've never

Manage Cookies

gt government technology

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SECURITY

There is No Such Thing as True Privacy in the Digital Age

When it comes to digital data – photos, conversations, health information or finances – nothing can be perfectly private.

BY MARISSA LANG, SAN FRANCISCO CHRONICLE / MARCH 10, 2017

THE DIGITAL AGE JUNE 18, 2018 ISSUE

WHY DO WE CARE SO MUCH ABOUT PRIVACY?

Big Tech wants to exploit our personal data, and the government wants to keep tabs on us. But "privacy" isn't what's really at stake.

National Defence Défense nationale

ASSISTANT DEPUTY MINISTER (SCIENCE AND TECHNOLOGY)

Chief of Staff

Panel Session | **"Networking and Systems - Theme: Cyber-systems: From Deep-Space to Deep-Waters"**

Would Low Earth Orbit (LEO) satellite systems and extended endurance Unmanned Air Systems (UAS) ensure improved communications and persistent air and surface surveillances in all areas including Arctic and Antarctic?

By Paul Labbé, Office of the Chief Scientist, DRDC

"This presentation contains information which is provided to the participants of the Twelfth International Conference on Advances in Satellite and Space Communications (SPACOMM 2020)

February 23, 2020 to February 27, 2020 - Lisbon, Portugal.

It does not contain any formal recommendations or positions from the Government of Canada, DND, ADM(S&T) or DRDC."

DND: Department of National Defence
ADM(S&T): Assistant Deputy Minister of Science and Technology
DRDC: Defence Research and Development Canada

Canada

Discussion on…

Would Low Earth Orbit (LEO) satellite systems and extended endurance Unmanned Air Systems (UAS) ensure improved communications and persistent air and surface surveillances in all areas including Arctic and Antarctic?

Or

Low Earth Orbit (LEO) satellite systems and extended endurance Unmanned Air Systems (UAS) ensure improved communications and persistent air and surface surveillances in all areas including Arctic and Antarctic.

LEO Constellations [8]

Maximum total system sellable capacity for OneWeb's, Telesat's and SpaceX's constellations are 1.56 Tbps, 2.66 Tbps and 23.7 Tbps respectively.

Ground segment of 42 ground stations will suffice to handle all of Telesat's capacity, whereas OneWeb will need at least 71 ground stations, and SpaceX more than 123.

Satellite efficiency (ratio between the achieved average data-rate per satellite and its maximum data-rate), Telesat's system performs significantly better (~59% vs. SpaceX's 25% and OneWeb's 22%) due to the use of dual active antennas on each satellite.

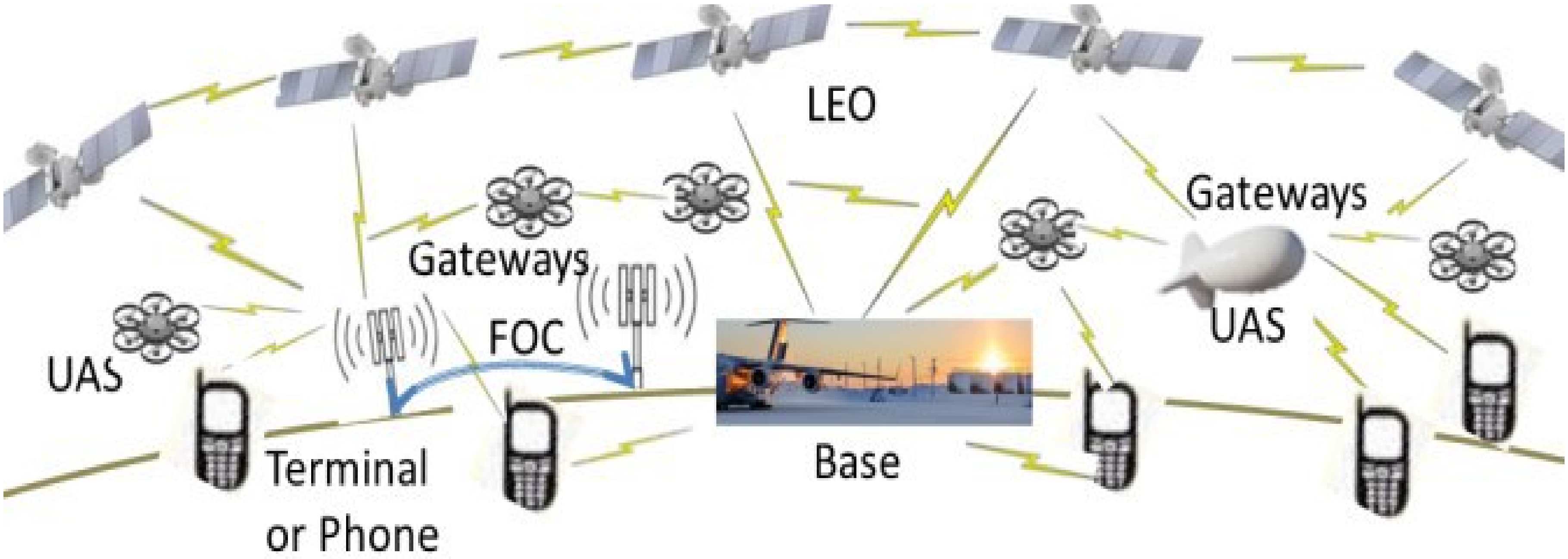
OneWeb's system lower throughput than Telesat's is due to its low-complexity satellite design, spectrum utilization strategy, orbital configuration, payload design, and lack of Inter Satellite Links (ISLs).

If ISLs were to be used in OneWeb's constellation the number of ground stations required could be reduced by more than half to 27 ground stations.

“OneWeb's strategy focuses on being first-to-market, minimizing risk and employing a low-complexity space segment, thus delivering lower throughputs. In contrast, Telesat's strategy revolves around high-capable satellites and system flexibility (in diverse areas, such as deployment, targeted capacity allocation, data routing, etc.), which results in increased design complexity. Finally, SpaceX's system is distinctive in its size; although individually each satellite is not significantly more complex than Telesat's, the massive number of satellites and ground stations increases the risks and complexities of the overall system considerably” [8]. However, this offers a high level of redundancy.

[8] I. del Portillo, B. G. Cameron and' E. F. Crawley, “A technical comparison of three low earth orbit satellite constellation systems to provide global broadband,” *Acta Astronautica,* vol. 159, pp. 123-135, 2019

Terrestrial Architectures



Multi-technology architectures where Inter Satellite Links (ISLs) and Inter UAS Links (IUASLs) play important roles in offering a large spectrum of potential services. Appropriate parameters and technologies could be selected to allow anticipating improvement in coverage, resilience, redundancy, dependability, data rate and low latency in the North.

Combining LEO with terrestrial communications build improved capabilities and dependability

By designing an affordable Arctic communications system that optimally combines their advantages to offer the quality of services required including dependability and security, one can propose an hybrid system that fulfill requirements for operations in the Arctic and Antarctic.

Orbits, altitudes and path lengths

Geostationary Earth Orbit (GEO) about 37000 km above the equator
Medium Earth Orbit (MEO) on 2000 to 35786 km orbits.

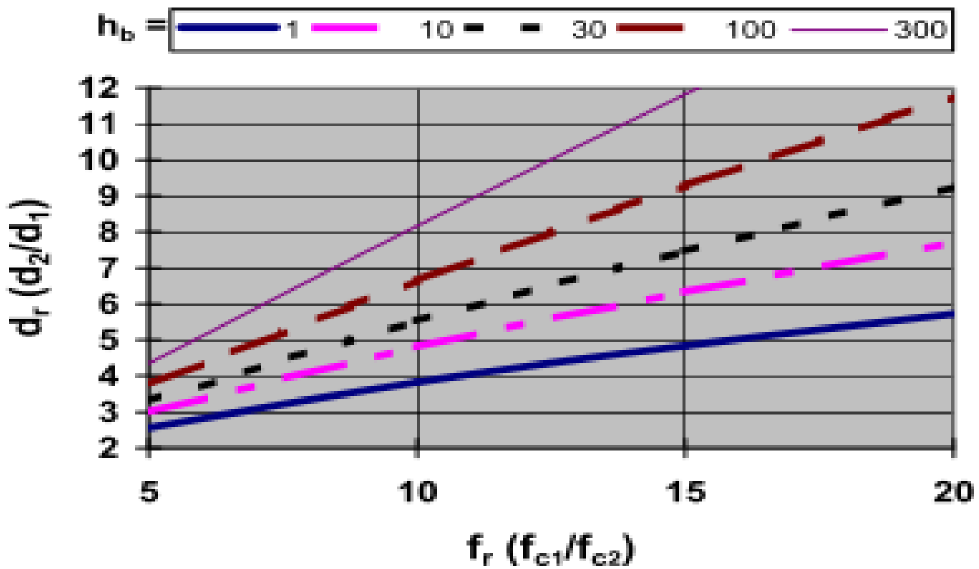
Highly Elliptical Orbit (HEO)
Three APogee (TAP) with an apogee around 43000 km
Low Earth Orbit (LEO) at altitudes below 2000 km.

Terrestrial gateways:
Base station towers 20 to 400 m
Unmanned Aerial Systems (UASs) 2 to 20 km

Fiber Optic Cable (FOC) path lengths from few m to several km

Path loss as ratio of (wave length / path length)^2

Increase in radio coverage when stepping down from 1500 MHz to 150 MHz. Reducing the mobile operating frequency by a factor of 10 extends the communication range by a factor of about 5 for a base station whose effective antenna height is 30 m. If the cell size were 5 km for normal service, it might extend to 25 km for the emergency temporary service, reducing the logistic burden of covering an area affected by a disaster.



POC

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National Defence Défense nationale

ASSISTANT DEPUTY MINISTER (SCIENCE AND TECHNOLOGY)

Chief of Staff

Panel Session | **"Networking and Systems - Theme: Cyber-systems: From Deep-Space to Deep-Waters"**

Could multistatic multiband cognitive radar technologies make a difference in providing accurate and timely situation awareness up to course-of actions such as engaging new types of targets?

By Paul Labbé, Office of the Chief Scientist, DRDC

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Canada

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Discussion on…

Could multistatic multiband cognitive radar technologies make a difference in providing accurate and timely situation awareness up to course-of actions such as engaging new types of targets?

Or

Multistatic multiband cognitive radar offers advantages over traditional radar systems in early detection of targets with small radar cross section or increases the likelihood of intercepting stealth targets or hypervelocity cruise missiles

Differences between adaptive and cognitive radars

- **Adaptive radar systems are capable of modifying their parameters using predefined rules or algorithms in response to a sensed environment or signal changes.**

- **Cognitive radar systems actively stimulate the environment by transmitting signals to dynamically and autonomously adjust their operational parameters according to the feedback obtained from the receiving antennas.**
  - **They learn by continuously stimulating the environment (the scene) and by analysing the signals received (observations) to adapt both their algorithms and waveforms in order to achieve predefined task objectives.**
  - **They are goal oriented.**

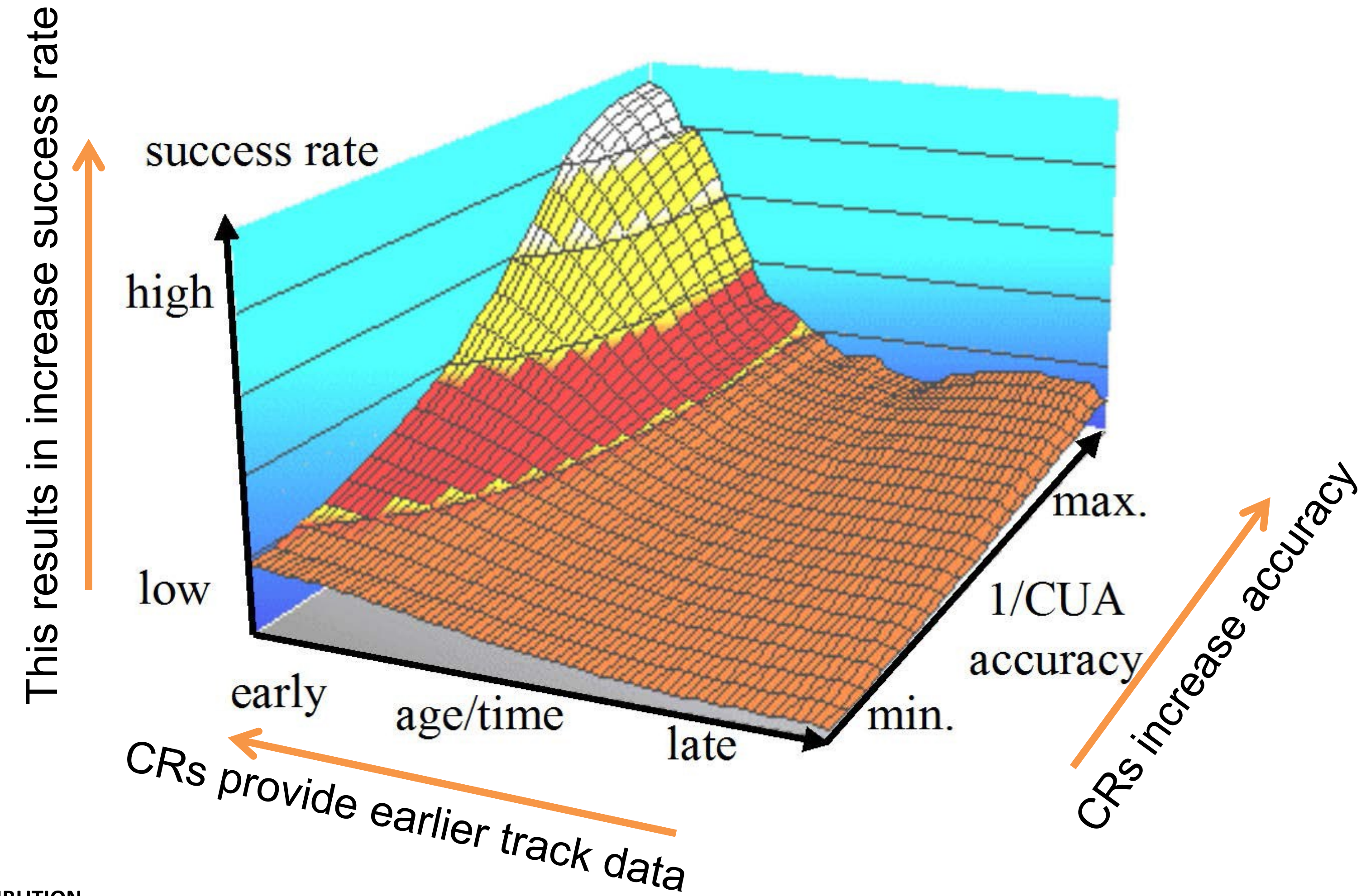
- Cognitive systems can learn from observed effects from stimuli they designed and generated. They can create new algorithms based on observations of their manipulation of the environment.
- Cognitive systems are proactive (anticipative or predictive) while adaptive ones are responsive; they wait that something happens, they don't probe the environment to see what happens if…

Expected advantages of cognitive radar

1. Extend detection range
2. Shorten the time to acquisition in target tracking
3. Improve the accuracy of positional information of tracked targets
4. Reduce risk in selecting an intelligent choice of decision-making mechanism in the transmitter for a prescribed goal of interest when confronted with environmental uncertainties and disturbances in real time
5. Offer the agility necessary to defeat ‘Digital Radio Frequency Memory’ based jammer/spoofing technology which essentially captures the transmitted signal and reradiates it towards the radar receiver, typically with some delay or modulation attached
6. Detect smaller radar cross section (RCS) targets such as drones and stealth platforms
7. Increase capabilities of passive radar and multistatic radar systems which could detect some stealth aircraft better than conventional monostatic radars, since first-generation stealth technology (such as the F-117) reflects energy away from the transmitter's line of sight, effectively increasing RCS in other directions, which multistatic passive radars can monitor
8. Increase the likelihood of defeating standard electronic warfare and CEW by unexpectedly and rapidly changing waveform characteristics
9. Use difficult to detect waveforms including wideband signals, limit opposing force opportunities to use or trigger their electronic countermeasures to reduce a potential range advantage a radar system may offer in targeting opposing force assets or platforms
10. Reduce the susceptibility (lower likelihood) of being fooled by artificial coherent target energy, including decoys
11. Use built-in shielding against misdirecting/degrading Direction-of-Arrival (DOA) measurements
12. Offer enhanced geolocalization by networked CRs
13. Deliver faster high precision information about targets
14. Can contribute to communications when other means are jammed

However, so far there seems to be no CR technologies currently deployed on military platforms or for military applications but there are indications that some are in development.

Networked CRs could deliver better track data



Source Paul Labbé 2002

Multistatic-multiband complexity adds capabilities

The hypothesis is how much is feasible and advantageous to build a Cognitive-Multistatic-Multiband-Radar Network (CMMRN)?

Essentially, a CMMRN is a system made of interconnected CR systems with the following capabilities:

Multistatic

Multiband

Use AESA

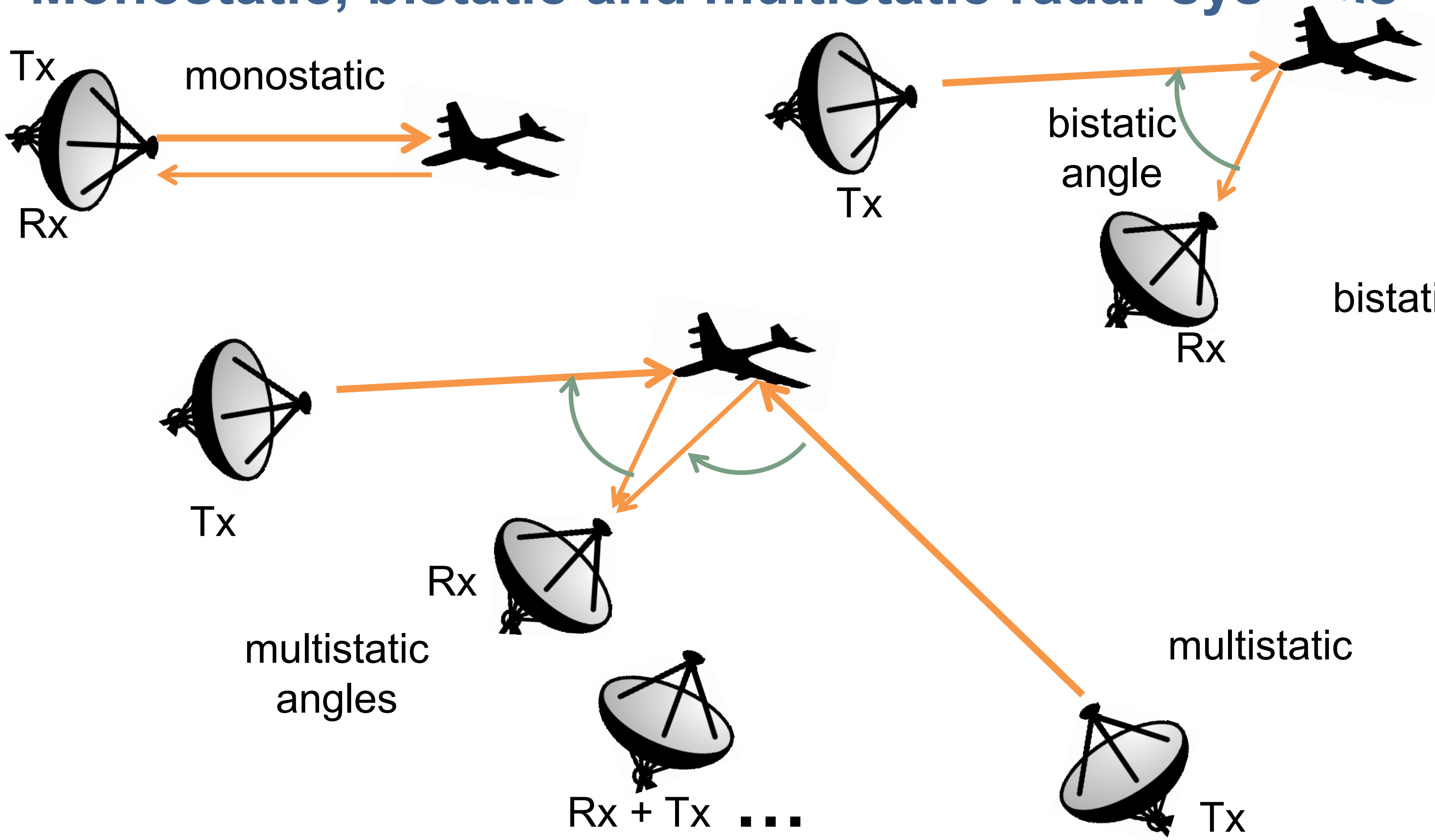
Multiband

Radar operating in one band offers advantages and disadvantages specific to that band. A multiband radar may optimally combine advantages from operating in several bands for predefined operational goals, e.g.,

- S-band for its strong immunity against weather clutter and good detection range,
- X-band to generate narrower beams for target tracking and improving spatial resolution, and
- VHF for extended range and its abilities to detect stealth targets.

Multiband radar systems allow enhancing target classification and detection, and exploiting multispectral imaging of complex targets.

Monostatic, bistatic and multistatic radar systems



In multistatic radar systems, each antenna could be only receiving or transmitting, or both. Using active electronically scanned array (AESA), it is cost effective to do both in addition to communications.

Aspect Angle Dependence of RCS

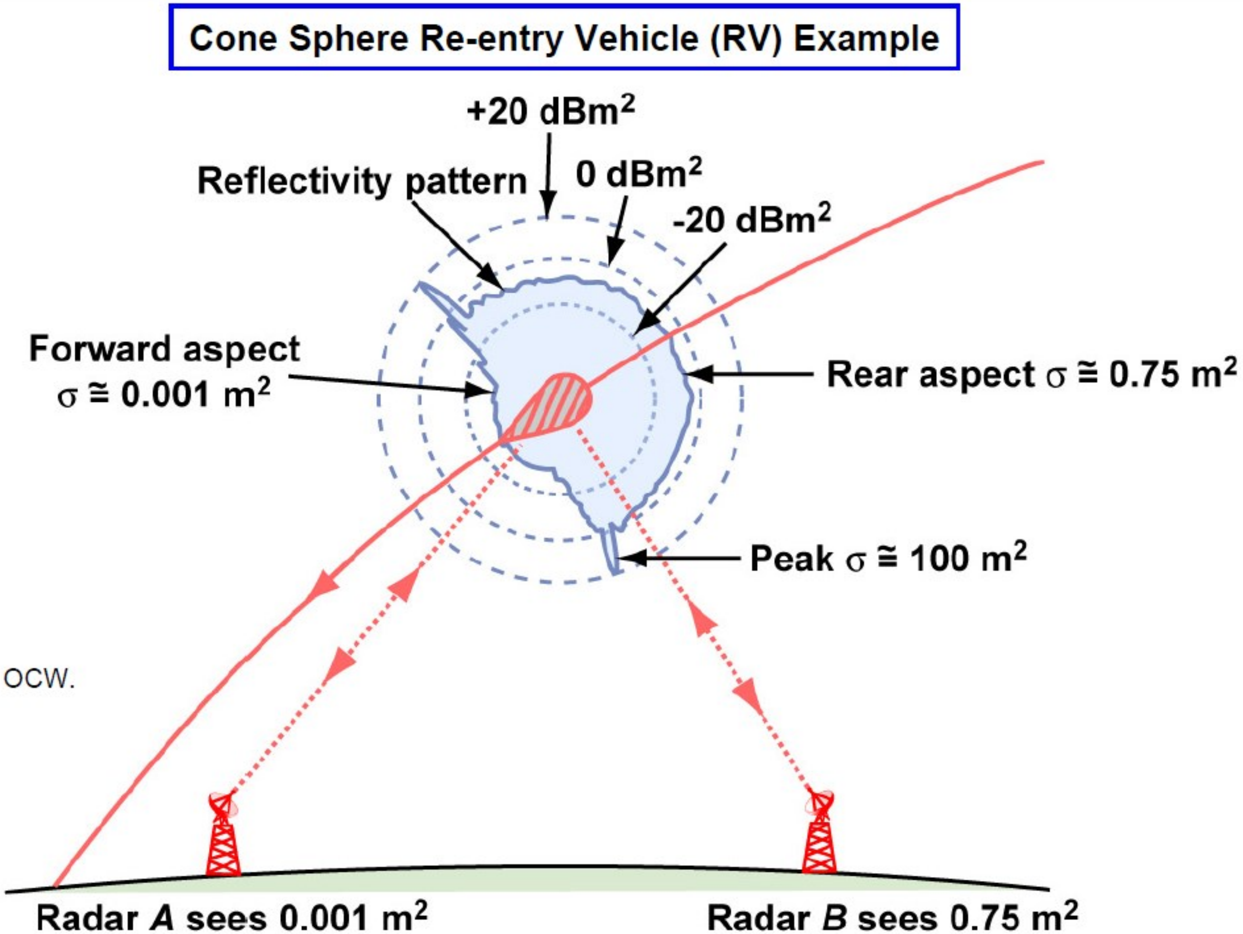
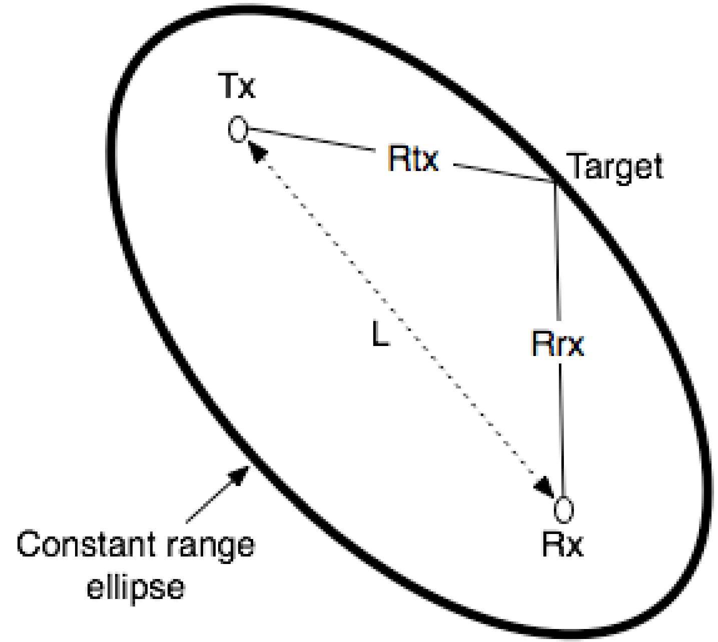


Figure by MIT OCW.

http://aess.cs.unh.edu/Radar%202010%20PDFs/Radar%202009%20A_7%20Radar%20Cross%20Section%201.pdf

Bistatic is a bit more complex, so is multistatic radars.

Bistatic range is $R_{rx}+R_{tx}-L$



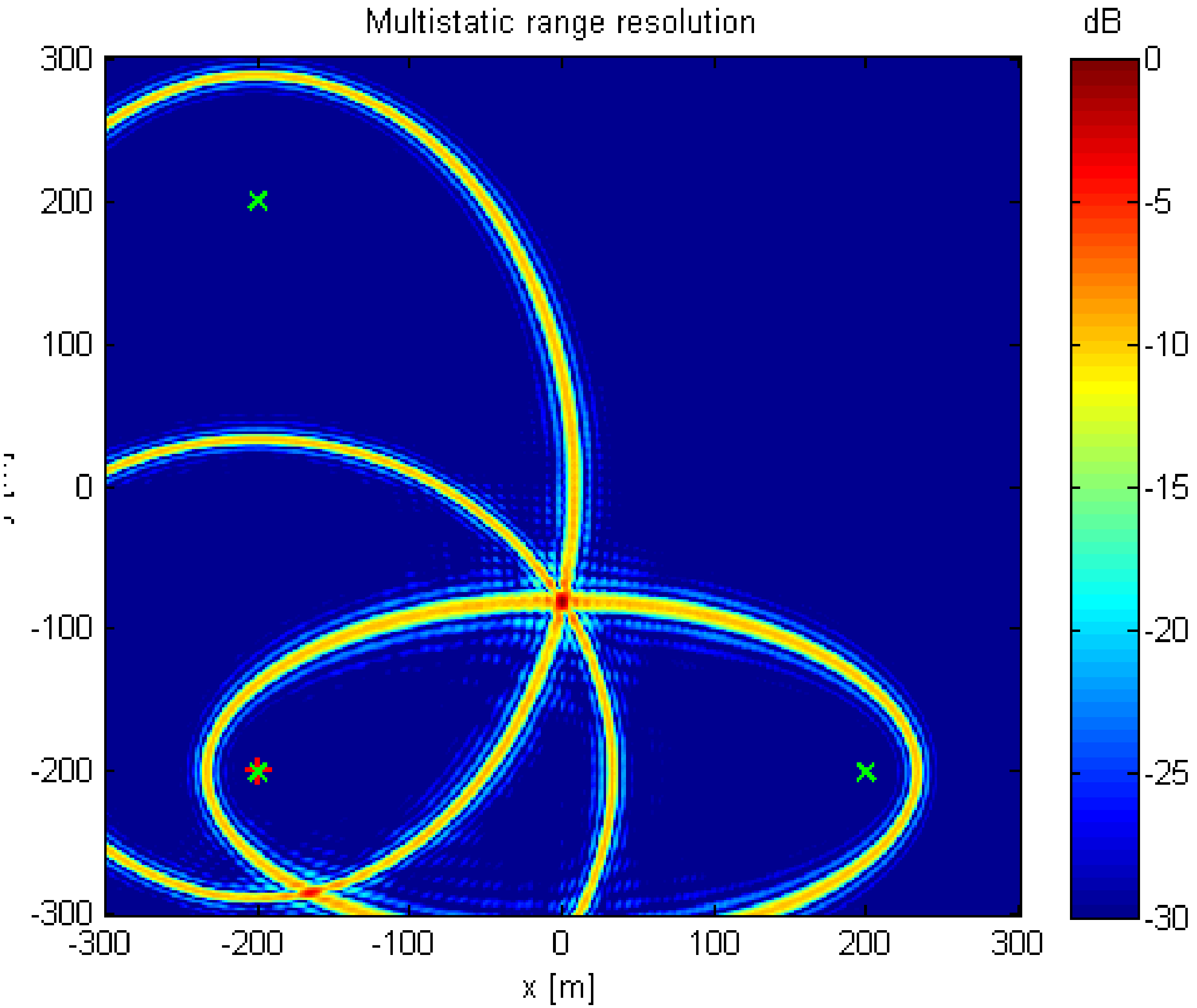
Bistatic Doppler shift is a specific example of the Doppler effect that is observed by a radar or sonar system with a separated transmitter and receiver. The Doppler shift is due to the component of motion of the object in the direction of the transmitter, plus the component of motion of the object in the direction of the receiver. Equivalently, it can be considered as proportional to the rate of change of bistatic range.

In a bistatic radar with wavelength λ, where the distance between transmitter and target is R_{tx} and distance between receiver and target is R_{rx}, the received bistatic Doppler frequency shift is calculated as:

$$f = -\frac{1}{\lambda}\frac{d}{dt}(R_{tx} + R_{rx})$$

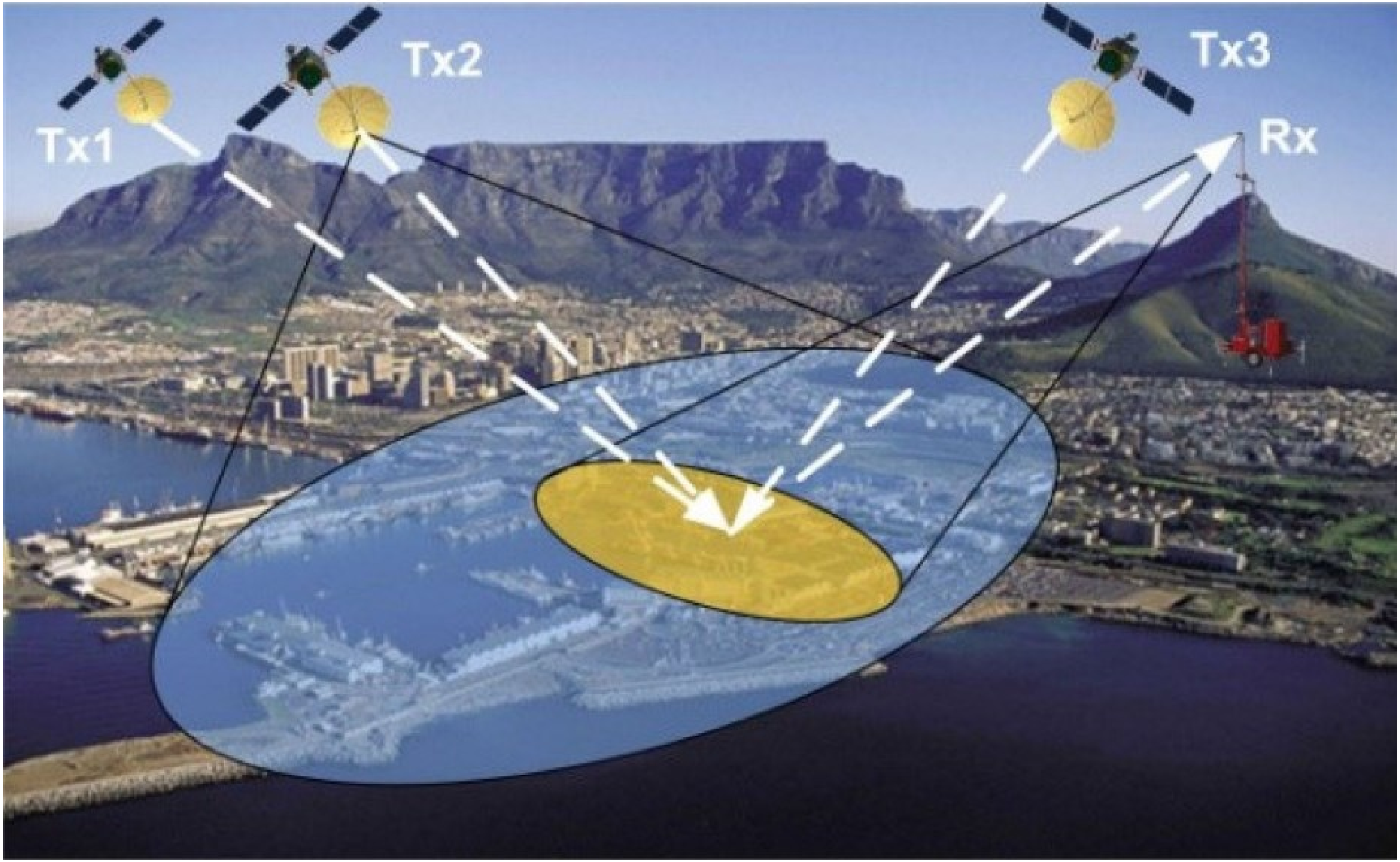
Note that objects moving along the line connecting the transmitter and receiver will always have 0 Hz Doppler shift, as will objects moving around an ellipse of constant bistatic range.

Additional material



J. Verzeilberg, “Coherent Multistatic Radar Imaging,” 2011

Experiments using multi-static SAR with GNSS transmissions



GNSS such as GPS or Galileo use Medium Earth Orbit (MEO) satellites (20200 km).

U. Nithirochananont, M. Antoniou, and M. Cherniakov, “Passive multi-static SAR–experimental results,” *IET Radar, Sonar & Navigation,* vol. 13, no. 2, pp. 222-228, 2018. L-band

Conclusion from: Experiments using multi-static SAR with GNSS transmissions (L-band 1-2 GHz)

This multi-static SAR "showed a drastic improvement over the bistatic SAR image despite utilising a basic combination technique, despite the spatial resolution of individual images is limited.

It can, not only detect the presence of targets but also reveal geometric features, such as edge, shape, and dimensions."

We expect improved results with new LEO constellations which are closer to Earth than MEO. They may offer more power on targets. Signals in Ku 12-18 GHz and Ka 27-40 GHz bands may offer more resolution, although signals will suffer from more attenuation at such higher frequencies.

U. Nithirochananont, M. Antoniou, and M. Cherniakov, "Passive multi-static SAR–experimental results," *IET Radar, Sonar & Navigation,* vol. 13, no. 2, pp. 222-228, 2018.

POC

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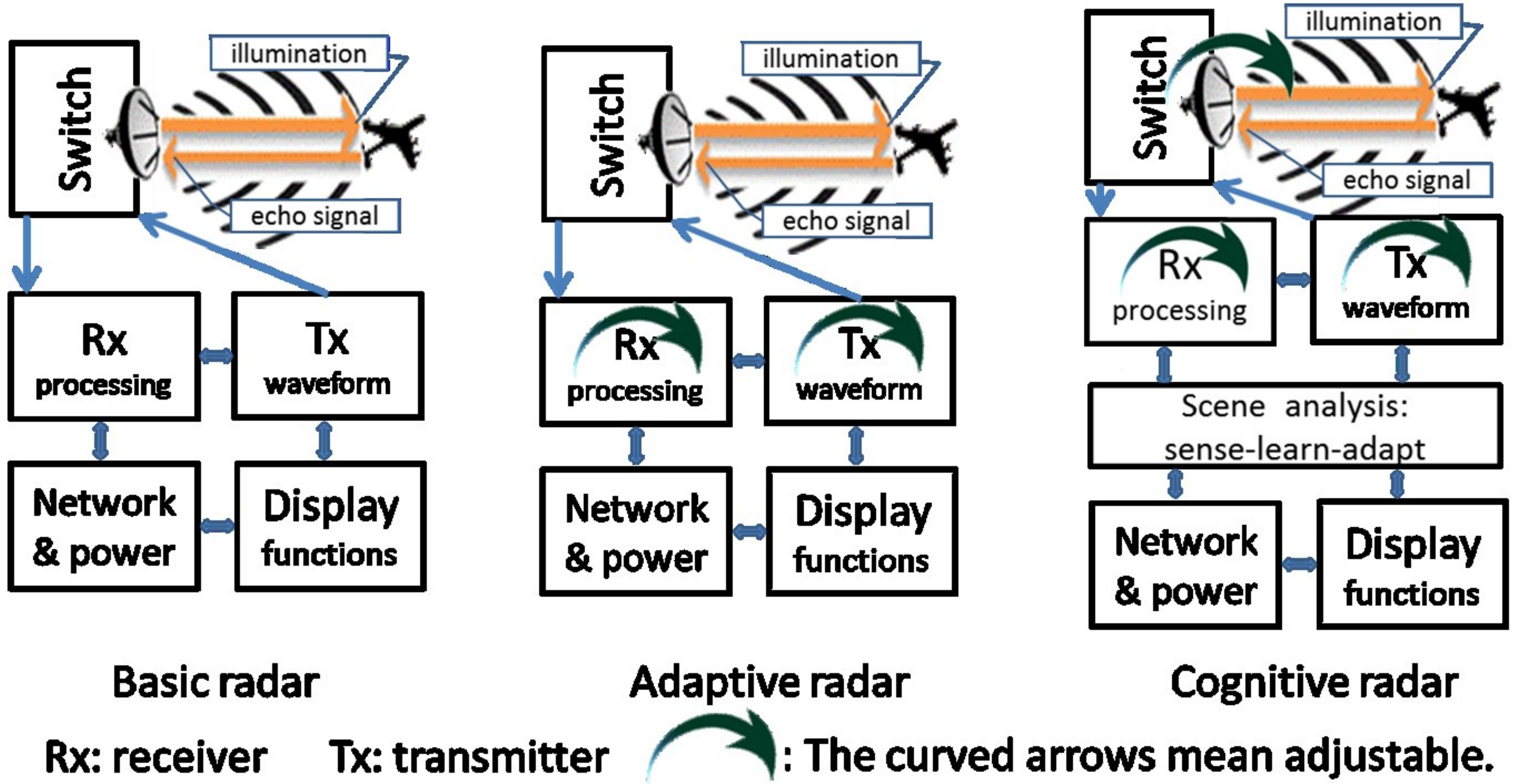
Basic, Adaptive, and Cognitive Radars (CRs)



Note the cognitive aspect in a single block: Scene analysis: sense-learn-adapt (SLA)