CARNAHAN CONFERENCE
SECURITY TECHNOLOGY

OUTDOOR PERIMETER SECURITY SENSOR INNOVATION
PAST, PRESENT AND FUTURE
by
Keith Harman, Ph.D.

A Quiz to Think Upon

- Please do NOT shout out the answer
- Even if bored, please do NOT search for the answer
- We will check for answers at the end of my talk
- Who said?
- "If I have seen further than others, it is by standing on the shoulders of giants."

An ever changing world

- My Parents Generation (1900-1985)
  - WW 1, WW 2, Korea, Vietnam, Cold War
  - First – car, telephone, electricity, radio, airplane, TV, Color TV
  - Can do attitude

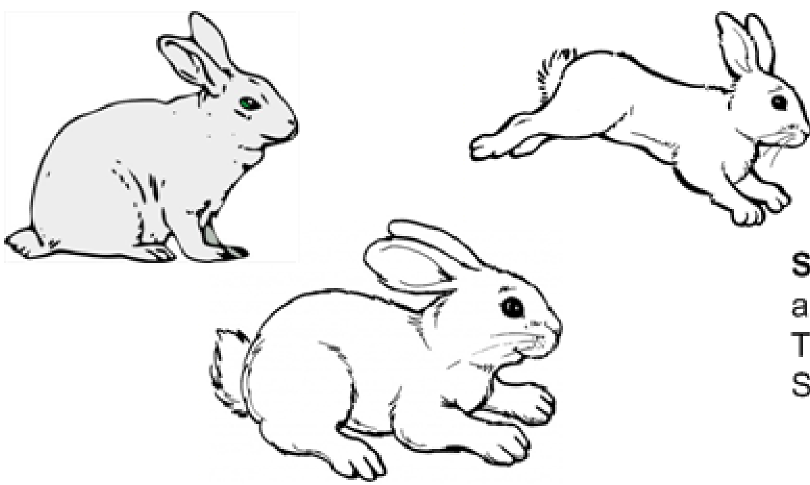
- My Generation (1940 to present)
  - End of Cold War, Terrorism, Organized Crime
  - First – transistor, integrated circuit, calculator, PC, Microprocessor, FPGA, GPS, Cellphone, Digital Camera, email, social media
  - A LONG WAYS FROM THE SLIDE RULE
  - Skeptics at every step

My 2012 Carnahan Paper

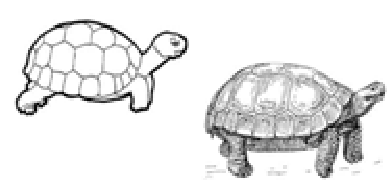
- "Outdoor Perimeter Security Sensors – a forty Year Perspective" – Col. Wayne Messner
- Slow-Tech in a Hi-Tech world
  - Most sensors spun off from Hi-Tech
  - The Role of the Pioneers
- Slow-Tech (NOT Low-Tech)
  - Long product life cycle
  - Small Niche Markets
  - Government regulated markets
  - High Margins
  - High performance – High PD & Low NAR/FAR

Two Very Different Animals!

Hi-Tech is like rabbits - They run very fast and eat a lot but have a short lifetime (road kill and all)
Success depends upon unbridled procreation



Slow-Tech is like turtles - They move slowly and don't eat much and have a long life time (if they stay off roads)
They live so long that no one remembers where they came from
Success depends upon persistence and determination.



The Origin of Perimeter Security Sensors

- Perimeter Security Sensors
  - Conceived in Hi-Tech Companies
  - Recognized as a different animal

Creation of Slow-Tech Pioneers start Perimeter Security Sensor Companies

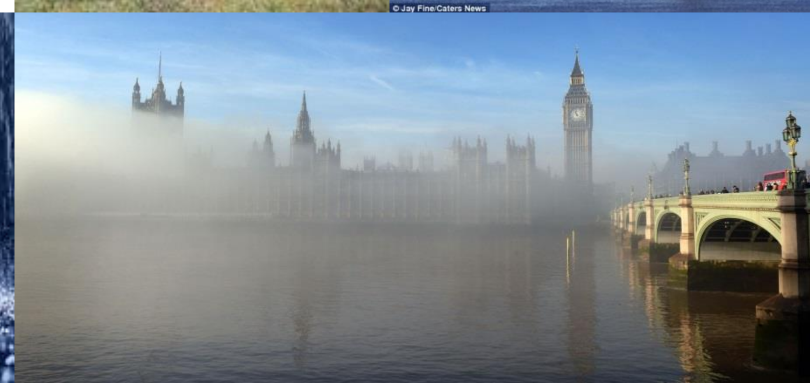
Outdoor Perimeter Security

- Traditional Markets (typically <2 km)
  - Military & Nuclear Facilities
  - Prisons
  - Power & Gas Utilities
  - Critical Infrastructure
  - VIP Protection

- More Recent Markets (longer perimeters)
  - Borders
  - Airports
  - Pipelines

Outdoor Environment

Sensors MUST perform under all environmental conditions



Classification & Performance

- Sensor Classification
  - Overt vs. Covert
  - Line-of-sight vs. Terrain Following
  - Volumetric vs. Line
  - Passive vs. Active
  - Block vs. Ranging

- Performance Measurement
  - Probability of Detection (PD)
  - Nuisance Alarm Rate (NAR)
  - False Alarm Rate (FAR)
  - Vulnerability to Defeat

The Role of Government Agencies

- RADC & Hanscom AFB
  - Base & Installation Systems Program Office (BISSPO) Col. Roger Kuzoma
  - Physical Security Equipment Action Group (PSAEG) Col. Boots Kuhla
- US Army Corp of Engineers (ERDC-WES)
- Sandia National Laboratories – Albuquerque
  - J.D Williams, Dan Pritchard
- Corrections Services Canada
  - Gerry Levitt, Mike Jonckheere, Pushkar Godbole
- British Home Office – Langhurst
  - Dr. Gordon Thomas, Dr. Mark Stroud

6 Selected Technologies

- Video Motion (Video Analytics)
- Electric Field Sensors
- Copper-Based Fence Disturbance Sensors
- Fiber Optics Cable Sensors
- Microwave Sensors
- Leaky Coaxial Cable Sensors

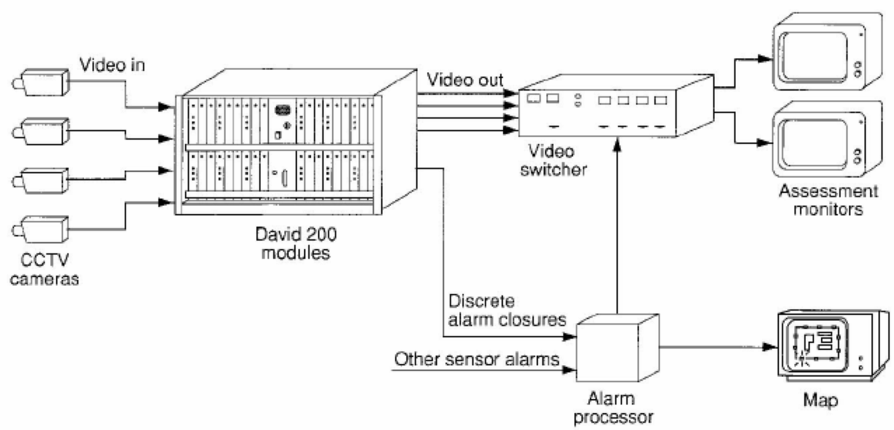
Over the past 44 years I have had the privilege to work on all six selected technologies

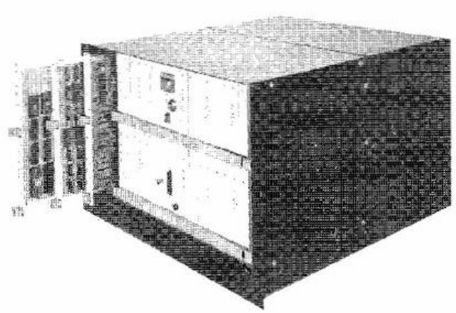
Video Motion/Analytics

The Processing of Video Images to Detect Intruders

- Control Data Corporation (CDC) early 1970's
  - US Military funded early digital video image processing
  - Dr. John Patchell, Mr. Dale Younge
  - Digital Automatic Video Intrusion Detection (DAVID)
  - Tracked changes across perimeter to create an Alarm

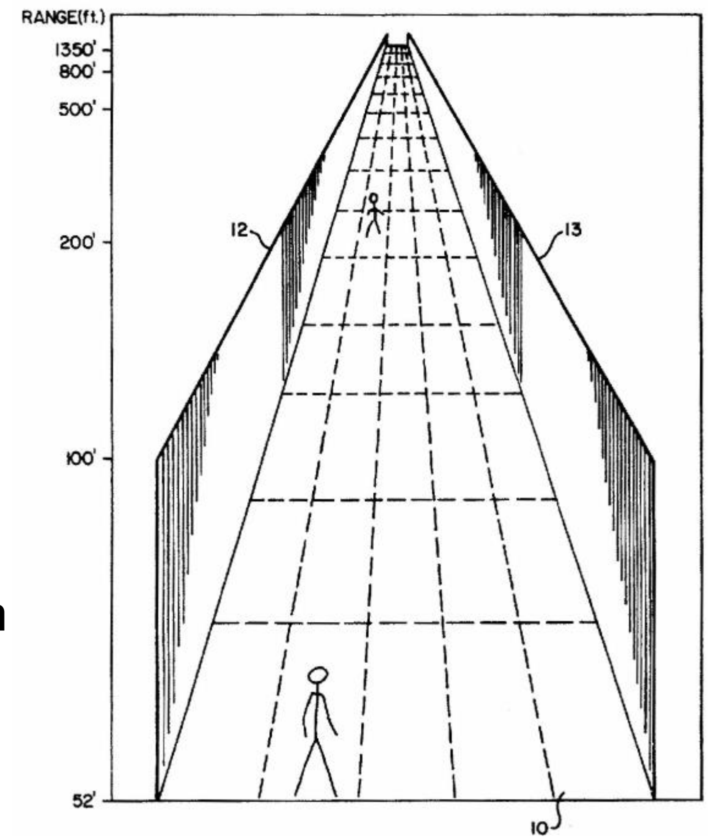
Video Motion – DAVID 1979





David 200 — cost-effective, modular design

Designed for CSC Application



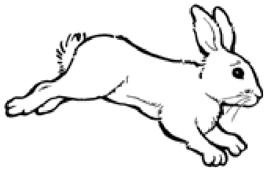
US Patent 4.249,207

Issues with Video Motion

- Challenges
  - Fog, snow, heavy rain
  - Car lights passing through image
  - Clouds on a sunny day
  - Camera Motion
  - Insects on camera lens
- Conclusion
  - Great Assessment Tool
  - It is **NOT** a sensor
- Competition
  - Geutebruck
  - ADPRO (Now Xtrallis)

Video Motion is Hi-Tech

- Reason – Video Motion is Hi-Tech
  - During 1980's and 1990's hardware for digitizing video imagery changing rapidly – would have to redesign equipment yearly to remain competitive
  - In more recent years hardware becomes a commodity and video processing software changing rapidly
- Many companies in a very large market



Video Motion – Prediction

- Continued Growth
- Extremely Competitive
- Software Driven
- Very Large Market
- Ever increasing role in crime prevention

- Important Assessment Tool
- Never should be used as a sensor

Electric Field Sensors

A vertical array of wires detect change in capacitance caused by intruder

- Siemens GMBH
  Early 1960's

The first Perifeld-M system was installed over 25 years ago and Is still in use today.

Electric Field Sensor Development

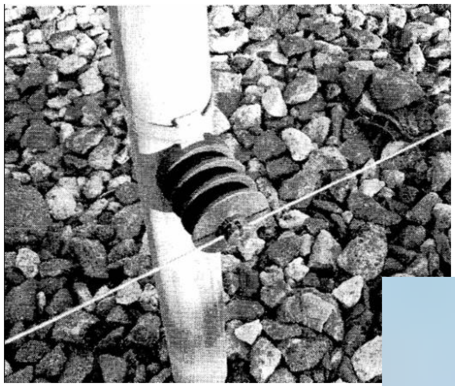
- Luc Den Dooven – several Carnahan papers describing the technology
- Now sold by G4S NSSC
- Stellar Corporation
  - E-Field

Ted Geiszler 1975

Nuclear Power Facilities

Regulatory Guide 5.44

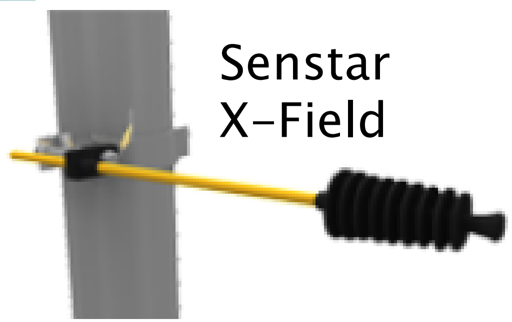
Electric Field – Insulators



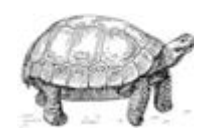
Stellar
E-Field
4000 Series

Measure Femtofarads
Change in Capacitance
Caused by Intruder
Using Low frequency 9 kHz

Stellar
E-Field
5000 Series



Senstar
X-Field



Electric Field & Regulations

- Perfect example of creating a market niche through influencing Government Regulations to include specifications that are product specific

- Ted Geiszler was a master at this art

- While Stellar was not a spin-off Ted also was a master at "improving" technologies developed in Hi-Tech companies

Electric Field Sensors Prediction

- Very Slow Growth
- Very limited Market
- Continued dependence on Government Regulations

- Potential for improved performance with more DSP but hard to justify the development

Fence Disturbance Sensors

- *Cables attached to fences that detect the vibrations due to an intruder climbing on, or cutting through, the fence*

- There are three classes of fence disturbance sensors:
  - Copper based cables,
  - Fiber optic cables and
  - Distributed geophone based

Copper Based Cable FDS

- There are 5 basic types of Copper Based FDS
  - Electret Cable – FPS
  - Triboelectric Cable – E-Flex
  - Piezoelectric Cable – Copperhead
  - Magnetic Core Cable – Guardwire
  - Time Domain Reflectometer (TDR) Cable – MicroPoint
- These cables are tie-wrapped to the fence fabric
- Type of fence is important
  - Chain Link
  - Weld Mesh
  - Palisade

Electret and Triboelectric FDS

- Electret Cable – early 1980's
  - Charged Teflon Core Coaxial Cable
  - GTE Sylvania – G. Kirby Miller
  - Perimeter Products – Mike Trimble, Martha Lee

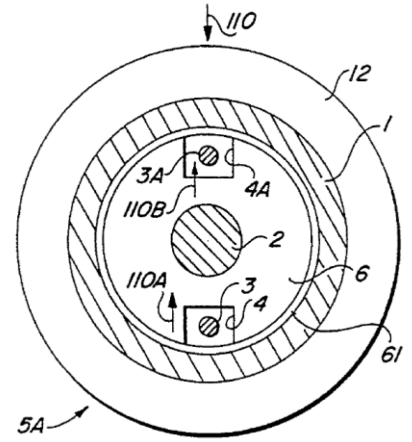
- Triboelectric Cable
  - Charge generated by frictional contact
  - Stellar – Ted Geiszler
  - Another example of Ted Geiszler's ingenuity

Piezoelectric and Magnetic FDS

- Piezoelectric Cable
  - Charge generated by impact on material
  - Many manufacturers – commodity cable
- Magnetic Core Cable
  - Wires moving in a magnetic field
- Geoquip 1982
  - Peter Elliot Founder
- Audio Output
  - Almost able to hear voices

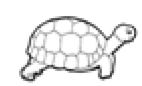
TDR Based FDS

- Time Domain Reflectometry
  - TX coded pulse on coaxial line
  - RX on balanced 2-wire line
- Targets located along line
  - Propagation delay to and from target
- Reduced NAR/FAR
  - Multiple hits at <u>same location</u>



Intrepid MicroPoint
A New Paradigm

- Required a PC to setup
- Calibrated Thresholds – Uniform Detection
- Software Defined Zoning
- Remote and Local Diagnostics using a PC
- Pinpoint Target Location – a Dot on a Map
- Power and Data over cables (like Sentrax)



Copper Based FDS – Prediction

- Highest growth in Slow-Tech
- Reduced cost with higher performance
- Longer length sensors
- Improved location
- Rudimentary target classification

- Fiber Optic Sensors will become more competitive

Fiber Optic Sensor Cables

Cables containing fiber optic lines that are used as FDS and Buried Line sensors

- Corning Glass – early 1970's
  - Light sent down a fiber and "speckle pattern" of returned light is monitored for changes
  - A zone-based or block type sensor
- Fiber SenSys – Sandra Reynolds & Duane Thompson
- NOT susceptible to EMI

Fiber Optic OTDR Sensors

- Standard Telephone and Cables 1976
  - A ranging fiber sensor – Melvin Ramsey
- Texas A&M early 1990's
  - Dr. Henry Taylor
  - OTDR – Optical Time Domain Reflectometry
  - 50 km buried fiber
  - $100k + light source
- US Navy Blue Rose
- AT&T Prairie Dog

Fiber Optic Interferometric Sensors

- McDonnell Douglas – Eric Udd 1986
- Plessey – John Dakin 1989
- Mason & Hanger – Brian Crawford 1992

Large companies start the ball rolling

- Future Fiber Technologies– Tapanes 1999
- Optellios – Jay Patel – 2004

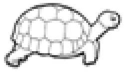
Small companies capitalize on the technology
Much lower cost than OTDR at the time

Fiber Optic Sensor Cables COTDR

- Like radar in a fiber – Rayleigh Backscatter
- These are possible today due to lower cost components

To learn more about the ins and outs of interferometric vs. COTDR sensor listen to technical paper

- **A Novel Long-Range Perimeter Security Sensor Based on** Hybrid Michelson and Mach-Zehnder Interferometers
  - Harman and Singh



Fiber Optic Sensor Predictions

- Continued growth in FDS market
- COTDR replace Interferometer sensor
- Reduced Cost
- Improved DSP

- Limited success in buried line application
- *Users will learn the hard way of the limitations of seismic sensors*

Microwave Sensors

- Bistatic
  - Transmit and Receive Microwave Link
  - Detect change in received signal due to person moving though the RF beam
- Monostatic
  - Transmitter and receiver co-located
  - Detect signal reflected from intruder

Operate in X and k Bands

Microwave Sensors Bistatic

- Shorrock in UK – Stanley Shorrock early 1960's
- OmniSpectra 1962
  - Dr. John Bryant, Jim Cheal & Vince McHenry
  - 300B 1975
- Racon – Dan Blattman 1972
  - Spinoff from Boeing
- Southwest Microwave 1980
  - 300B still selling – record Slow-Tech product
- ProTech – Dr. Palmer 1980
  - Dual microwave IR

Microwave Sensors Bistatic

- Dish antennas
- Classic microwave guide components
  - Made at SMI
- X Band then k Band
  - Width of detection zone
  - Regulatory approval
- Stacked Microwave
- Digital Microwave
  - Digital Signal Processing

Microwave Sensors Monostatic

- 385 Monostatic 1987
  - Dual Frequency
  - Range Cut-off
  - Sensitivity Leveling

- Ranging Microwave
  - K&G Spectrum
  - Andre Gagnon
  - Spread Spectrum Technology
  - Shaped detection beam

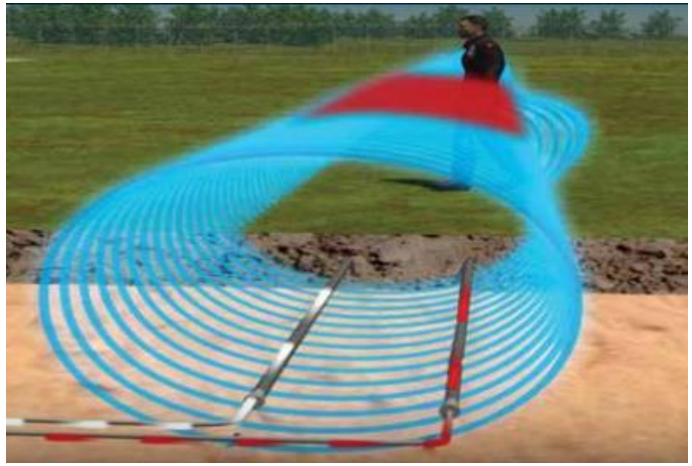
Microwave Sensors – Prediction

- Continued Slow Growth
- More competitors
- More Spread Spectrum sensors
- Dual Monostatic and Bistatic sensors
- Phased Array Narrow Beam Antennas
- Integration with other sensor technologies

- Limitations Remain; Line of Sight, issues with snow

Leaky Coaxial Cable Sensors

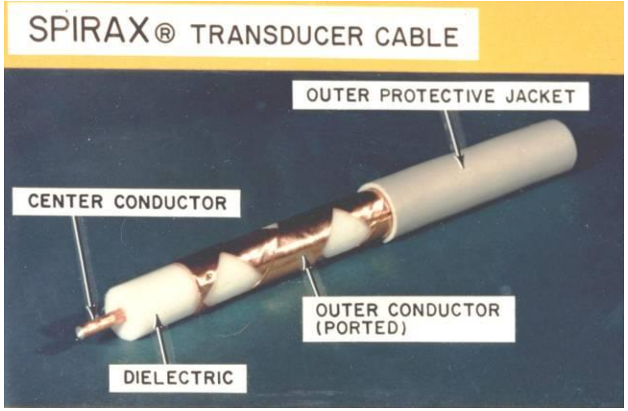
- Terrain following cable guided radar
- Features:
  - Terrain following
  - Covert
  - Vegetation tolerant
- Types
  - CW – block
  - Coded Pulse – locates
  - FMCW – locates



Much of the signal processing comes from classical radar

Early Days

- All sensors start with a transducer
- In this case a leaky coaxial cable
- Queen’s University – early 1970’s
  - Single cable
  - Dr. John Beal & Dr. Neilson Mackay
- Two Cable Innovation



Leaky Cable Sensor Evolution

- Control Data Corporation
  - Two cable – bistatic
  - GUIDAR (PCCS) – Ranging –1974
- Stellar – 1981
  - CW Co-directionally Coupled
- Senstar –1981
  - Sentrax– Distributed CW 1981
  - MC6801– 2k bytes of EPROM & 128 bytes of RAM – Dale Younge
  - Power and Data on Cables
  - Panther – CW 1985
  - Perimitrax – Distributed CW –1996

Leaky Coaxial Cable Sensors Ranging

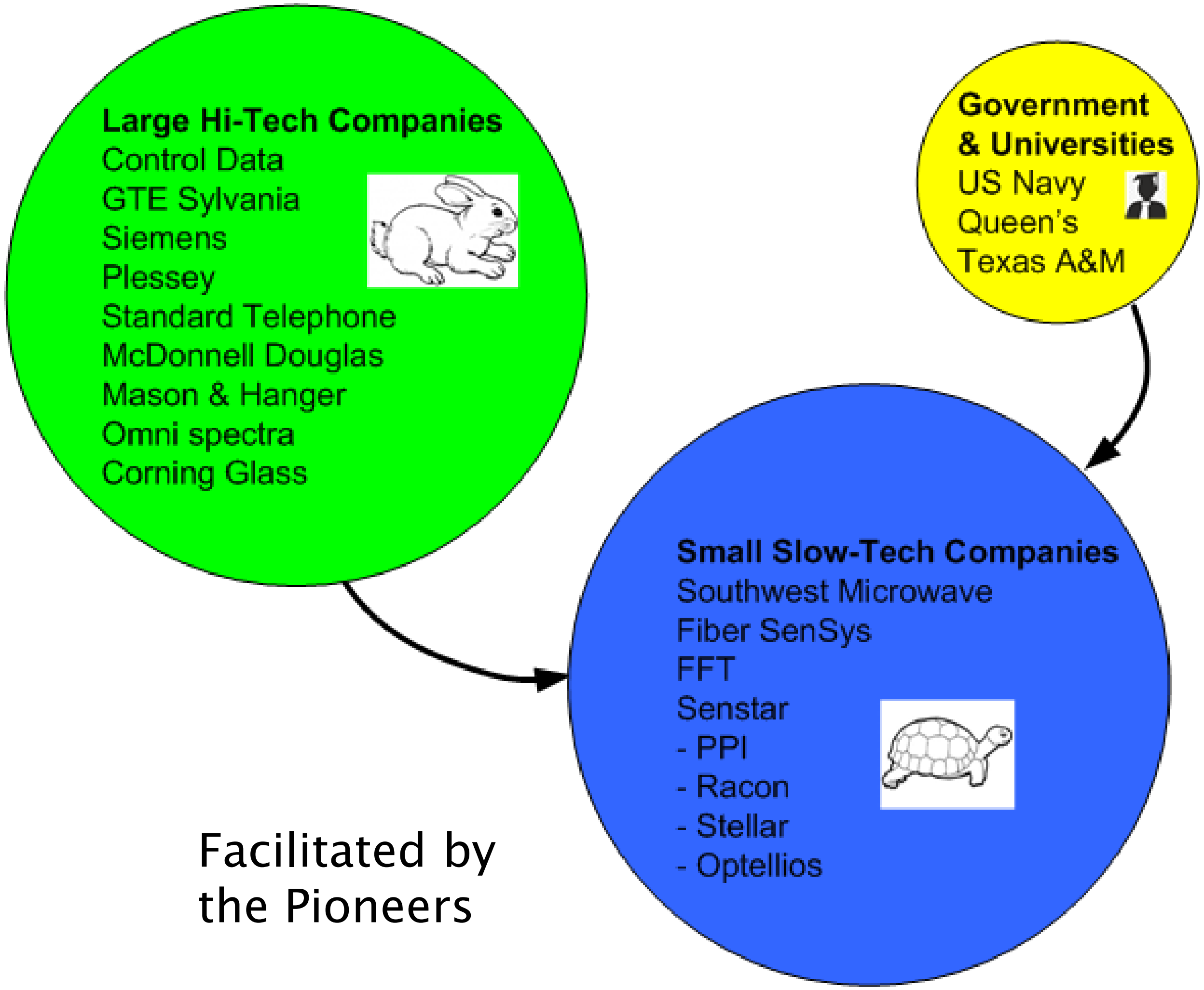
- Southwest Microwave
  Intrepid MicroTrack 2001
  - FMCW
  - Calibrated Thresholds
  - Software Zoning
- Senstar
  OmniTrax 2004
  - Coded Pulse
  - Calibrated Thresholds
  - Software Zoning
  - Power and Data on Cables

Leaky Coaxial Cable Sensors Prediction

- It provides the only real covert terrain following sensor
- Slow growth in Traditional Market
- But – Borders and airports provide exciting opportunity

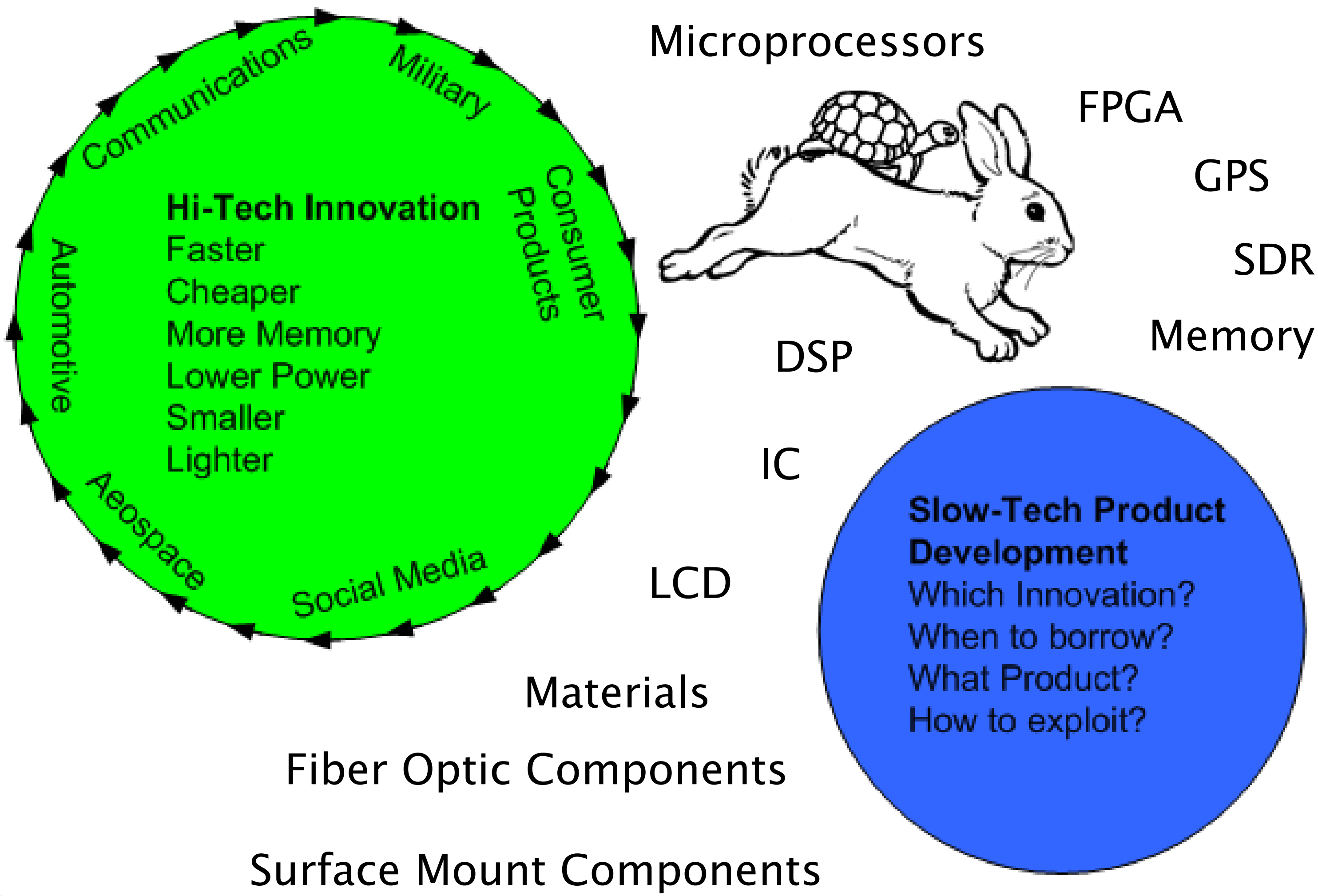
- The technology is due for next innovation
  - Software Defined Radio – the next step
  - Enhanced performance – utilize more data
  - Target classification

Basic Technology Migration



Facilitated by the Pioneers

Slow-Tech Product Development



Keys to Successful Innovations

- Determine the market need and application
- Understanding the limitations and the strengths of the transducer
- Awareness of high-tech innovations
  - Seeing the relevance
  - Timing the introduction
- Getting the innovation specified

Quiz Answer

- "If I have seen further than others, it is by standing on the shoulders of giants."

Sir Isaac Newton

- Discovering Truth by building on previous discoveries

Conclusion

- The Carnahan Conference plays an important role in this process
  - Sharing of Experience
- Given 50 minutes for the 50th anniversary lets hope we are not around for the 100th!
- QUESTIONS