2004 RFID Summit for Industry
RFID Technology Primer

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April 7, 2004

Agenda

- **The History**

- **The Basics - What RFID is and how it works**

- **Types of RFID**

- **Smart Labels**

- **How RFID compares to barcode**

- **Applications**

- **DoD Technical Working Group (TWG) and Vendor Action Group (VAG)**

RFID: The History

Pre-50's	1950's	1960's	1970's	1980's	1990's	2000's

- **1926: Baird's radio object detection patent**
- **1935: Watson-Watt's radar patent**
- **WW II: Radar refined**
- **1948: Harry Stockman - Communications By Means of Reflected Power**

- **1952: Vernon "Application of the Microwave Homodyne"**
- **Harris patent: "Radio transmission systems with modulatable passive responder"**

- **Harrington "Active & Loaded Scatterers"**
- **1966: Sensor-matic & Check-point EAS**
- **1969: Mario Cardullo RFID concept**

- **1973: Cardullo patent**
- **1975 LASL releases research to public sector**
- **LASL spins-off IDX & Amtech**
- **Fairchild, RCA & Raytheon initiate pgms**
- **1977: Electronic license plate for motor vehicles**
- **1979: RFID animal implants**
- **1st Toll Collection System - Norway**

- **1984: IDX/Allen Bradley install GM System**
- **Multiple early adopter installations**

- **Over 350 direct - reference patents**
- **1991: AAR standard**
- **1994: All US railcars outfitted**
- **1997: US Army rolls out TC-AIMS II**
- **Vast number of companies enter RFID marketplace**
- **Texas, Georgia / Oklahoma Tolls**

- **MIT Auto-ID Center formation**
- **EPC™ introduced**
- **National & international standards emerge**
- **Smart shelves**
- **2003: RFID prominent in Iraqi Freedom**
- **EPCglobal formed 2003**
- **2004: TREAD**
- **2005: Walmart initial deadline**
- **Wide-scale US Roll-out**

RFID TIMELINE

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What is RFID?

- **RFID is Radio Frequency Identification**
  - Used for automatic identification and data collection

- **Similar to bar code**
  - RFID tag stores data ~ bar code label
  - RFID reader ~ bar code reader

- **Radio waves vs. light waves**

Technical Aspects of RFID

- **Tag Power Source**
- **Tag Components**
- **Read- Read/Write**
- **Anti- Collision**
- **Who talks first?**
- **Protocol**

Tag Types

RF antenna

RF & Digital Circuitry
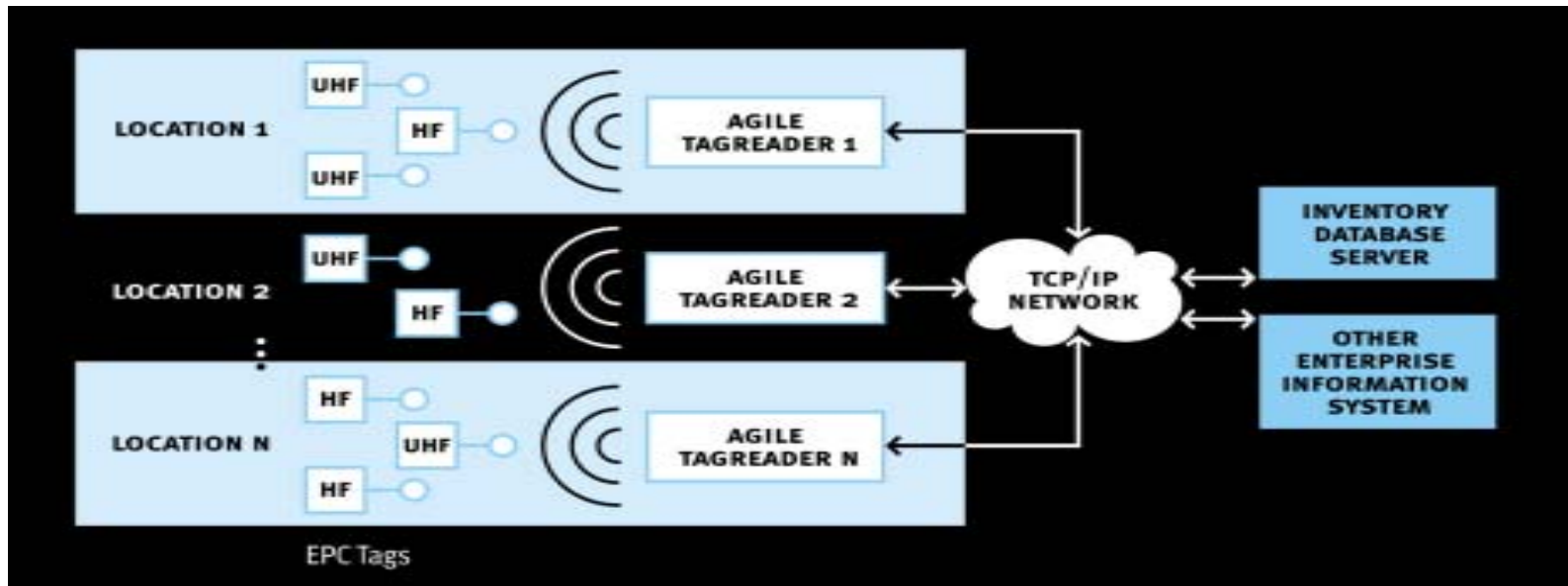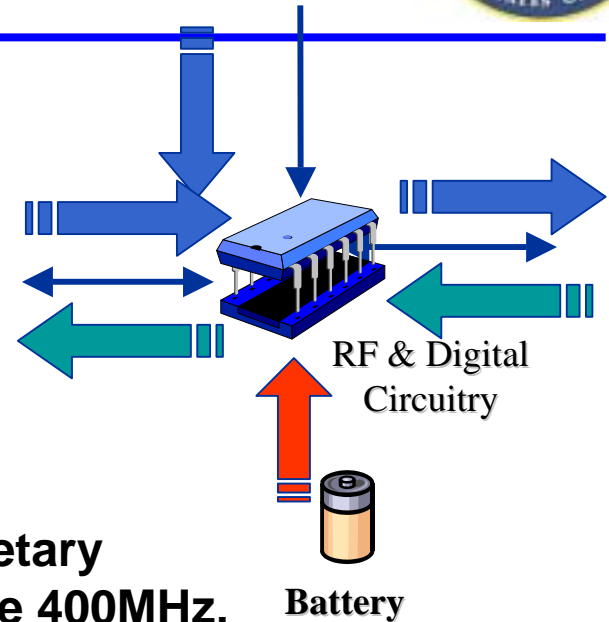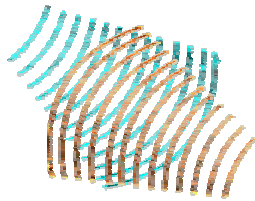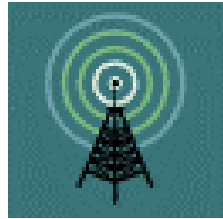
Battery

- **Active:**
  - **Standard: None, Mainly Manufacturers Proprietary Systems/Protocols (transmits RF energy in the 400MHz, 900MHz, and 2.45GHz ranges)**
  - **Range: Generally 300 Feet or less (battery replacement)**
  - **Used Predominantly in Transportation Systems (rail, toll systems, trucking, container).**
  - **Characteristics: Tag with Internal Power Cell Mounted to Item or container/pallet/box, Interrogator Queries Tags, Uploads/Downloads Data. Do not transmit all of the time. Data Capacity Varies.**

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Tag Types

RF
antenna

Memory
(EEPROM)

Digital Logic
& Control
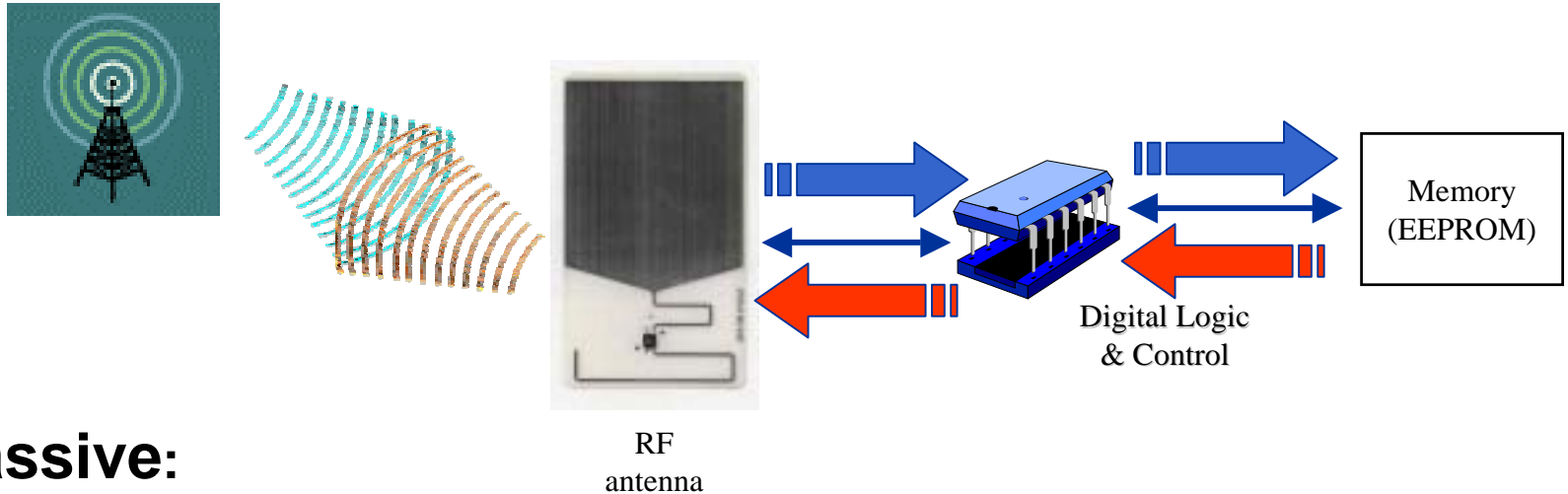
- **Passive:**
  - **Standard: None, Mainly Manufacturers Proprietary Systems/Protocols (uses back scatter technology)**
  - **Range: Typically Measured in "Inches", Industry Working Toward "Meters" (dependant system layout, interference, etc.)**
  - **Used Predominantly in Retail Systems and Transportation Systems.**
  - **Characteristics: Small Tag Loaded with License Plate Data, Typically Mounted to End Item, Reader Captures Data as Item Moves Through Choke Point (door, pathway, frame, etc.). Could have a battery. Data Capacities are Limited. Paper tag!**

Tag Types

RF antenna

Digital Logic & Control

Memory (EEPROM)
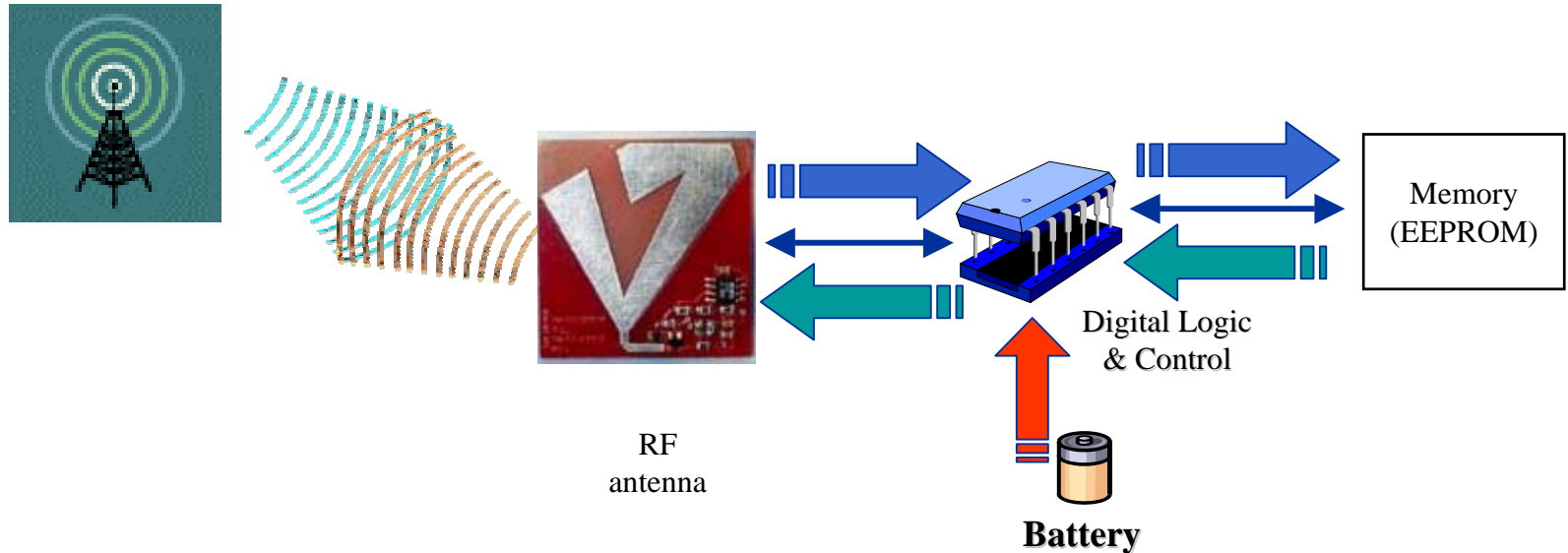
Battery

- **Semi-Active or Battery Assisted Passive**
  - **On-board battery power source**
    - **Uses Passive Technology (no transmitter)**
    - **Greater range but higher cost (less than active)**
    - **Requires less power from reader**
    - **Finite life**
    - **Can use thin batteries (little change to form factor)**

Tag Types - Read vs Read/Write

- **Read Only:**
  - **Information can only be read from an RFID device – programmed at manufacture**

- **User Programmable**
  - **WORM - Write Once Read Many - Ability to initialize an RFID device outside of the RFID manufacturer's facility *after manufacture***

- **Read/Write:**
  - **Information can be read from or written to an RFID transponder during the time it is presented to a reader/writer**
  - **Typically asymmetric read and write operating range**

Technical Considerations

- ## Anticollision
  - **Ability to communicate with several transponders *simultaneously***
  - **Important in longer range readers**
  - **Must be implemented in the silicon of the RFID device**
- ## Who Talks First
  - **Tag Talks First (TTF)**
    - **After the tag is energized, it sends out a signal that says "I am here"**
  - **Reader Talks First (RTF)**
    - **As reader sends out energization signal it says "who is there"**
  - **Problems**
    - **With TTF you can get tag pollution but slower total read time**
    - **Compatibility issues?**

Protocol

- **The method used to talk to a tag**

  - **Modulation method**

  - **Error correction**

  - **Anti-collision technique**

  - **Message format**

  - **Commands**

Tag Types- Operating Frequency

- **Low Frequency (LF) - 125 kHz**
  - Short range; good propagation
  - Higher cost; slower data transfer

- **High Frequency (HF) - 13.56 MHz**
  - Reasonable range; reasonable propagation
  - Low cost; faster data transfer

- **Ultra High Frequency (UHF) – 860-960 MHz, 2.45GHz, 5.8GHz**
  - Low cost; fast data transfer
  - Good range but regulatory restrictions may limit (passive tags)
  - Some propagation issues:
    - Line of sight/shadow effect (one tag may obscure another)
    - Attenuation by water (paper based packaging)

Frequency Selection Issues

- **Desired Pattern**

- **Required Range**

- **Tag-to-Tag Spacing**

- **Data Rate**

- **Size Requirements**

- **Power Requirements**

- **Interference Issues**

- **Noise Environment**

- **Cost / Performance Tradeoffs**

Worldwide Regulatory Environment

	North America	Europe (current)	Europe (future)	Japan (new)	Korea (new)	Australia	Argentina Brazil Peru	New Zealand
Band size	902-928	869.5	866-868	950-956	910-914	918-926	902-928	864-929 spotty
Power	4W EIRP	.5W ERP	2W ERP	4W EIRP	4W EIRP	4W EIRP	4W EIRP	.5 – 4W EIRP
Channels #	50	1	10	12	16	16	50	varied
Class 0 Rate	1000	200	200	1000	400	1000	1000	varied
OOB spurious	-50dBc	-63dBc+	-63dBc+	-54dBc	-50dBc	-50dBc	?	?

No Global Solution

Smart Labels

Substrate

Die attach

Tag IC

Antenna
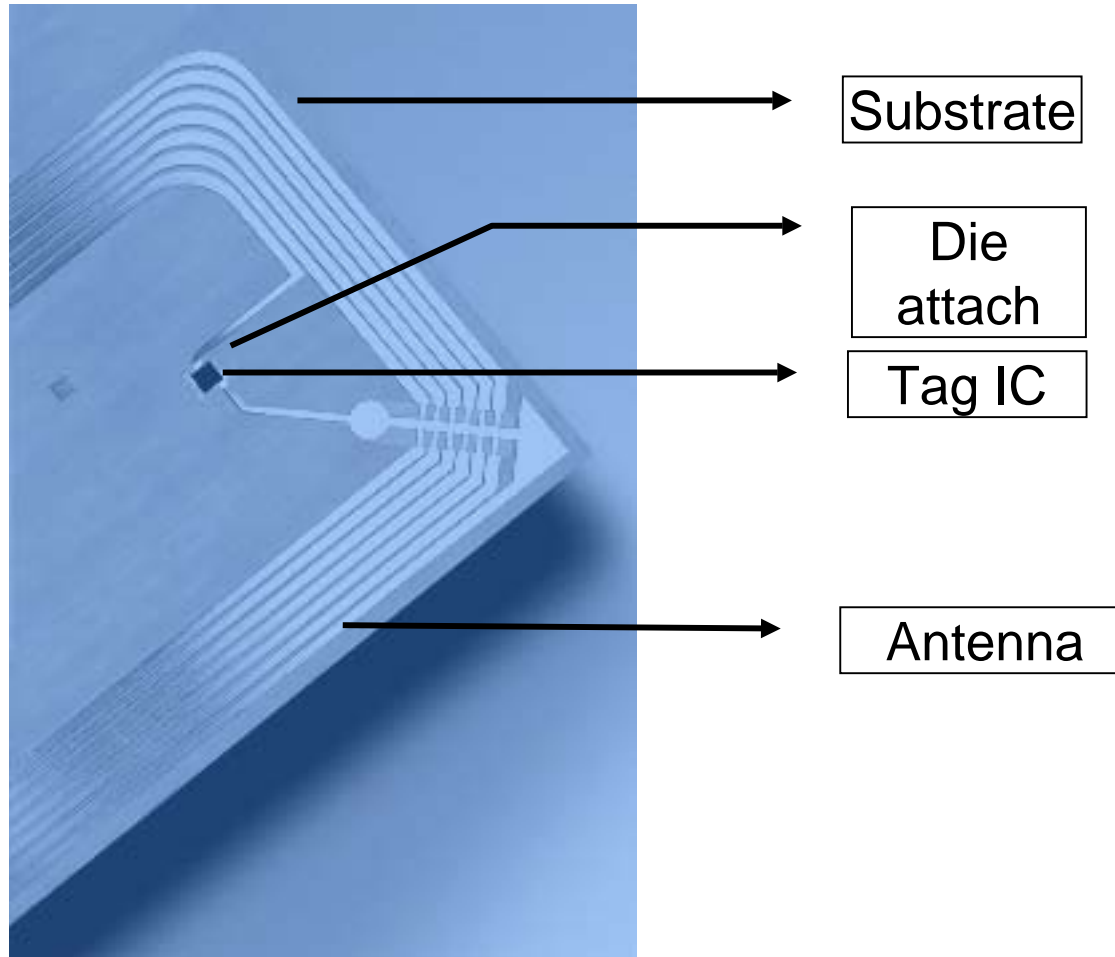
How they compare to 2D barcodes

	Smart Label	2D Barcode
Line of sight	Not required	Required
Capacity	Low to high	Low to medium
Security	High	Low to Medium
Change Information?	Yes – Read/Write	NO – new label
Cost (today)	$0.40 - $1.00 (in millions)	$0.05 or less

A Hybrid World

- **Traditional bar codes**
  - **Will remain the dominant auto ID technology in most mainstream applications for the foreseeable future**
    - **Lowest cost, broadest applicability, huge infrastructure investment**

- **2D bar codes**
  - **Will be increasingly adopted for value added applications**
    - **Portable data files, supplementary retail coding etc.**

- **RFID**
  - **Will be increasingly adopted where non-line of sight, read/write, multiple detection offers real advantages**

Warehouse Management Solutions

- **Uniquely Identify, Collect, Sort and Track more efficiently**
- **Hard data on pallets, containers, fork lift trucks, equipment & man-hours**
- **Data collection in rugged environments where barcodes can't**

Enhanced Productivity, Reduced Costs

Vehicle Identification

Electronic Seals

Vehicle Identification

Automotive Manufacturing

Tire tags

Parcel Logistics

Manufacturing

Manufacturing

- **Attach to work-item**
- **Program progressive build and QC status**
- **Automatic product tracking through production, shipping and after-sales service**

Retail Supply Chain

Retail supply chain

- **Program "contents" data at manufacturing source**

- **Program "destination" data at distribution center**

- **Identify whole carton contents, while closed**

- **Trace returns**

Electronic Article Surveillance (EAS)

Electronic Article Surveillance (EAS)

- **Already exists**
- **RFID technology detects if an item is removed from a store without tag being deactivated**
  - **Amorphous magnetic strips**
  - **Destructible tuned circuits**
- **Existing technology cannot uniquely identify goods**
- **New RFID technology provides significant features:**
  - **Able to write SKU number into transponder**
  - **Automatic inventory with a hand held reader**
    - **Anti-collision mandatory for this feature**
  - **Cash registers can automatically ring up merchandise**

RFID Technical Working Group (TWG)

- **Background**
  - **RFID TWG Established Dec 2003**
  - **Mission**
    - Technical specifications
    - Standards
    - Identify appropriate RFID technologies for DOD
  - **TWG team composition**
    - Military services, Defense Agencies, National Labs
    - RFID vendors
    - Academia
    - Consultants
  - **RFID Vendor Advisory Group**

RFID Technical Working Group (TWG)

- **Technical Requirements**
  - **Identified and agreed upon (parameters)**
    - **Conformance**
    - **References**
    - **Concepts**
    - **Data content**
    - **Human readable**
    - **Tag operation**
    - **Tag presentation and location**
    - **Interoperability**

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RFID Technical Working Group (TWG)

- **Supply Chain Functional Areas**
  - **Acquisition**
  - **Warehousing**
  - **Transportation**
  - **Maintenance**
  - **Disposal**
  - **Yard management**
  - **Freight security**

How Far – How Fast – How Many – How Much

QUESTIONS?