Basics of RFID Technology

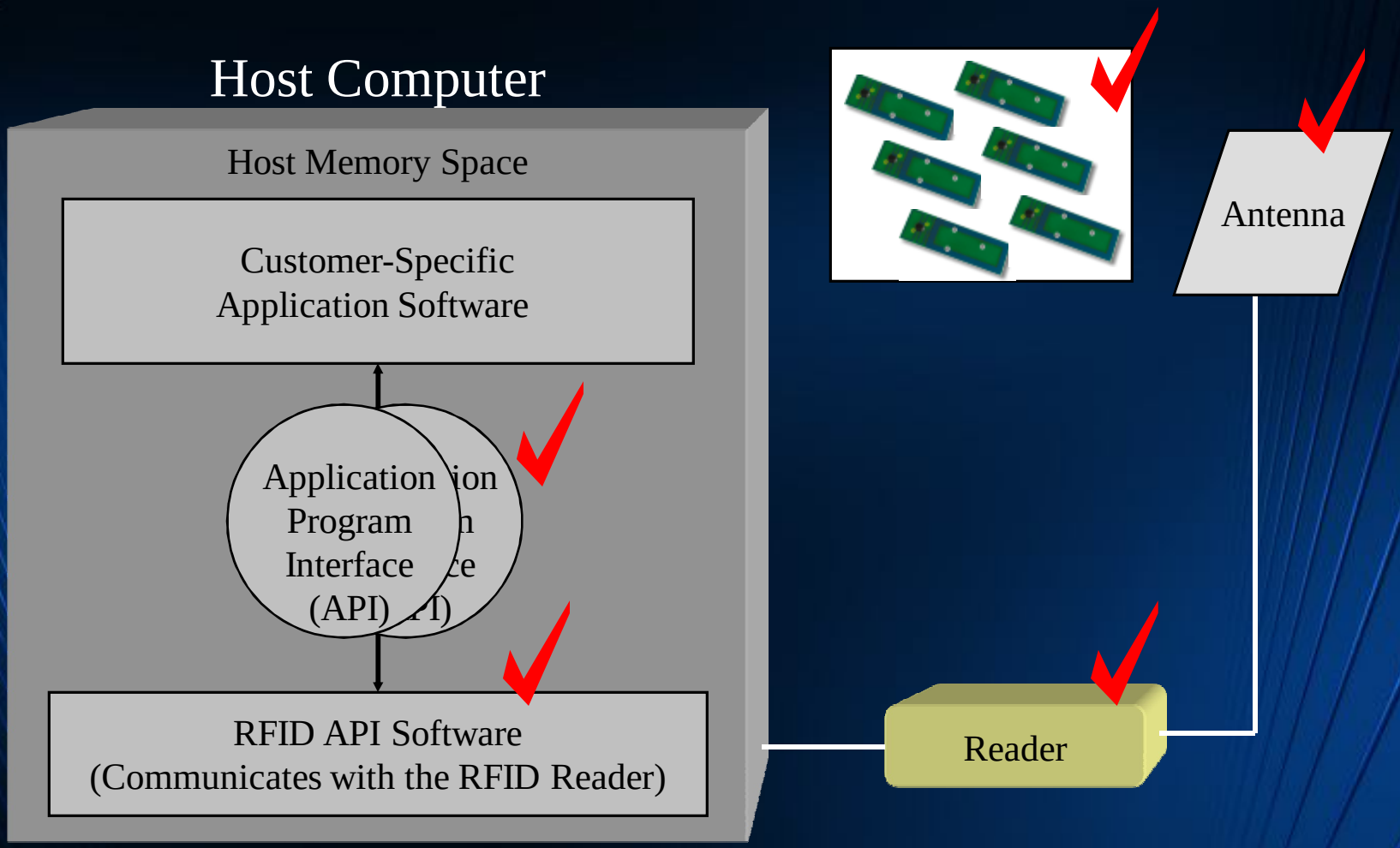
What is RFID?

- RFID is an ADC technology that uses radio-frequency waves to transfer data between a reader and a movable item to identify, categorize, track...
- RFID is fast, reliable, and does not require physical sight or contact between reader/scanner and the tagged item

What Constitutes an RFID System?

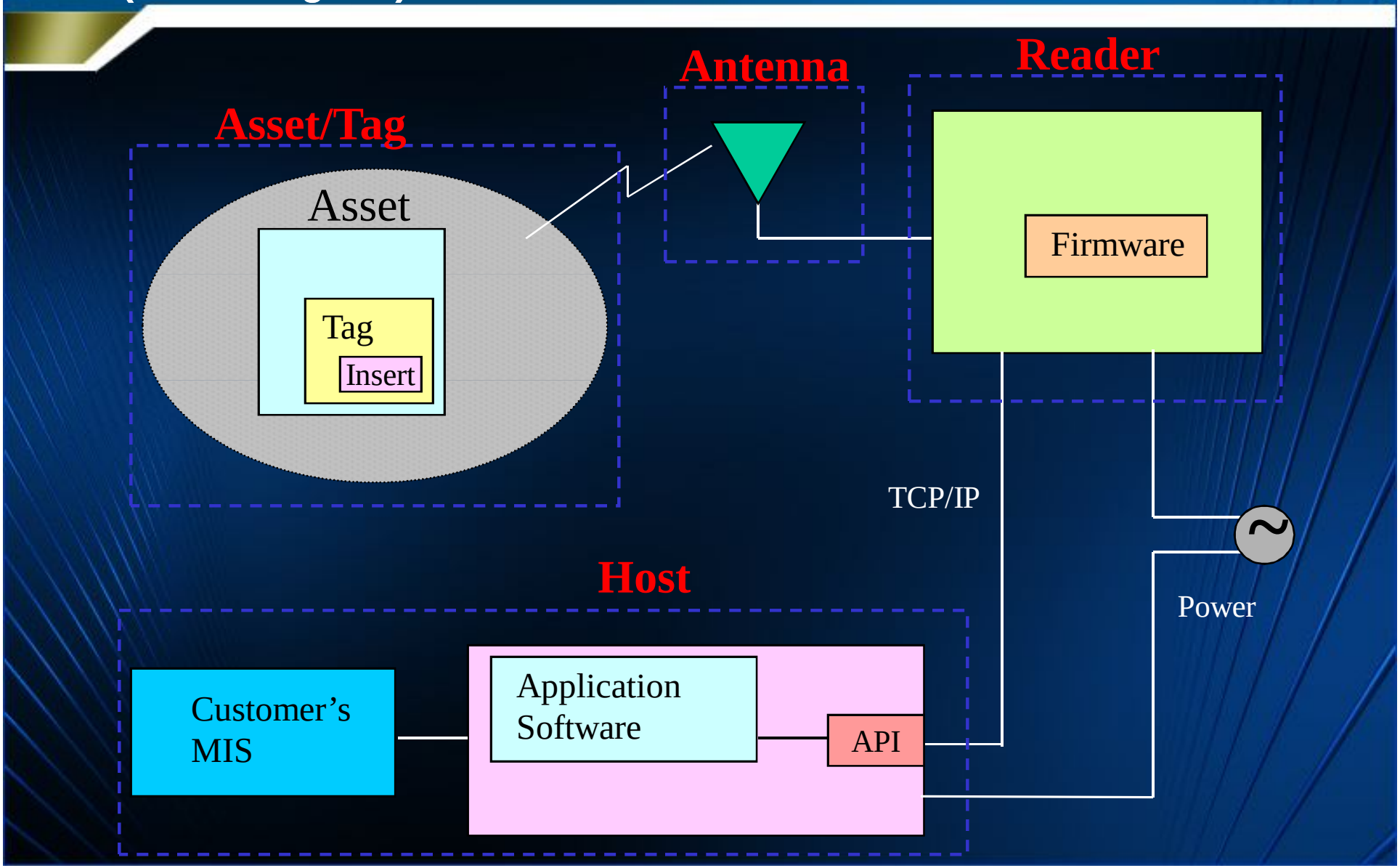
- One or more RF tags
- Two or more antennas
- One or more interrogators
- One or more host computers
- Appropriate software

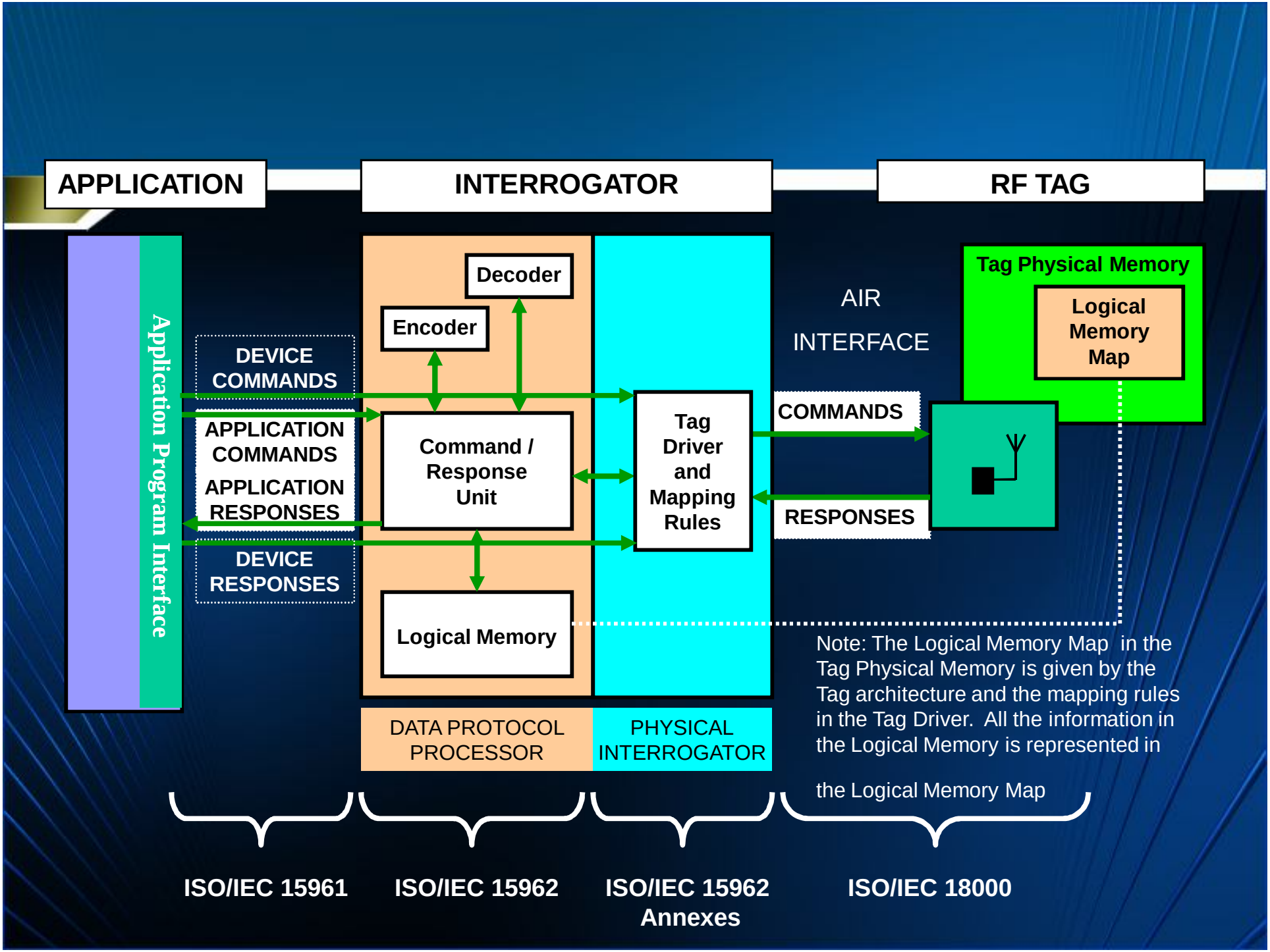
Components of an RFID System



RFID System Components

(block diagram)



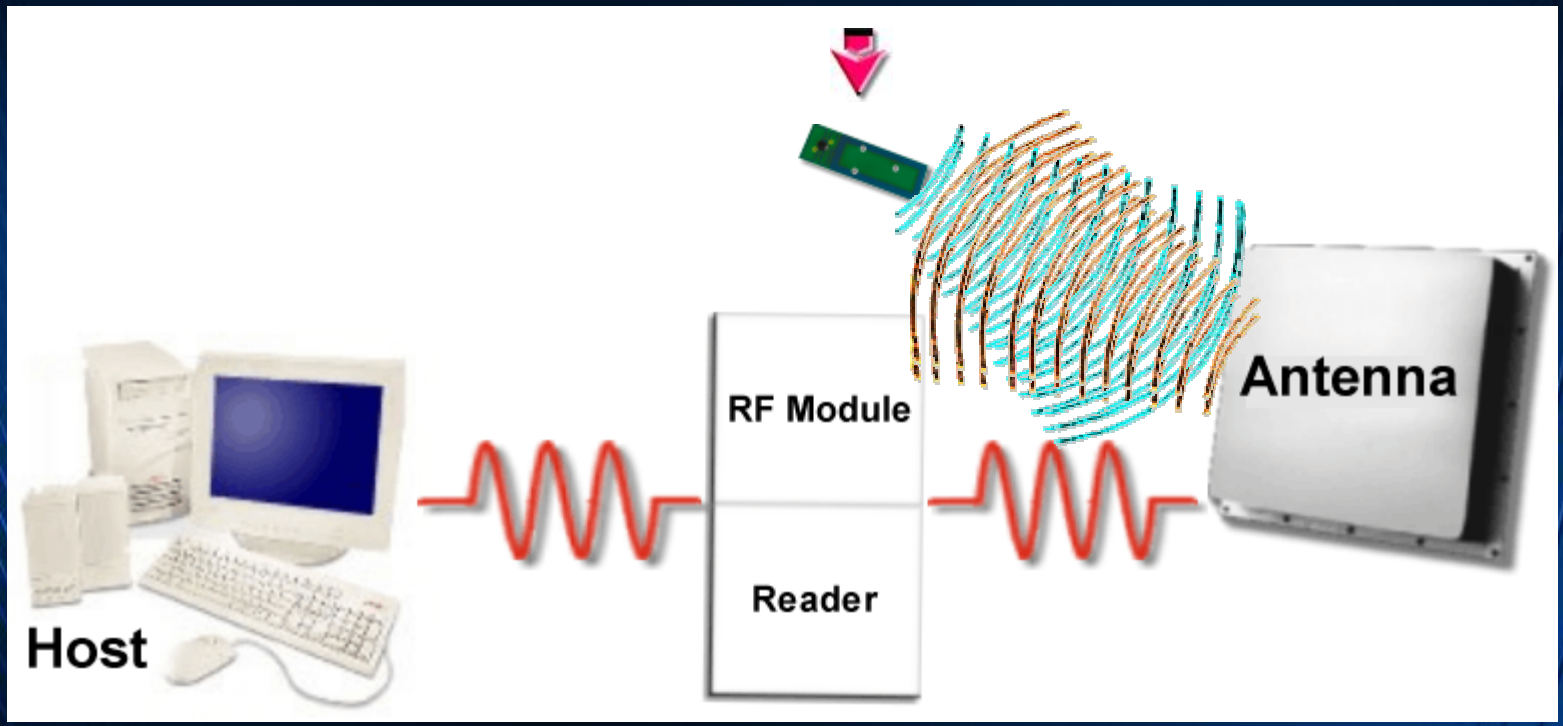

APPLICATION
INTERROGATOR
RF TAG
Application Program Interface
DEVICE COMMANDS
APPLICATION COMMANDS
APPLICATION RESPONSES
DEVICE RESPONSES
Decoder
Encoder
Command / Response Unit
Logical Memory
Tag Driver and Mapping Rules
AIR INTERFACE
COMMANDS
RESPONSES
Tag Physical Memory
Logical Memory Map
DATA PROTOCOL PROCESSOR
PHYSICAL INTERROGATOR
Note: The Logical Memory Map in the Tag Physical Memory is given by the Tag architecture and the mapping rules in the Tag Driver. All the information in the Logical Memory is represented in the Logical Memory Map
ISO/IEC 15961
ISO/IEC 15962
ISO/IEC 15962 Annexes
ISO/IEC 18000

RFID Operation

Sequence of Communication

- Host Manages Reader(s) and Issues Commands
- Reader and tag communicate via RF signal
- Carrier signal generated by the reader (upon request from the host application)
- Carrier signal sent out through the antennas
- Carrier signal hits tag(s)
- Tag receives and modifies carrier signal
  - "sends back" modulated signal (Passive Backscatter - FCC and ITU refer to as "field disturbance device")
- Antennas receive the modulated signal and send them to the Reader
- Reader decodes the data
  - Results returned to the host application

RFID Operations



What is RFID? -- The Tags

- Tags can be read-only or read-write
- Tag memory can be factory or field programmed, partitionable, and optionally permanently locked
- Bytes left unlocked can be rewritten over more than 100,000 times

RFID System Basics

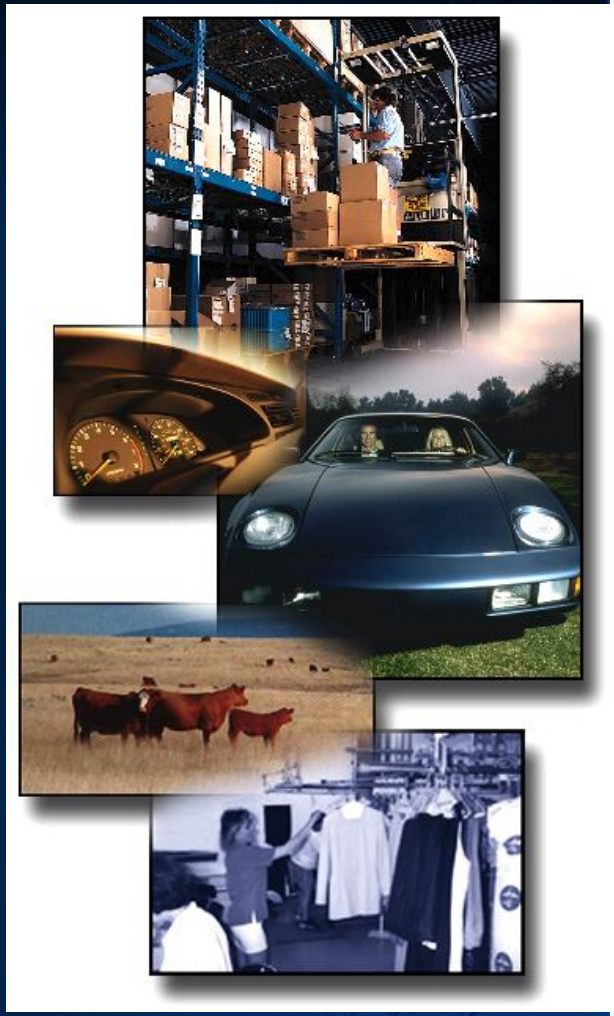
- Tag ID Only
- Programmable Database Pointer
- Mission Critical Information
- Portable Database

- Read Only (Factory Programmed)
- WORM - Write Once, Read Many times
- Reprogrammable (Field Programmable)
- Read/Write (In-Use Programmable)

What is RFID? -- The Tags

Tags can be attached to almost anything:

- pallets or cases of product
- vehicles
- company assets or personnel
- items such as apparel, luggage, laundry
- people, livestock, or pets
- high value electronics such as computers, TVs, camcorders



Are All Tags The Same?

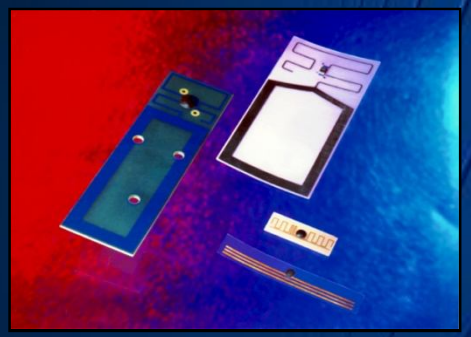
Basic Types:

- ✓ **Active**
  - Tag transmits radio signal
  - Battery powered memory, radio & circuitry
  - High Read Range (300 feet)
- ✓ **Passive**
  - Tag reflects radio signal from reader
  - Reader powered
  - Shorter Read Range (4 inches - 15 feet)

Are All Tags The Same?

Variations:

- Memory
  - Size (16 bits - 512 kBytes +)
  - Read-Only, Read/Write or WORM
  - Type: EEProm, Antifuse, FeRam
- Arbitration (Anti-collision)
  - Ability to read/write one or many tags at a time
- Frequency
  - 125KHz - 5.8 GHz
- Physical Dimensions
  - Thumbnail to Brick sizes
- Price ($0.50 to $250)

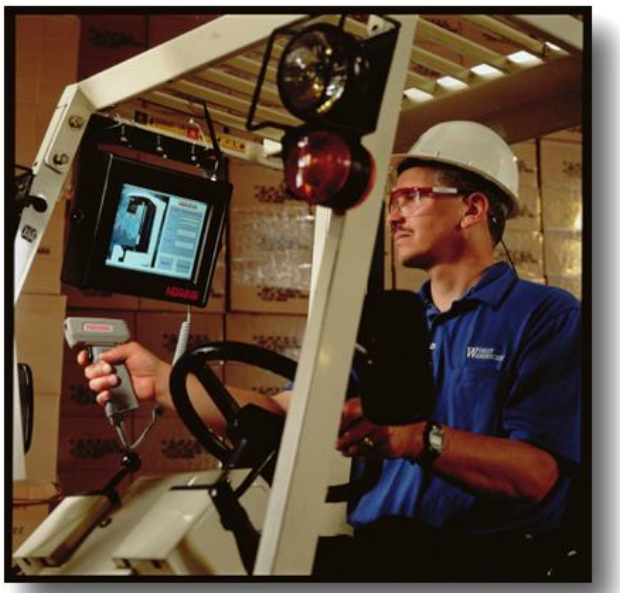


RFID System Basics

- How far?
- How fast?
- How many?
- How much?
- Attached to and surround by what?

What is RFID? -- The Readers

- Readers (interrogators) can be at a fixed point such as
  - Entrance/exit
  - Point of sale
  - Warehouse

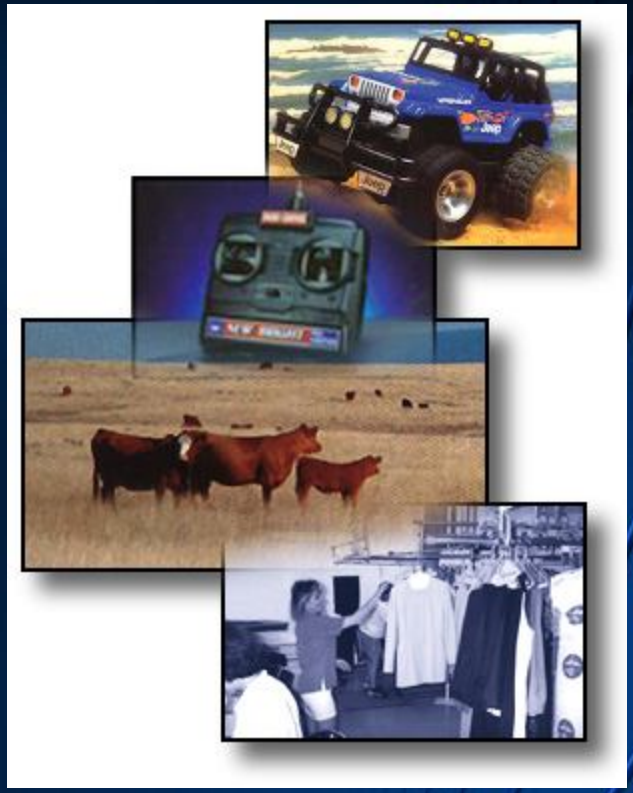


- Readers can also be mobile -- tethered, hand-held, or wireless

<150 kHz (125 kHz & 134 kHz)

Advantages

- Uses normal CMOS processing — basic and ubiquitous
- Relative freedom from regulatory limitations
- Well suited for applications requiring reading small amounts of data at slow speeds and minimal distances
- Penetrates materials well (water, tissue, wood, aluminum)



<150 kHz (125 kHz & 134 kHz)

Disadvantages:

- Does not penetrate or transmit around metals (iron, steel)
- Handles only small amounts of data
- Slow read speeds
- Large Antennas -- compared to higher frequencies
- Minimal Range

<150 kHz (125 kHz & 134 kHz)

Disadvantages:

- Tag construction:
  - is thicker (than 13.56 MHz)
  - is more expensive (than 13.56 MHz)
  - more complex
    (requires more turns of the induction coil)

13.56 MHz

Advantages

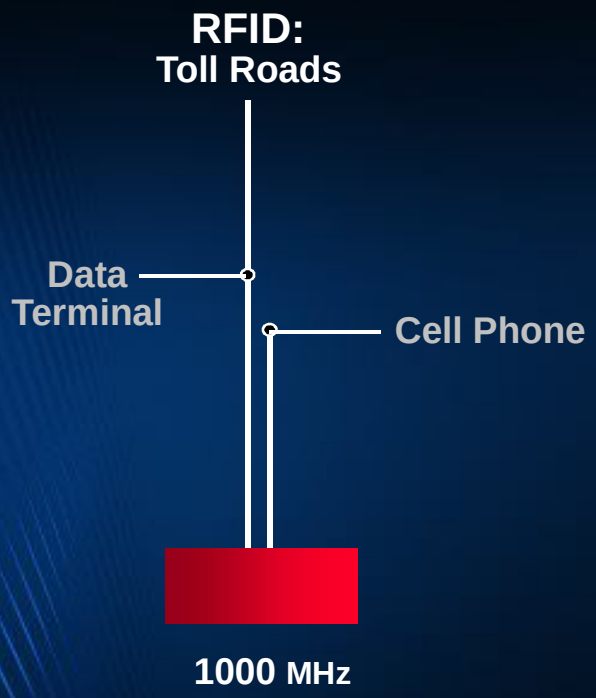
- Uses normal CMOS processing--basic and ubiquitous
- Well suited for applications requiring reading small amounts of data and minimal distances
- Penetrates water/tissue well
- Simpler antenna design (fewer turns of the coil); lower costs to build
- Higher data rate (than 125 kHz--but slower than higher MHz systems)
- Thinner tag construction (than 125 kHz)
- Popular Smart Card frequency

13.56 MHz

Disadvantages

- Government regulated frequency (U.S. and Europe recently harmonized)
- Does not penetrate or transmit around metals
- Large Antennas (compared to higher frequencies)
- Larger tag size than higher frequencies
- Tag construction: requires more than one surface to complete a circuit
- Reading Range of ≈ 0.7 m

RFID Primer…Frequencies



Electromagnetic Field

Coupling: Lower Range UHF

>300 MHz <3 (<1) GHz

(862-928 MHz ANSI MH10.8.4, ISO 18185, B-11 & GTAG)

(433.92 MHz ISO 18185)

>300 MHz <1GHz

Advantages

- Effective around metals
- Best available frequency for distances of >1m
- Tag size smaller than 13.56 MHz
- Smaller antennas
- Range: licensed to 20-40' with reasonable sized tag (stamp to eraser size). Unlicensed 3-5 m.
- Good non-line-of-sight communication (except for conductive, "lossy" materials)
- High data rate; Large amounts of data
- Controlled read zone (through antenna directionality)

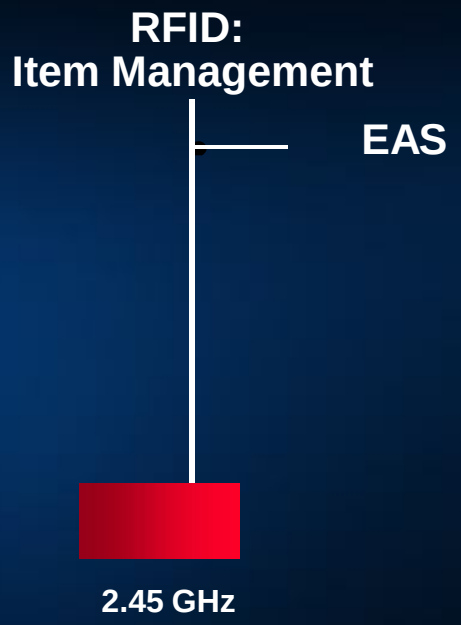
>300 MHz <1GHz

Disadvantages

- Does not penetrate water/tissue
- Regulatory issues (differences in frequency, channels, power, and duty cycle)
- Regulatory issues in Europe (similar band 869 MHz requires frequency agile chip)

↳ 950 - 956 MHz under study in Japan

RFID Primer…Frequencies



Electromagnetic Field Coupling:

2.45 GHz

2.45 GHz

Advantages

- Tag size smaller than inductive or lower range UHF (1"x 1/4")
- Range: greater range than inductive w/o battery
- More bandwidth than lower range UHF (more frequencies to hop)
- Smaller antennas than lower range UHF or inductive
- High data rate

2.45 GHz

Advantages

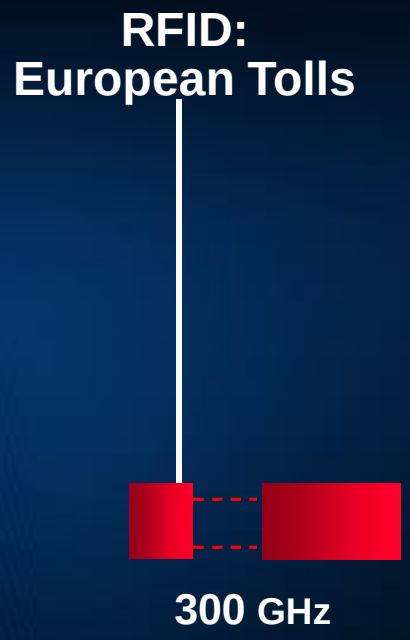
- Good non-line-of-sight communication (except for conductive, "lossy" materials)
- Can transmit large amounts of data more quickly than lower frequencies
- Controlled read zone (through antenna directionality)
- Effective around metals with tuning/design adaptations

2.45 GHz

Disadvantages

- More susceptible to electronic noise than lower UHF bands, e.g. 433 MHz, 860-930 MHz
- Shared spectrum with other technologies--microwave ovens, RLANS, TV devices, etc.
- Requires non-interfering, "good neighbor" tactics like FHSS
- Competitive requirement: single chip--highly technical; limited number of vendors
- Regulatory approvals still "in process"

RFID Primer…Frequency



>5.8 GHz (European Road Telematics Frequency)

Advantages:

- Less congested band/less interference

Disadvantages:

- Not available in U.S. or many other countries (5.9 now in FCC review)
- Must orient antennas carefully
- Range limited (due to scaling issues/wavelengths)
- Chip difficult to build
- Expensive

Spectrum Regulation

- The radio frequency (RF) spectrum is a scarce and shared resource, used nationally and internationally, and subject to a wide range of regulatory oversight. In the U.S., the Federal Communications Commission is a key regulatory body that allocates spectrum use and resolves spectrum conflicts. The International Telecommunication Union (ITU) is a specialized agency of the United Nations which plays the same role internationally.

Regulations - ITU

Regulatory Differences

- Usage of channel
  - Primary service
  - Secondary service
    - Cannot interfere with primary service
    - Cannot claim protection of interference from primary service
    - Can claim protection of interference from other secondary users
  - Industrial, Scientific, & Medical (ISM) Bands
- Narrowband or Spread Spectrum
- Power level
- Duty cycle

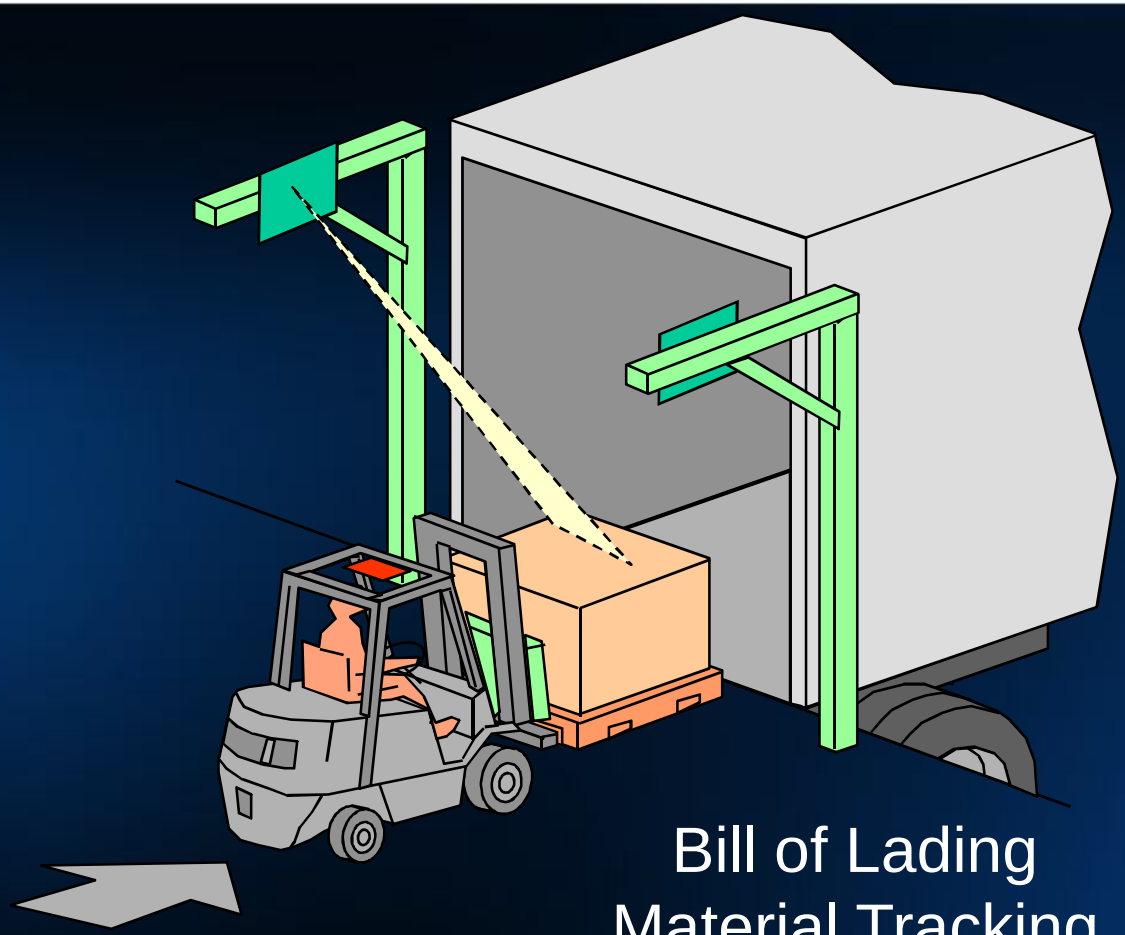
How far, how fast, how much, how many, attached to what?

Frequency	Regulation	Range	Data Speed	Comments
125-150 kHz	Basically unregulated	Å 10 cm	Low	Animal identification and factory data collection systems
13.56 MHz	ISM band, differing power levels and duty cycle	< 1m	Low to moderate	Popular frequency for I.C. Cards (Smart Cards)
433 MHz	Non-specific Short Range Devices (SRD), Location Systems	1 Š 100 m	Moderate	Asset tracking for U.S. DoD (Pallets)
860-930 MHz	ISM band (Region 2); increasing use in other regions, differing power levels and duty cycle	2 Š 5 m	Moderate to high	EAN.UCC GTAG, MH10.8.4 (RTI), AIAG B-11 (Tires)
2450 MHz	ISM band, differing power levels and duty cycle	1 Š 2 m	High	IEEE 802.11b, Bluetooth, CT, AIAG B-11

Radio Frequency Identification (RFID)

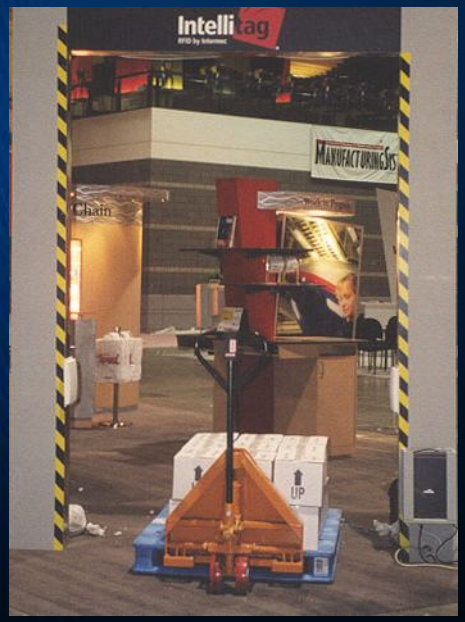
Applications

Portal Applications



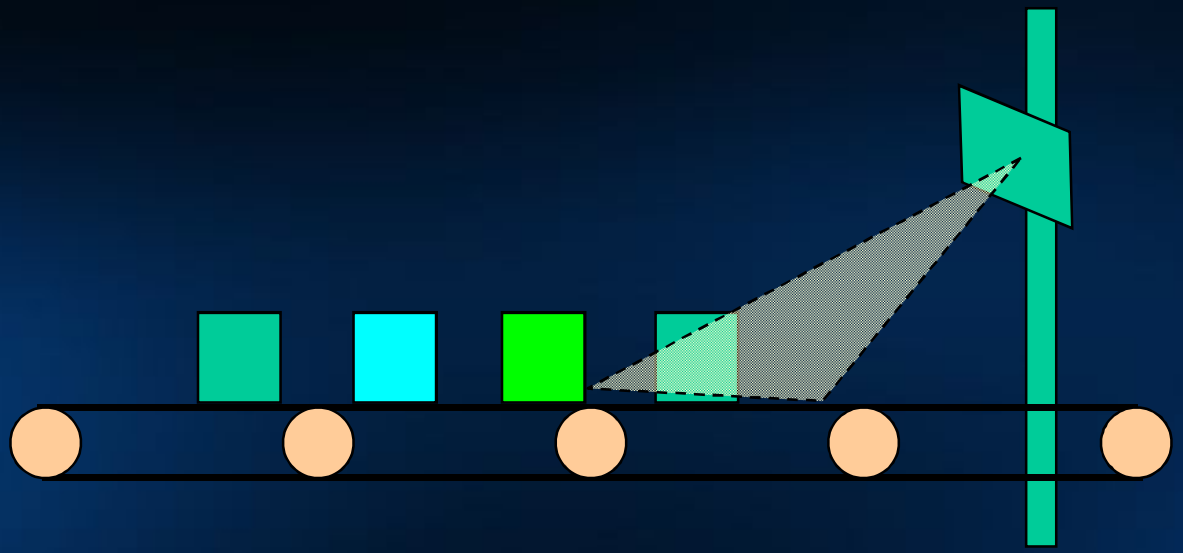
Bill of Lading
Material Tracking

Portal Applications



- Limited number items at forklift speeds
- 8’ X 10’ doorways
- Electronic receipt & dispatch
- Wrong destination alert
- Electronic marking
- Pallet/container item tracking

Conveyor / Assembly Line

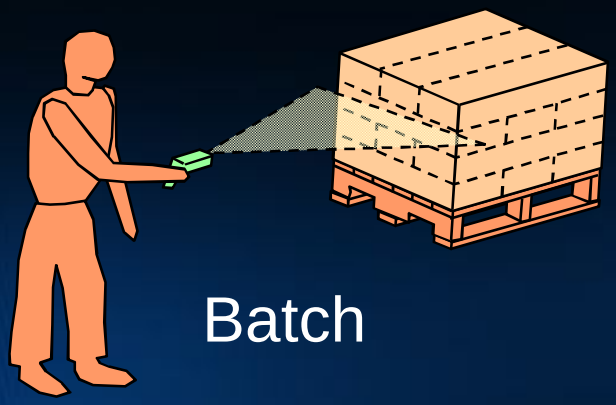


Read / Write Operations
Higher Accuracy than Bar Code

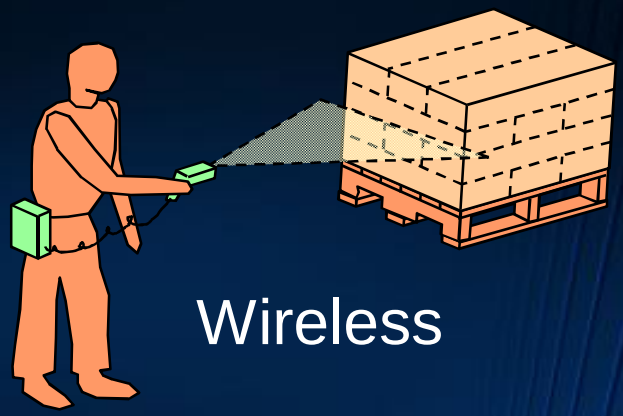
Conveyor / Assembly Line

- Up to 450 fpm
- 60+ items per container
- Inexpensive tunnels
- Longer tunnel more items
- Electronic receipt
- Sorting
- Electronic marking

Hand Held Application Categories



Batch



Wireless

Fixed Station

Application Examples

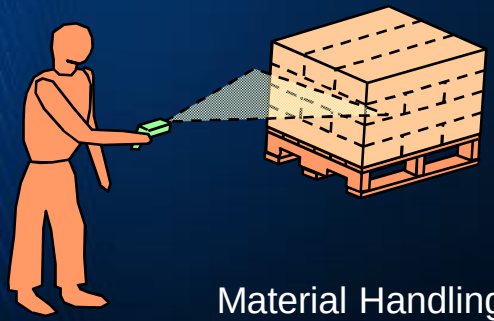
Wireless / Batch

Inventory Management

Where is it? What is it?
What is inside the box?

Material Handling
By Destination

Where is it going? Where has it been?
Should it be here?



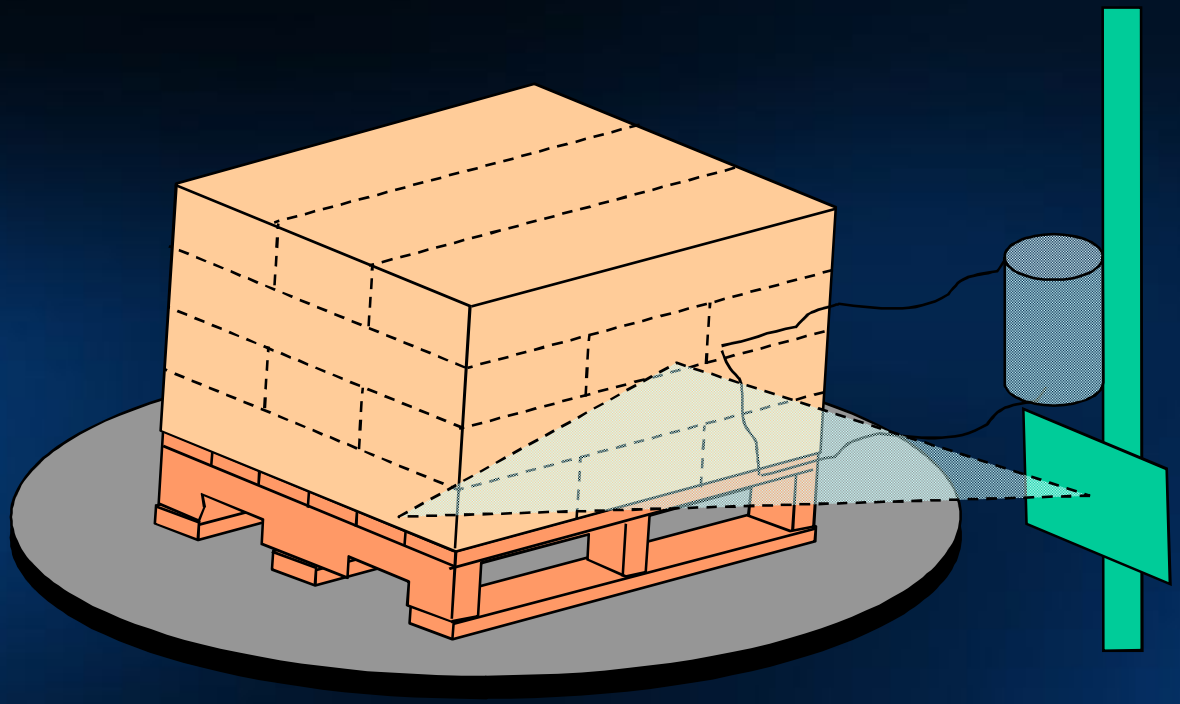
Material Handling
Aggregate / De-aggregate

What have I assembled or disassembled?
How many do I have? Do I have enough?

Material Handling
Inspecting / Maintaining

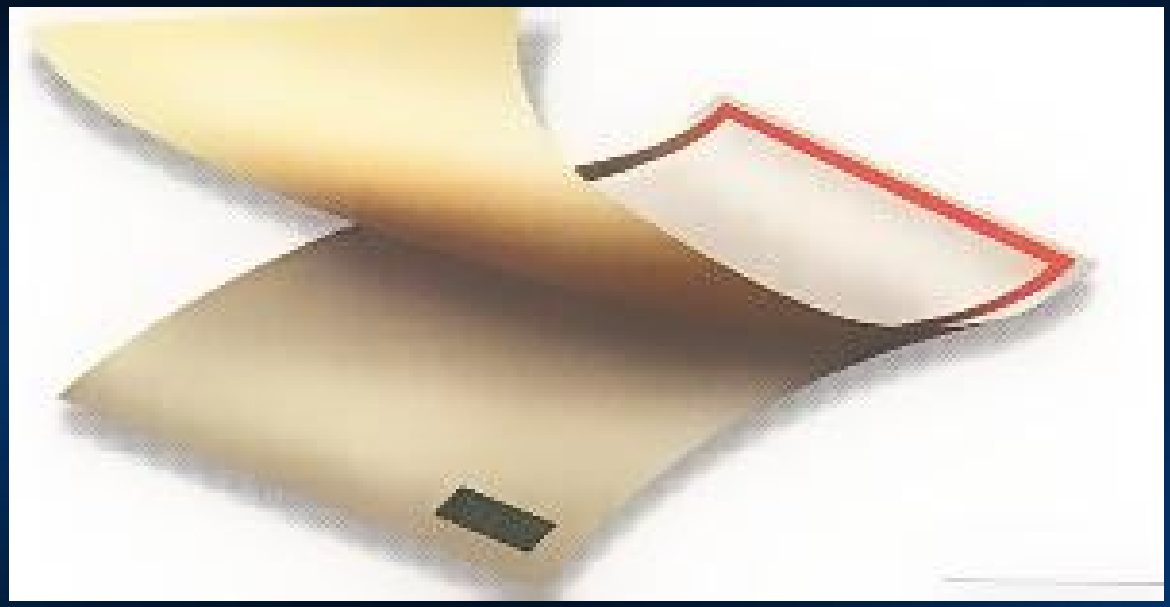
Has this been repaired?
Is this under warrantee?
Has this been inspected?
Is this complete?
What is the asset's status or state?

Shipping Validation

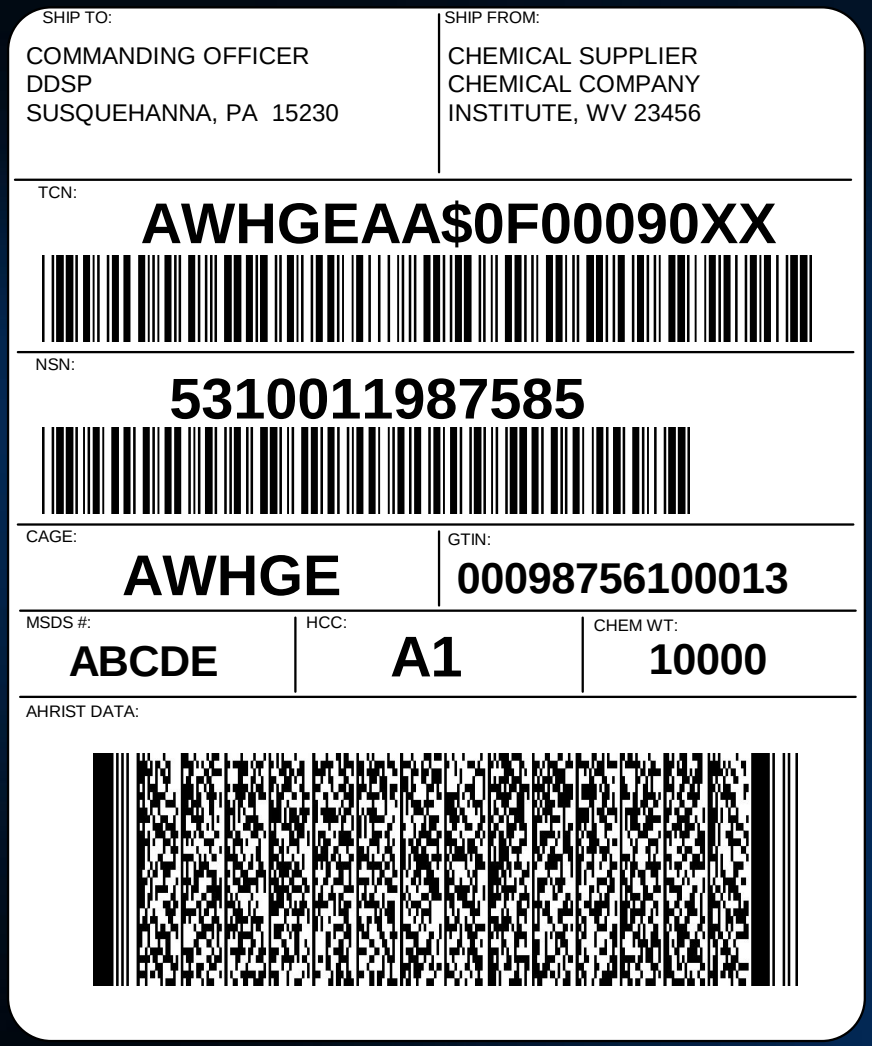


Tote/Box/Unit Level Inventory

Intelligent Labels

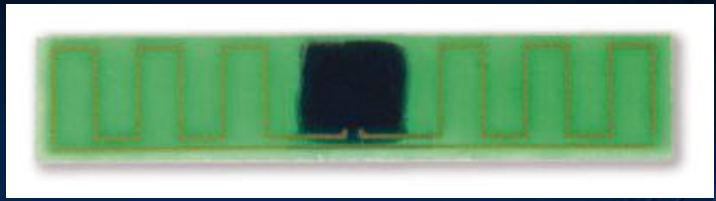


The HazMat Label



HazMat Smart Label

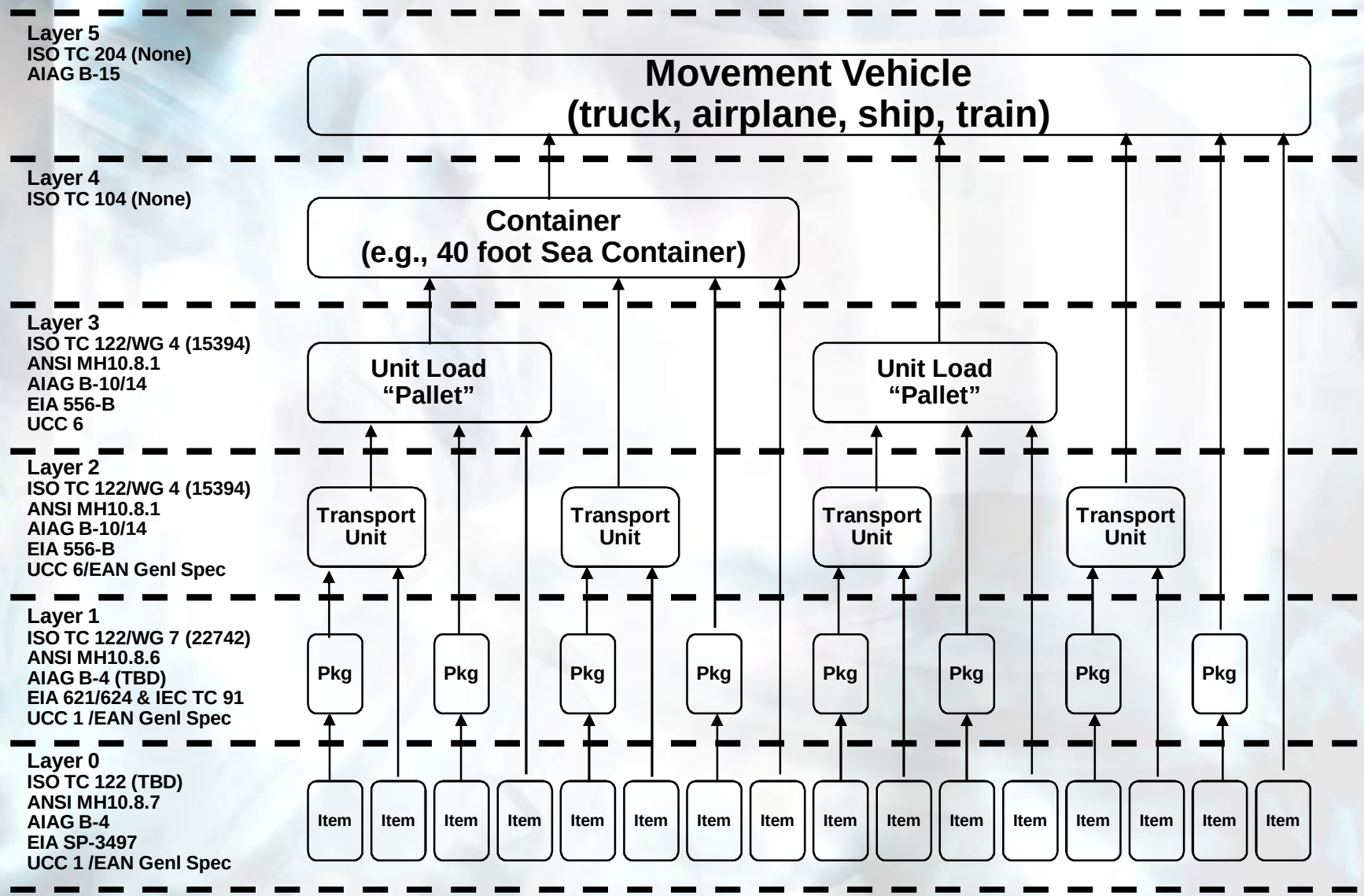
- Low power > long range
- 1024 bit memory
- Read/write/lock on 8 bits
- Advanced protocol
  - Efficient multi-id
  - 12 ms/8 byte read
  - Group select
  - 40 tags/second
  - Lock data permanently
  - 25ms/byte write
  - Broadcast write
  - Anti-collision



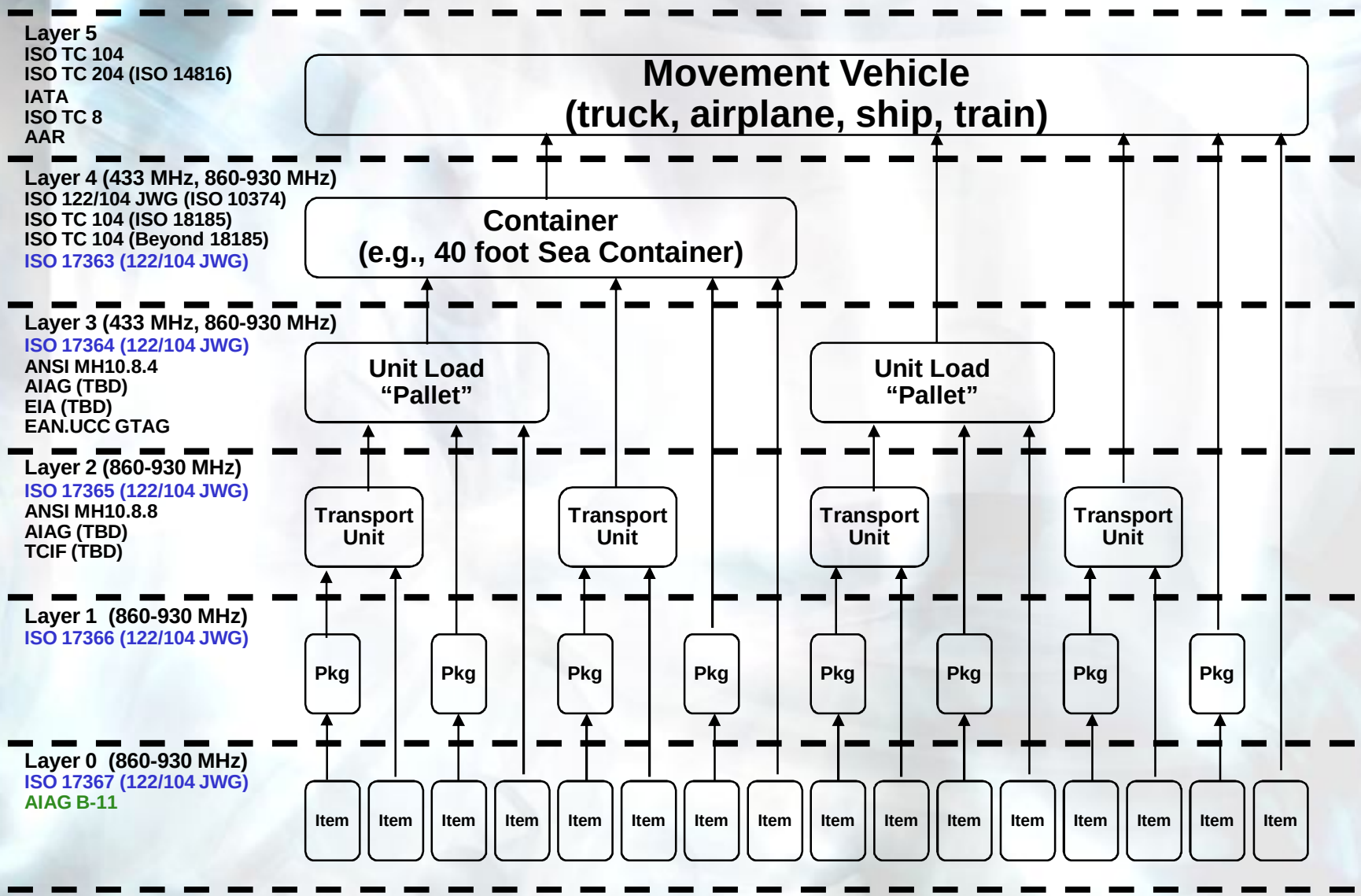
Radio Frequency Identification (RFID)

Standards

The Layers of Logistic Units (Optically Readable Media)



The Layers of Logistic Units
(Radio Frequency Identification - RFID)



Application Requirements

- **Wal-Mart - Suppliers will mark inbound cases and pallets with RFID - 1 January 2005 - May, 2003 specification calls for ≈256 bit read/write tag**
- **U.S. Department of Defense - Draft RFID policy to be completed by 18 September 2003 - To issue final policy in July of 2004 that will require suppliers to put passive RFID tags on selected case/pallet packaging by January of 2005. Draft policy calls for passive tags (est. 256 byte) and active tags**

Lads, Dads, & Granddads