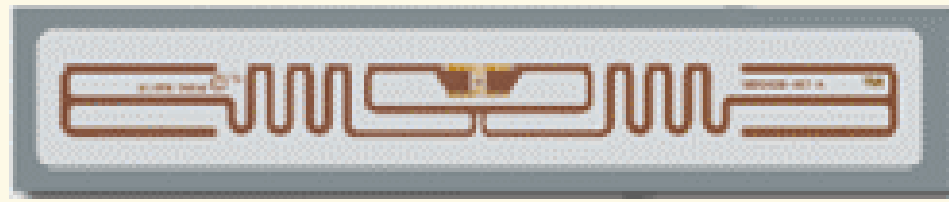


# RFID: What's it all about?



Presented by  
Leonard E. Miller

# Abstract

## RFID: What it's all about?

It seems like everyone's talking about RFID. What's it all about? In this presentation, the background of the current "buzz" on RFID technology is given and examples of RFID sensor systems are shown. Also, the basic operation of the technology is explained and standardization efforts are summarized.

## Contents

1. Introduction: What is RFID?
2. RFID Technology
3. RFID Systems
4. RFID Standards Organizations
5. RFID Standards
6. References

## Introduction: What is RFID?

- Radio Frequency Identification (RFID) is a technology with several *aspects* that correspond to different *applications*.
- The common element of all RFID applications is the use of radio signals to sense the presence of a tagged object and, in most instances, to retrieve data stored on the object.
- The different applications of RFID are distinguished by their uses of the information that is developed by the sensing and/or data retrieval, and by their operational requirements.
- Each application is made efficient or economically viable by specific *enabling technologies*.

## What is RFID? (continued)

- From the sensing point of view, the many RFID applications are quite diverse, including
  - Radar
  - Access control systems and smart cards
  - Automatic toll collection
  - Asset tracking (e.g., railroad cars)
  - Animal tagging, including implants
  - Hazardous substance tracking
  - Inventory and supply chain tracking

## What is RFID? (continued)

- The recent interest in RFID is primarily connected with the “killer application” of automated inventory and supply chain tracking.
- This application was already established using another sensing technology—optically scanned bar code labels—and the enabling technology of computer networking.
- Therefore, in this sense the “buzz” surrounding “RFID” is not about something “new” but about the enhancement of an existing application.
- However, the enhancements to the supply chain application using RFID are made possible by advances in microchip-embedded tags, as well as development of techniques for reading multiple tags.

What is RFID? (continued)

The enhancement using RFID is about utility [3]:

“RFID also allows easy and as-needed, uninterrupted access to data on the tag. Unlike the barcode where identification is limited by line-of-sight, RFID technology and its reliance on radio waves does not require a line-of-sight for identification nor a straight-line alignment between the tags and readers. RFID tags are also sturdier than barcodes, allowing for use in adverse conditions, and tags can be affixed or embedded on the product packaging or inside the item.”



What is RFID? (continued)

The enhancement using RFID is also about more data [3]:

“The technology itself offers several improvements over its predecessor technologies – the barcode and magnetic stripe cards. The central data feature of RFID technology is the Electronic Product Code (EPC), which is viewed by many in the industry as the next-generation barcode or Universal Product Code (UPC). This EPC code can carry more data than the UPC code and can be reprogrammed with new information if necessary. Like the UPC, the EPC code consists of a series of numbers that identify the manufacturer and product type. The EPC code also includes an extra set of digits to identify unique items.”



# Electronic Product Code

**016.37000.123456.1000000000**

Header   EPC manager   Object class   Serial number

Header: identifies the length, type, structure, version, and generation of EPC

Manager Number: identifies the company or company entity

Object Class: similar to a stock keeping unit or SKU

Serial Number: specific instance of the Object Class being tagged

## Example Type 1 EPC (96 bits) [4]

In hexadecimal notation, the 96 bits are represented here by 24 characters (4 bits/character):

02.0000A68.0001BD.001C2DE3F

Header (8 bits): 256 possible values

- Manager number (28 bits): over 268 million companies
- Object class (24 bits): over 16 million different objects
- Serial number (36 bits): over 68 billion individual products

Plus, 32 bits of item-unique information, such as shipping data.

0000↔0  
0001↔1  
0010↔2  
0011↔3  
0100↔4  
0101↔5  
0110↔6  
0111↔7  
1000↔8  
1001↔9  
1010↔A  
1011↔B  
1100↔C  
1101↔D  
1110↔E  
1111↔F

What is RFID? (continued)

But the scale of the application requires business decisions [3]:

“Although supply chain applications ...probably account for the largest dollar value driver of the technology for RFID, a survey of...developers around the world...suggests that RFID is currently being used more for security applications. However, as the costs of RFID tags continue to fall, use of the technology for inventory control will likely increase.”

“Mandates by Wal-Mart, other large retailers, and the U.S. Department of Defense (DOD) requiring their top suppliers to use RFID tags on pallets and containers to track shipments have spurred the recent uptake of this technology.”



## RFID in DoD [7]

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**VISION:** Implement knowledge-enabled logistics through fully automated visibility and management of assets in support of the warfighter



# RFID Technology

## RFID Technology

- RFID devices and systems first appeared in tracking and facility-access applications during the 1980s.
- These wireless automatic identification and data capture (AIDC) systems allow for non-contact detection and data reading, and are effective in manufacturing and other potentially damaging environments in which other identification devices, such as bar code labels, could not survive.
- RFID technologies are well established in a wide range of applications, including livestock identification and automated vehicle identification (AVI) systems because of their ability to track moving objects.

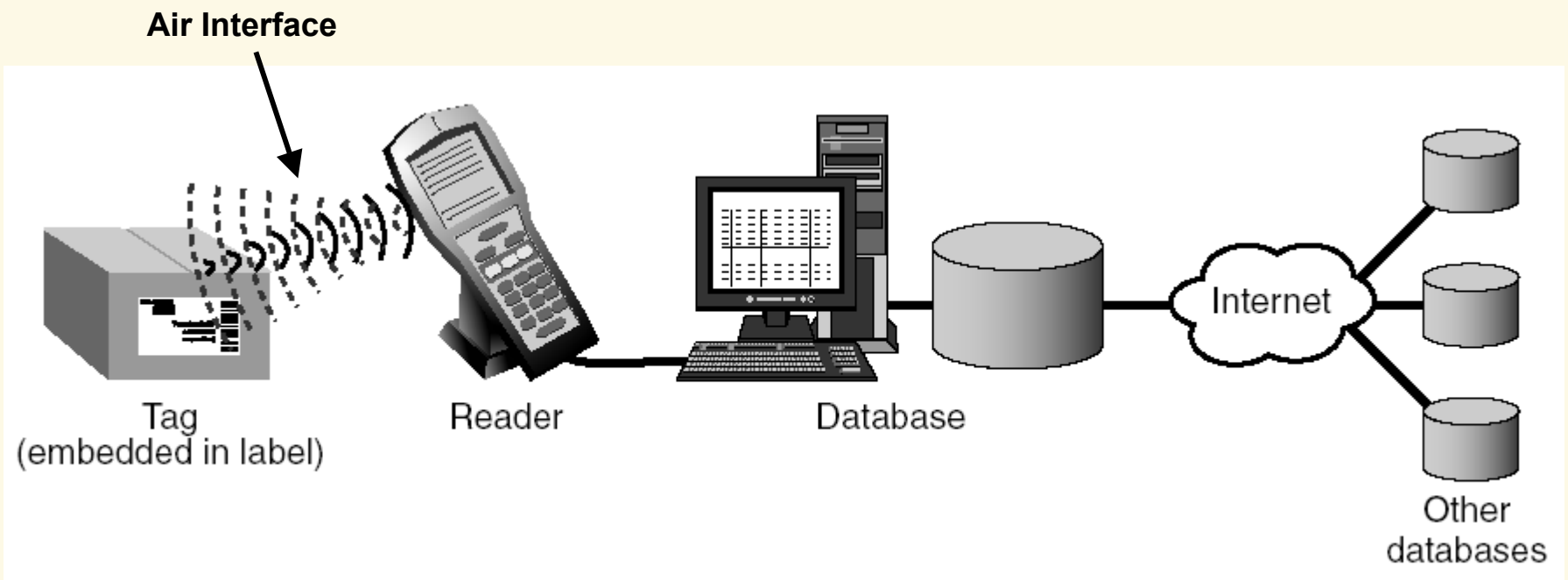


## RFID Technology (continued)

- A basic RFID system consists of three types of components:
  - Antennas or coils, which are the means of coupling electromagnetic energy between the data device and a transceiver.
  - A transceiver, which is the unit that provides the electromagnetic energy to the data device and that detects and extracts information from (decodes) the data device.
  - A data device or transponder (RFID tag), which contains a semiconductor chip that has previously been programmed with unique information.
  - A display for the data retrieved from the tag, and/or a computer interface to a database.



### RFID Technology (continued)



Components of an RFID system [5]

## RFID Technology (continued)

- Reader antennas are available in various shapes and sizes.
  - For example, they can be built into a doorframe to receive tag data from persons or things passing through the door, or mounted on an interstate tollbooth to monitor traffic passing by on a freeway.
  - The electromagnetic field may need to be constantly present when multiple tags are expected, but if constant interrogation is not required, the field can be activated by a separate sensing device or subsystem.
  - Often the antenna is packaged with the transceiver/decoder to constitute a handheld or self-contained “reader” or “interrogator.”



## Example Readers with Built-in Antennas



Custom: Intermec



PCMCIA card: Intermec

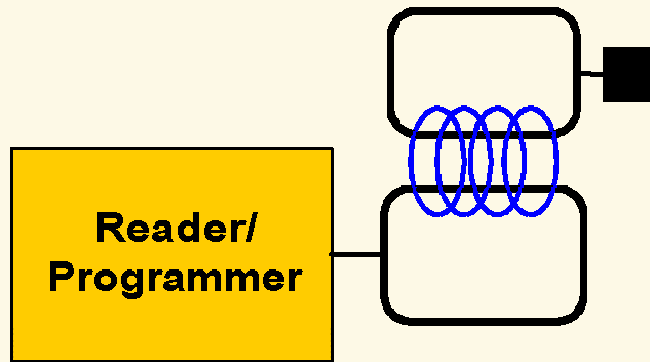
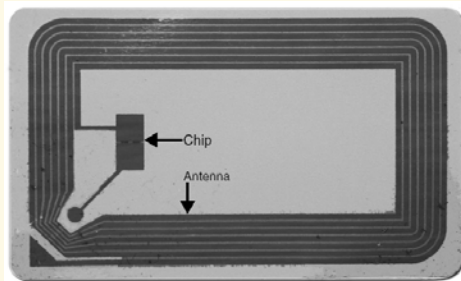


CF card: ACG

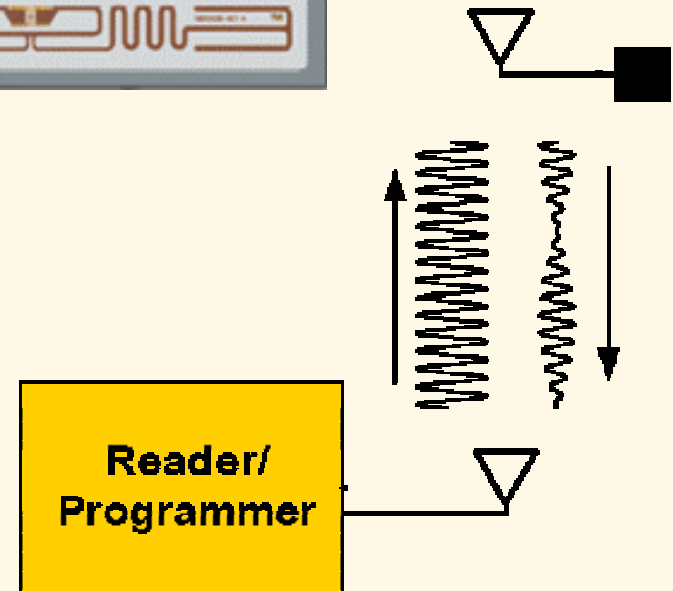
## RFID Technology (continued)

- The extraction of data from the RFID tag can be based either on inductive coupling or on “propagation coupling” [1]
- In inductive (proximity) coupling, the tag is brought very close to the reader, so that the tag in effect becomes a part of the reader’s circuitry and can be queried as if the tag’s data chip were connected by wires.
- In propagation (remote) coupling, the reader emits a modulated radio signal to the tag, which simultaneously
  - Extracts energy from the signal (if no battery on the tag) and
  - Reads the signal’s modulation in order to receive commands from the reader and/or to verify the authenticity of the reader.
  - Depending on the particular system, the tag then sends modulated data back to the reader with the desired data.

### RFID Technology (continued)



Inductive (Proximity)  
Coupling



Propagation (Remote)  
Coupling

### Types of RFID coupling

## RFID Technology (continued)

- The advantages and disadvantages of these two kinds of communication between the transceiver and the tag depend on the particular application.
- For example, if the transceiver and tag must communicate with sufficient power to cover a certain distance—as in the remote type of coupling—the use of that frequency is excluded from other units nearby, and it is possible that an unauthorized receiver can be positioned to intercept the RFID tag's response.





## RFID Technology (continued)

- RFID tags come in a wide variety of shapes and sizes.
  - Animal tracking tags, inserted beneath the skin, can be as small as a pencil lead in diameter and one-half inch in length.
  - Tags can be screw-shaped to attach to and identify trees or wooden items, or credit-card shaped for use in building access applications.
  - Anti-theft hard plastic tags attached to merchandise in stores are RFID tags.
  - Heavy-duty 5- by 4- by 2-inch rectangular transponders—used to track shipping containers or heavy machinery, trucks, and railroad cars—are RFID tags.



## RFID Technology (continued)

## Read/Write Options [8]

- Read Only:
  - Information can only be read from an RFID device – programmed at time of its 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

## RFID Technology (continued)

## Protocol Options [8]

- Physical and medium access layer issues:
  - Modulation, error correction, anti-collision technique, message formats, command structure, ...
- Anti-collision techniques
  - Necessary for reading multiple tags (intentional or not)
  - Programmed into tag chip logic
- Access protocols
  - TTF (tag talks first): “I’m here.”
  - RTF (reader talks first): “Who’s there?”

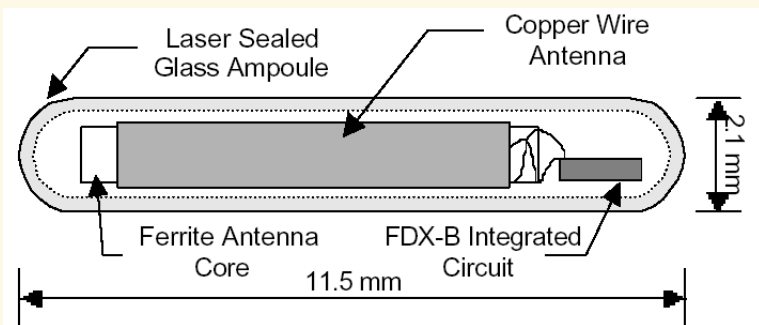
## RFID Technology (continued)

- An *active* RFID tag is powered by a battery and is typically read/write, *i.e.*, tag data can be rewritten and/or modified.
  - For example, a tag on a part being manufactured might give a machine-tool a set of instructions, and the machine would then store performance data on the tag that become part of the tagged part's history.
  - The battery of an active tag generally gives it a longer read range, but increases tag size and cost, and has a limited operational life.
- A *semi-active* or *battery-assisted* tag uses passive signaling technology but has a greater range.

## RFID Technology (continued)

- A *passive* RFID tag operates without an external power source and obtains operating power “over the air” from the reader.
  - Passive tags are much lighter than active tags, less expensive, and offer a virtually unlimited operational lifetime, but have shorter read ranges than active tags and require a higher-power reader.
  - Read-only tags are typically passive and are programmed with a unique set of data (usually 32 to 128 bits) that cannot be modified.

# Example RFID Tags



Glass tags for insertion under the skin of animals (Allflex)



Key ring tag for vehicle anti-theft use (TI)



Industrial-grade "transponders" (Tectus)



## Example RFID Tags



30-mm disc for industrial applications such as waste bin identification, work and asset tracking (TI)

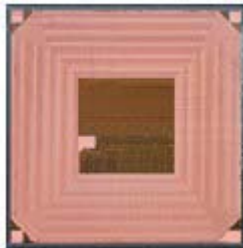


Proximity tags for identification, personnel access control (AWID)

## Example RFID Tags



Labels with RFID tags embedded  
(Impinj)



2.5 mm coil-on-chip RFID tag for  
close proximity applications (Maxell)

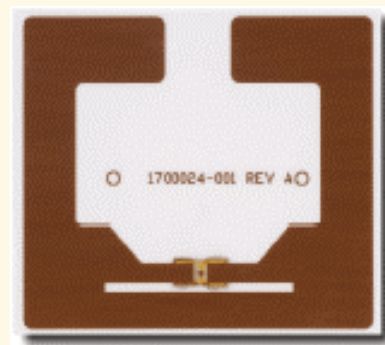
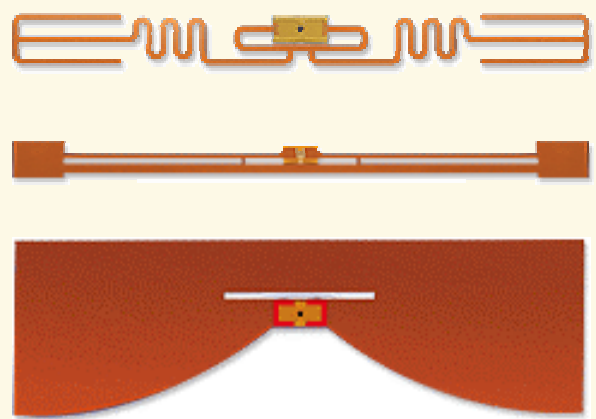


active



(Smartcode)

passive



(Alien Technology)

# RFID Systems

## RFID Systems

- RFID systems can be distinguished by their frequency ranges and applications.
- Lower frequency (30 KHz to 500 KHz) systems have short reading ranges and lower system costs. They are most commonly used in security access, asset tracking, and animal identification applications.
- Higher frequency (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz) systems, offering long read ranges (greater than 90 feet) and high reading speeds, are used for such applications as railroad car tracking and automated toll collection.

# Frequency Bands

Band	Nomenclature	Frequency	Wavelength
ELF	Extremely Low Frequency	3 - 30 Hz	100,000 - 10,000 km
SLF	Super Low Frequency	30 - 300 Hz	10,000 - 1,000 km
ULF	Ultra Low Frequency	300 - 3000 Hz	1,000 - 100 km
VLF	Very Low Frequency	3 - 30 kHz	100 - 10 km
LF	Low Frequency	30 - 300 kHz	10 - 1 km
MF	Medium Frequency	300 - 3000 kHz	1 km - 100 m
HF	High Frequency	3 - 30 MHz	100 - 10 m
VHF	Very High Frequency	30 - 300 MHz	10 - 1 m
UHF	Ultra High Frequency	300 - 3000 MHz	1 m - 10 cm
SHF	Super High Frequency	3 - 30 GHz	10 - 1 cm
EHF	Extremely High Frequency	30 - 300 GHz	1 cm - 1 mm

	Name	Frequency Bandwidth
Part 15.247	ISM band	902 – 928 MHz (26MHz) 2400 – 2483.5 MHz (83.5MHz) 5725 – 5850 MHz (125MHz)
Part 15 Subpart E	U-NII band	5150 – 5250 MHz (100MHz) 5250 – 5350 MHz (100MHz) 5725 – 5825 MHz (100MHz)
Part 15 Subpart D	U-PCS band	1910 – 1920 MHz (10MHz) pair 2390 – 2400 MHz (10MHz) for data 1920 – 1930 MHz (10MHz) voice
Part 15.255		59 – 64GHz

## Unlicensed Bands

## RFID Band Characteristics [4]

<b>Band</b>	<b>Frequency</b>	<b>Read Range</b>	<b>Applications</b>
LF	100-500 kHz	up to 20 in	Access control, animal ID, keyless entry
HF	13.56 MHz	up to 3 ft	Access control, smart cards, libraries, anti- theft tagging
UHF	866-956 MHz	20 ft or more	Supply chain, baggage handling, toll collection
UHF	2.45 GHz	3-10 ft.	Item tracking, toll collection

Note: The read range is a function of power, antenna efficiency, and tag capability (active or passive)

## RFID Systems (continued)

- The significant advantage of all types of RFID systems is the non-contact, non-line-of-sight nature of the technology.
- Tags can be read *through* a variety of substances and visually and environmentally challenging conditions, where barcodes or other optically read technologies would be useless.
- RFID tags can also be read at high speeds, in most cases responding in less than 100 milliseconds.
- The read/write capability of an active RFID system is also a significant advantage in interactive applications such as work-in-process or maintenance tracking.

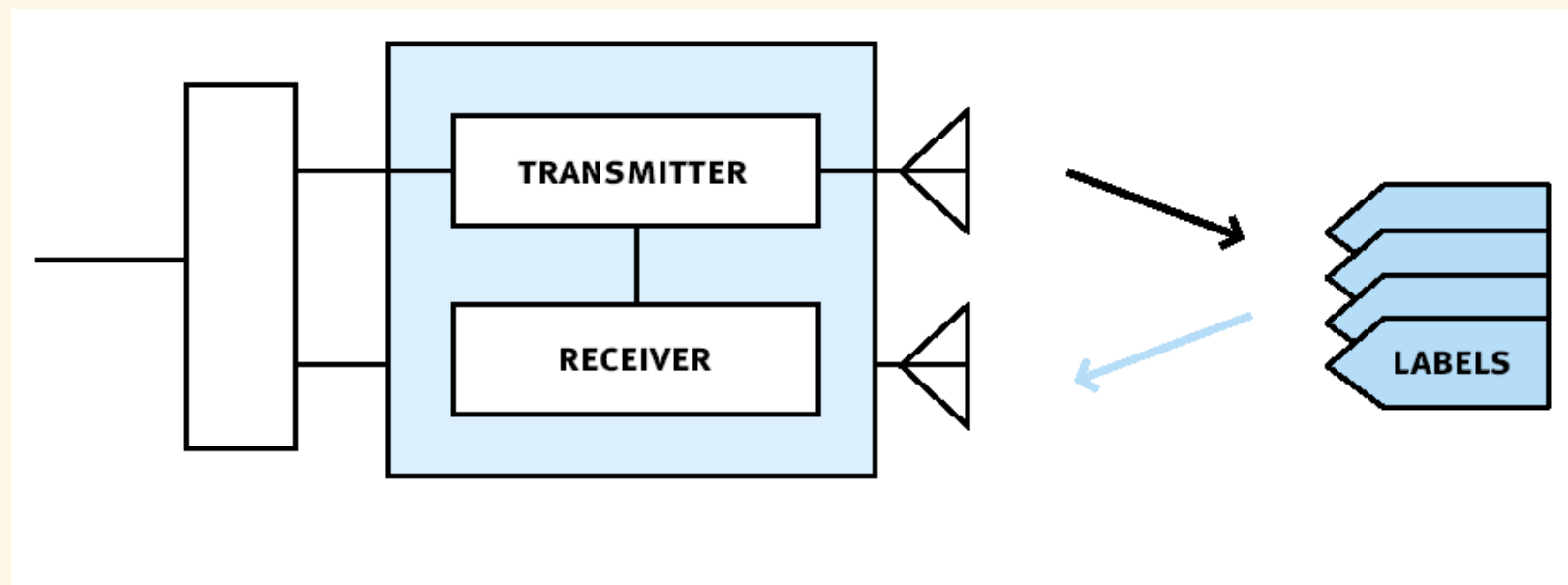


## RFID Systems (continued)

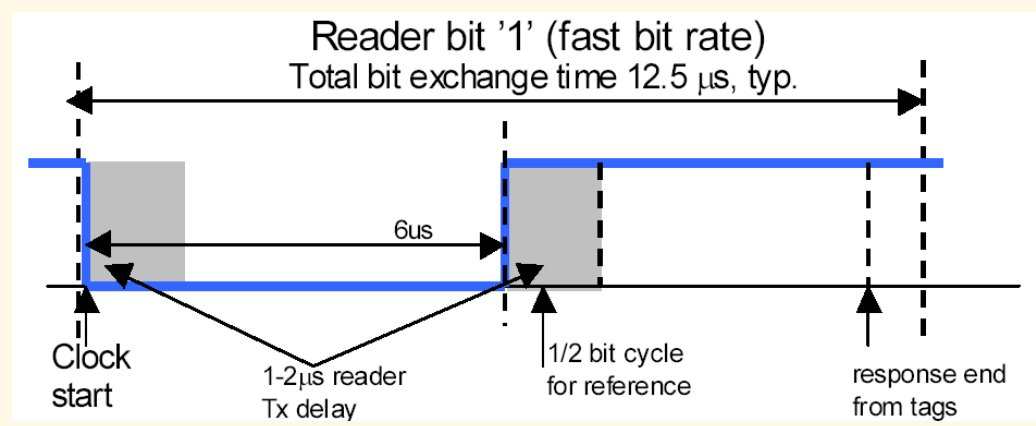
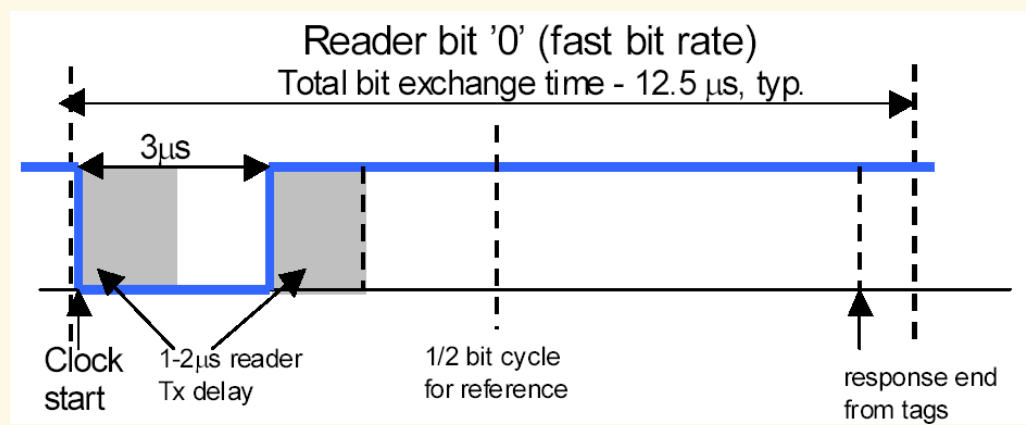
- More applications [2]:
  - In the pharmaceutical industry, RFID tags on drug bottles are being used as anti-counterfeiting devices.
  - Pet owners have begun implanting their cats and dogs with RFID chips to locate them should they become lost.
  - In libraries, books are being tagged for self-automated checkout, freeing up librarians. This also allows a librarian to easily locate a book misplaced on the wrong shelf.
  - The USDA is pushing to give every cow in the US its own unique identification number, making it easier to track diseases, such as mad cow disease, back to the originating farm.

# How do RFID systems work?

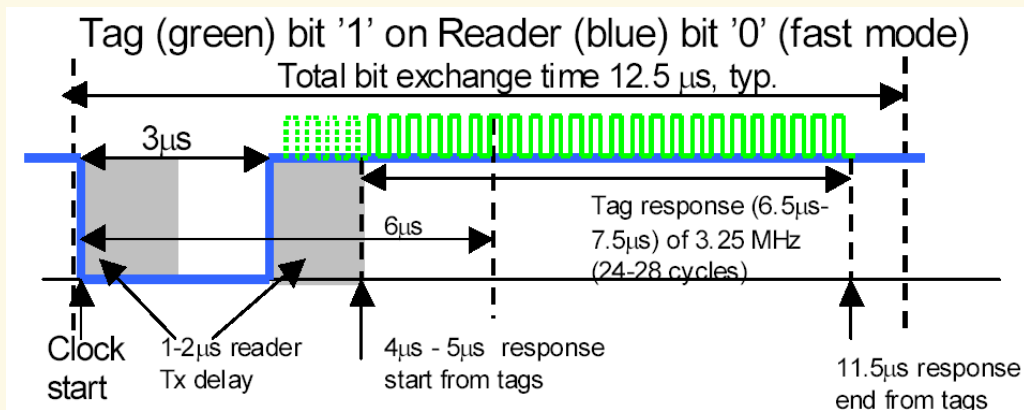
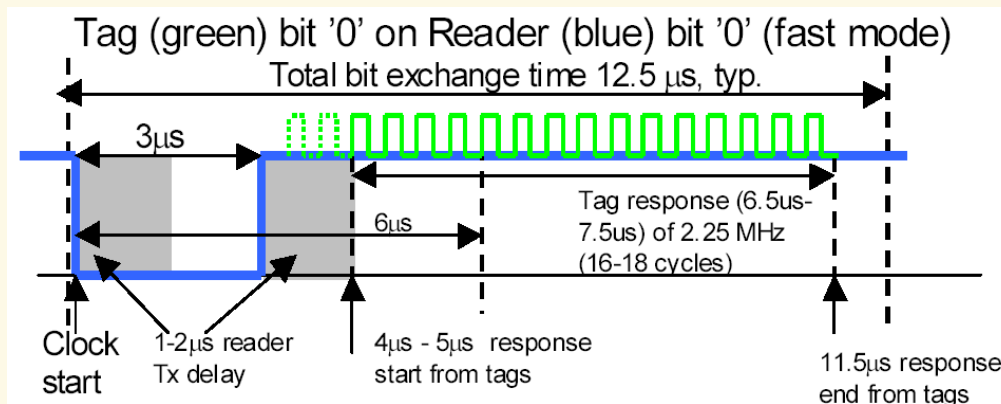
# Reading Multiple Class 0 Tags [9]



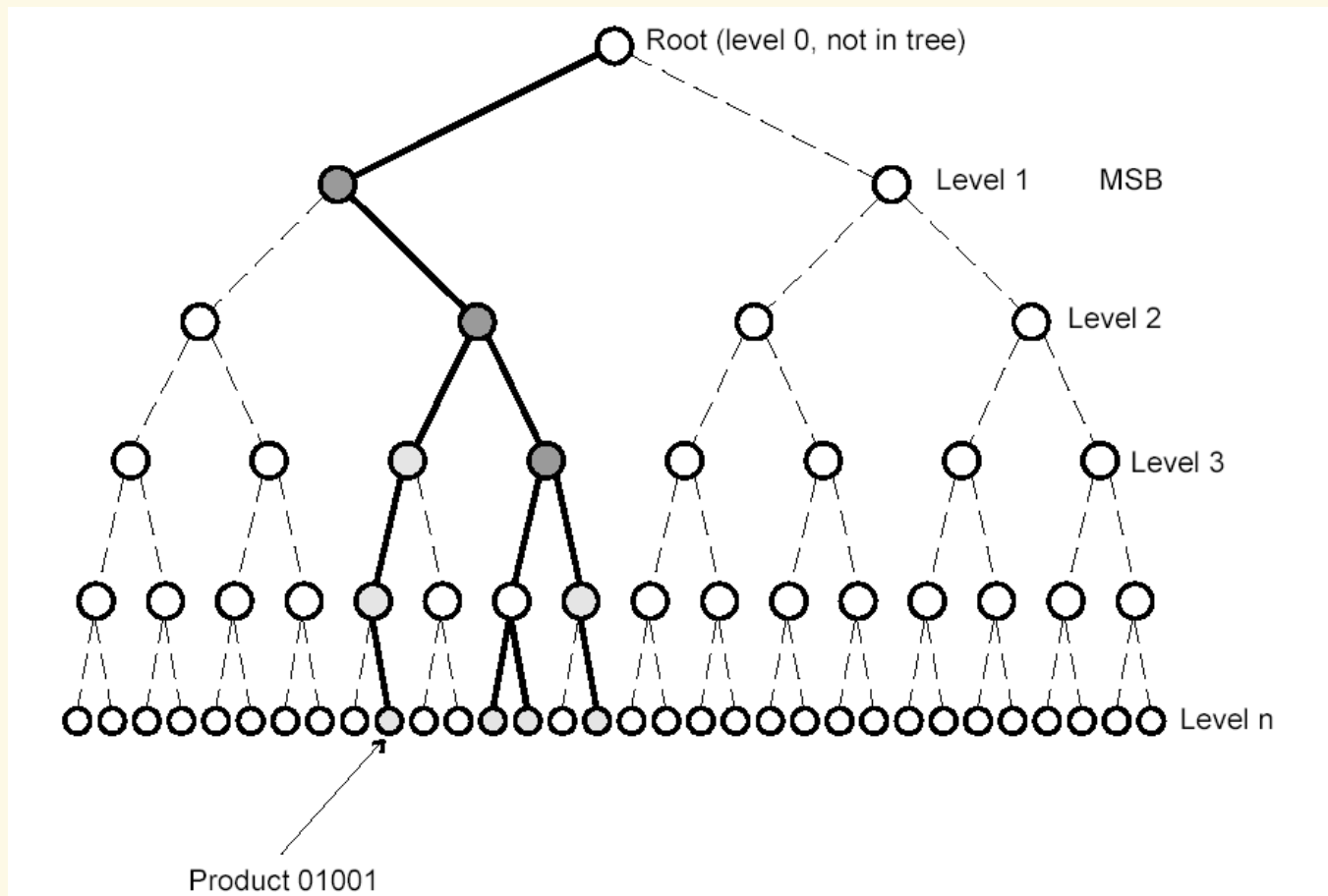
## Reader to Tag Signaling



## Tag to Reader Signaling



### Tree representation of Class 0 "singulation"





## Class 1 Reader-to-Tag Commands [10]

COMMAND NAME	COMMAND CODE (BINARY MSB-LSB)	TAG REPLY
ScrollAllID	0011 0100	ScrollID Reply
ScrollID	0000 0001	ScrollID Reply
PingID	0000 1000	PingID Reply
Quiet	0000 0010	None
Talk	0001 0000	None
Kill	0000 0100	None
ProgramID	0011 0001	None
VerifyID	0011 1000	VerifyID Reply
LockID	0011 0001*	None
EraseID	0011 0010	None

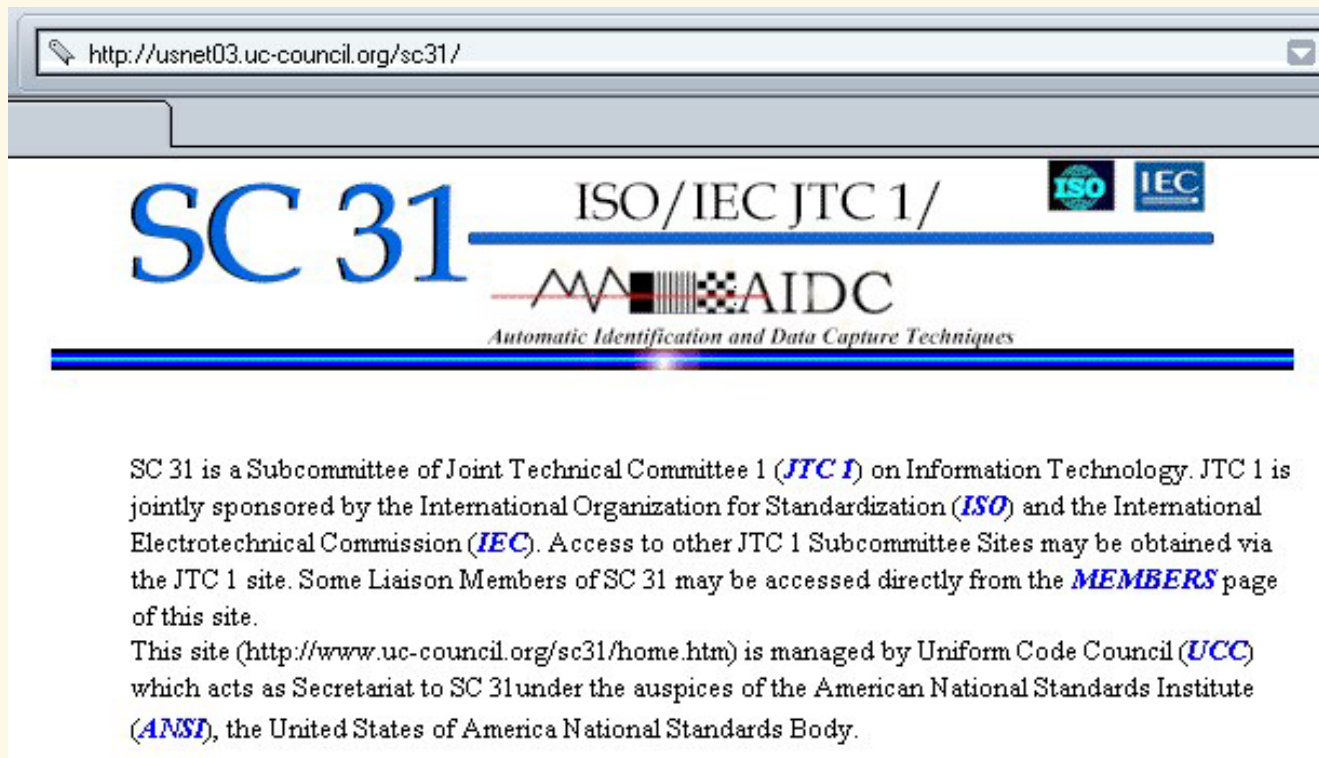
# RFID Standards Organizations

## RFID-Related Standards Organizations [4]

<b>Organization</b>	<b>Mission</b>	<b>Scope</b>
ANSI	Commercial trade standards	USA
APEC	Commercial trade standards	Asia Pacific
APICS	Supply chain, business process	Global
Auto ID Center	RFID standards	→EPCglobal
CEN	Commercial trade standards	Europe
CEPT	RF broadcast standards	Europe
EAN	Supply chain ID and EDI (electronic data interchange)	Global
ECCC	Bar codes and e-commerce	Canada
EPCglobal	EPC & RFID	Global
FCC	RF broadcast regulations	USA
IEC	Electrical and electronic standards	Global
ISO	Commercial trade standards	Global
MPHPT	RF broadcast standards	Japan
UCC	Supply chain and EDI	USA

## RFID Standards Organizations (continued)

- JTC1/SC31: <http://usnet03.uc-council.org/sc31/>



The screenshot shows a web browser window with the address bar containing <http://usnet03.uc-council.org/sc31/>. The page content features the text "SC 31" in large blue font, followed by "ISO/IEC JTC 1/" and logos for ISO and IEC. Below this is the AIDC logo, which includes a barcode and the text "AIDC Automatic Identification and Data Capture Techniques". A horizontal blue line separates the header from the main text. The main text describes SC 31 as a Subcommittee of Joint Technical Committee 1 (JTC 1) on Information Technology, jointly sponsored by ISO and IEC. It also mentions that the site is managed by the Uniform Code Council (UCC) under the auspices of the American National Standards Institute (ANSI).

SC 31 is a Subcommittee of Joint Technical Committee 1 (**JTC 1**) on Information Technology. JTC 1 is jointly sponsored by the International Organization for Standardization (**ISO**) and the International Electrotechnical Commission (**IEC**). Access to other JTC 1 Subcommittee Sites may be obtained via the JTC 1 site. Some Liaison Members of SC 31 may be accessed directly from the **MEMBERS** page of this site.

This site (<http://www.uc-council.org/sc31/home.htm>) is managed by Uniform Code Council (**UCC**) which acts as Secretariat to SC 31 under the auspices of the American National Standards Institute (**ANSI**), the United States of America National Standards Body.

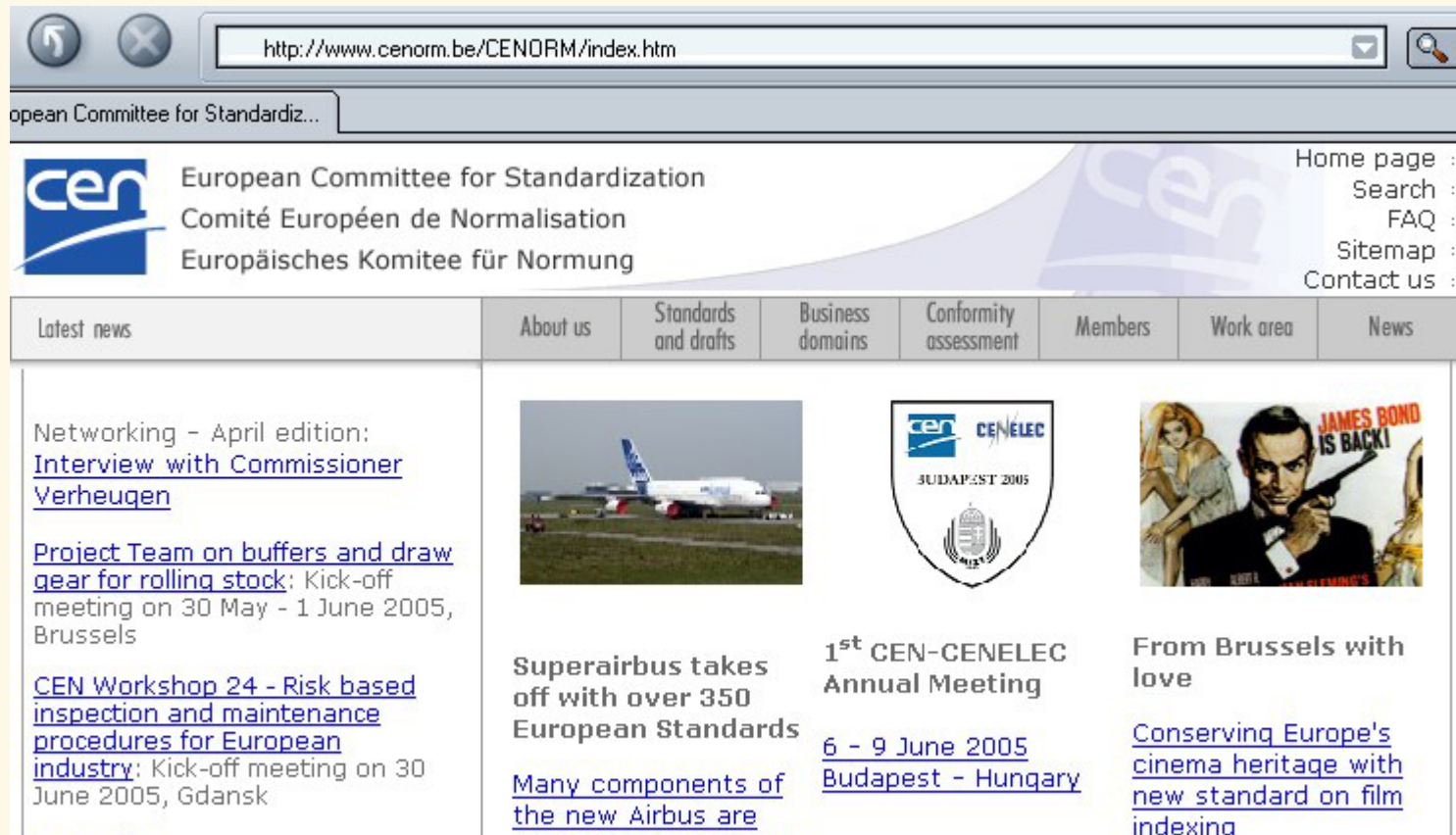
## RFID Standards Organizations (continued)

- ISO/IEC JTC1/SC31 working groups:
  - WG1: Data Carrier
    - Data carrier specifications and related documentation for linear and 2-dimensional bar code symbologies
  - WG2: Data Structure (Syntax)
  - WG3: Conformance
  - WG4: RFID for item management
    - Interoperability of wireless, non-contact omnidirectional RFID devices capable of receiving, storing, and transmitting data while operating at power levels that are in freely available international frequency bands in the area of item level identification and management across the supply chain.
  - WG5: Real-time locating systems (RTLS)
    - Air interface protocol(s) for interoperability of RTLS in the area of asset identification and management.






## RFID Standards Organizations (continued)

- CEN: <http://www.cenorm.be/CENORM/index.htm>



The screenshot shows the homepage of the European Committee for Standardization (CEN). The browser address bar displays <http://www.cenorm.be/CENORM/index.htm>. The page features the CEN logo and name in three languages: English, French, and German. A navigation menu includes links for Home page, Search, FAQ, Sitemap, and Contact us. Below the header is a horizontal menu with categories: Latest news, About us, Standards and drafts, Business domains, Conformity assessment, Members, Work area, and News. The main content area is divided into three columns:

- Latest news:**
  - Networking - April edition: [Interview with Commissioner Verheugen](#)
  - [Project Team on buffers and draw gear for rolling stock](#): Kick-off meeting on 30 May - 1 June 2005, Brussels
  - [CEN Workshop 24 - Risk based inspection and maintenance procedures for European industry](#): Kick-off meeting on 30 June 2005, Gdansk
- Standards and drafts:**
  -  **Superairbus takes off with over 350 European Standards**
  - [Many components of the new Airbus are](#)
- Business domains:**
  -  **1<sup>st</sup> CEN-CENELEC Annual Meeting**
  - [6 - 9 June 2005 Budapest - Hungary](#)
- Members:**
  -  **From Brussels with love**
  - [Conserving Europe's cinema heritage with new standard on film indexing](#)



## RFID Standards Organizations (continued)

- Example CEN technical committees:

**Technical Committees, Workshops and other bodies**

----- Select Technical Committee -----

- CEN/TC 269 Shell and water-tube boilers
- CEN/TC 270 Internal combustion engines
- CEN/TC 271 Surface treatment equipment - Safety
- CEN/TC 274 Aircraft ground support equipment
- CEN/TC 275 Food analysis - Horizontal methods
- CEN/TC 276 Surface active agents
- CEN/TC 277 Suspended ceilings
- CEN/TC 278 Road transport and traffic telematics**
- CEN/TC 279 Value management - Value analysis, functional an[...]
- CEN/TC 280 Offshore containers
- CEN/TC 281 Appliances, solid fuels and firelighters for barb[...]
- CEN/TC 282 Installation and equipment for LNG
- CEN/TC 283 Precious metals - Applications in jewellery and [...]
- CEN/TC 284 Greenhouses
- CEN/TC 285 Non-active surgical implants
- CEN/TC 286 Liquefied petroleum gas equipment and accessories
- CEN/TC 287 Geographic Information
- CEN/TC 288 Execution of special geotechnical works
- CEN/TC 289 Leather
- CEN/TC 290 Dimensional and geometrical product specification[...]

## RFID Standards Organizations (continued)

- EPCGlobal: <http://www.epcglobalinc.org/index.html>



The screenshot shows a web browser window with the address bar containing <http://www.epcglobalinc.org/about/about.html>. The page features a header with the slogan "Right Partner. Right Now." and the EPCglobal logo. A navigation menu includes links for Home, About, Subscribe, Action Groups, Standards & Technology, Public Policy, News, and Contact Us. A search bar is present with the text "About EPCglobal".

**About EPCglobal**

- About the EPCglobal Network
- [Auto-ID Center Archives](#)
- [Board of Governors](#)
- [FAQs](#)

**About EPCglobal Inc**

**Overview**  
EPCglobal Inc is industry's trusted partner for driving the global adoption and implementation of the EPCglobal Network™ across industry sectors. Our mission is to make organizations more effective by enabling true visibility of information about items in the supply chain. To that end, EPCglobal develops and oversees standards for the EPCglobal Network™. Additionally, EPCglobal provides a global EPC™ number registry service for electronic product codes in the supply chain.

As a joint venture between GS1 and the Uniform Code Council® (UCC®), EPCglobal Inc leverages a nearly thirty-year heritage of successfully partnering with industry. EPCglobal is a neutral, consensus-based, not-for-profit standards organisation.

**EPCglobal Network**  
The EPCglobal Network is an enabling technology that will transform the global supply chain through a new, open global standard for real-time, automatic identification of items in the supply chain of any

# RFID Standards

# RFID Standards

- The following example general (pre-“revolution”) RFID standards are identified on the RFID.org web pages [1]:
  - JTC 1/SC 31 Automatic Identification and Data Capture Techniques
  - JTC 1/SC 17 Identification Cards and related devices
  - ISO TC 104 / SC 4 Identification and communication
  - ISO TC 23 / SC 19 Agricultural electronics
  - CEN TC 278 Road Transport and Traffic Telematics
  - CEN TC 23/SC 3/WG 3 Transportable Gas Cylinders - Operational Requirements - Identification of cylinders and contents

## RFID Standards (continued)

- The following standards pertain to the growing interest in RFID for the supply chain:

EPCglobal specifications and standards:

[http://www.epcglobalinc.org/standards\\_technology/specifications.html](http://www.epcglobalinc.org/standards_technology/specifications.html)

SC31 standards related to RFID in the supply chain:

[http://www.hightechaid.com/standards/RFID\\_Standards\\_SC31.htm](http://www.hightechaid.com/standards/RFID_Standards_SC31.htm)

ISO 18000 air interface standards:

<http://www.hightechaid.com/standards/18000.htm>



## RFID Standards (continued)

### Evolution of EPCglobal RFID tag classes [4]

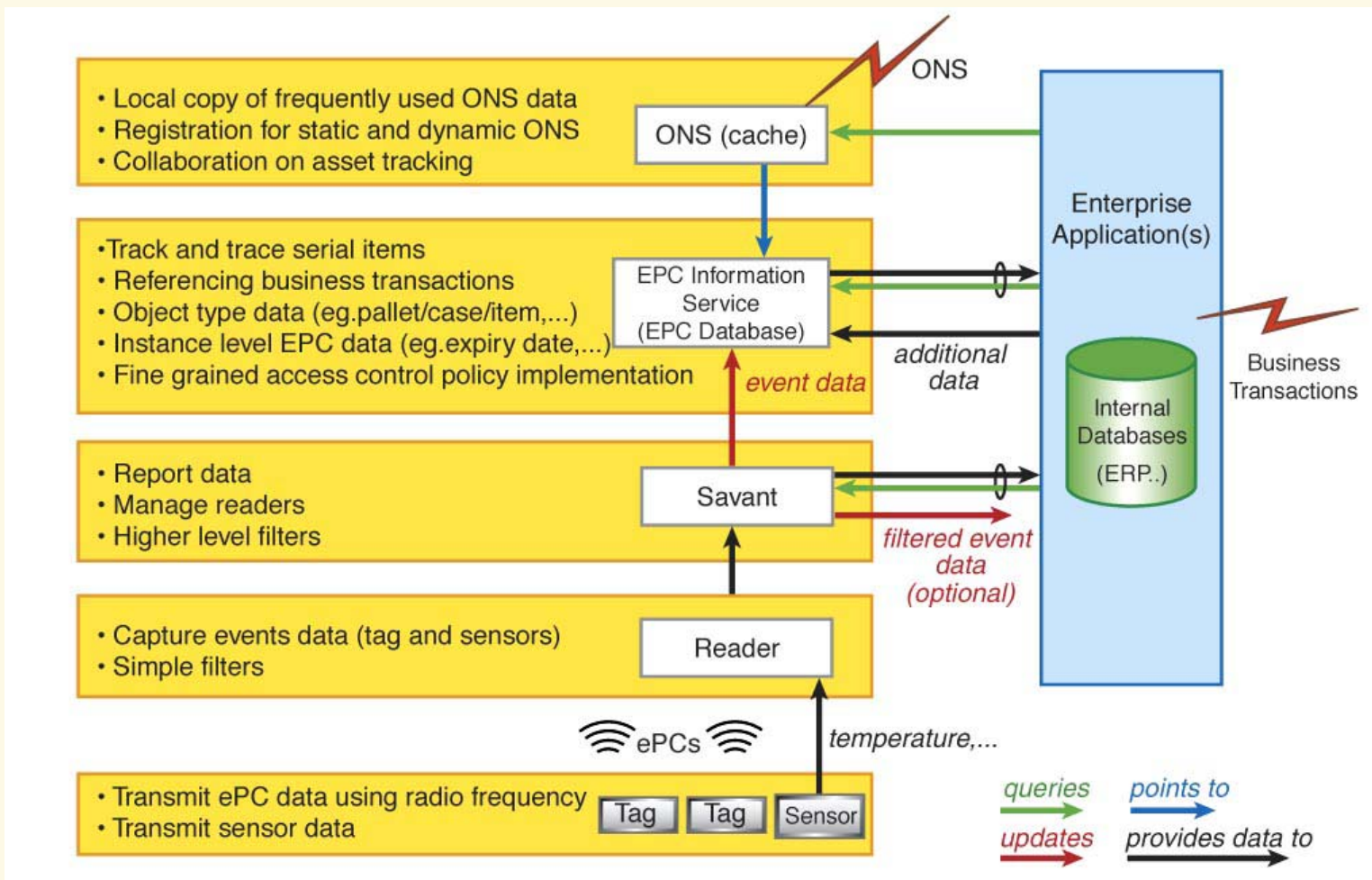
- Class 0: passive, UHF, factory programmed (preset)—associated arbitrarily with an item or pallet through a computer.
  - Well-suited to anti-theft, where serial number is not important.
- Class 0+: Class 0 with write-once read-many (WORM) capability.
- Class 1: passive, UHF or HF, WORM structure, field programmable.
- UHF Gen 2 of Class 1: passive, UHF, read/write.



## RFID Standards (continued)

- In its Draft EPC specifications, EPCglobal has developed a suite of standards for not only RFID devices, but also the networking required to use the data.
- The architecture envisioned by the EPC standards has a layered structure similar to other distributed database networks, with the following components:
  - Readers that detect when tags enter their read range and that possibly interrogate tags/sensors.
  - “Savant” middleware, software that processes tag/sensor data from one or more readers—filtering, aggregation, prior to forwarding the data to Enterprise Applications.
  - EPC information service, a database server for information on tags.
  - Object name server (ONS) and cache for looking up EPCs.

# EPCglobal Standards (continued)



## EPCglobal Standards (continued)

- The draft EPCglobal specifications include the following [6]:
  - *EPC Tag Data*: identifies the specific encoding schemes for a serialized version of the EAN.UCC **Global Trade Item Number**, **Serial Shipping Container Code**, **Global Location Number**, **Global Returnable Asset Identifier**, **Global Individual Asset Identifier**, and a General Identifier (GID).
  - *Communication interfaces and protocols for 900 MHz Class 0, 13.56 MHz ISM Band Class 1, and 860-930 MHz Class 1 RFID tags*.
  - *Reader Protocol*: defines the communications messaging and protocol between tag readers and EPC compliant software applications, including Savant.
  - *Savant and ONS services*.
  - *Physical Markup Language (PML) Core Specification, Extensible Markup Language (XML) Schema and Instance Files*: establishes a common vocabulary set to be used within the EPCglobal Network and provides a standardized format for data captured by readers; this specification also includes XML Schema and Instance files for reference.

## EPCglobal Standards (continued)

Also, EPCglobal has ratified a standard for physical and logical requirements for a Class 1 “Gen 2” RFID system:

- Passive-backscatter tag
- Interrogator-talks-first (ITF) protocol
- 860 MHz - 960 MHz frequency range

## EPCglobal and ISO:

- The intention of EPCglobal is for its specifications to become ISO standards, and the EPCglobal documents parallel those of ISO.
- The ISO has approved the concept of adding additional modes to its 18000 tag standards that will incorporate the EPCglobal versions.

## RFID Standards (continued)

### ISO has published its 18000 series of RFID standards:

ISO/IEC 18000-1:2004 Information technology -- Radio frequency identification for item management -- Part 1: Reference architecture and definition of parameters to be standardized

ISO/IEC 18000-2:2004 Information technology -- Radio frequency identification for item management -- Part 2: Parameters for air interface communications below 135 kHz

ISO/IEC 18000-3:2004 Information technology -- Radio frequency identification for item management -- Part 3: Parameters for air interface communications at 13.56 MHz

ISO/IEC 18000-4:2004 Information technology -- Radio frequency identification for item management -- Part 4: Parameters for air interface communications at 2.5 GHz

ISO/IEC 18000-6:2004 Information technology -- Radio frequency identification for item management -- Part 6: Parameters for air interface communications at 860 MHz to 960 MHz

ISO/IEC 18000-7:2004 Information technology -- Radio frequency identification for item management -- Part 7: Parameters for active air interface communications at 433 MHz



## Highlights from the ISO 18000 Standards

- 18000-2 – Parameters for Air Interface Communications below 135 kHz
  - Scope: specifies the physical layer for communication between the interrogator and tags of Type A (FDX) and Type B (HDX), the protocol and commands, and the method to detect and communicate with one tag among several tags (“anti-collision”).
  - *Tags*: FDX tags operate at 125kHz and are permanently powered by the interrogator, including during the tag-to-interrogator transmission. HDX tags operate at 134.2kHz and are powered by the interrogator except during the tag-to-interrogator transmission.



## ISO 18000 RFID Standards (continued)

- 18000-3 – Parameters for Air Interface Communications at 13.56 MHz
  - *Scope:* Physical Layer, Collision management System and Protocol Values.
  - *Modes:* Two proprietary, non-contending modes are defined.
    - In Mode 1, the Interrogator to Tag data rate is 1.65 kbps or 26.48 kbps, and the Tag to Interrogator data rate is 26.48 kbps; the protocol extension has a precursor data rate ~ 52.97 kbps and a main reply data rate ~105.94 kbps.
    - In Mode 2, the Interrogator to Tag data rate is 423.75 kbps and the Tag to Interrogator data rate is 105.9375 kbps on each of 8 channels.

## ISO 18000 RFID Standards (continued)

- 18000-4 – Parameters for Air Interface Communications at 2.45 GHz
- *Scope:* supports a standard API and standard air interface implementations for wireless, non-contact information system equipment in applications operating at ranges greater than 1 m.
- *Modes:*
  - Mode 1 is a passive backscatter RFID system employing either a single-frequency or frequency-hopping with one or more tags within the interrogation zone.
  - Mode 2 is a long range high data-rate RFID system using battery-assisted tags and offering a gross data rate up to 384 kbps at the air interface in case of a Read/Write (R/W) tag; in case of Read Only (R/O) tag the data rate is 76.8 kbps.

## ISO 18000 RFID Standards (continued)

- 18000-6 – Parameters for Air Interface Communications at 860 to 930 MHz
- Scope: describes the physical interactions between the interrogator and the tag, the protocols and commands, and the collision arbitration schemes.
- Types:
  - For the forward link, Type A uses pulse-interval encoding; Type B uses bi-phase modulation and Manchester encoding.
  - For collision arbitration, Type A uses an Aloha-based mechanism; Type B uses an adaptive binary tree mechanism.
  - Both types use bi-phase space (FM0) return link encoding.

## ISO 18000 RFID Standards (continued)

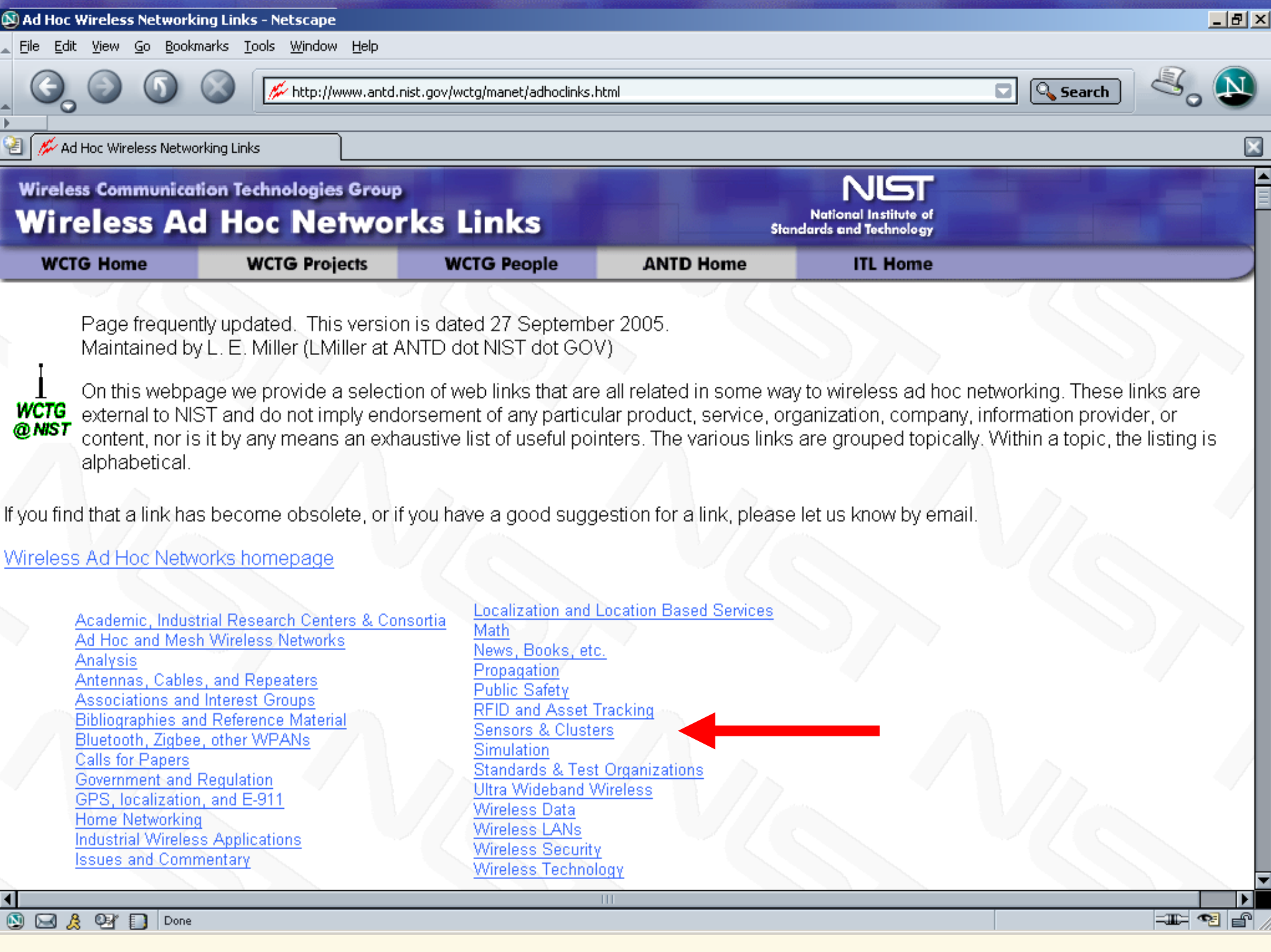
- 18000-7 – Parameters for Air Interface Communications at 433 MHz
- *Scope:* supports a standard API (ISO/IEC 18000-1) and standard air interface implementations for wireless, non-contact information system typical applications operation at ranges greater than one meter.
- One mode, long distance capability, active tag system

# References

1. AIM (RFID.org) website on RFID at <http://www.aimglobal.org/technologies/rfid/>
2. "The Future Is Here: A Beginner's Guide to RFID," on the RFID Gazette website: <http://www.rfidgazette.org/>
3. "Radio Frequency Identification: Opportunities and Challenges for Implementation," US DOC report, 2005.
4. R. Kleist, et al., *RFID Labeling*, Printronix, 2004.
5. "RFID in the Federal Government," GAO report 05-551, 2005.
6. EPCglobal standards and specifications web page at [http://www.epcglobalinc.org/standards\\_technology/specifications.html](http://www.epcglobalinc.org/standards_technology/specifications.html)
7. A. Estevez, 2004 RFID Summit for Industry, DoD Logistics Office, at <http://www.dodait.com/>
8. D. Kimball, "RFID Technology Primer," 2004 RFID Summit for Industry, DoD Logistics Office, at <http://www.dodait.com/>
9. Auto-ID Center, 900 MHz Class 0 RFID tag protocol specification, 2003
10. Auto-ID Center, 860-930 MHz Class 1 RFID interface specification, 2002

**For more information...**





Page frequently updated. This version is dated 27 September 2005.  
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