International Conference on Smart Objects & Ambient Intelligence

2005

state of art

in

RFID

Radio Frequency Identification

presented by Dominique PARET

PHILIPS SemiConductors

Emerging Business
Innovation & Systems
Automotive & Identification Markets
Technical Support Mgr

and more …

- PHILIPS SC representative in AFNOR & ISO WG for all « contactless applications » (SC 17 / SC 31 / TC 23 / …)

content

- *some technics*
- *some technology*
- *some market informations*

- *ISO standardization*
- *regulations* *(UIT, CEPT, FCC, ETSI, ART & C°)*
- *« human exposure »*

- *conclusions*

RFID – key words

- « physical laws »
- international & local « regulations »
    - powers, templates, duty cycliques, etc.
    - « WHO », EMC, safety, etc.
- « IP » (patents, licences, royalties)
- « standardization » and « conformance tests » to ISO, ETSI, FCC, etc.

- ... « costs » ;-)

some technics

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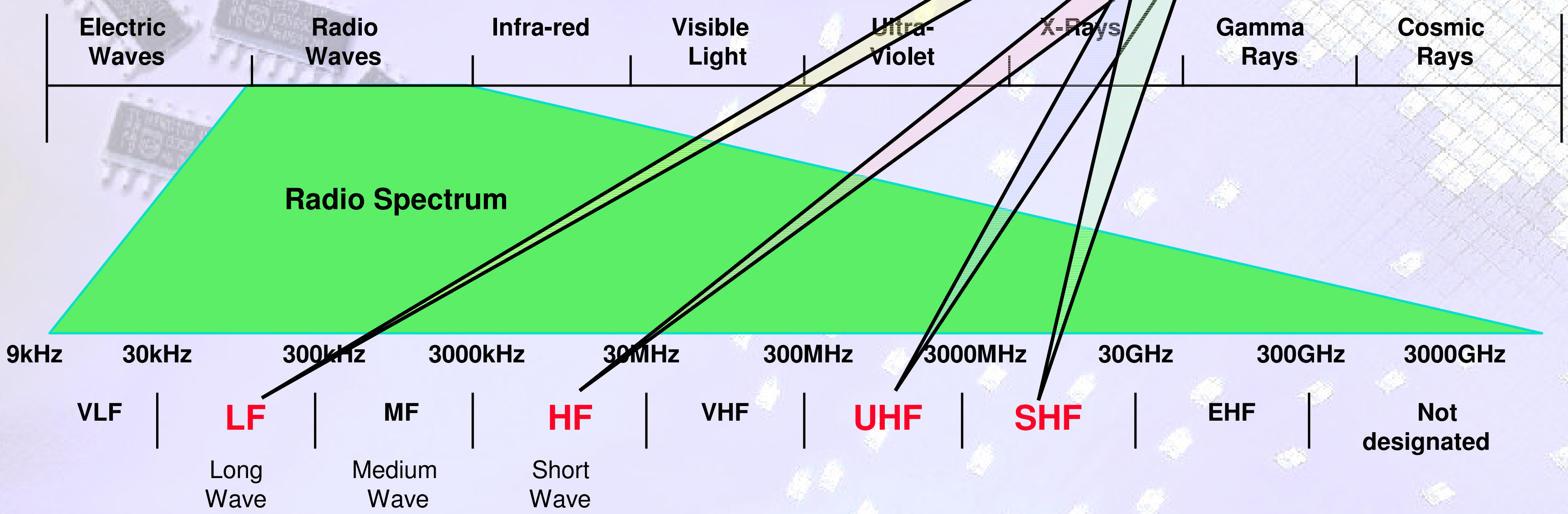
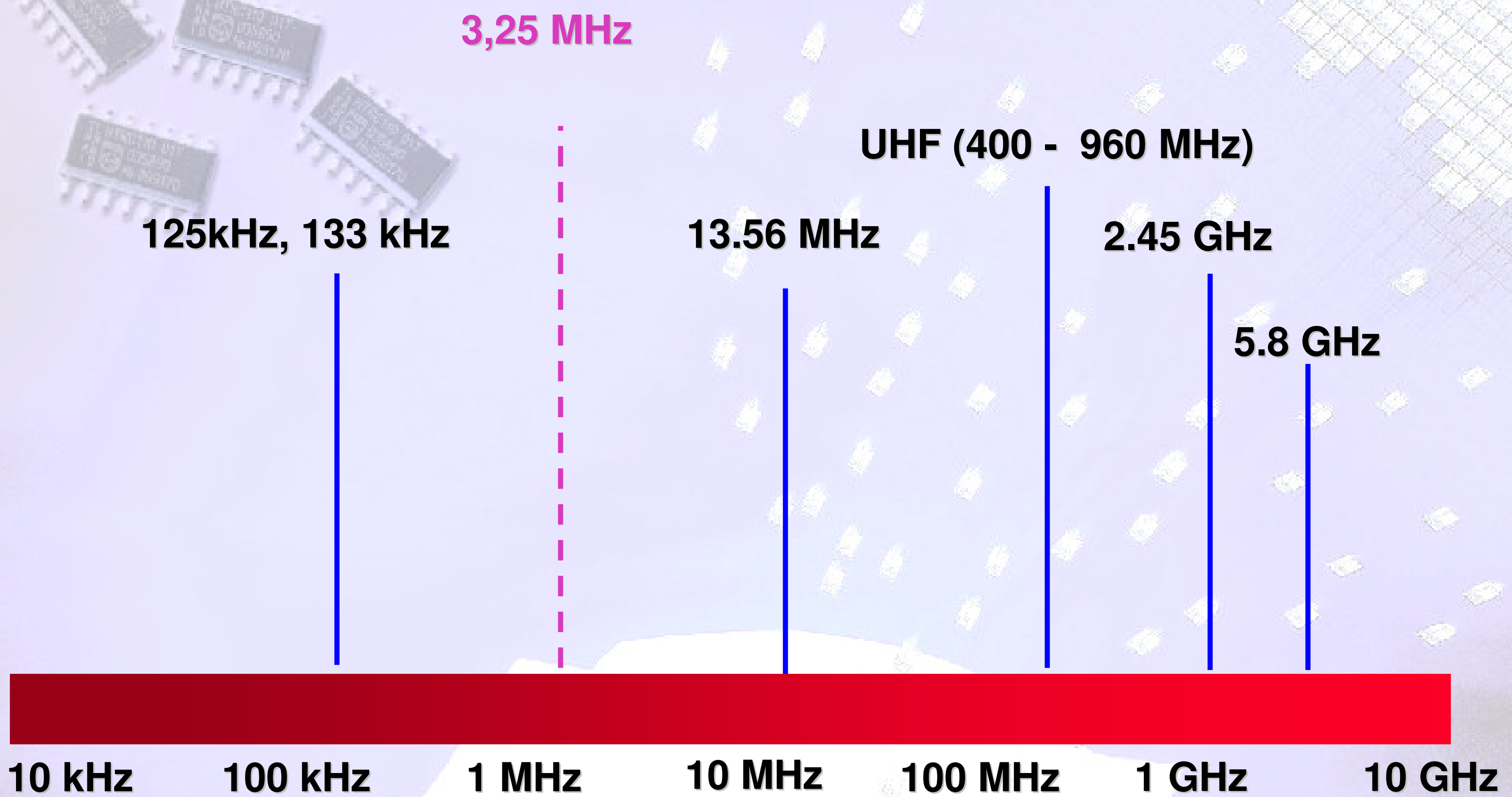
RF electromagnetic spectrum and RF ..ID



VLF	Very Low Frequency	VHF	Very High Frequency
LF	Low Frequency	UHF	Ultra High Frequency
MF	Medium Frequency	SHF	Super High Frequency
HF	High Frequency	EHF	Extremely High Frequency

RFID – available frequencies



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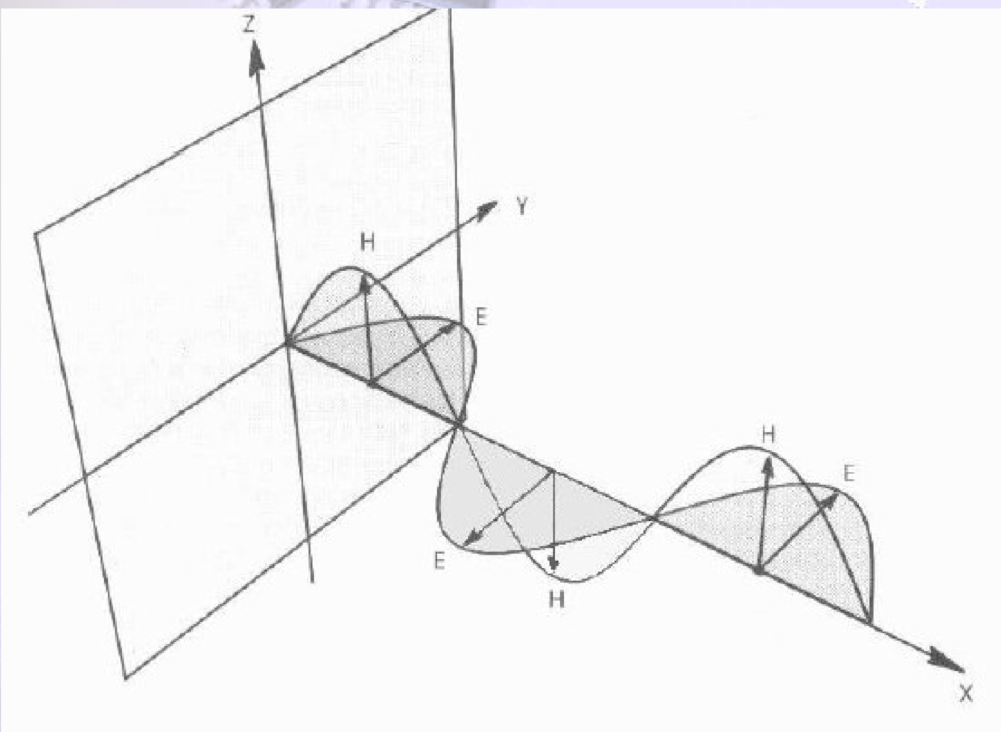
Physics



propagation

Wave length

Remote power

up link / down link

(via modulated signal)

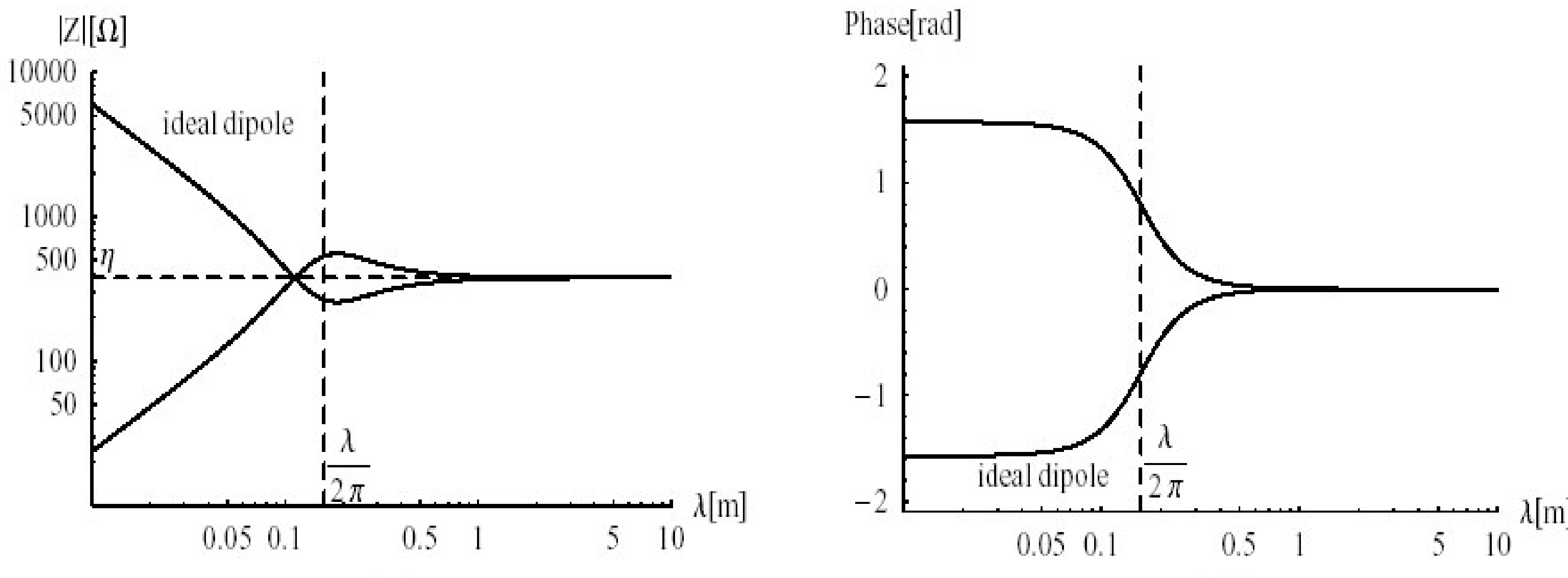
Maxwell equations

$$E_r = \left[-i \, \frac{2 \, I_o l \, \cos\theta}{4 \pi \varepsilon_0 \omega} \left(\frac{1}{r^3} + \frac{i k}{r^2} \right) \right] \times e^{i(\omega t - kr)}$$

$$E_\theta = \left[-i \, \frac{I_o l \, \sin\theta}{4 \pi \varepsilon_0 \omega} \left(\frac{1}{r^3} + \frac{i k}{r^2} - \frac{k^2}{r} \right) \right] \times e^{i(\omega t - kr)}$$

$$H_\varphi = \left[\frac{I_o l \, \sin\theta}{4 \pi} \left(\frac{1}{r^2} + \frac{i k}{r} \right) \right] \times e^{i(\omega t - kr)}$$

near field $r < \lambda / (2\pi)$
far field $r > \lambda / (2\pi)$



(a) (b)

relation between « f » and « λ » is wellknown :

$$\lambda = v / f = (3 \times 10^8) / f$$

« near filed » < $\lambda / (2\pi)$ < « far field »

(magnetic coupling) (propagation)

(Biot & Savart law) (Maxwell equations)

examples :

f = 150 kHz	λ = 2 km	« near field »
f = 10 MHz	λ = 30 m	« near field »
f = 900 MHz	λ = 33 cm	« far field »
f = 3 000 MHz = 3 GHz	λ = 10 cm	« far field »

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RFID

in

LF & HF

< 135 kHz & 13,56 MHz

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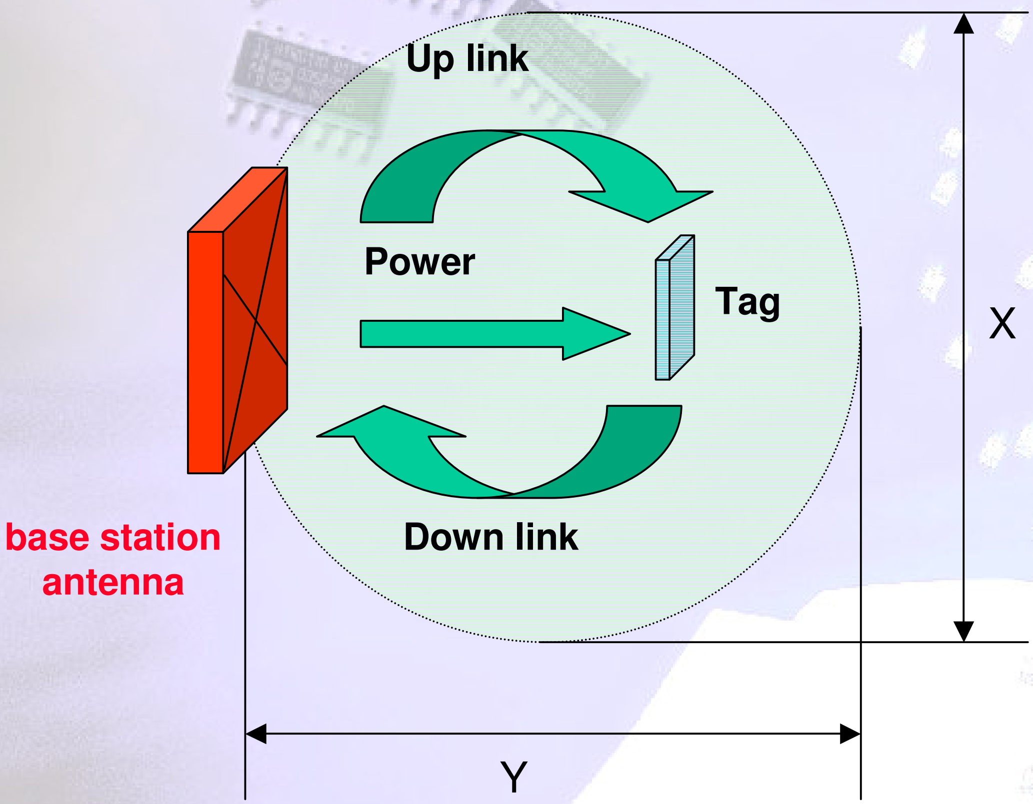
principle used in LF et HF frequencies < 135 kHz & 13,56 MHz



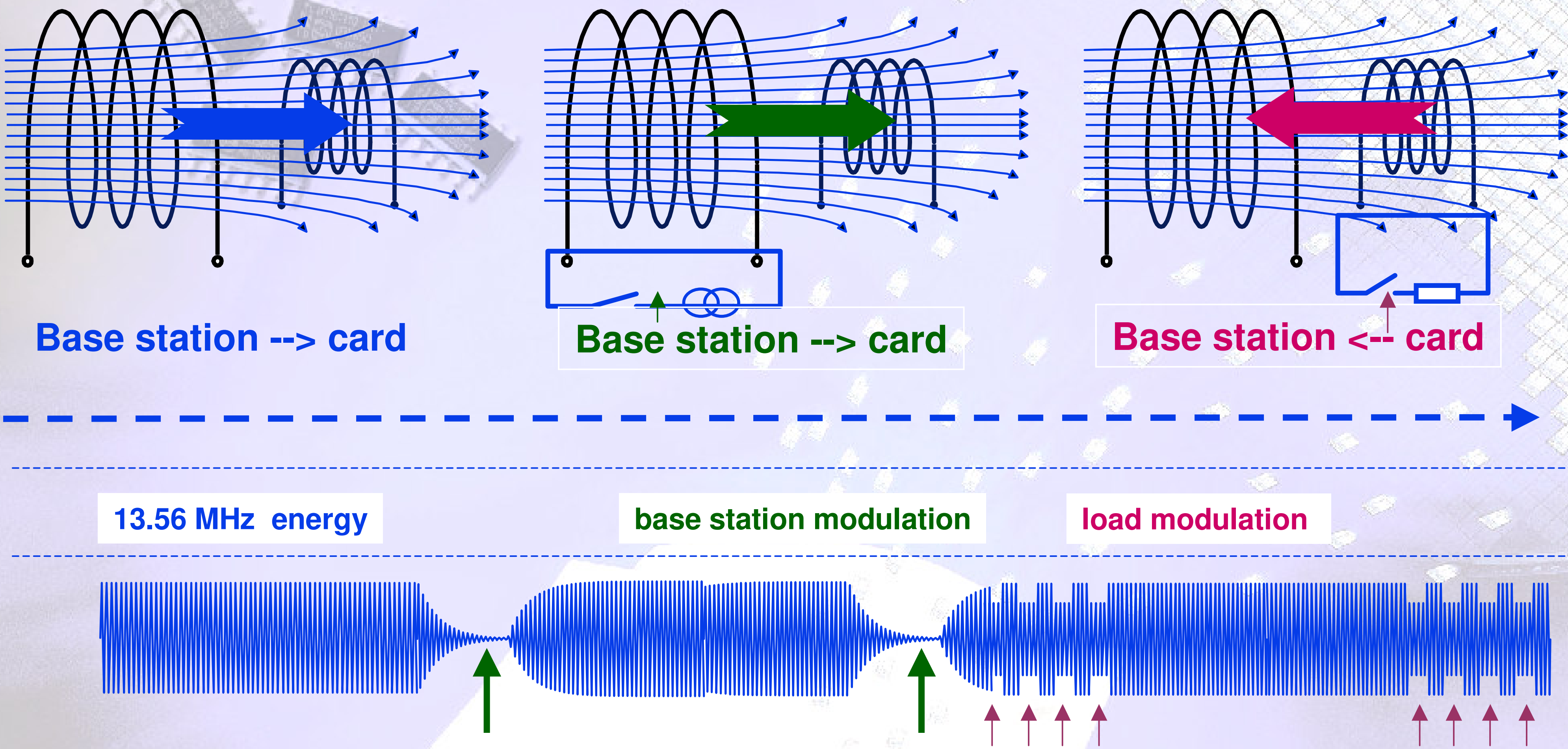
Magnetic field
« near field »

Remote supply (battery less)

Up link
From base station to transponder

Down link
from transponder to base station
(via load modulation)

principle in LF et HF
frequencies < 135 kHz & 13,56 MHz



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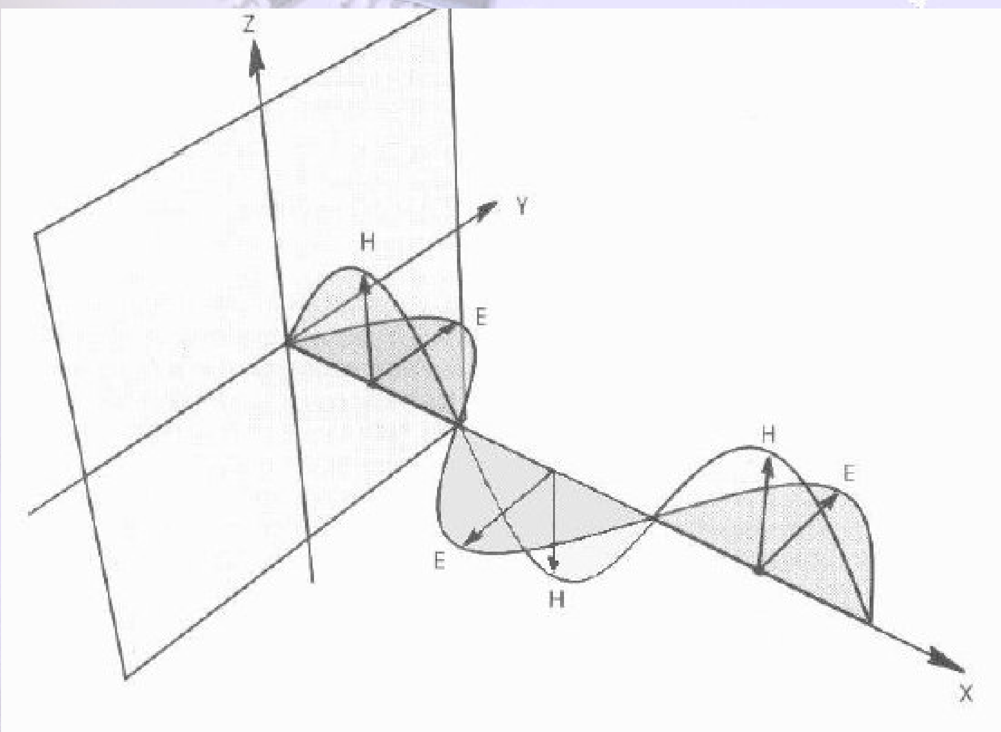
RFID

in

UHF & SHF

433 MHz, 860 / 960 MHz & 2,45 GHz

principle used in UHF et SHF
frequencies 433 , 860/960 MHz & 2,45 GHz



propagation

« far field »

Wave length

some cm

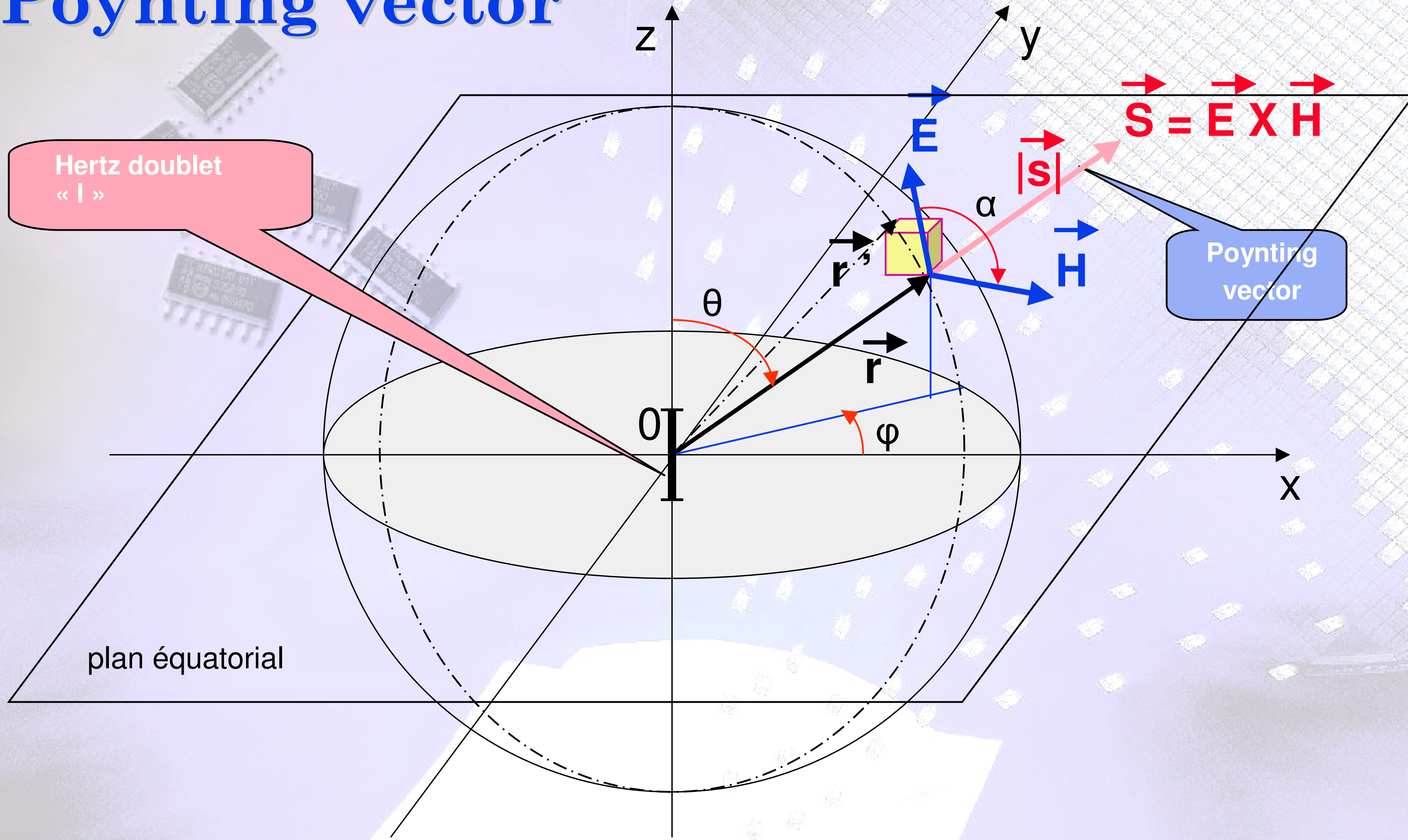
Battery less and battery assisted

down link

From transponder to base station

(via modulated backscattering)

Poynting vector



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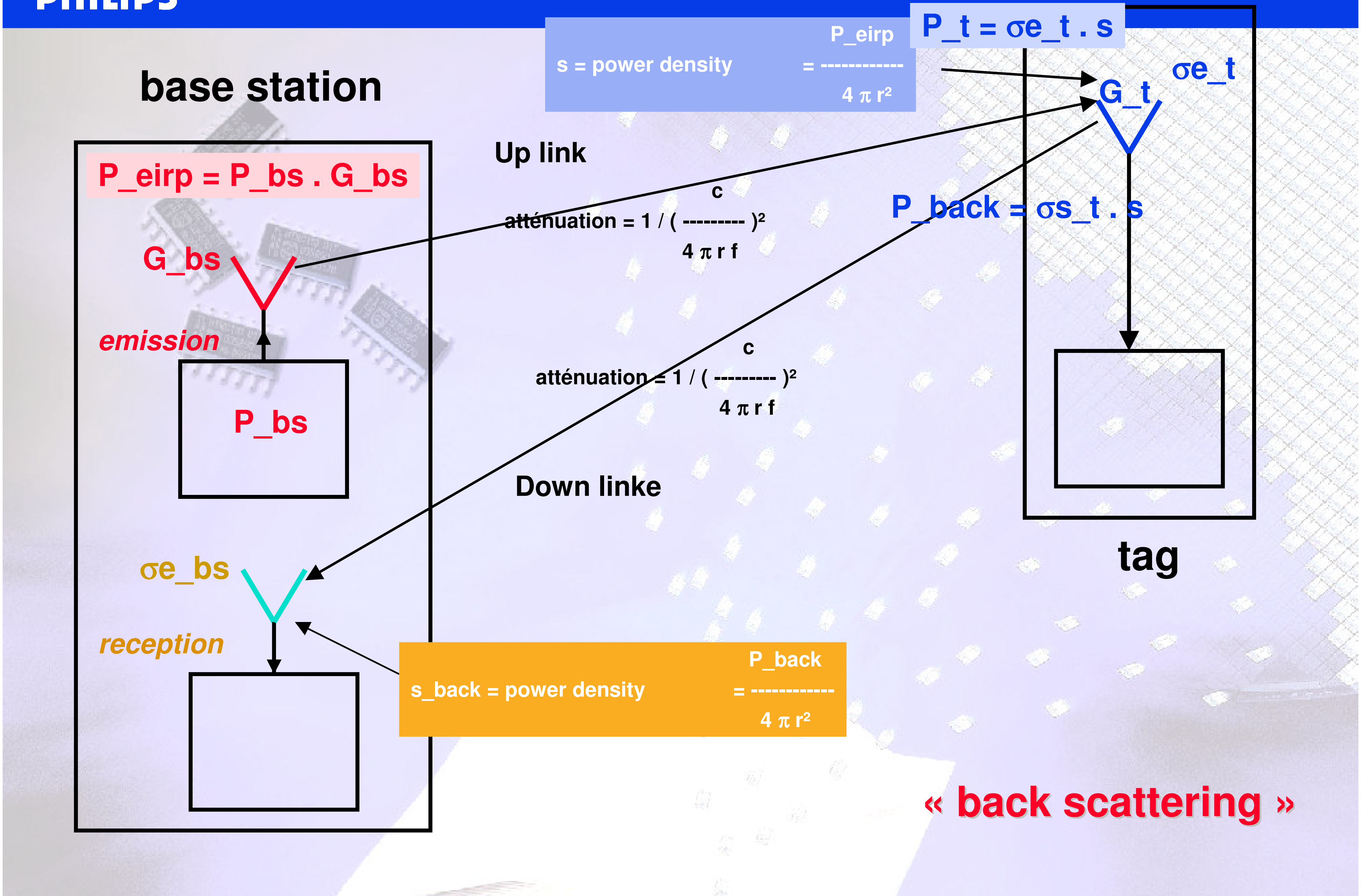
base station
P_eirp = P_bs . G_bs
G_bs
emission
P_bs
σe_bs
reception
s = power density = P_eirp / 4 π r²
P_t = σe_t . s
σe_t
G_t
Up link
atténuation = 1 / (c / 4 π r f)²
P_back = σs_t . s
atténuation = 1 / (c / 4 π r f)²
Down linke
tag
s_back = power density = P_back / 4 π r²
« back scattering »

environment

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environmental versus frequencies

	125 kHz	13.56 MHz	UHF	2.45 GHz
eau, humidité corps humain	↗	↗	→	↘
environment métallique	↗	→	↗	↗
caractéristiques des champs	↗	↗	→	↗
facilité de design de Tag	↗	↗	→	↘

performances versus frequencies

	125 kHz	13.56 MHz	UHF	2.45 GHz
data rate de communication	→	↗	↗	↗
plage / distance de fonctionnement	→	→	US ↗ EU →	→
vitesse de gestion des collisions	→	↗	↗	US ↗ EU ↘
fonctionnement continu (duty cyle)	↗	↗	US ↗ EU →	US ↗ EU ↘

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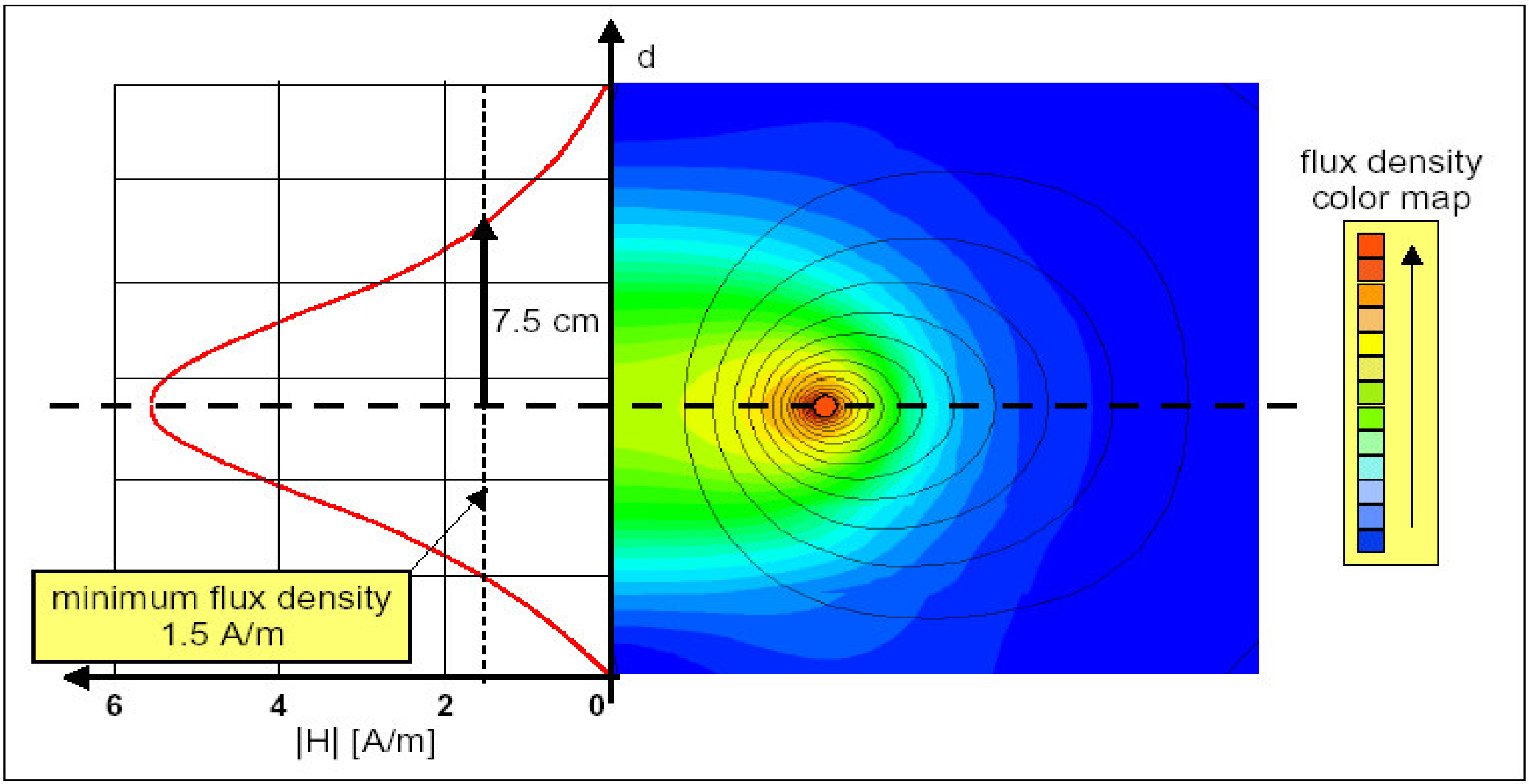
in the air, ... without screen



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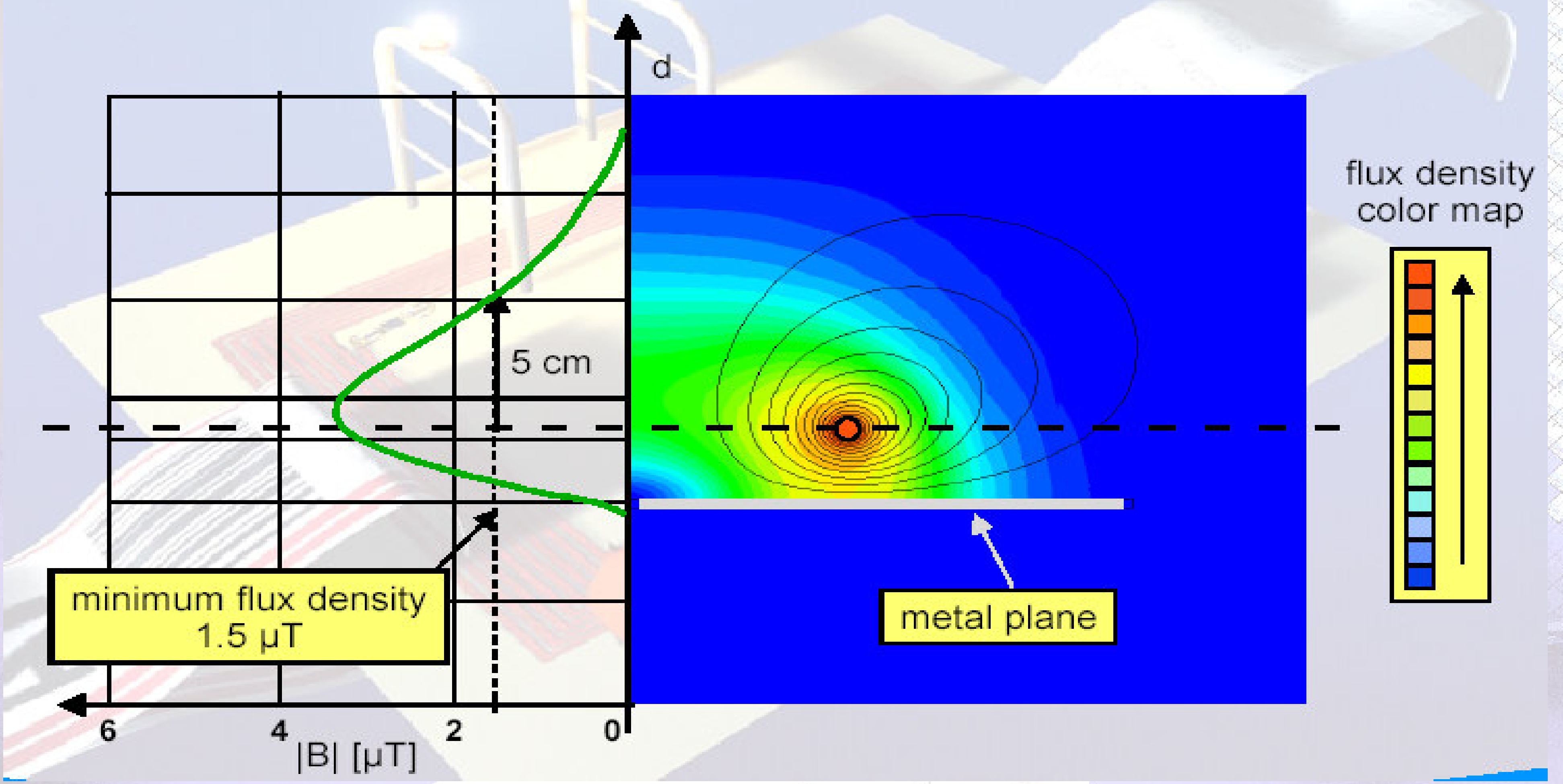
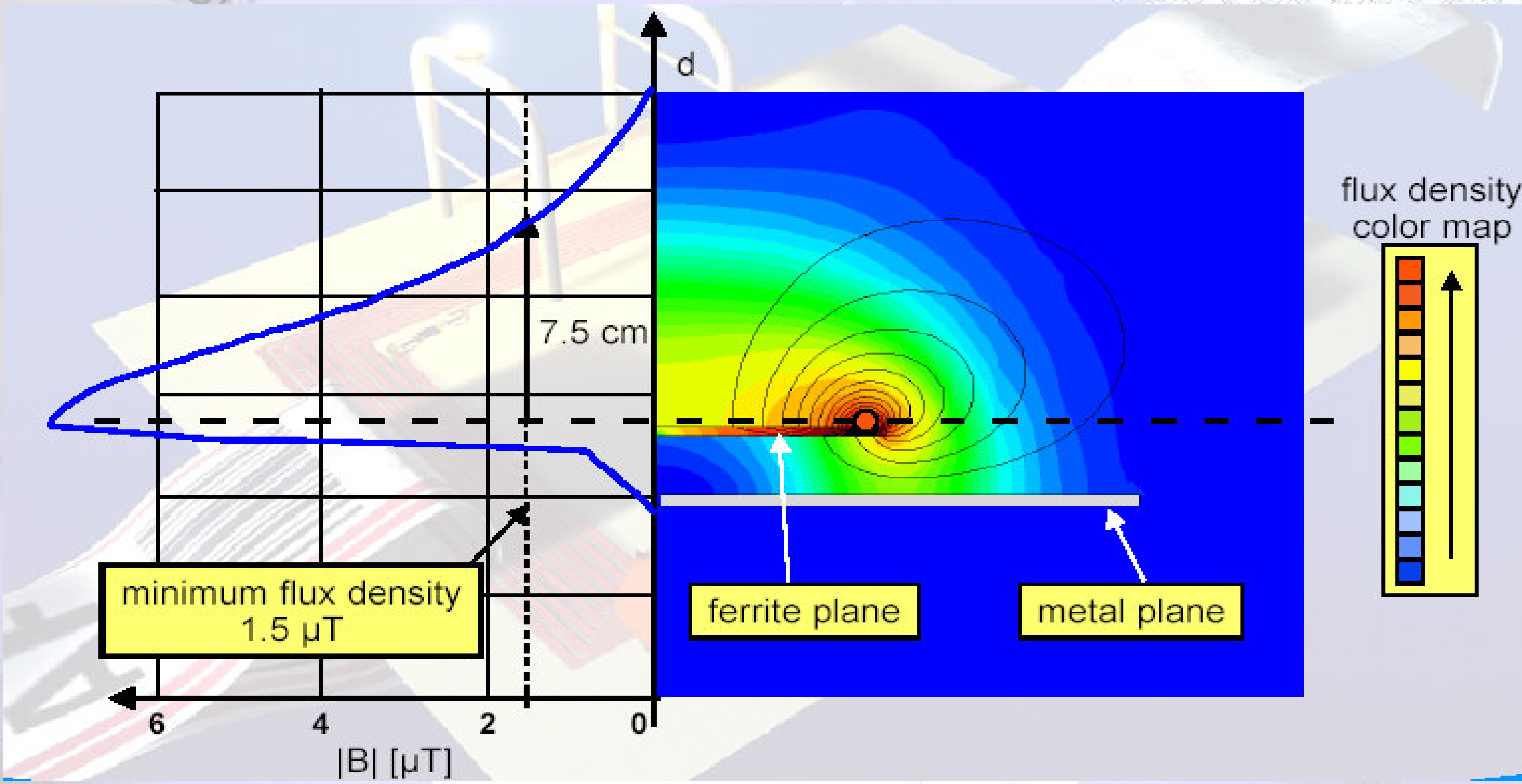
with metal shielding



with ferrite shielding



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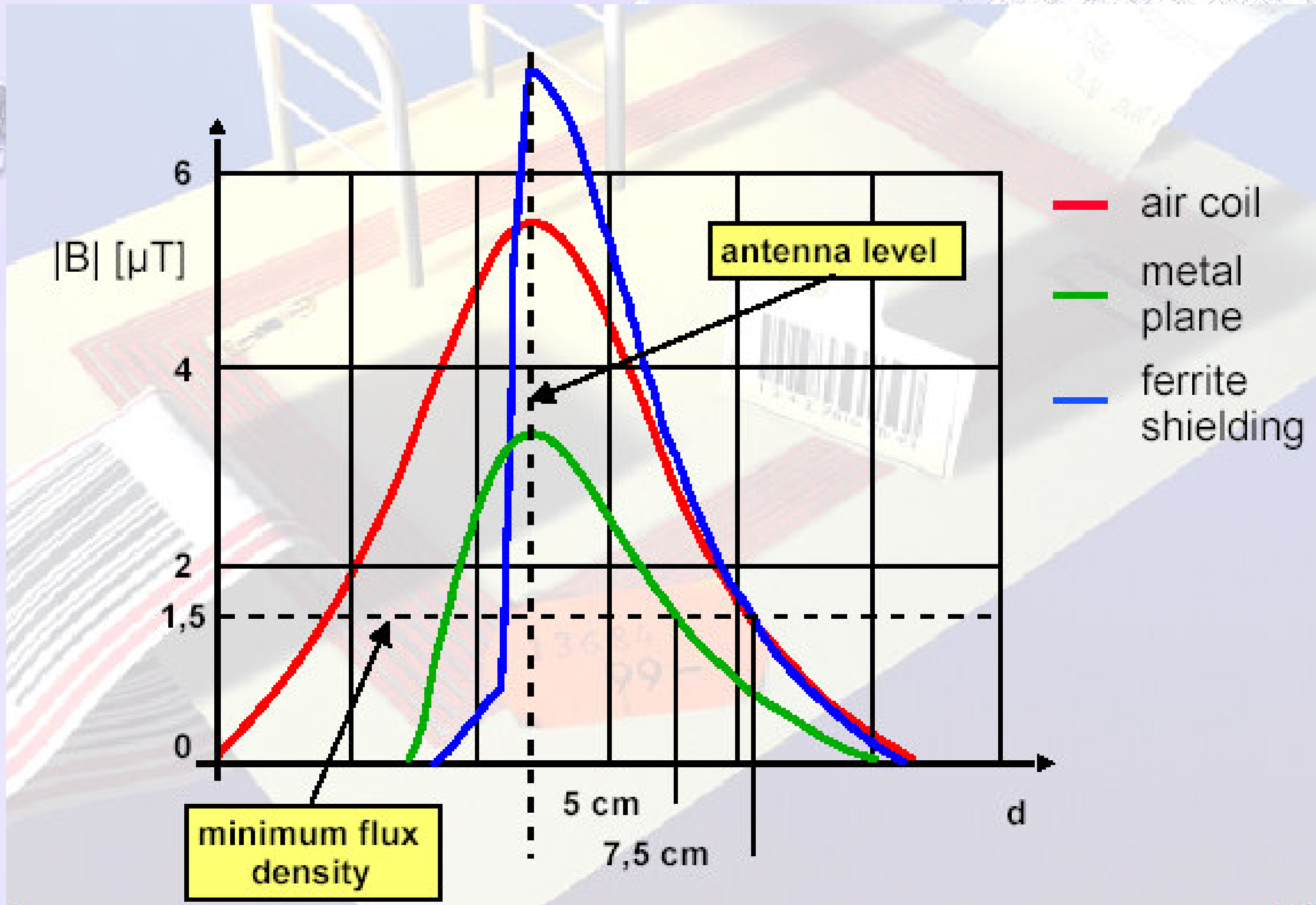
conclusion



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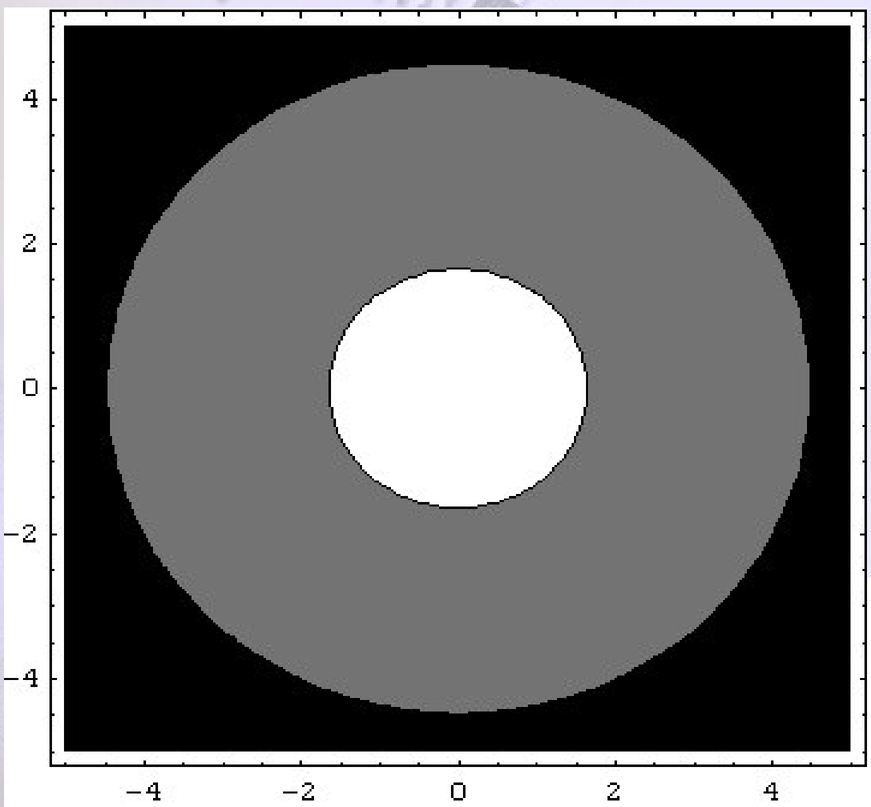
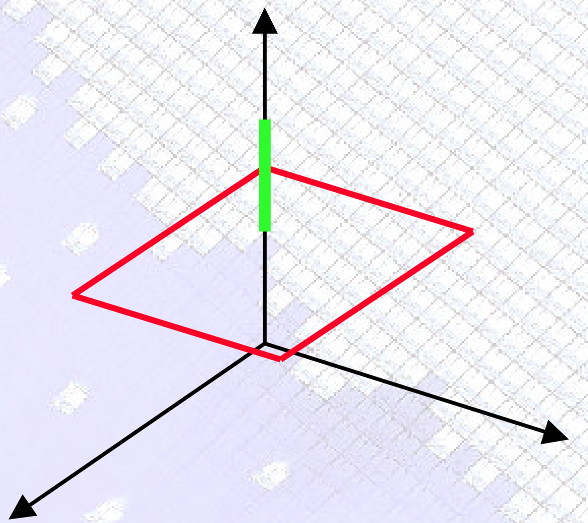
UHF- SHF
Environmetal Influence

Example 1/1

Propagation of traveling waves in free space





Idealized linear polarized dipole

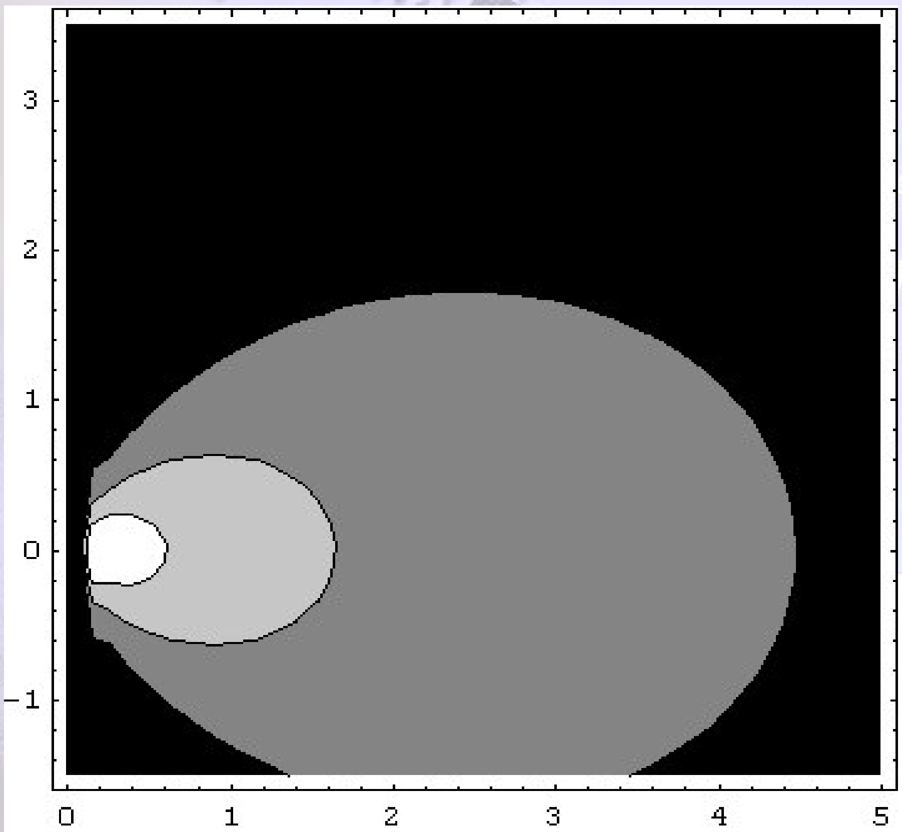
Polarisation: y - axes

Picture: xz - plane

UHF – SHF Environmetal Influence

Example 1/2

Propagation of traveling waves in free space



Idealized linear polarized dipole

Polarisation: y - axes

Picture: xy - plane

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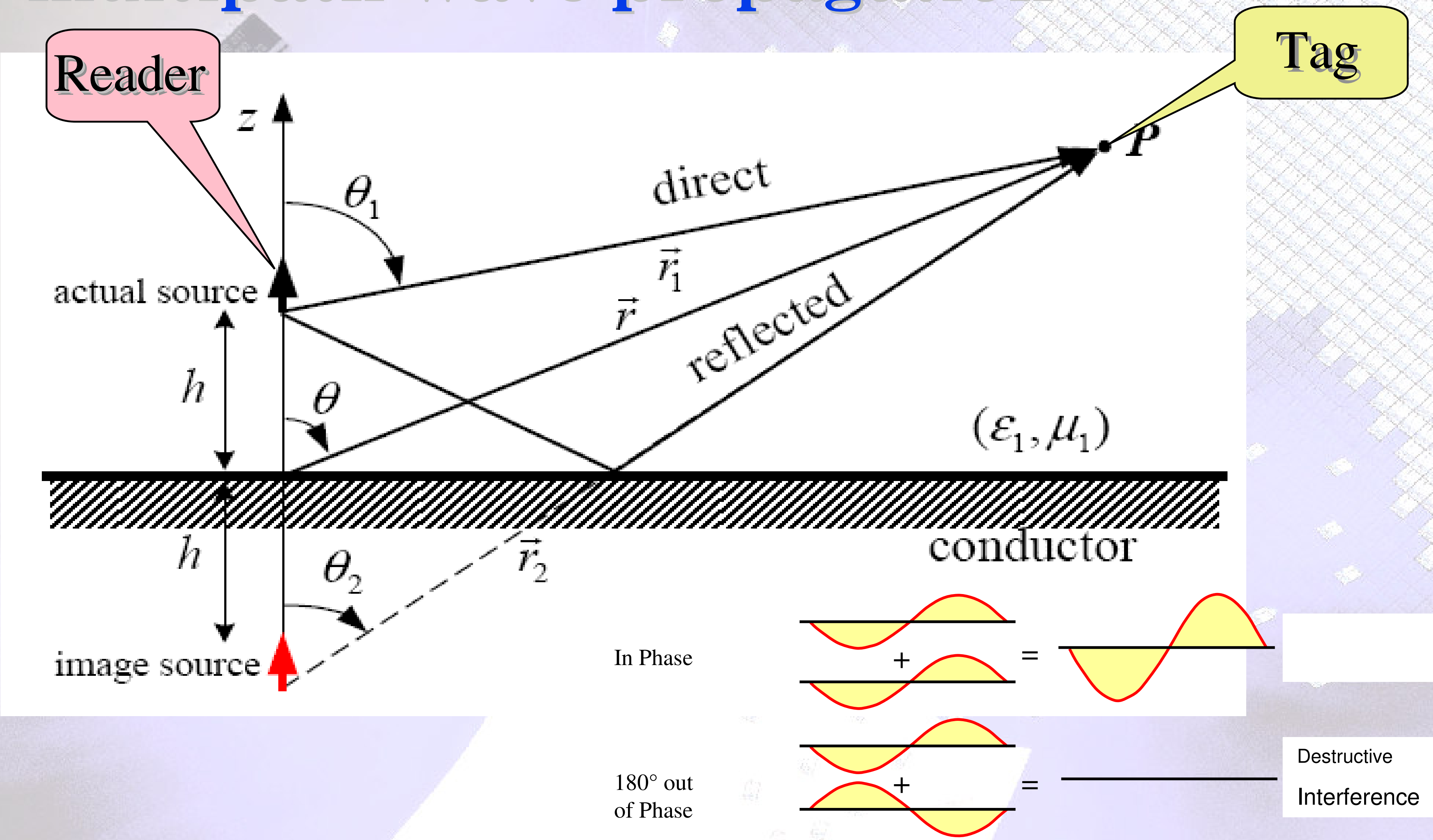
multipath wave propagation



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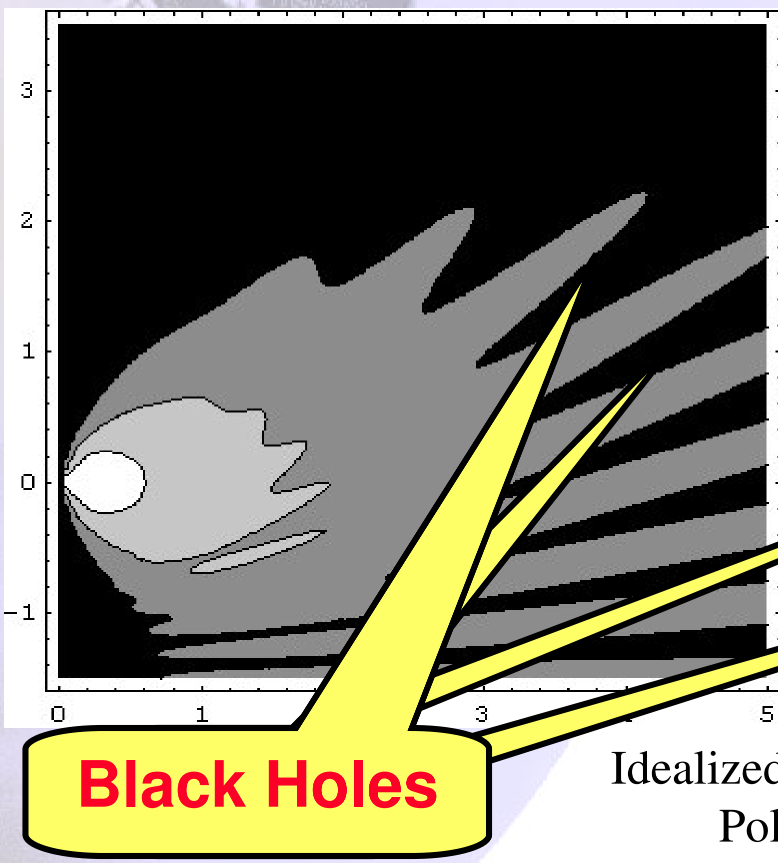
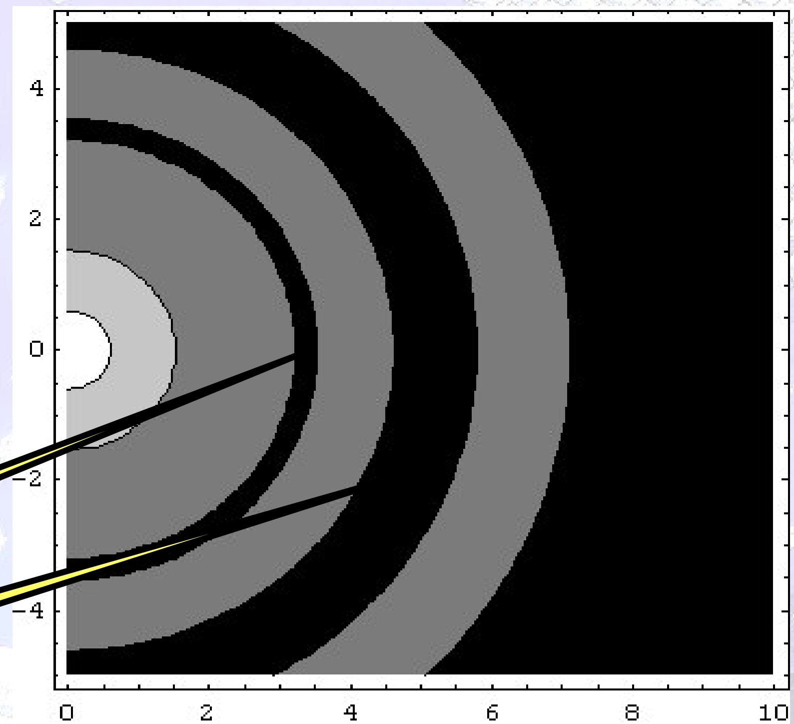
UHF – SHF
Environmetal Influence

Example 2/1

Propagation of traveling waves with reflecting floor





Idealized linear polarized dipole

Polarisation: y - axes

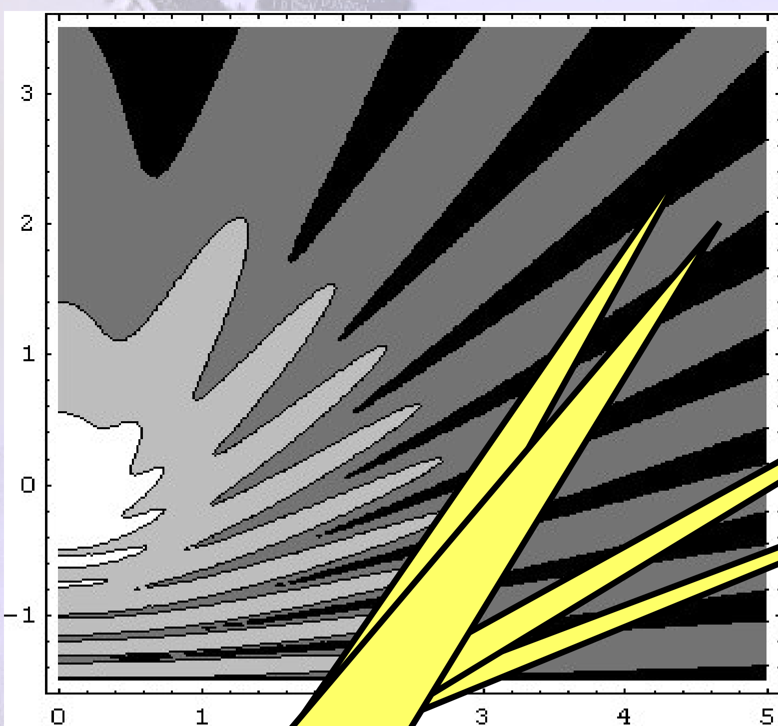
Picture left: xy - plane

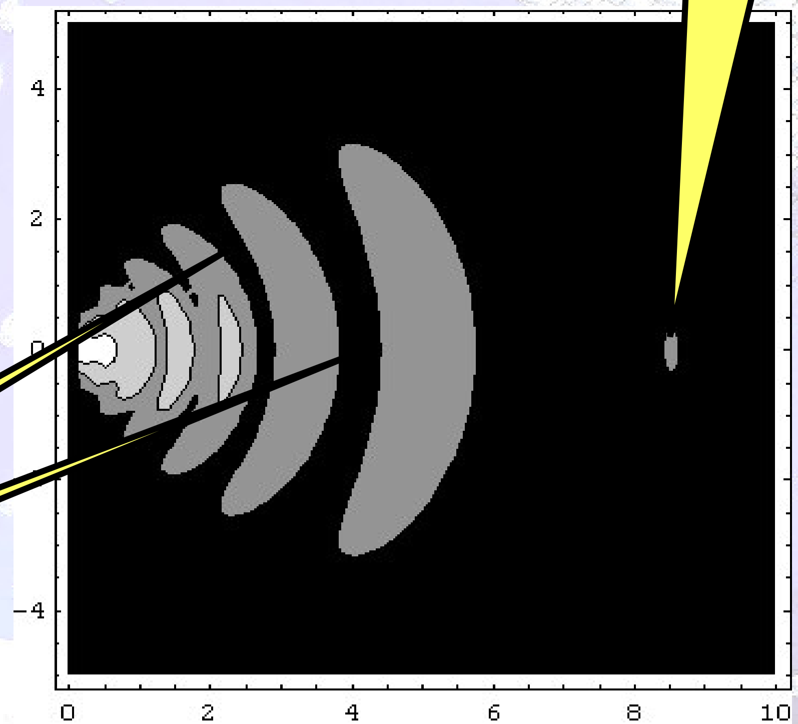
Picture right: xz - plane

UHF – SHF
Environmetal Influence

Example 2/2

Propagation of traveling waves with reflecting floor



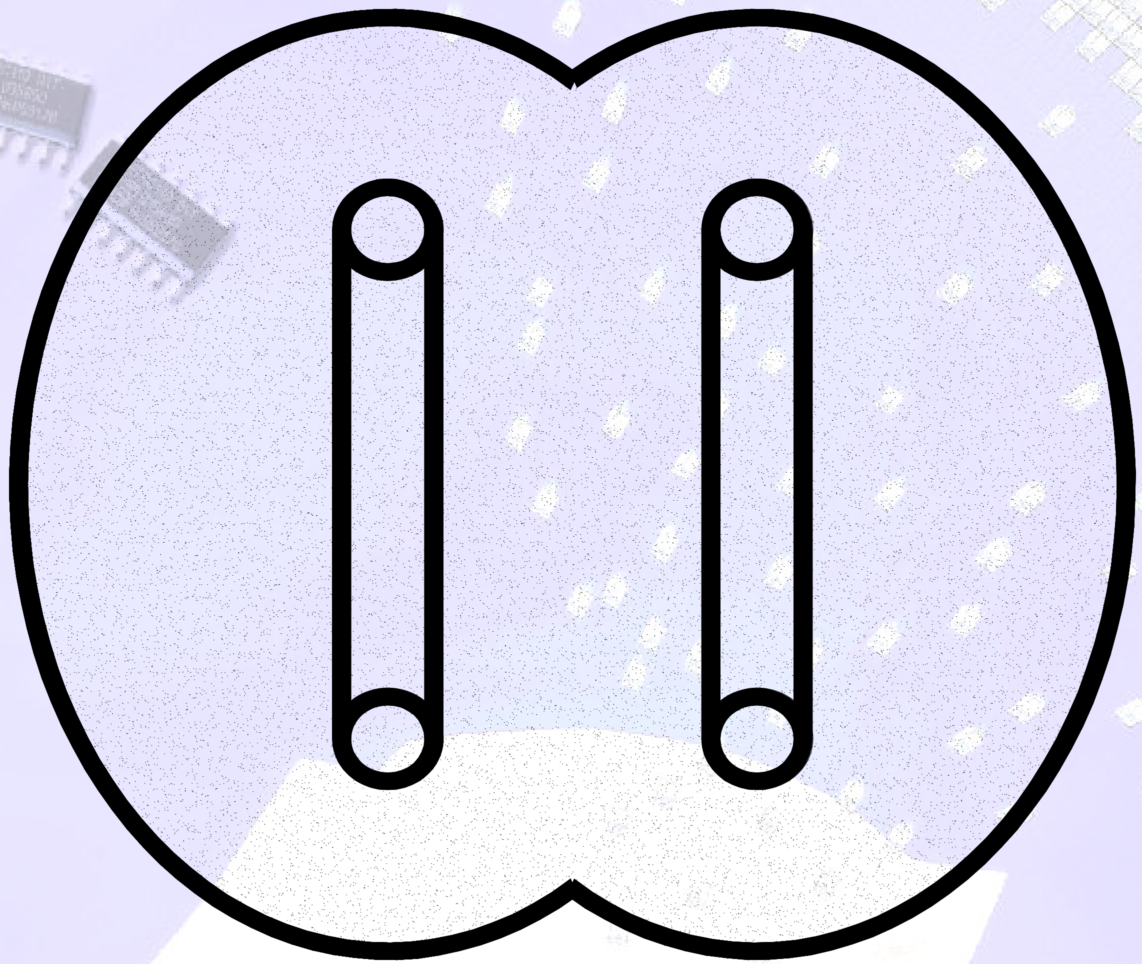


Idealized linear polarized dipole
Polarisation: x - axes

Picture left: xy - plane

Picture right: xz - plane

125 kHz / 13,56 MHz fields



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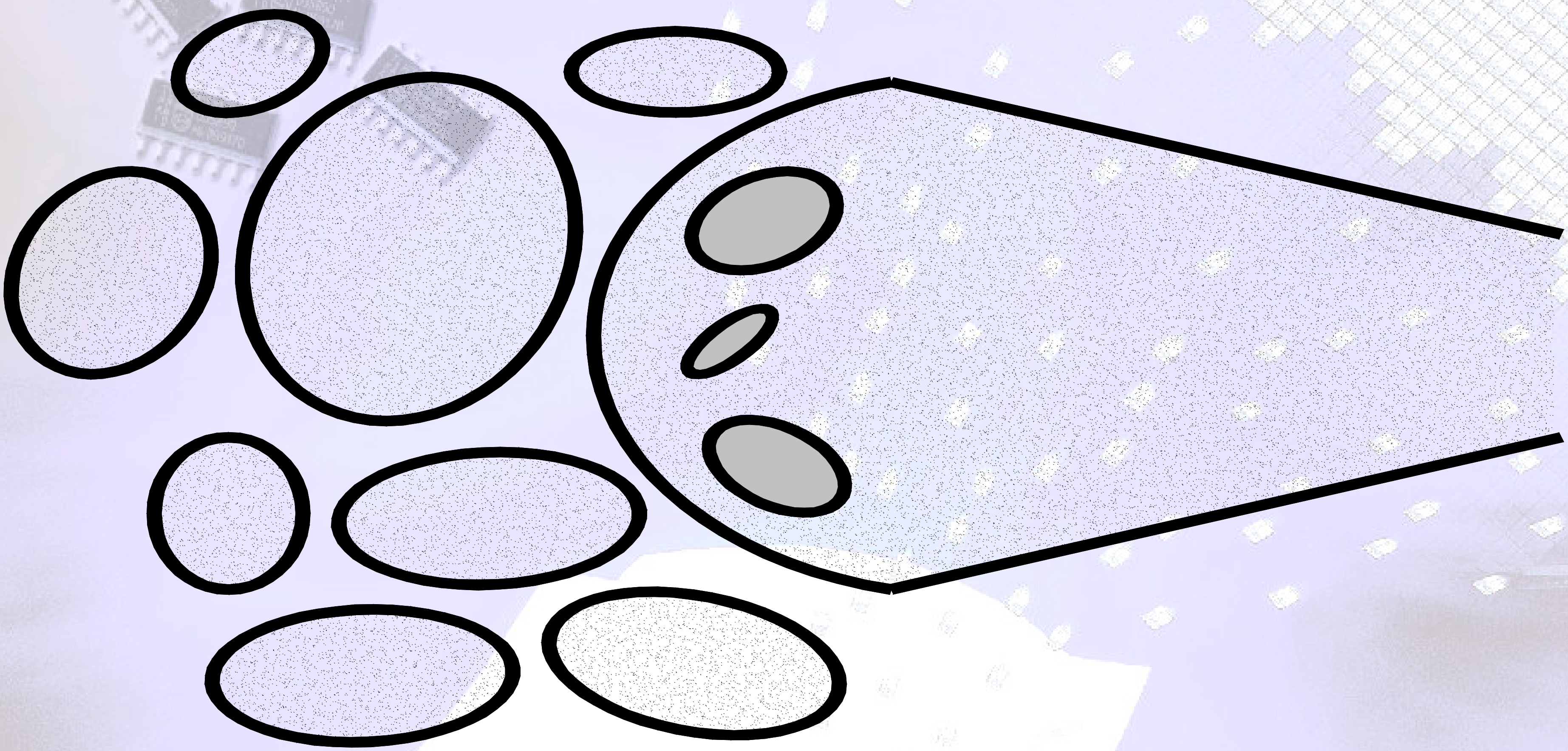
UHF / 2,45 GHz fields



final conclusion ...

Please do tests !!!

some vocabulary

« passif »,
« actif »,
« batteryless »,
« battery assisted »

… vocabulary and C°

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state of art - technology

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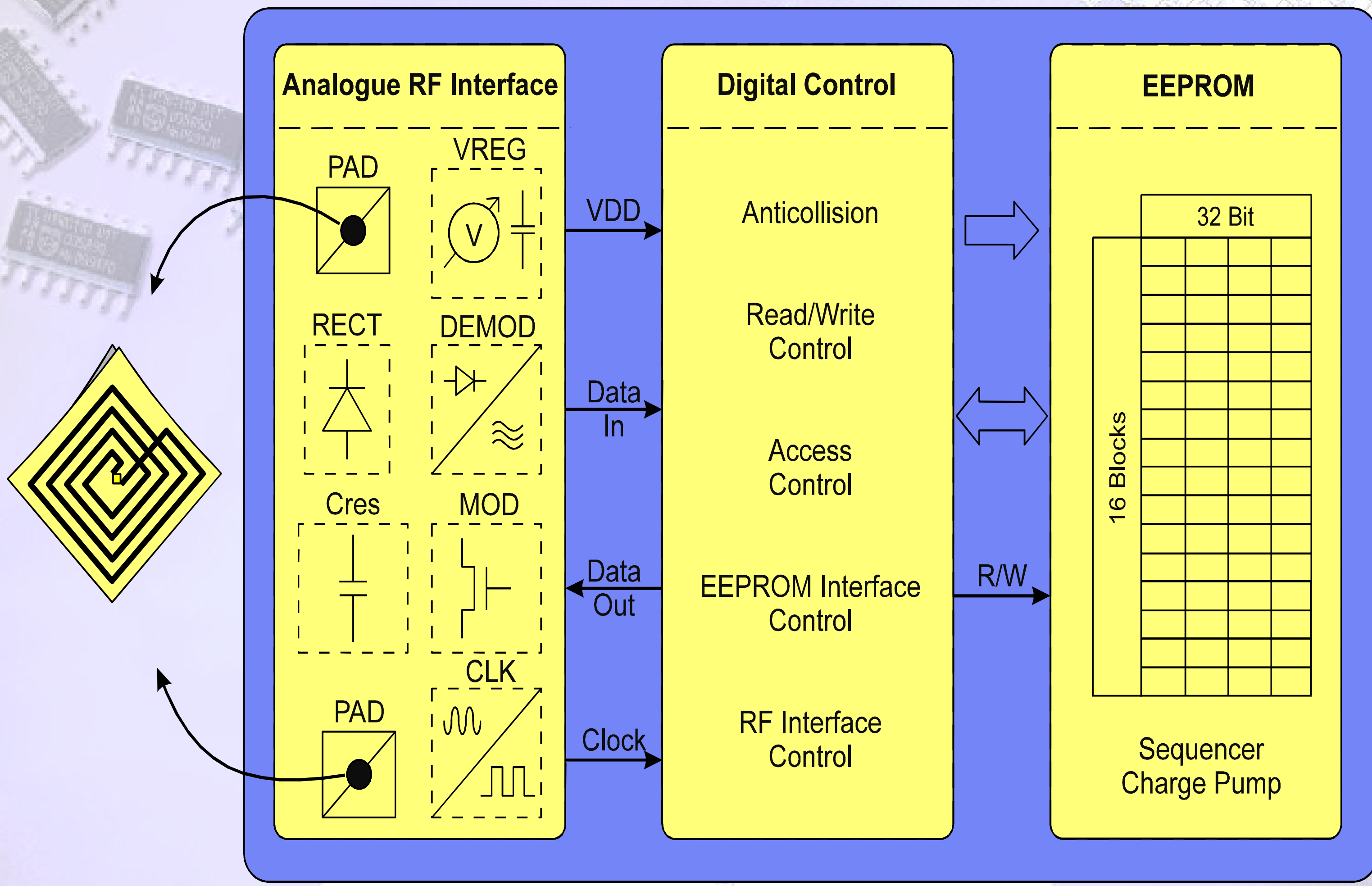
simple transponder



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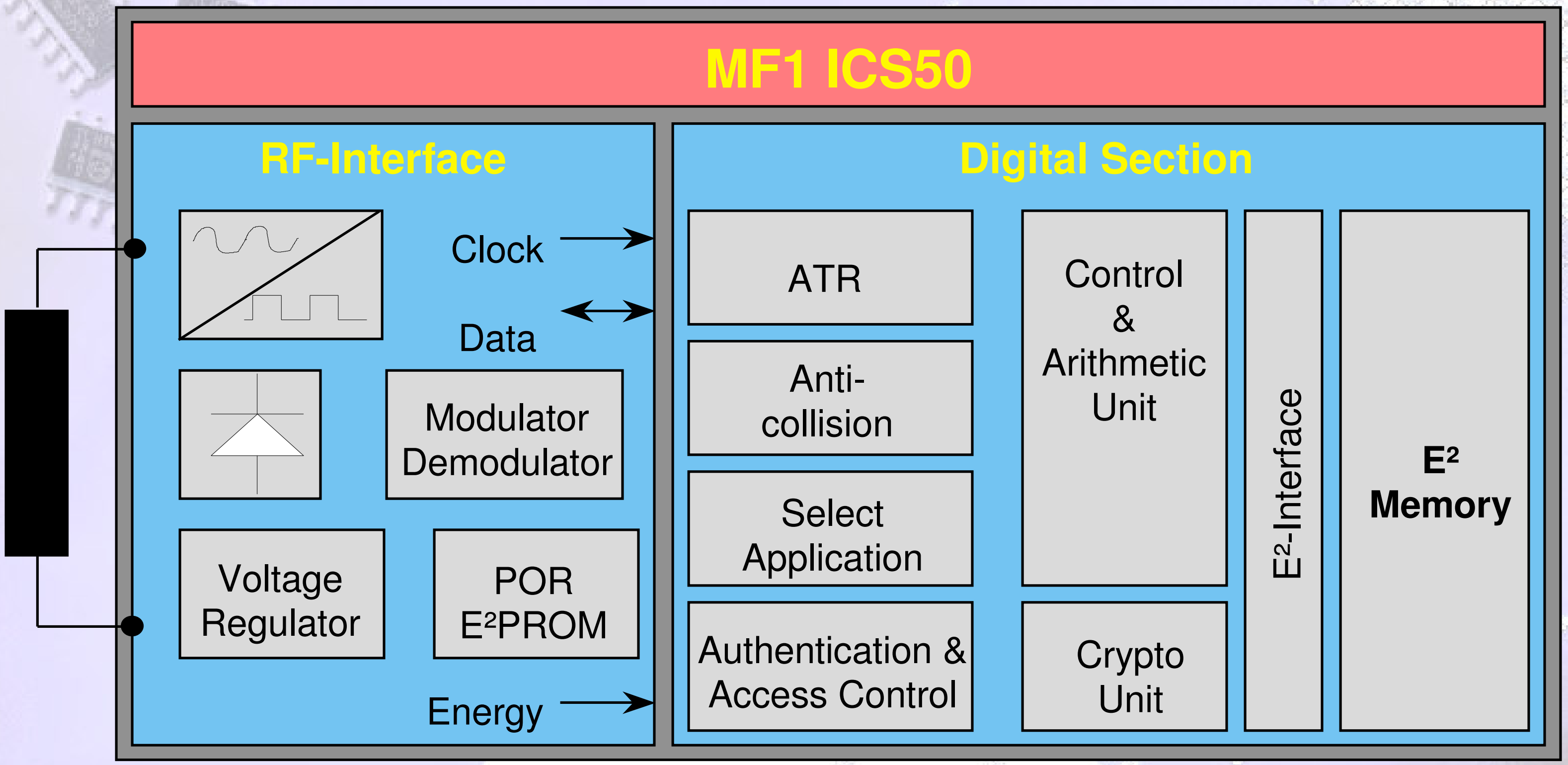
… evolution



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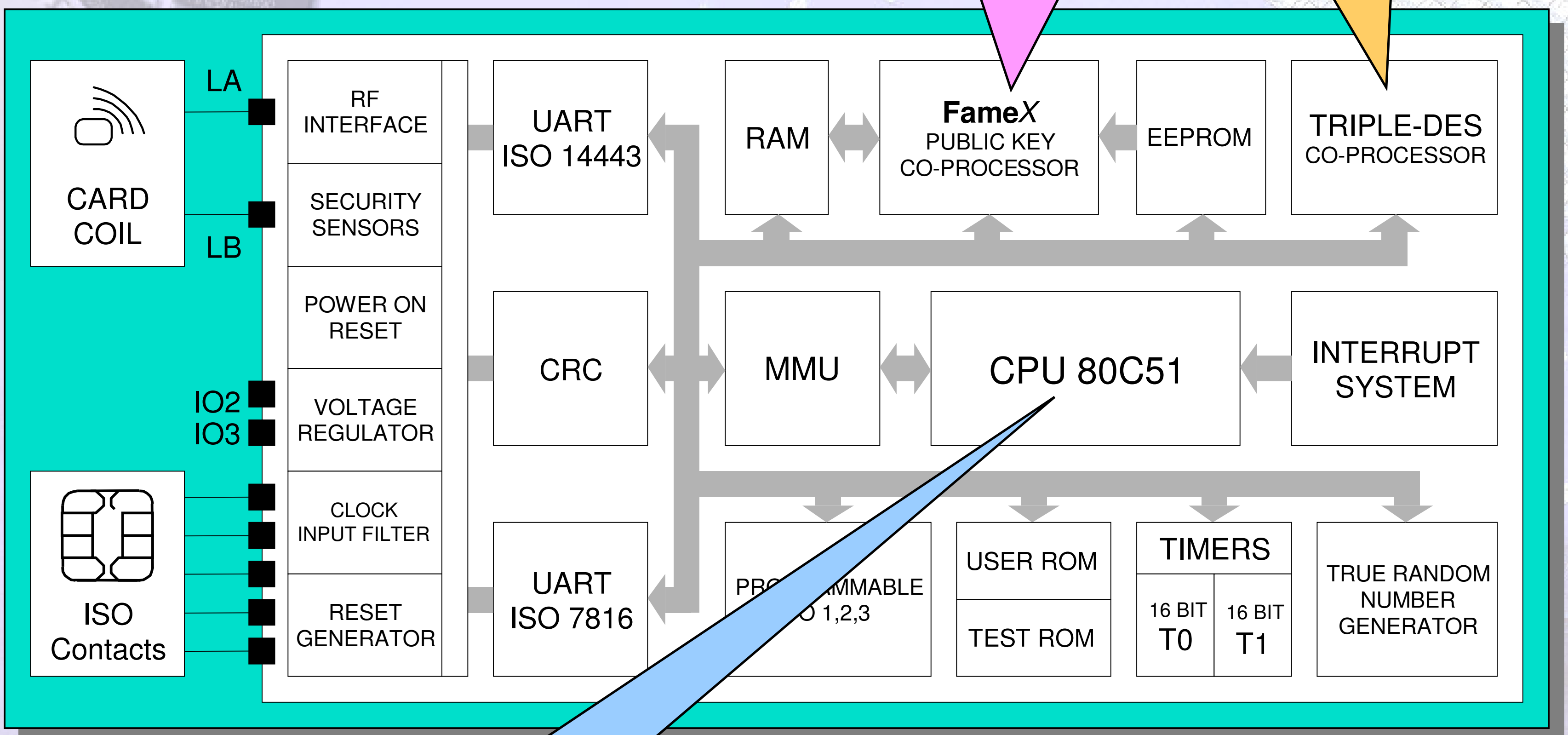
top class transponder using microcontr…

coprocessor
Crytographic
Public key

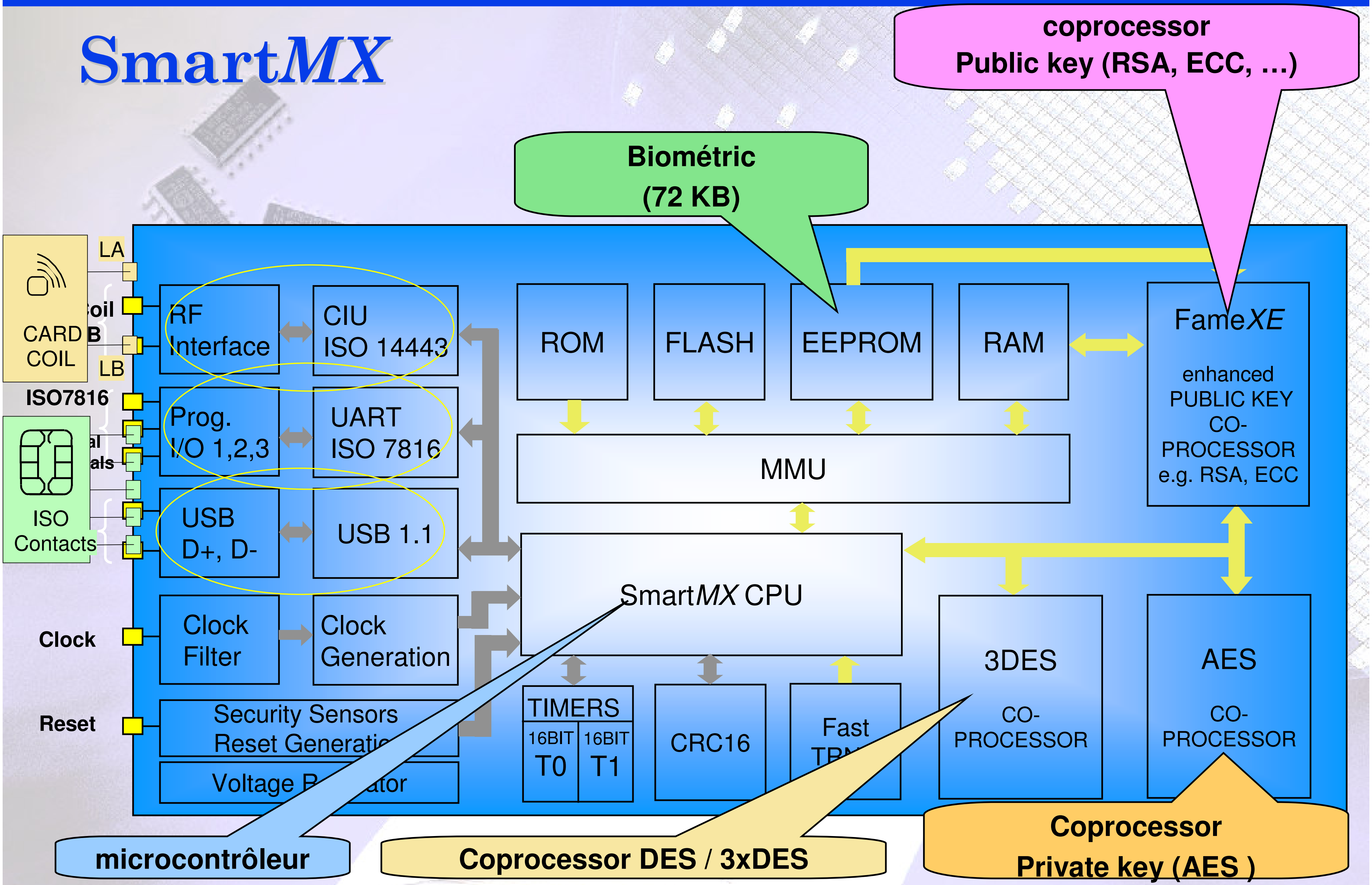
coprocessor
Crytographic
Private key



microcontroller

FAME = Fast Accelerator for Modular Exponentiation

Smart*MX*


coprocessor
Public key (RSA, ECC, ...)
Biométric
(72 KB)
LA
CARD COIL
LB
ISO7816
ISO Contacts
Clock
Reset
RF Interface
CIU ISO 14443
Prog. I/O 1,2,3
UART ISO 7816
USB D+, D-
USB 1.1
Clock Filter
Clock Generation
Security Sensors
Reset Generati
Voltage R
ator
ROM
FLASH
EEPROM
RAM
MMU
SmartMX CPU
TIMERS
16BIT T0
16BIT T1
CRC16
Fast
FameXE
enhanced PUBLIC KEY CO-PROCESSOR e.g. RSA, ECC
3DES CO-PROCESSOR
AES CO-PROCESSOR
microcontrôleur
Coprocessor DES / 3xDES
Coprocessor
Private key (AES)

les éléments de la RFID

transpondeur

- puce (silicium … ou à venir en polymère)
- inlet (puce + antenne)
- carte / étiquette blanche
- étiquette imprimée
- personnalisation du contenu de la carte / l'étiquette

base station

- hardware (antenne, traitement du signal)
- software (applicatif)
- host

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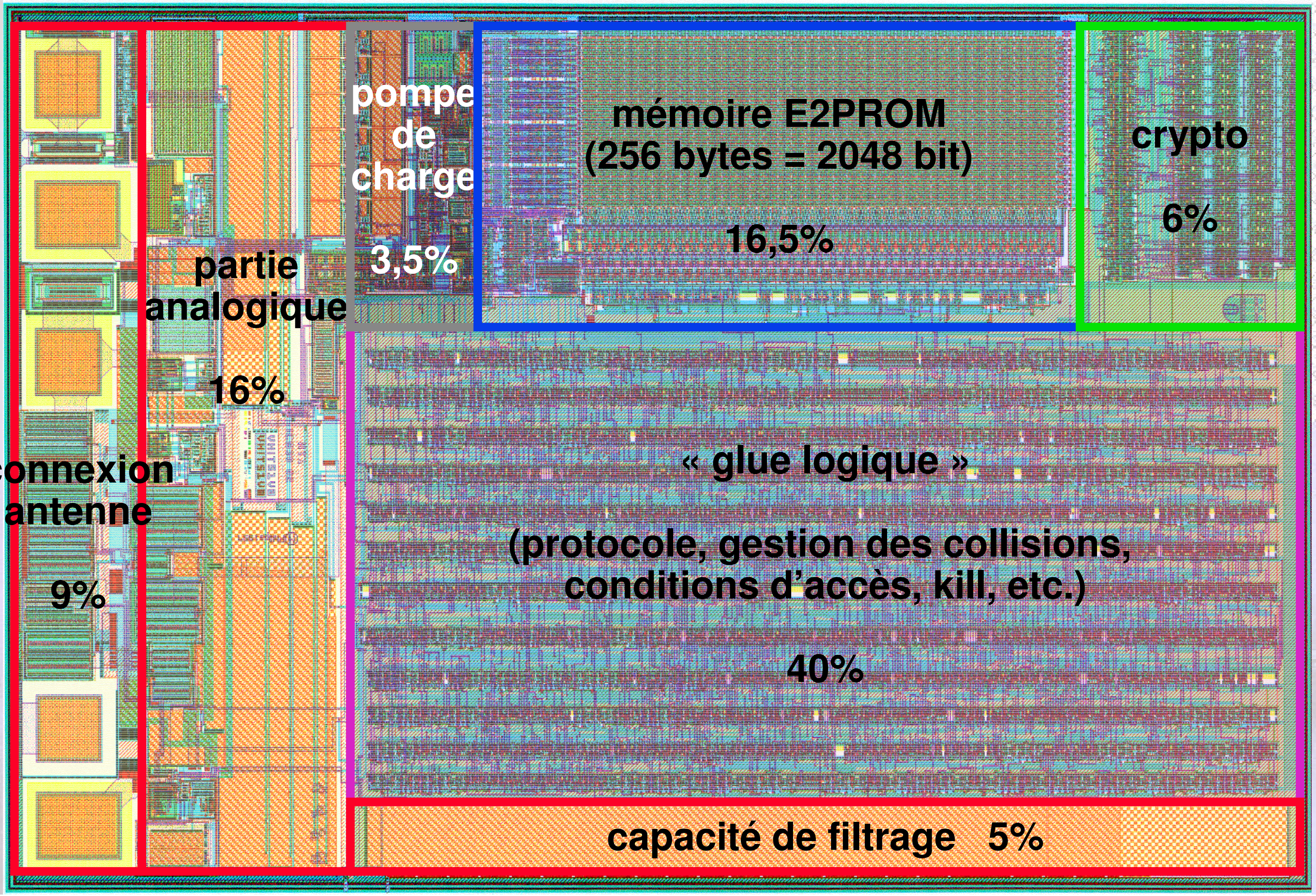
example …



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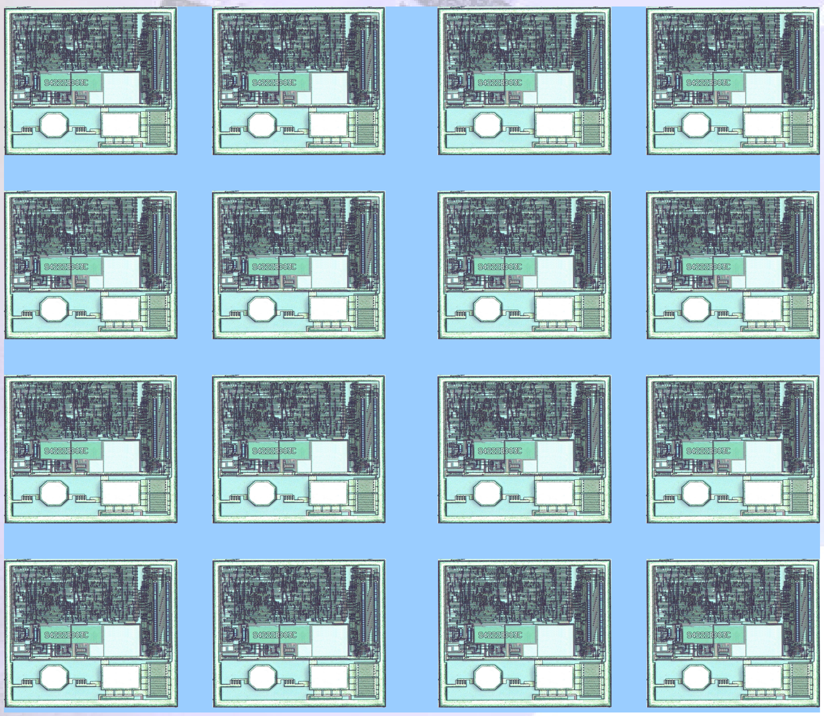
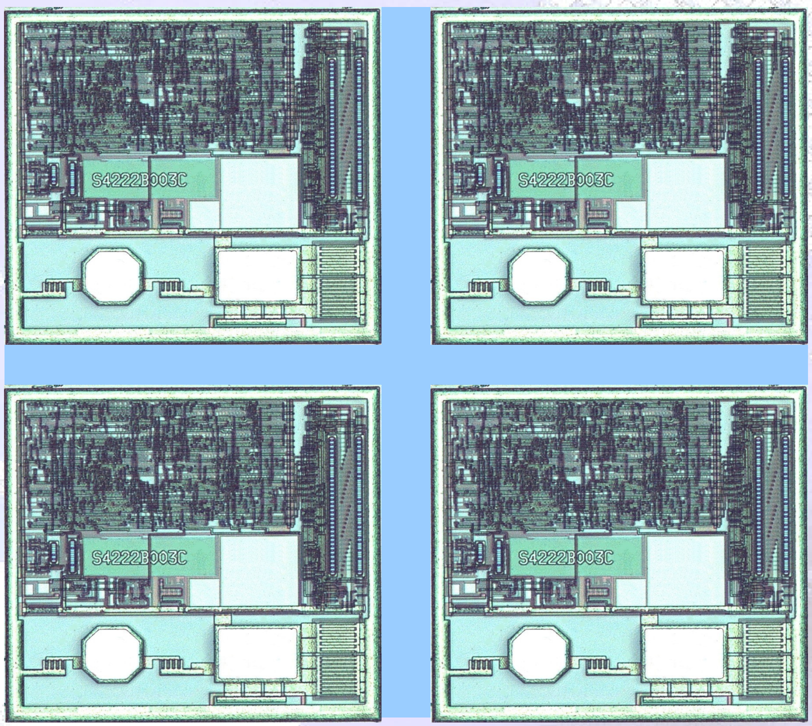
scribe line issue

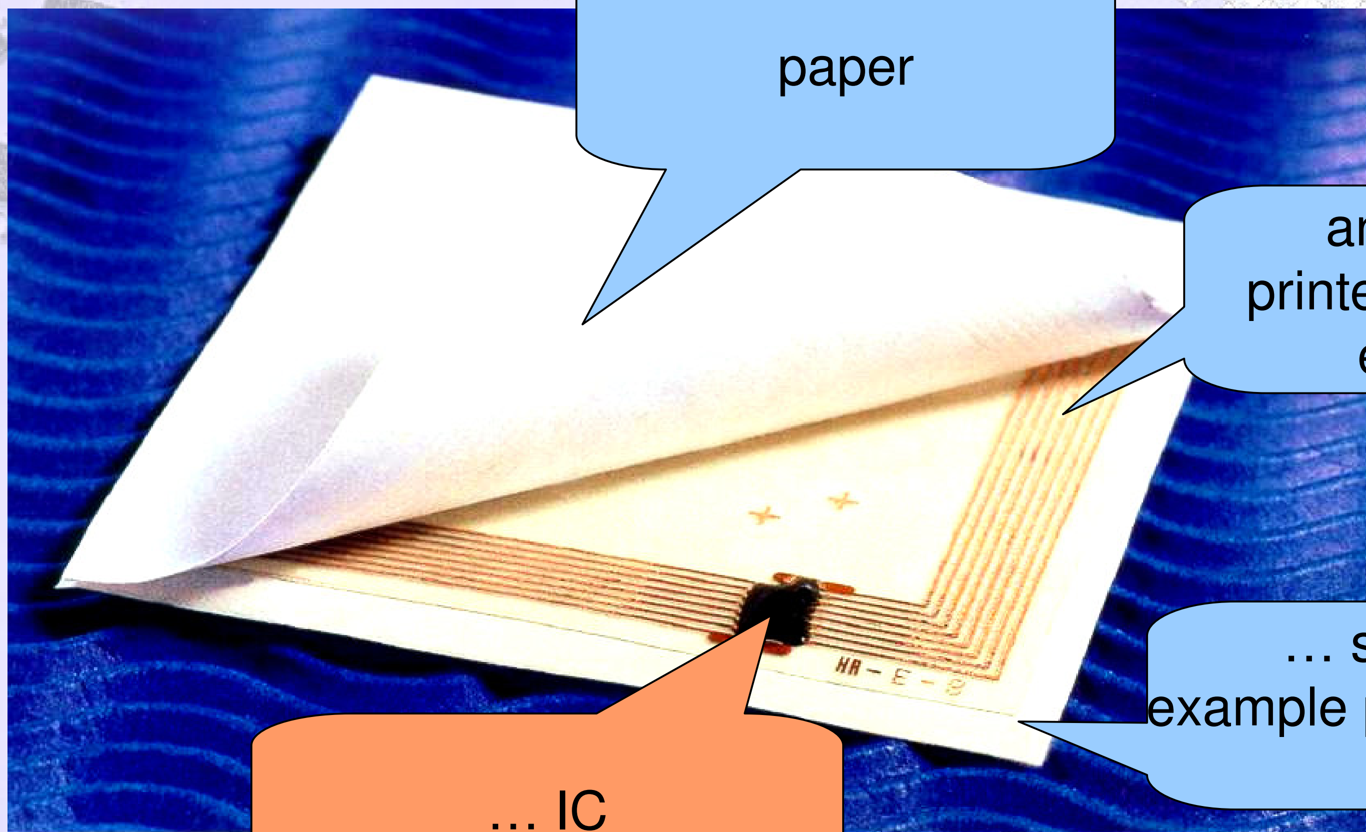
75,6% usable surface



91,5% usable surface



"Smart Label" example



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“contactless” smart card

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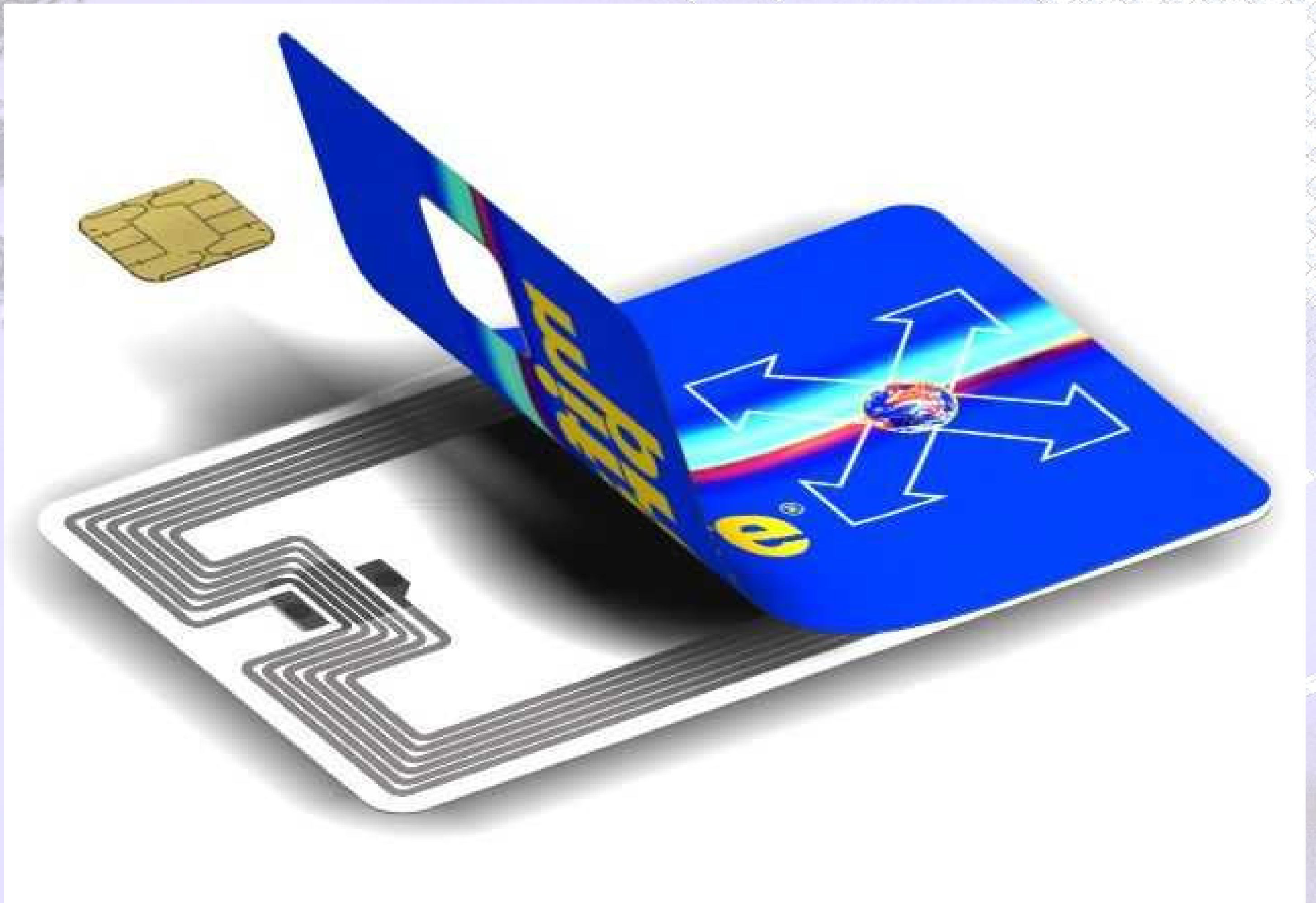
mifare®

Dual Interface Options



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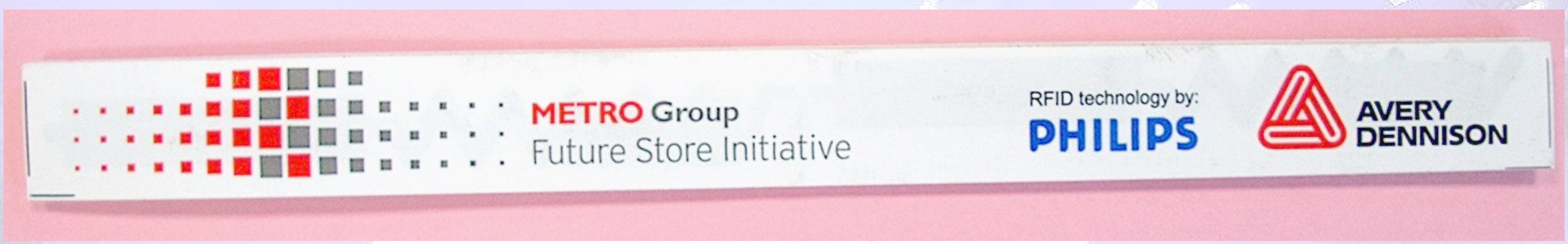
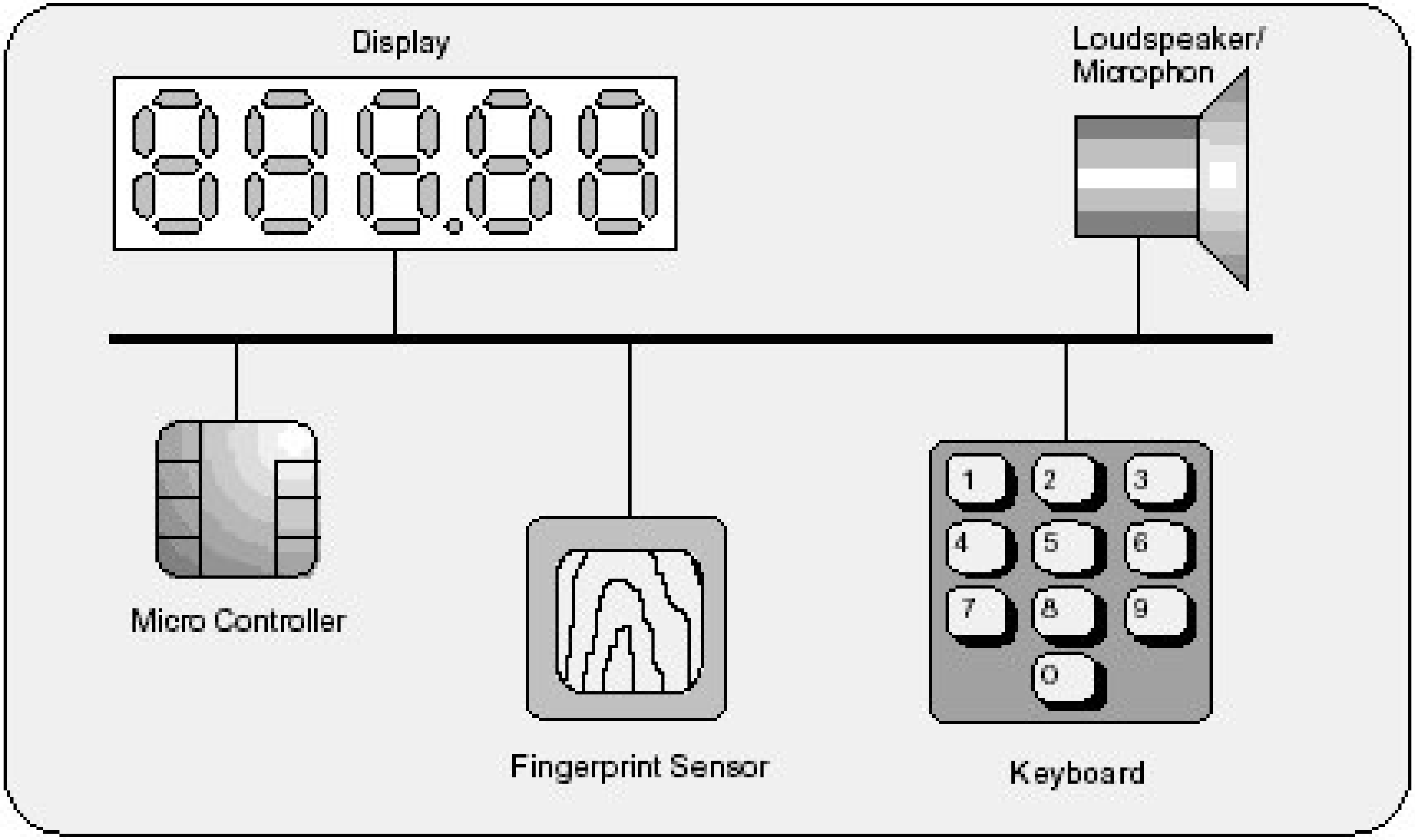
UHF - “Smart Label” example



example


Display
Loudspeaker/
Microphon
Micro Controller
Fingerprint Sensor
Keyboard
1
2
3
4
5
6
7
8
9
0

state of art - market

actors

- silicon

- card / inlets / labels manufacturers

- system integrators

- final users

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… please don’t confuse who is who !

Chip Design

Silicon Production

Wafer treatment and testing

Chip Assembly

Antenna design and production

FCP Assembly

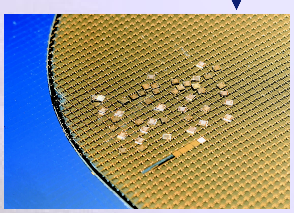
Label / Tag production

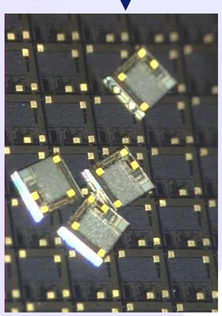
Label Conversion

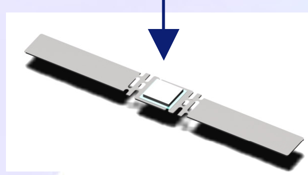
End User

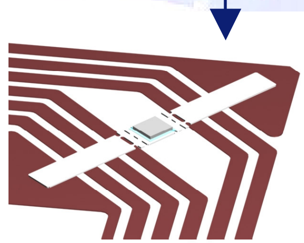
Philips Waferfab and

Philips Assembly Centre









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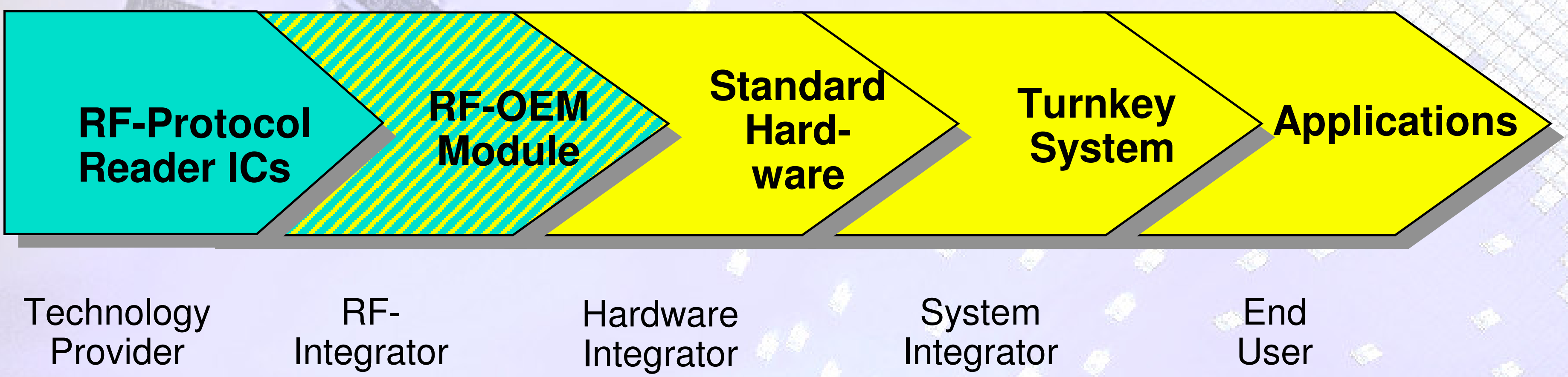
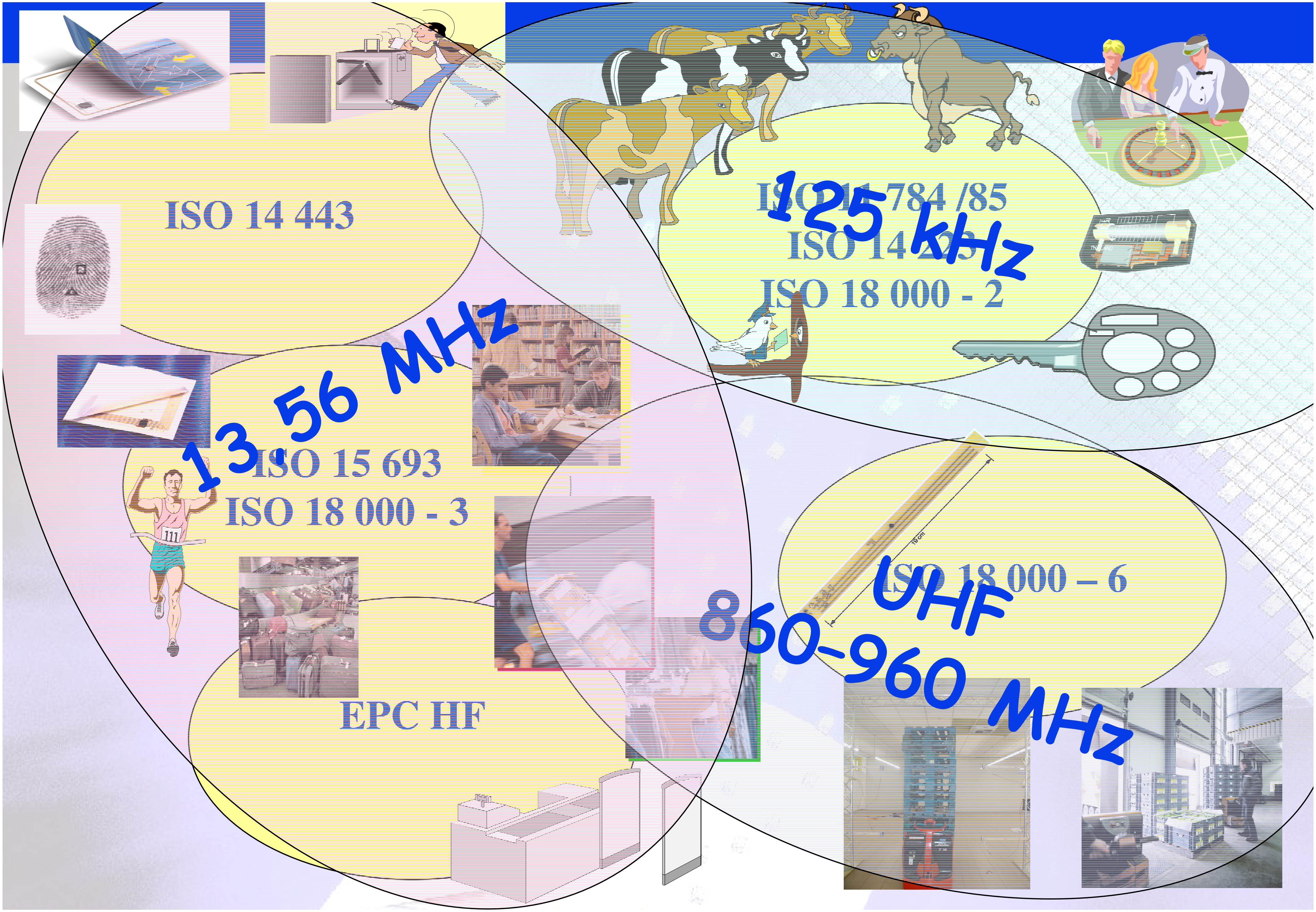
base station

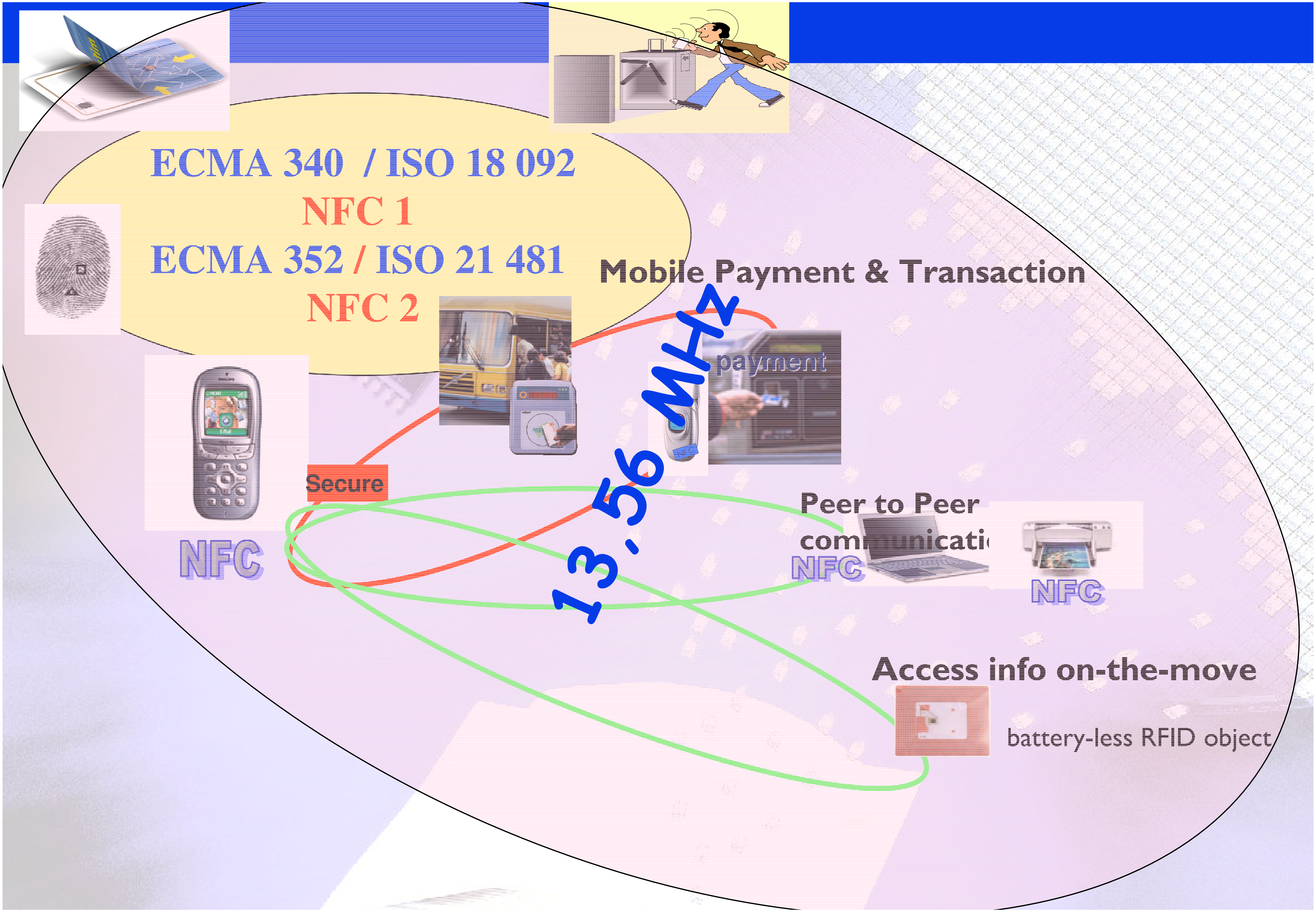


industrial segments

- industrials RFID
- immobilizers and C°
- contacless smard cards
- RFID labelling

some market infos


ISO 14 443
13.56 MHz
ISO 15 693
ISO 18 000 - 3
EPC HF
125 kHz
ISO 11 784 /85
ISO 14 223
ISO 18 000 - 2
UHF
860-960 MHz
ISO 18 000 – 6


ECMA 340 / ISO 18 092
NFC 1
ECMA 352 / ISO 21 481
NFC 2
Mobile Payment & Transaction
payment
13,56 MHz
Secure
NFC
Peer to Peer
communicati
NFC
NFC
Access info on-the-move
battery-less RFID object

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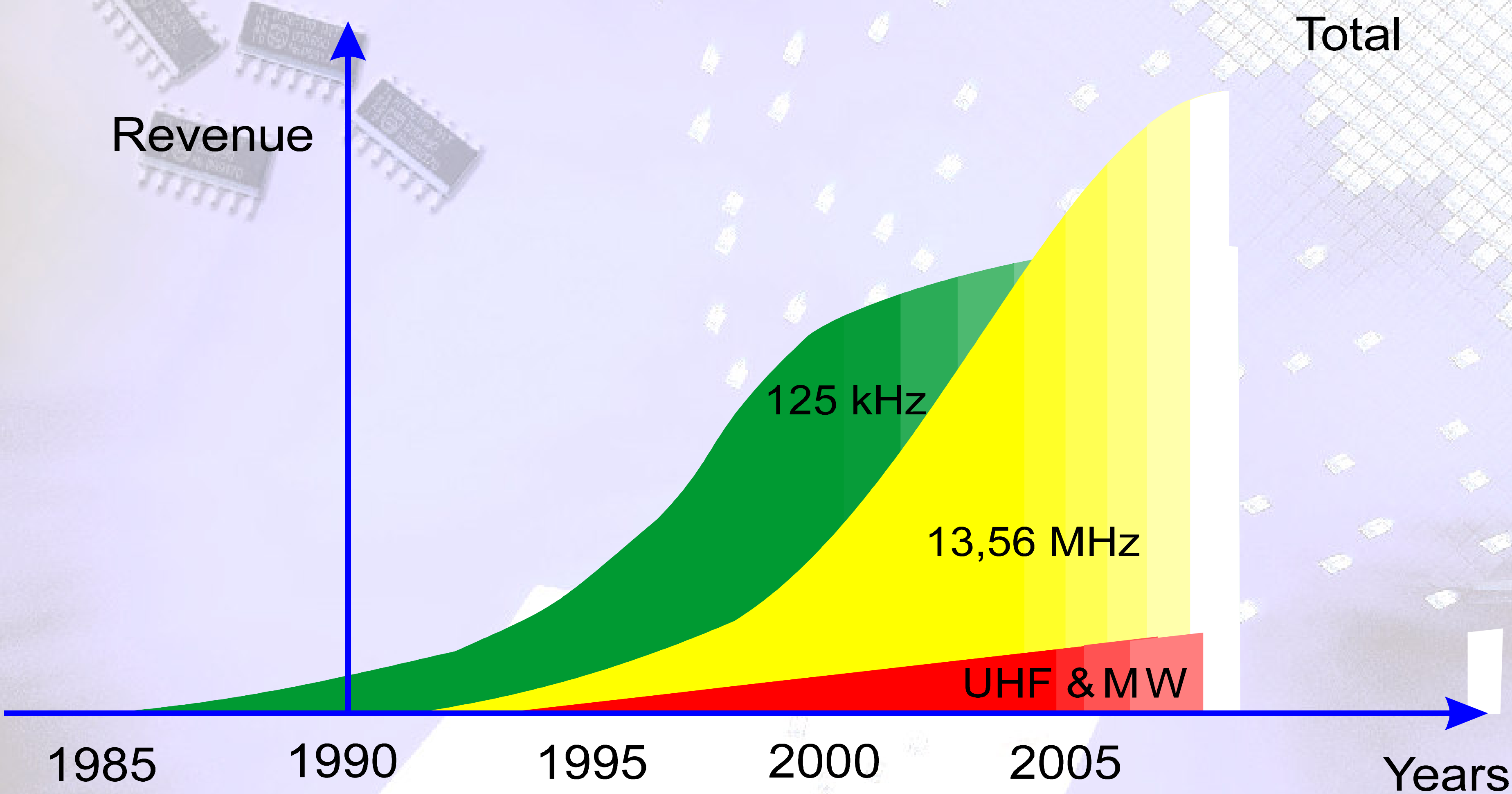
RFID Market
… versus frequency



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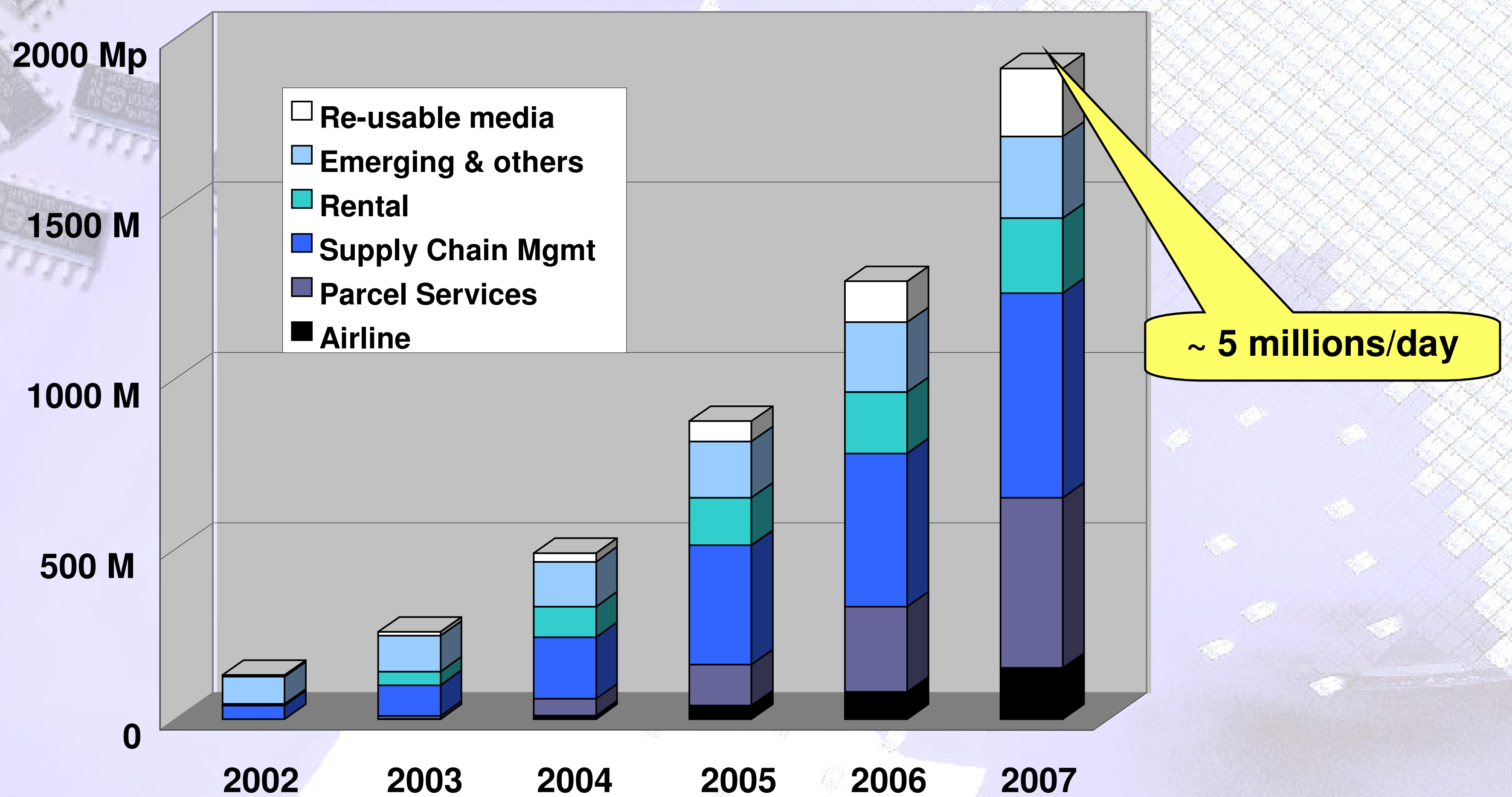
"smart label" partitioning



RFID

« Standardization » & « Regulations »

… and state of ART

standardization, regulation, & C°

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ISO and C°

The way to work with ISO

example : JTC1 / SC 17 / SC 31 /

patents declarations

RAND (Reasonable and Non Discriminatory)

standardization

Global

International Standards Organisation (ISO)

International Electro-technical Commission (IEC)

International Telecommu-nications Union (ITU)

ISO/IEC Joint Technical Committee 1 (JTC1)

TC23 / SC19
Animal Identification

TC104
Freight Containers

TC204
Road Informatics

SC17 Cards & Personal ID

SC31 Automatic Data Capture

Regional

Comité Européen Normalisation (CEN)

Comité Européen Nor-malisation Electro-technique (CENELEC)

ETSI ↔ CEPT/ ERC

National

BSI | AFNOR | ANSI | DIN | JISC | a.m.o.

Simplified Structure !

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ISO IEC

- “Cards & ...” Standards

Joint - Technical Committee JTC 1
“Information Technologies Standard”

Other Subcommittees

Subcommittee SC 17
“Cards & Personal ID”

Working Group WG 4
“Chip Cards”

Working Group WG 8
“Contactless IC Cards”

ISO 7810

“Contact”
ISO 7816

Task Force (TF) 1
“Close Coupling”

ISO 10 536

Task Force (TF) 2
“Proximity Coupling”

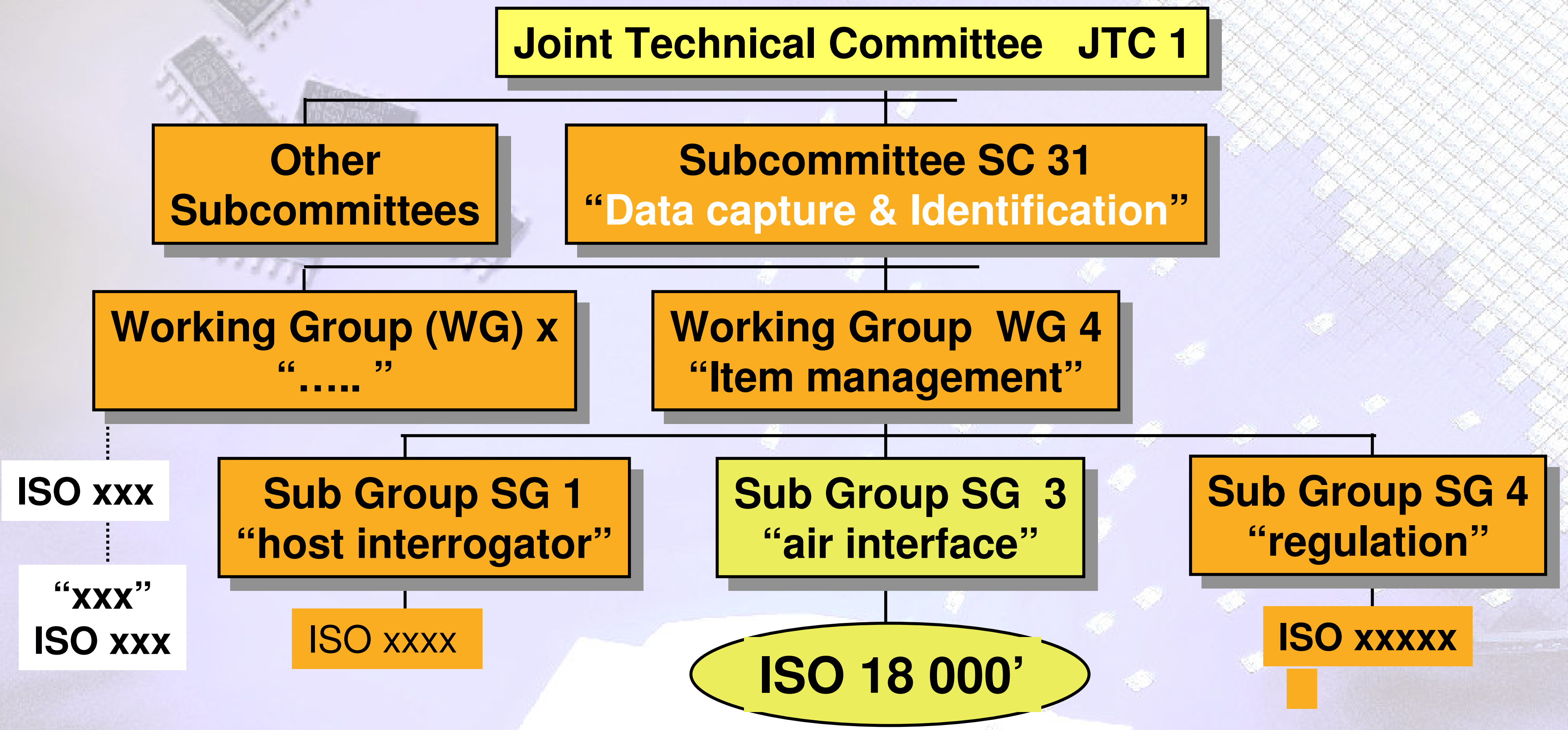
ISO 14 443

Task Force (TF) 3
“Vicinity Coupling”

ISO 15 693

See specific slides on ISO 14 443

- “Item” Standards



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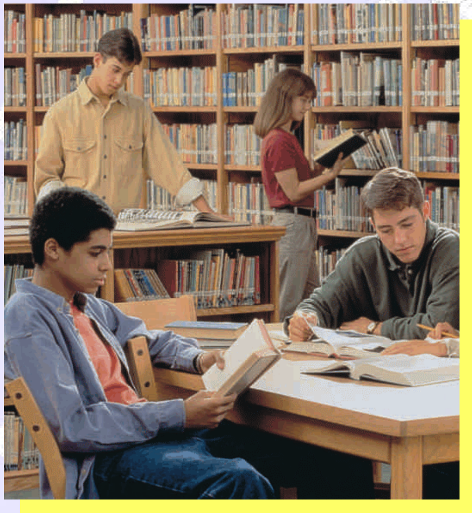
RFID
"item management"



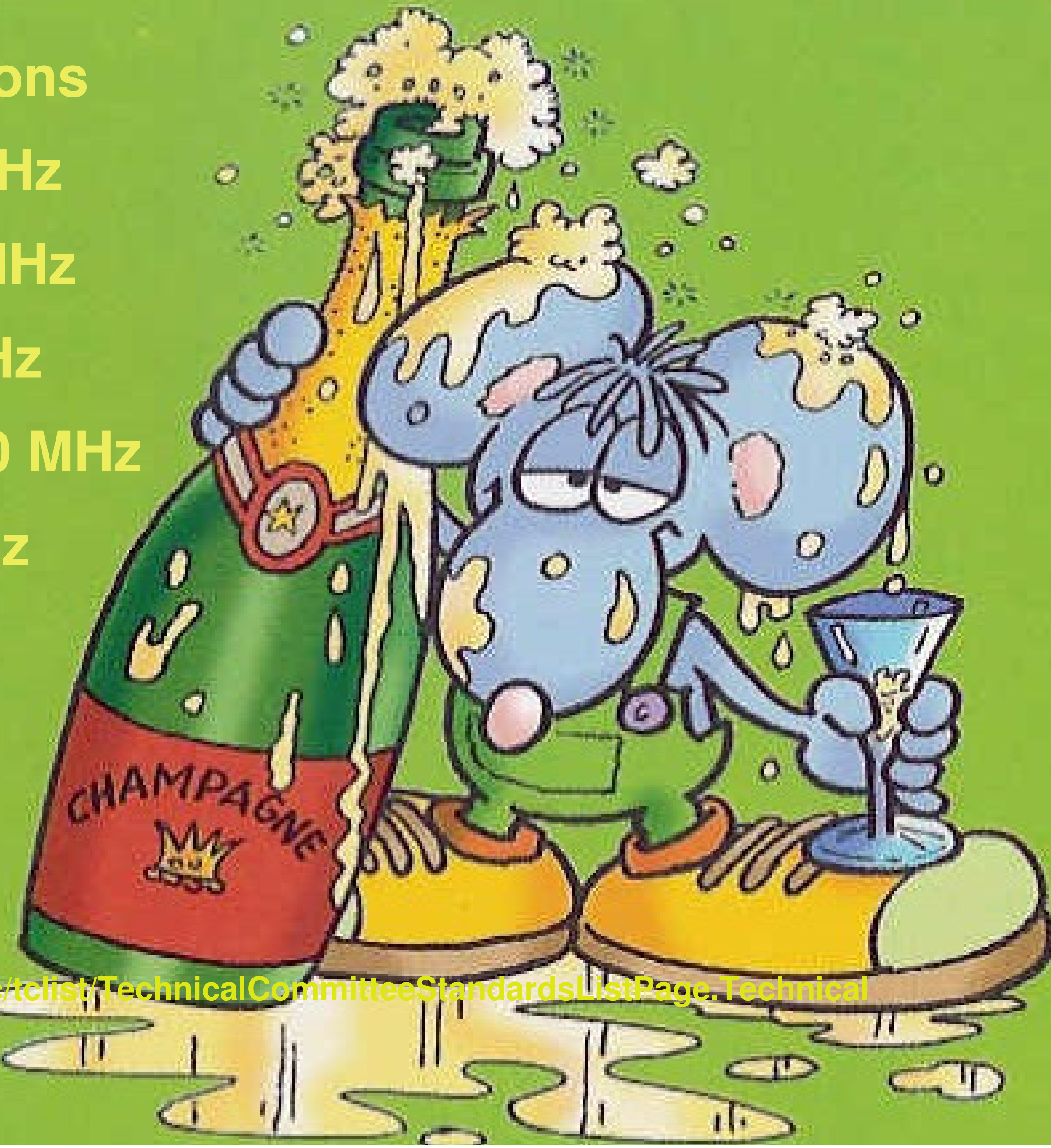



ISO 18 000

- 1 reference parameters
- 2 < à 135 kHz,
- 3 13,56 MHz, (~ ISO 15 693 + particularities)
- 4 2,45 GHz,
- 5 5,8 GHz (stopped)
- 6 860 / 960 MHz, mode A & B. (C in progress)
- 7 433 MHz

IS	18 000 – 1	definitions
	18 000 – 2	< 135 kHz
	18 000 – 3	13,56 MHz
	18 000 – 4	2,45 GHz
	18 000 – 6	860-960 MHz
	18 000 – 7	433 MHz

… since sept. 13th 2004



… OUFFFFFFFFFF !!!!

http://www.iso.org/iso/en/stdsdevelopment/tc/tclist/TechnicalCommitteeStandardsListPage.TechnicalCommitteeStandardsList?COMMID=156

ISO and C°

existing UHF standards

ISO 18 000 – 4	2,45 GHz
ISO 18 000 – 5	on ice
ISO 18 000 – 6	860 – 960 MHz (mode A & B)
ISO 18 000 – 7	433 MHz

In (final) discussion

EPC UHF	Class xxx V yyy …. Up to GEN2 AMD for ISO 18 000 – 6 to add a mode « C » in accordance to EPC Gen 2 technical spec.

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« conformance tests » standards

Conformance tests	related to	
- ISO 10 373 – 6 + amendements	ISO 14 443	proximity
- ISO 10 373 – 7 + amendements	ISO 15 693	vicinity
- ISO 18 047 – x	ISO 18 000 – x	item
- NFC Forum	ECMA 340 / ISO 18 092	

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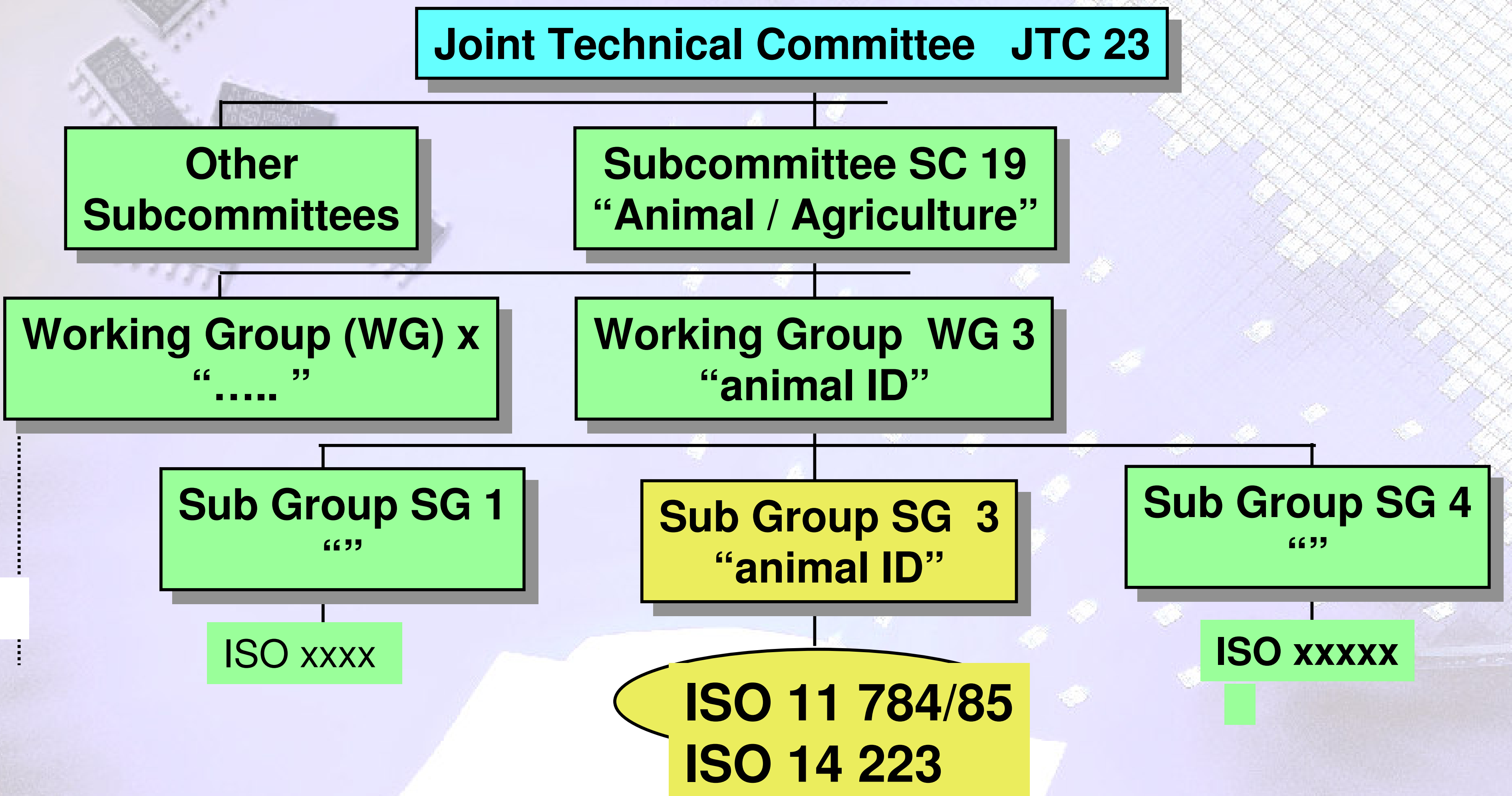
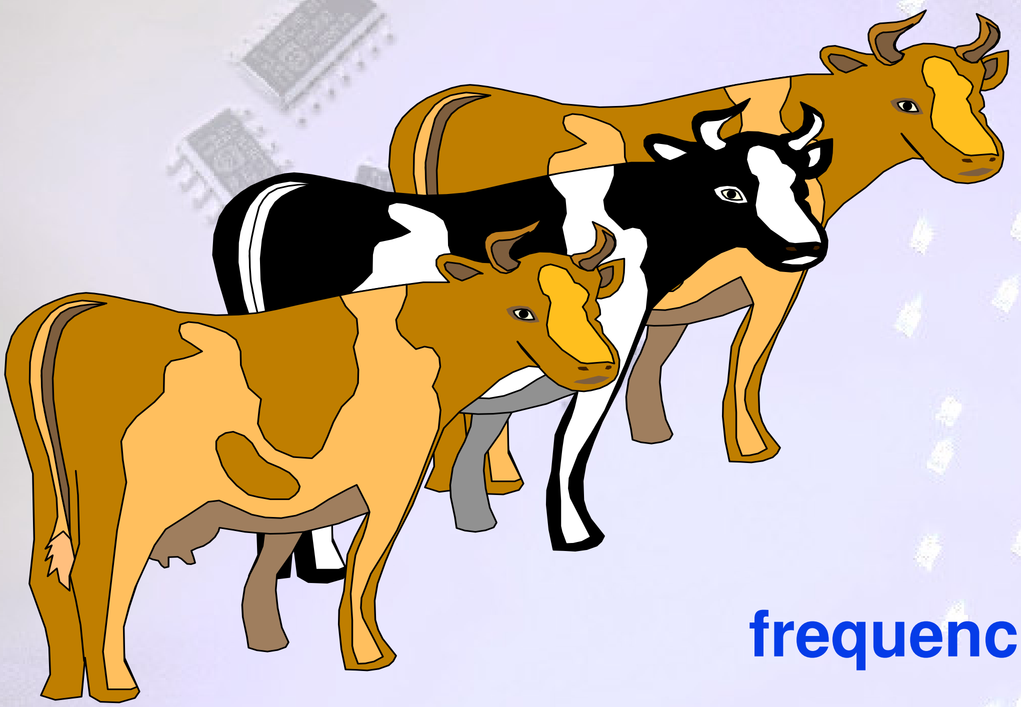
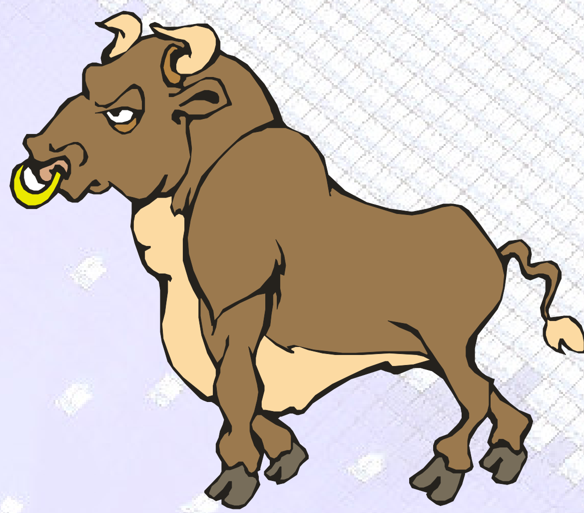
ISO IEC - "Animal" Standards



ISO – animal RFID





	frequencies	applications
- ISO 11784 et 785	134,2 kHz	animal identification
- ISO 14 223	134,2 kHz	animal identification

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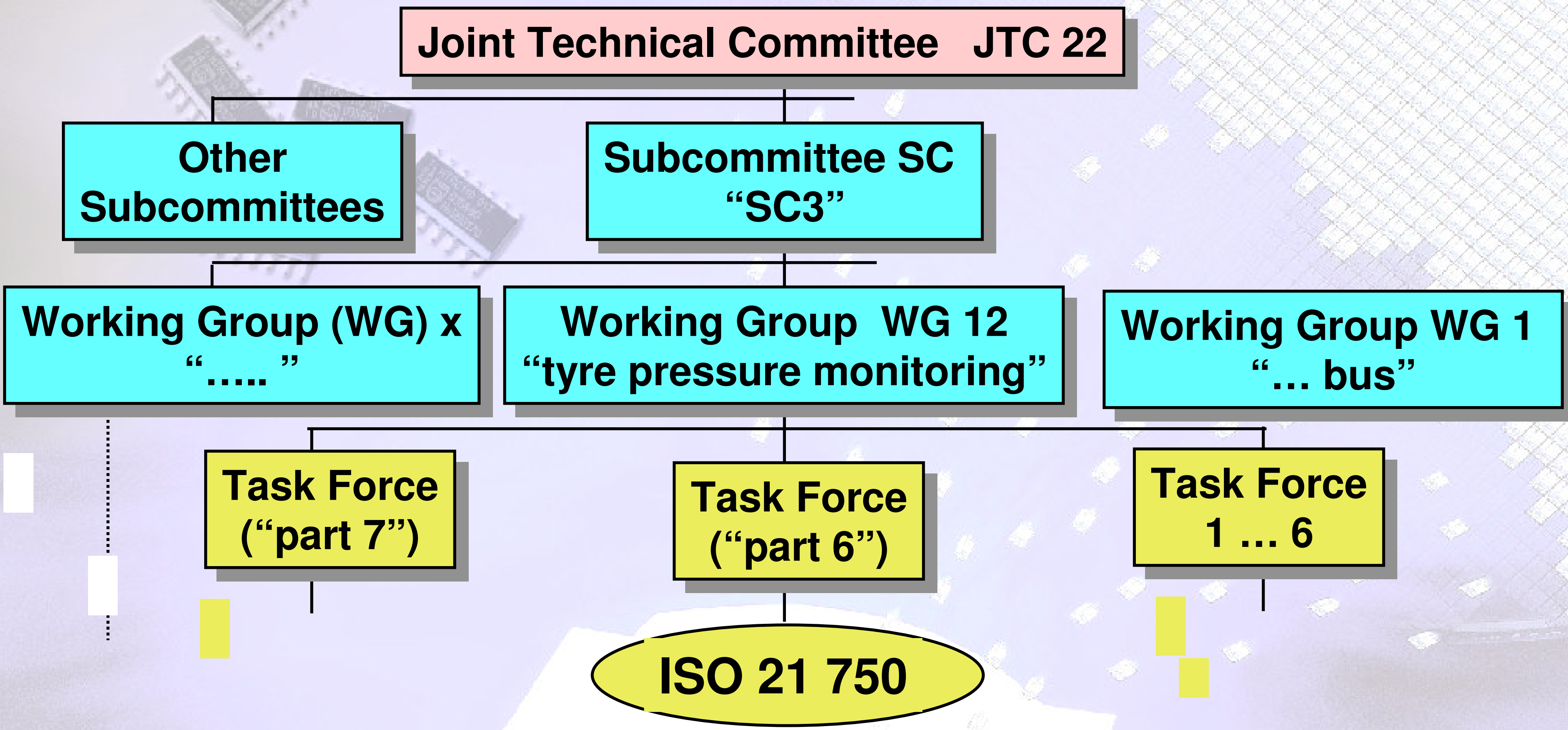
ISO IEC - “road vehicles” Standards



regulations ...

CEPT

ITU

ERO

National Archives and Records Administration

code of federal regulations

ART Autorité de Régulation des Télécommunications

ETSI

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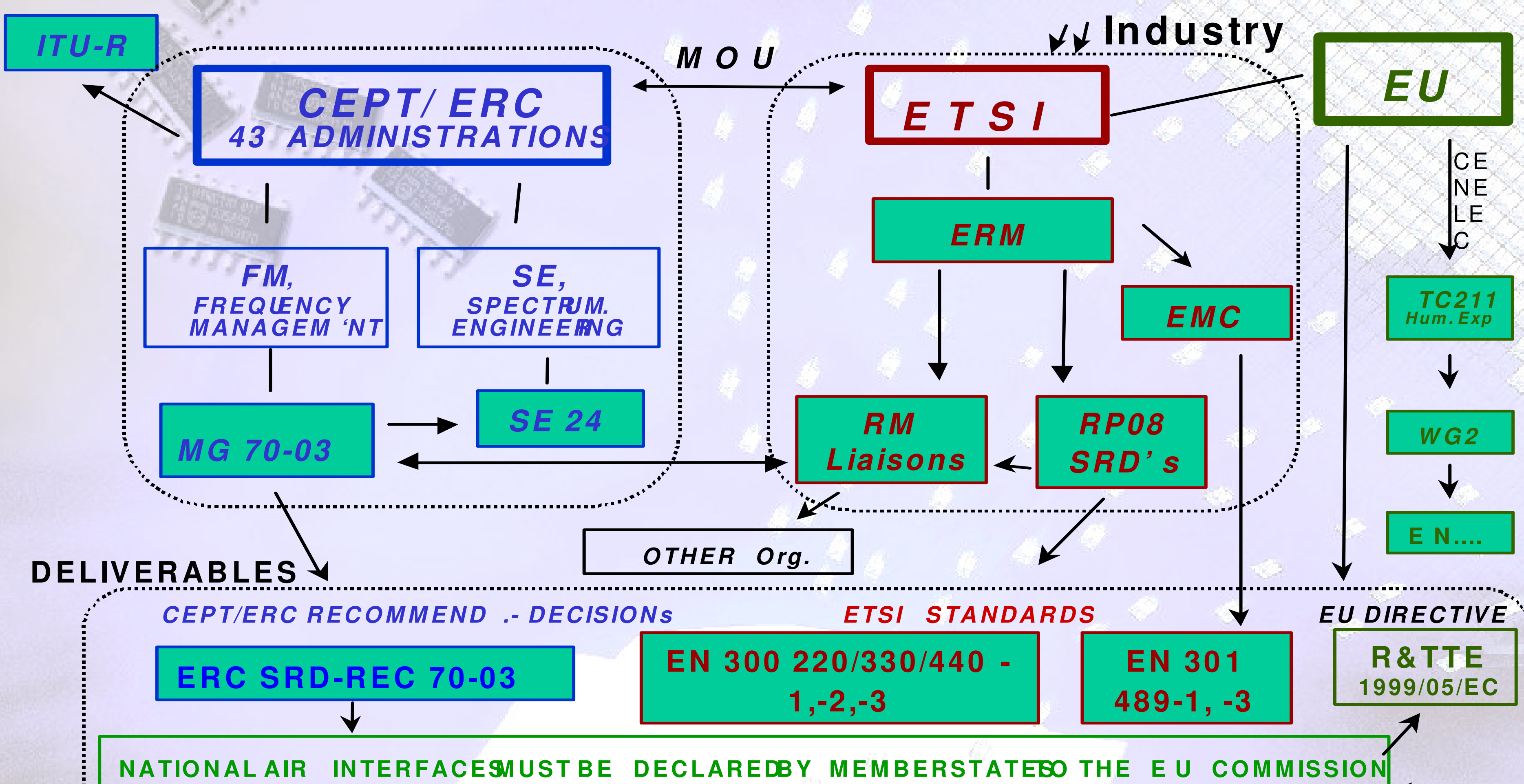
ITU and regions ...

« SRD »

Short Range Device RADIO REGULATION



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European bible ... - ERC 70 - 03

ERC Recommendation 70-03

STATUS
of
ERC RECOMMENDATION 70-03

RELATING TO THE USE OF SHORT RANGE DEVICES (SRD)
Including Appendixes and Annexes

RFID regulations

LF

< 150 kHz

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regulations 120 - 148 kHz

USA/Canada	2400/f (in kHz) µV/m at 300 m	(= 65 dBµA/m at 10 m)
China	Peak Power < 1 W	(= ~ 65 dBµA/m at 10 m)
Japan	30 V/m at 3 m	(= 67 dBµA/m at 10 m)
Europe	Up to 135 kHz 135-148 kHz	65 dBµA/m at 10 m Request for 42 dB µA/m at 10 m. Will be granted.

European limit acc. to EN 300-330 at 120 kHz (= 65 dBµA/m at 10 m) is taken for further calculations with regards to “Human Exposure” .

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RFID regulations

HF

13,56 MHz

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regulations 13,56 MHz band

Europe	13.553-13.567 MHz:	60 (ex 42) dBµA/m at 10 m.
	13.410-13.710 MHz:	9 dBµA/m at 10 m.
	Outside band :	- 3.5 dBµA/m at 10 m.
Canada	same as Europe only:	
	Outside 13.560-14.010 MHz :	- 12 dB µA/m at 10 m.
USA	same as Canada. NPRM*. Not yet approved by the NTIA** Probably interference with Astronomy, Aeronautical, Safety of life frequencies	
China	13.553-13.567 MHz:	42 dBµA/m at 10 m. (10,020 µV/m at 3 m)
Japan	See attached next slide	

* National Proposal for Rulemaking

**National Telecommunication and Information Administration

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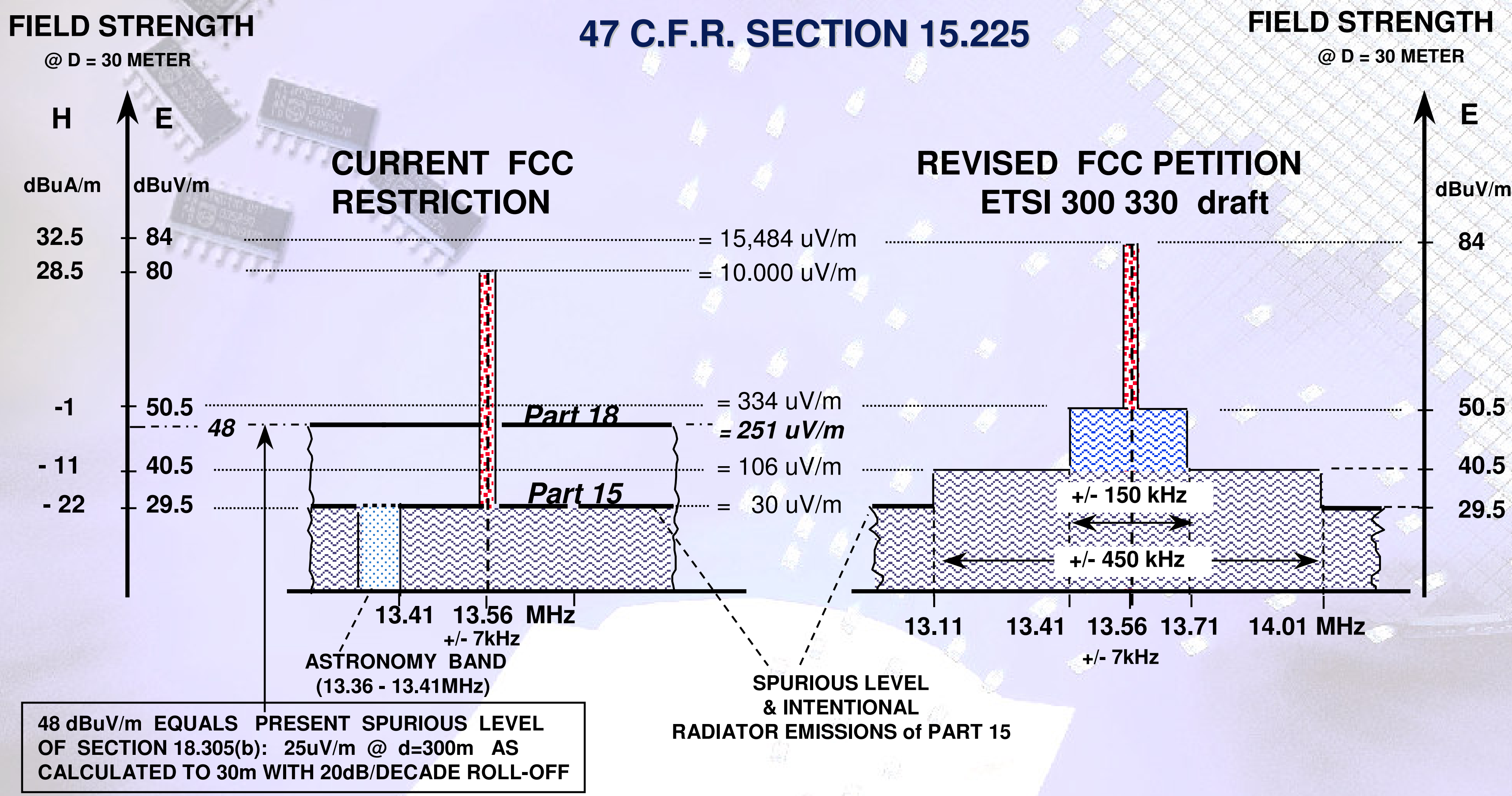
SOURCE: ANSI NCITS, B 10.5
REFER.: ISO/IEC JTC1/SC17/WG8/TF2,TF3 ISO14443, 15693

PURPOSE: International Harmonization of Radio Regulation for Inductive Systems

47 C.F.R. SECTION 15.225



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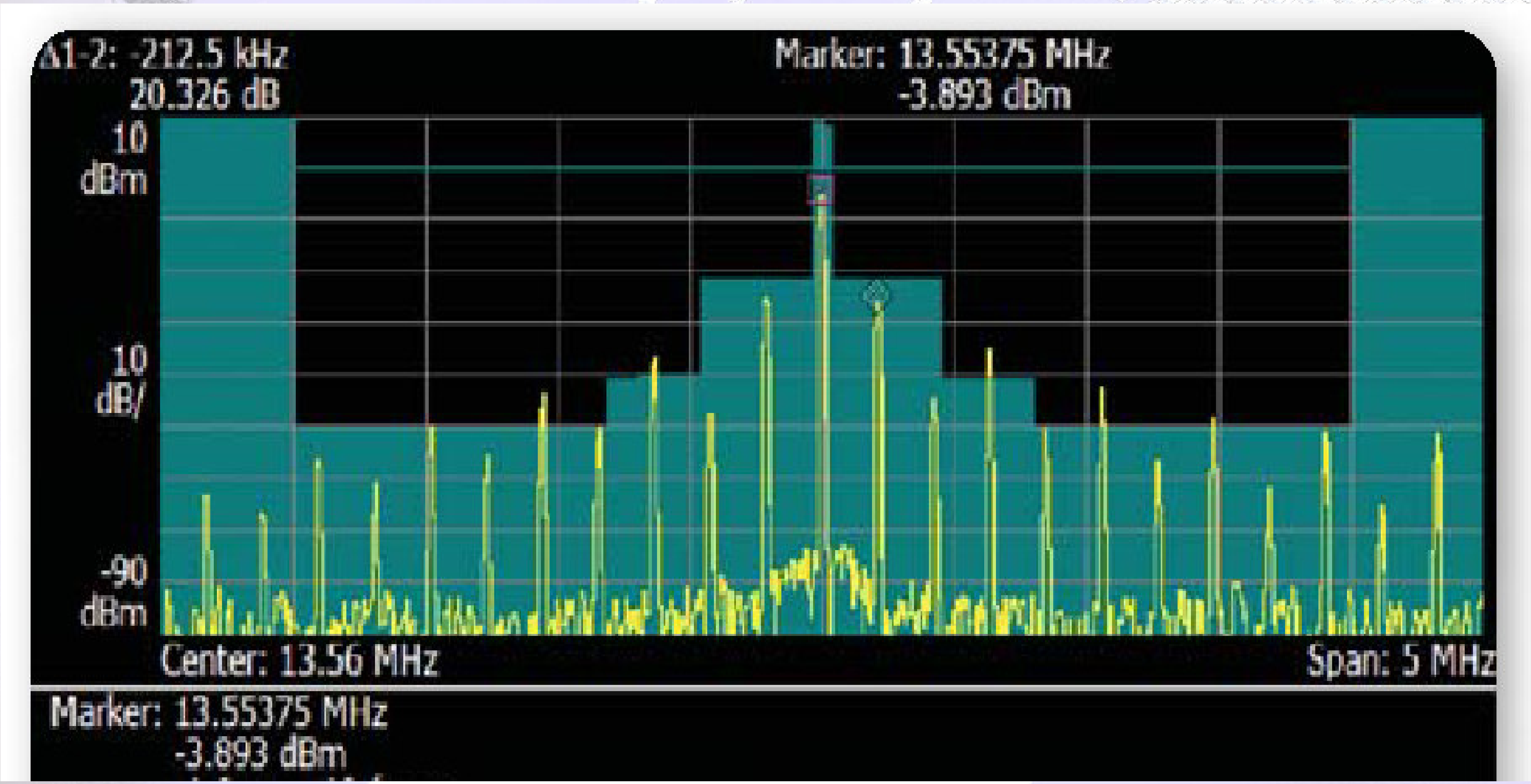
ISO 14 443 – « proximity » ETSI / FCC regulations



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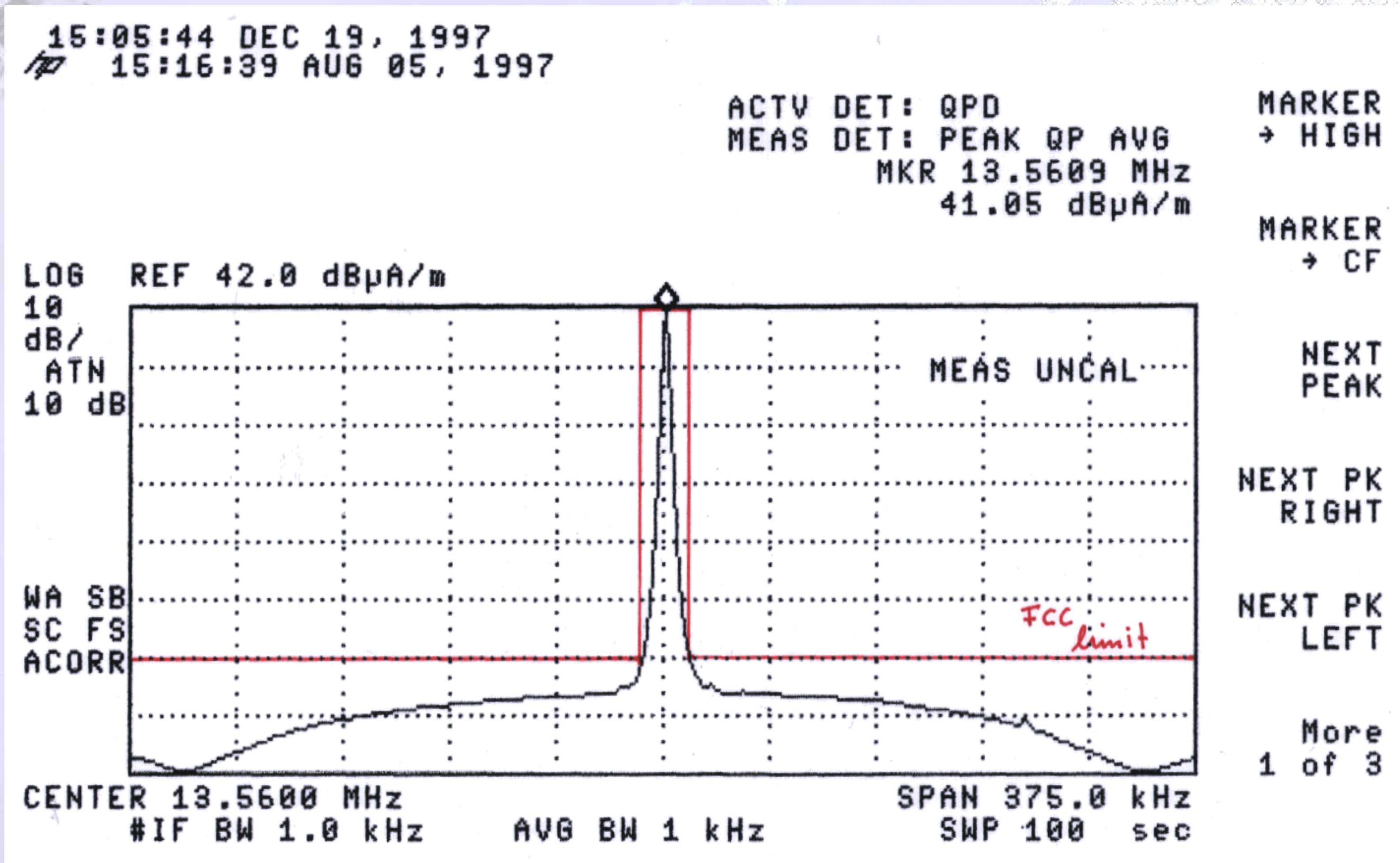
ISO 18 000 – 3 (or ISO 15 693) ETSI / FCC regulations



measurement conditions: 16 timeslots / 6 tags / continuous write

RFID regulations

UHF

433 et 860 / 960 MHz

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UHF Frequencies

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regulations 860 - 960 MHz Band

USA and Canada	902 - 928 MHz	Peirp = 4 W (unlicensed) (dc = 100% FHSS = yes) Peirp = 30 W ! (with license)
Europe	869,4 - 869,65 MHz	Perp = 500 mW (dc =10%)
	865,6 - 867,6 MHz	Perp = 2 W ~ Peirp = 3,28 W (LBT)
Japan and China	no allocation	952 - 954 MHz band (in discussion jan. 2005)

for Information:

Australia	918 - 928 MHz	Peirp = 1 W
New Zealand	864 - 868.1 MHz	Peirp = 4 W
South Africa	915,3 MHz	Peirp = 8 W (as proposed by SABS WG1 of TC 74)

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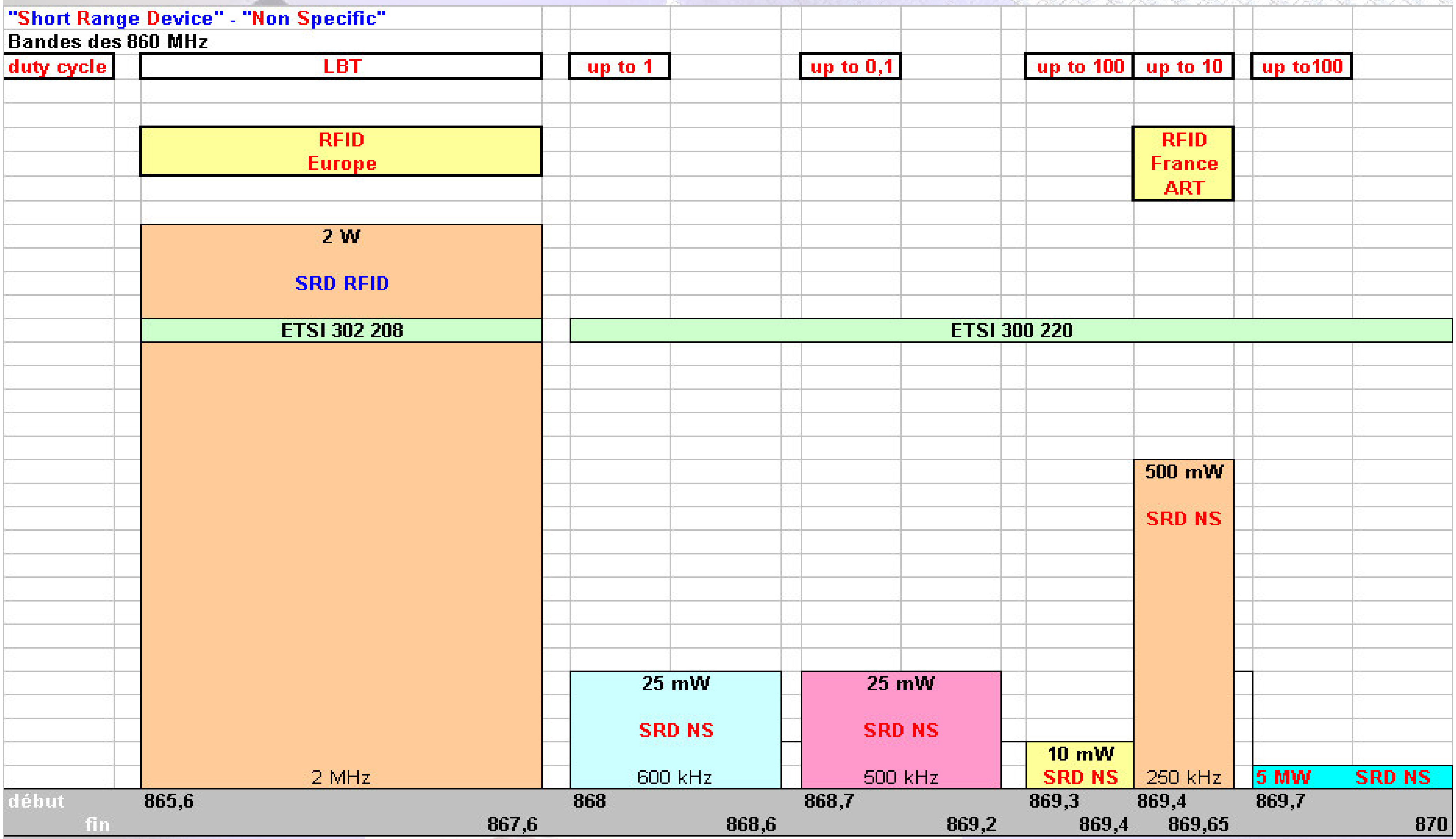
ERC 70 03 – (jan. 2005)



important remarque

From FDIS ISO 18 000 – 6

2.2 Tag conformance and obligations

- To conform to this International Standard, the tag shall support at least one type. It may optionally support both.

The tag shall operate over the frequency range of 860 MHz to 960 MHz.

NOTE

- Depending on the tag antenna characteristics, the operating performance (i.e. operating range) may vary depending on the actual frequency used in the 860-960 MHz band.

example - UHF et SHF tag télé alimenté

Dominique Paret

le 1er sept 2003

Range Calculations for UHF & SHF Systems (theorical, "out of" & "including" tolerances)

				INPUT																	OUTPUT
						base station					tag										
tag téléalimenté				Frequency		power - Pbs ERP		antenna gain		P EIRP = Pbs.Gbs	antenna gain		Min. Power for the chip		antenna polarization		antenna efficiency		antenna matching		Max. Operating range
			note	f MHz	λ m	P W	Prdr W	Gbs	equals dB	P EIRP	Glbl	equals dB	Pchip µW	equals dBm	polar	equals dB	AntEff %	equals dB	Match %	equals dB	range m
UHF	europe	in/outdoor	a	900,0	0,333	0,5		1	0,00	0,50	1	0,00	60	-12,22	100	0,00	100	[illegible]	[illegible]	0,00	2,42
		in/outdoor	b	900,0	0,333	0,5		1,64	2,15	0,82	1,64	2,15	60	-12,22	100	0,00	100	[illegible]	[illegible]	0,00	3,97
			c	868,5	0,345	0,5		1	0,00	0,50	1	0,00	60	-12,22	100	0,00	100	[illegible]	[illegible]	0,00	2,51
			d	868,5	0,345	0,5		1,64	2,15	0,82	1,64	2,15	60	-12,22	100	0,00	100	[illegible]	[illegible]	0,00	4,12
	europe	indoor only	e	872,0	0,344	2		1	0,00	2,00	1	0,00	60	-12,22	100	0,00	100	0,00	[illegible]	0,00	5,00
	(future)	indoor only	f	873,0	0,344	2		1,64	2,15	3,28	1,64	2,15	60	-12,22	100	0,00	100	0,00	[illegible]	[illegible]	8,19
	america	in/outdoor	g	915,0	0,328		4	1	0,00	4,00	1,64	2,15	60	-12,22	100	0,00	100	0,00	[illegible]	[illegible]	8,63
			h	915,0	0,328		1	4	6,02	4,00	1,64	2,15	60	-12,22	100	0,00	100	0,00	[illegible]	[illegible]	8,63
	xxx		i	868,5	0,345		1	4	6,02	4,00	1,64	2,15	60	-12,22	100	0,00	100	0,00	[illegible]	[illegible]	9,09
	xxx		j	868,5	0,345	2,44	2,44	1,64	2,15	4,00	1,64	2,15	60	-12,22	100	0,00	100	0,00	[illegible]	[illegible]	9,09
SHF	europe	in/outdoor		2450,0	0,122					0,5	1	0,00	150	-8,24	100	0,00	100	0,00	100	[illegible]	[illegible]
		in/outdoor		2450,0	0,122					0,5	1,64	2,15	150	-8,24	100	0,00	100	0,00	100	[illegible]	[illegible]
	europe	indoor (15%)		2450,0	0,122					4	1,64	2,15	150	-8,24	100	0,00	100	0,00	100	[illegible]	[illegible]
	america	in/outdoor		2450,0	0,122					4	1	0,00	150	-8,24	100	0,00	100	0,00	100	[illegible]	[illegible]
				2450,0	0,122					4	1,64	2,15	150	-8,24	100	0,00	100	0,00	100	0,00	[illegible]
vos propres chiffres !!				860,0	0,349	0,5		1,64		0,82	1,5	1,76	80	-10,97	50	-3,01	70	-1,55	80	-0,97	1,82

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interrogator populations

« singles », « multiples » & « denses »

dense interrogator, channelized signaling

EPC C1 G2 philosophie …

«… all parameters can be adapted to local regulations …»

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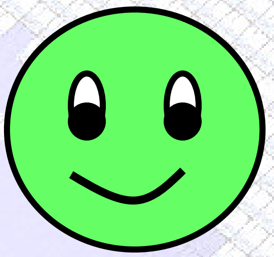
EPC C1 G2
… reality …

Don't confuse
« hardware »
« software »
« paperware »
& « slideware » !!!!!

1600 tags/s max … need two rounds (wake up + read) **per tag !**

i.e	800 tags/s max	… USA … free space
	110	… USA … « dense »
	90	… Europe (ETSI 302 208 … 2 MHz, LBT)
	50	… France (ART mono channel 250 kHz)

EPC C1 G2 / dense interrogators

EPC C1 G2	USA	4W eirp FHSS	
EPC C1 G2	Europe	2W erp LBT	
EPC C1 G2	France	0,5W erp 10% ou LBT	

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portal reader

Requirements I

US regulations

Tagging of		38 wooden pallets
	on	2 piles
Gate width:		3 m
Gate height:		3 m
Speed of moving pallets: ≈		5 km/h (= 1,4 m/s)

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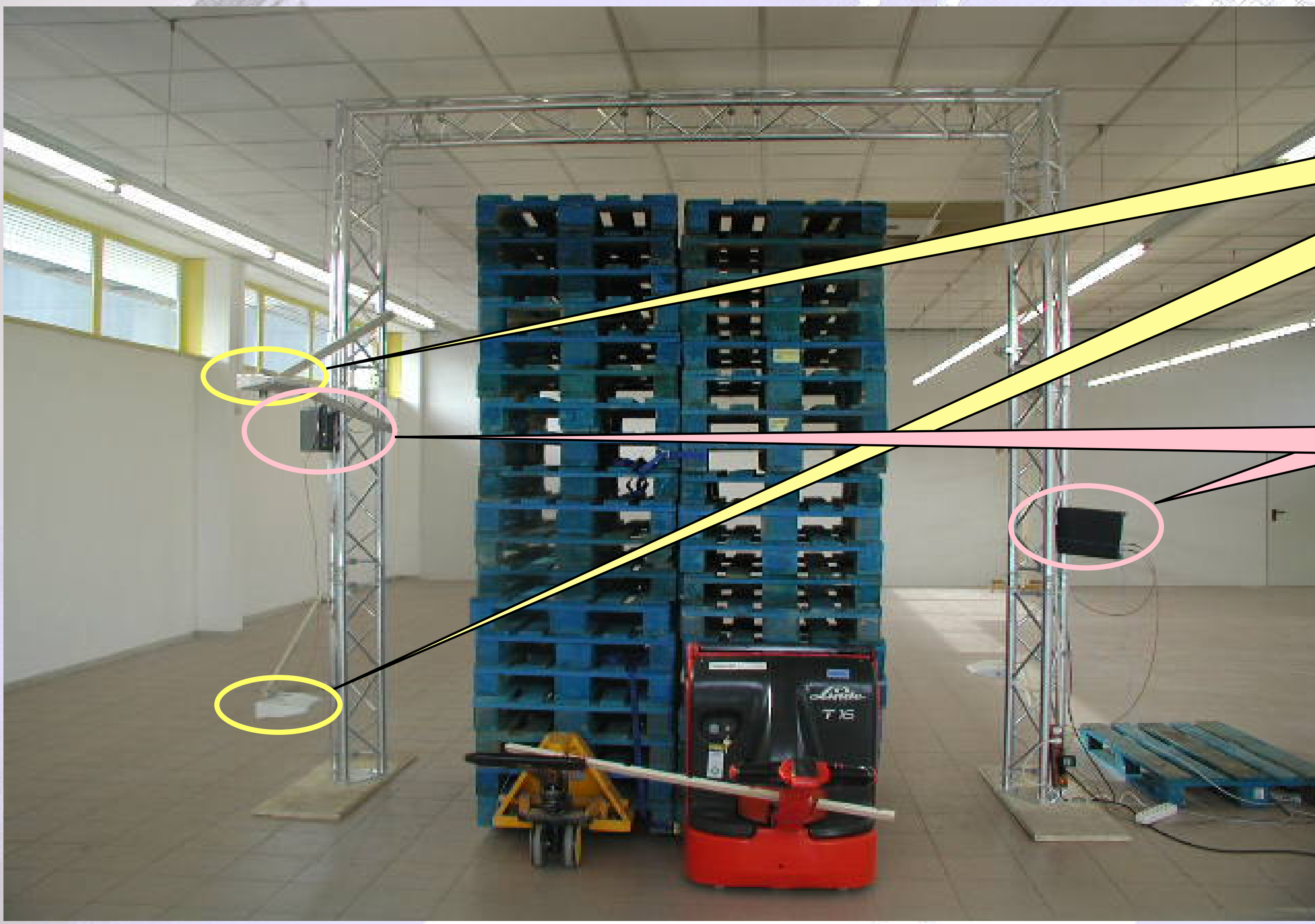
portal reader



Pallets and reader gate

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portal reader

Antenna positioning

Requirements 2

Current european power regulations

Tagging of		19 wooden pallets
	on	1 pile
Gate width:		1.7 m
Gate height:		3 m
Speed of moving pallets: ≈		5 km/h (= 1,4 m/s)

RFID regulations

SHF

(2,45) / 5,8 GHz

regulations 2,400 - 2,483 GHz

USA/Canada	2400 - 2483 MHz	Peirp = 4 W.
	- FHSS = Frequency Hopping Spread Spectrum.	
	- No duty cycle.	
Europe	2446 - 2454 MHz	Peirp = 4 W , resp. 0.5 W
	- 4 W indoors, duty cycle: 30 ms on/ 170 ms off	
	- 500 mW indoors/outdoors, no duty cycle.	
	(France : "ART don't accept 4 W")	
Japan	2400 - 2483.5 MHz	3mW/MHz : Peirp = 1 W.
(Proposal)		Same restrictions as USA/Canada.
China	2400 - 2425 MHz	250 mV/m at 3m (: Peirp = 21 mW)

regulations 5,8 GHz

USA/Canada	5725 - 5850 MHz.	Peirp = 4 W. FHSS No duty cycle.
Europe	5725 - 5875 MHz.	Peirp = 25 mW No duty cycle - For Non-specific SRD (France : non autorised)
Japan	No allocation. (Peirp = 6W, for ETC*, not for RFID).	
China	No allocation.	

*Electronic Toll Collection

« human exposure »

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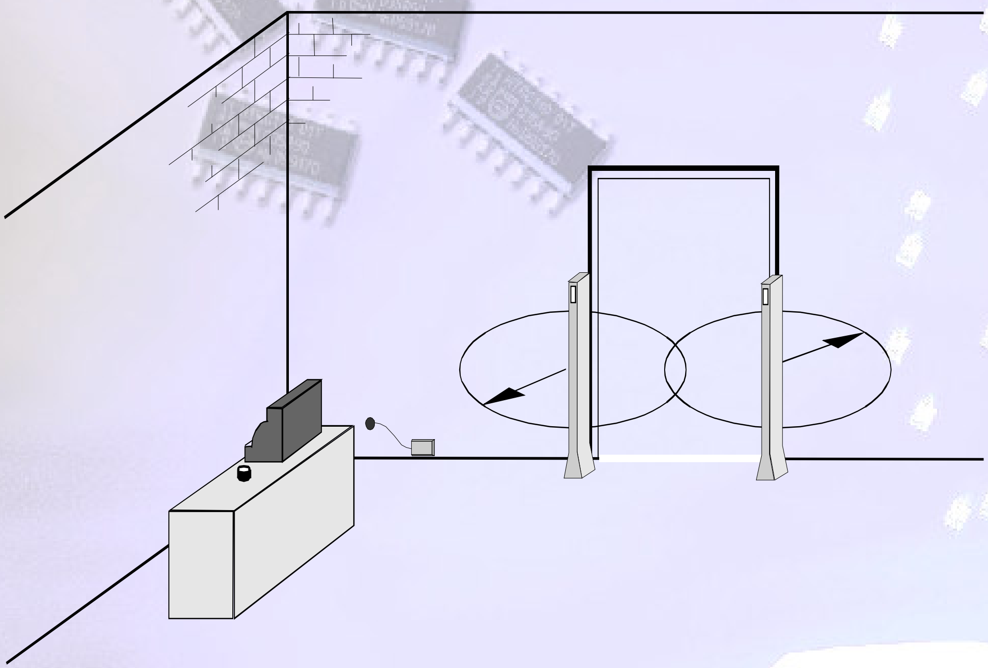
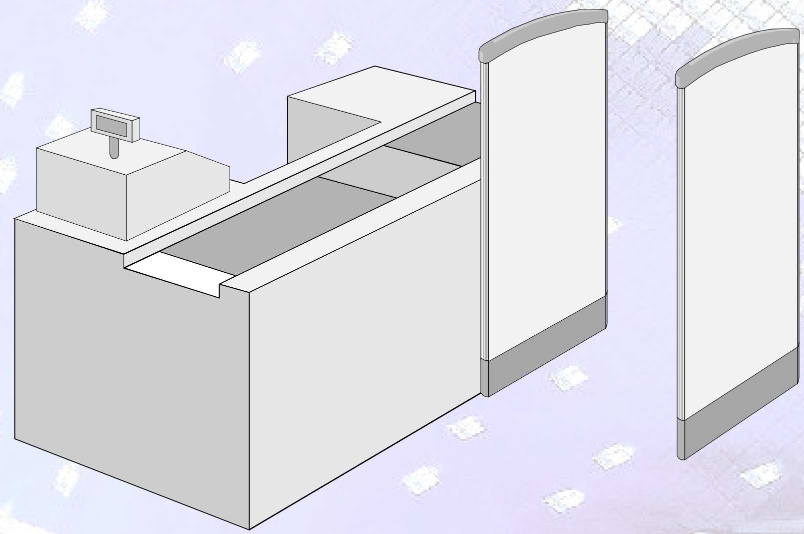
« WHO » = Organisation Mondiale de la Santé - OMS

Documents based on

- ANSI,
- IEEE 95.1,
- DIN/VDE 0848,
- ICNIRP (International Commission on Non Ionising Radiation Protection),
- AS/NZS 2772.1,
- etc.

exemples





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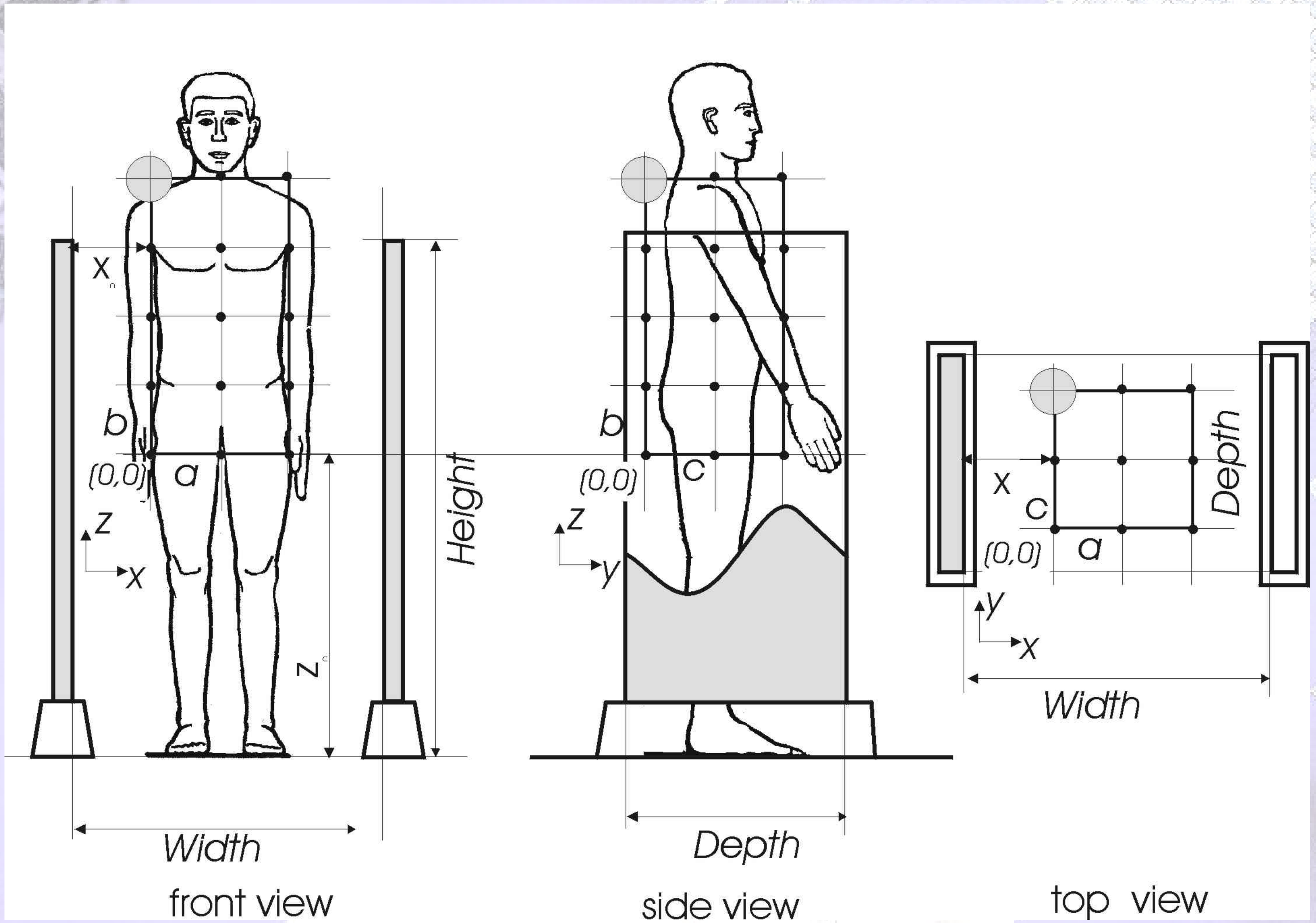
exemple



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Europe

ENV 50 166 - 1 : 1995

human exposure to electromagnetic fields

low frequency (0 Hz to 10 kHz) -

ENV 50 166 - 2 : 1995

human exposure to electromagnetic fields

high frequency (10 kHz to 300 GHz) -

ES 59 005 : 1997

human exposure to electromagnetic fields for Mobile Telecommunication Equipment in the range of 30 MHz to 6 GHz.

EN 50 357 : octobre 2001

« human exposure to electromagnetic fields from devices used in Electronic Article Surveillance (EAS), Radio Frequency Identification (RFID) and similar applications »

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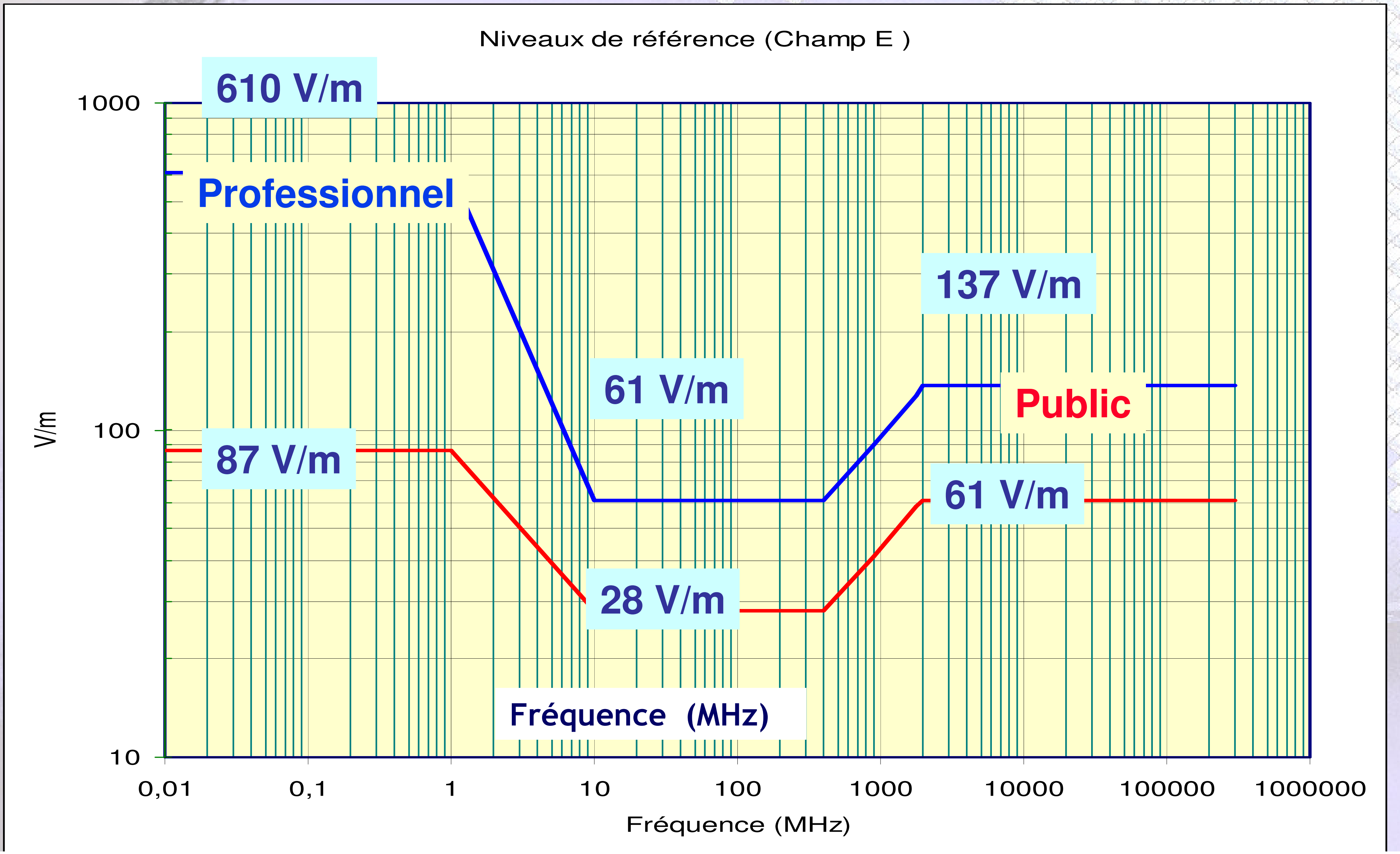
E field reference levels



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MPE & SAR

MPE - Maximum Permissible Exposure,

SAR - Specific Absorption Rate

SAR

definition :

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right)$$

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In contactless applications, :

$$SAR = \frac{\sigma \; |E|^2}{\rho} = c \; \frac{\Delta T}{\Delta t} \qquad mW / g$$

with :

σ	=	conductivity human tissus	S/cm
ρ	=	human tissus density	g/cm3
c	=	tissus thermal capacity	Joule/g/°C
E	=	electrical field	V/cm
ΔT	=		°C,

during dt, in seconde.

conclusions