



**Results of UHF Gen 2 RFID full pallet test for  
Consumer Electronics products**

**Mieloo & Alexander**

May 2007

## Background

- Since passive UHF RFID technology has been available, Mieloo & Alexander has tested the readability performance of this technology for the products of several of our clients in the Consumer Electronics (CE) and High-Tech industry, for utilisation in the supply chain
- The challenge has been to read all items on densely stacked pallets with CE products tagged at least at case level within one pass of maximum 5 seconds (see next slide)
- The high density of and the metal and liquids (LCD's) in these products have made this a real challenge, but the advance of the technology EPC/UHF Gen 2 has been so rapid, that recently a new test cycle was conducted. The results are documented in this summary

## The Challenge: Quantity, Penetration, Metals



Cables



Metal & LCD

CD



Stacking pattern	cases on pallet
5x7x10	350
5x7x10	350
5x7x9	315
5x6x10	300
5x6x10	300
5x6x9	270
4x6x10	240
3x3x24	216
4x6x9	216
4x6x9	216
5x6x7	210
5x6x7	210
5x6x7	210
5x7x5	175
4x6x7	168
4x6x7	168
1x6x24	144
4x6x6	144
4x6x5	120
4x5x5	100
4x6x4	96
3x4x8	96
1x6x12	72
2x6x6	72
3x4x6	72
2x5x6	60
2x3x9	54
3x4x4	48
2x6x3	36

## Test Objectives

- The objective of the test is to assess the current (max.) readability performance levels of UHF Gen2 RFID readers, antennae and tags for utilisation in the Consumer Electronics (CE) supply chain
- This test focuses on two aspects of readability performance:
  - Reading of densely stacked cases with CE products with high degrees of metal and liquids (LCD's)
  - Reading large tag volumes (up to 300 tags) within 4-10 seconds

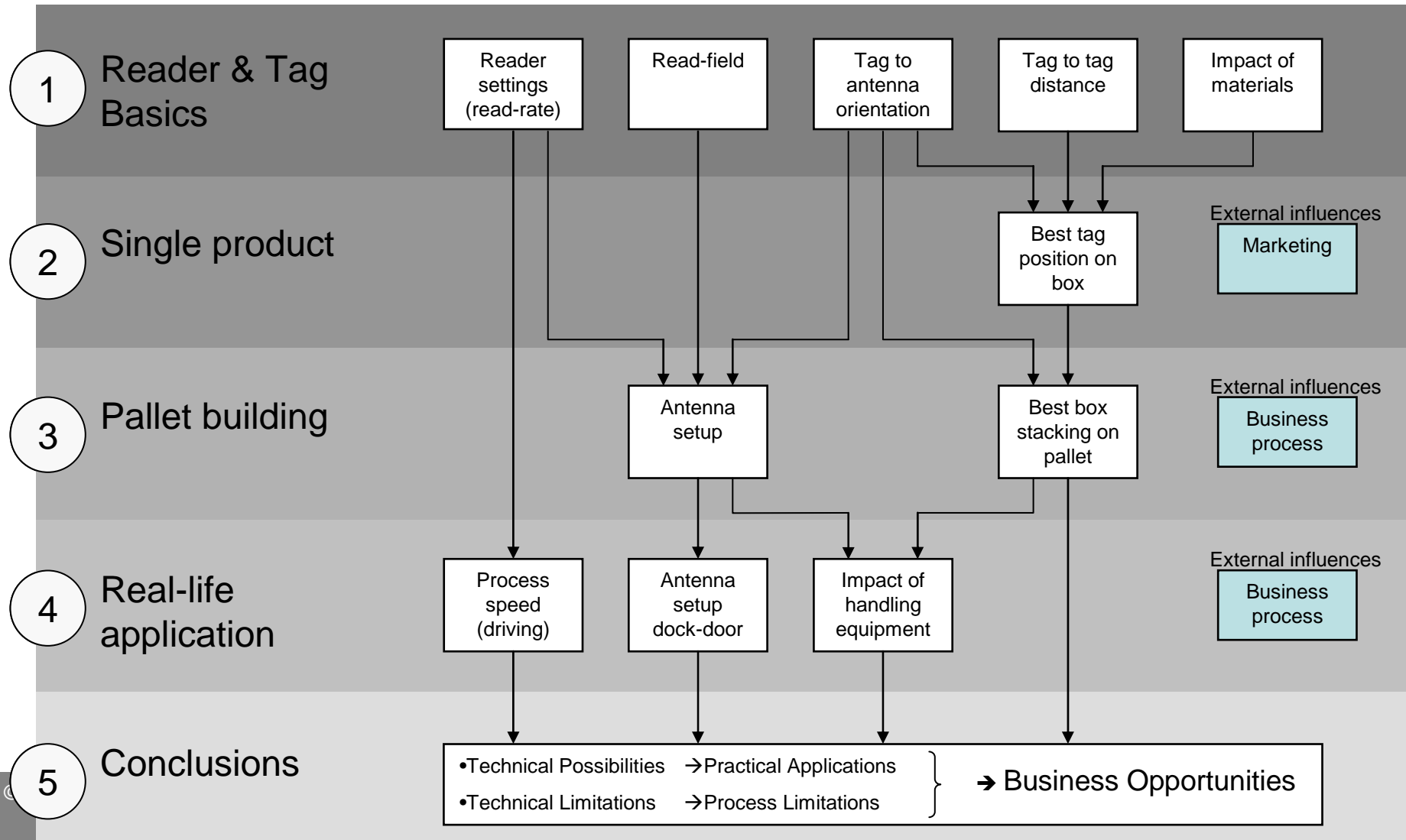


## Technology Scope

- The newest readers, firmware versions and the latest tag releases were selected:
  - UHF EPC Gen 2 RFID Readers:
    - Symbol XR-480 (3.1.6)
    - Sirit Infinity 510 (1.3.5695)
    - Impinj Speedway (2.4.2.240)
  - UHF EPC Gen 2 Tags
    - Raflatac Dogbone
    - Avery Dennison AD-821
  - Test products (300)
    - Sony DCR-HC27E Camcorder



## Test Approach – General M&A Test Approach

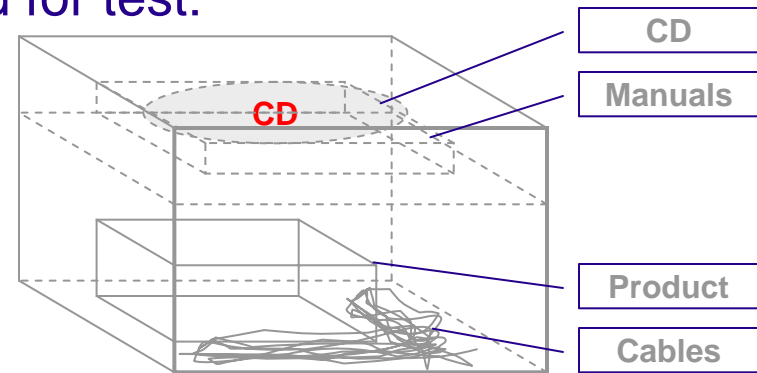


## Test Approach – Consumer Electronics Testing

- All reader settings of the three vendors and the impact on readability performance are evaluated in the first phase
- Find best tag placement on product:
  - Location on packaging (6 sides)
  - Orientation: horizontal or vertical tag placement
- Build pallet with 300 products:
  - With and without air gaps for RF penetration (waveguides)
- Setup RFID portal:
  - With reflective walls and without
- Optimize reader settings to find all tags (unlimited time window), to determine if reading of encapsulated tags is possible
- Introduce read window (20 sec. – 1 sec.) by moving the pallet through a portal setup with variable speed

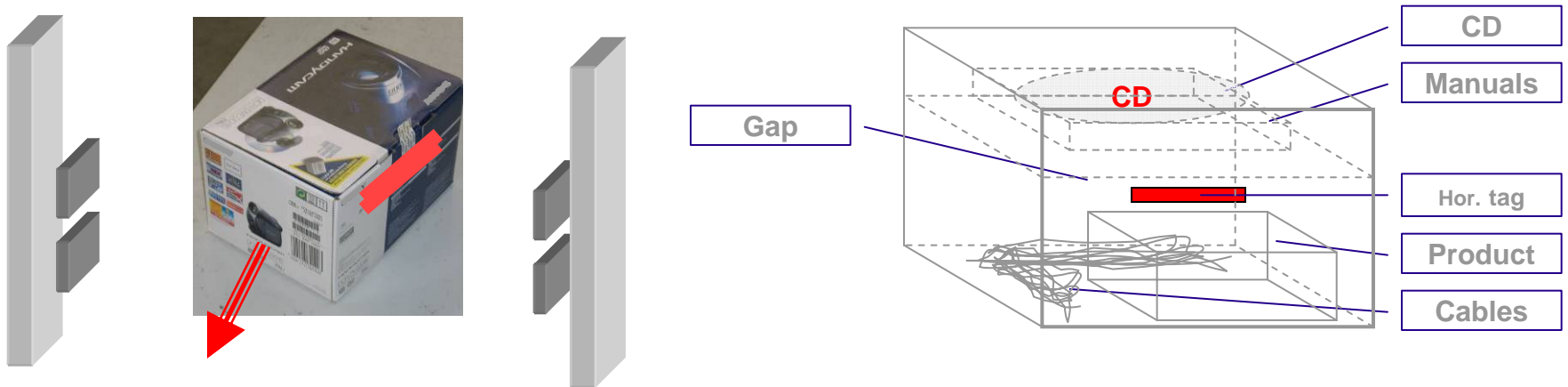
## Test Approach – Product Analysis

- Consumer Electronics product used for test:
  - Camcorder
  - 300 pcs on a pallet
  - 10 layers of 30 pcs
  - Box contains:
    - Battery
    - Power cord
    - Power adapter
    - Data cable
    - Camcorder



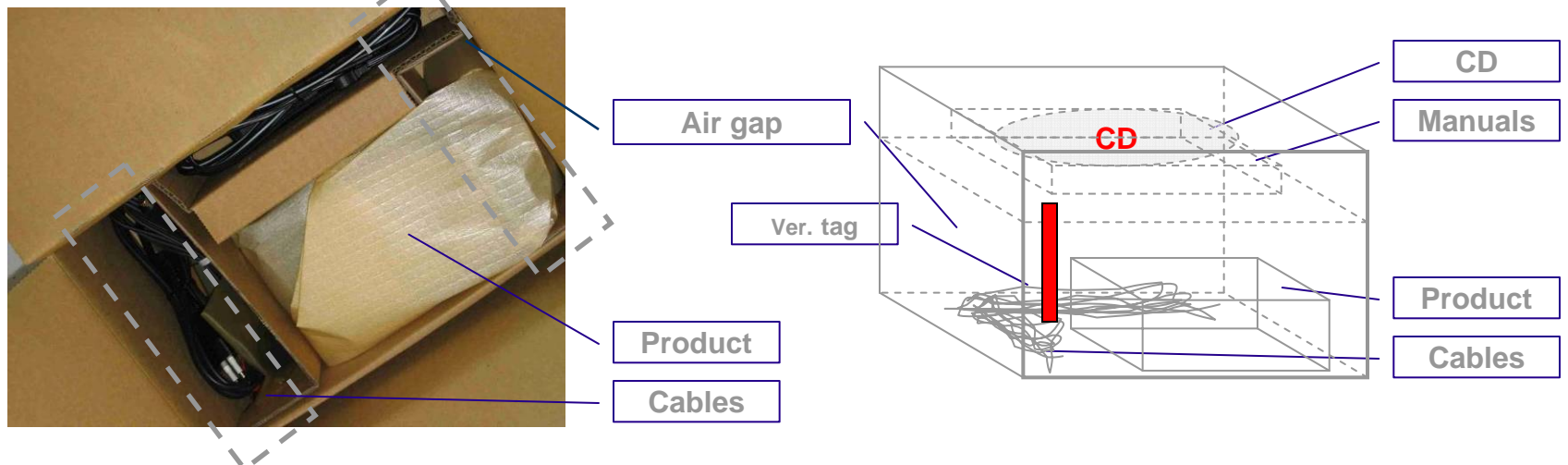
## Test Approach – Tag Placement (1)

- Horizontal tag placement (non-permanent adhesive)
  - The horizontal placement allows radio waves to reach inside the bulk through the metal free gap that results from the pack of manuals
  - Tests with these horizontal tags showed always less than 100% read success
  - Furthermore horizontal placement restricts the usage as the tag always has to face the antennae head-on



## Test Approach – Tag Placement (2)

- Vertical tag placement (non-permanent adhesive)
  - Vertically placed tags allow readings regardless of the tag-antennae orientation
  - The optimal position for vertical tag placement could be identified on one corner of the packaging, where a free air gap behind the tag allowed radio-waves to penetrate the bulk
  - All following tests were performed with vertically placed tags on this position



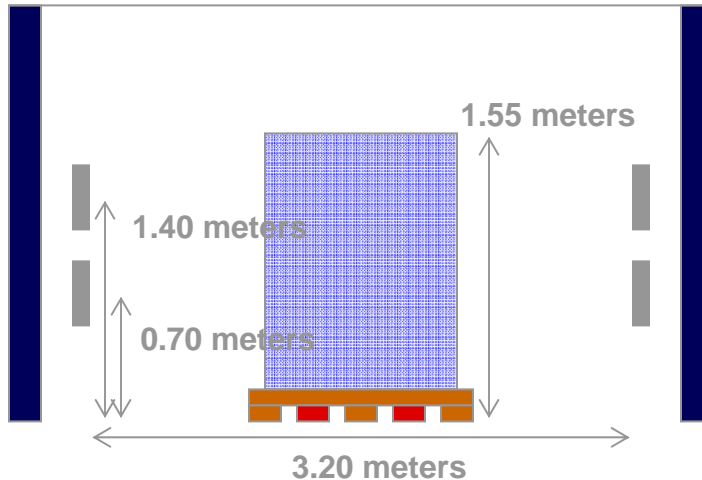
## Test Approach – Pallet

- Pallets were tested with and without waveguides
  - Waveguides constructed of 10 mm thick cardboard sheets
  - Purpose of waveguides is to increase the size of the air gaps and to allow RF energy to penetrate inside pallet structure more easily



## Test Approach – Portal Setup

- RFID portal setup
  - 4 x AN480 antennas arranged like:



- Pallets were tested with or without reflective walls (mesh wire)
- Mesh wire shielding (10 mm mesh size) around the portal leads to reflection of radio-waves and increases readability



## Test Results (1)

- After optimization of tag placement, orientation and reader settings the following variables remained:

Remaining variables					
	Reader	Tag	Waveguides	Mesh fencing	Movement speed
Options	Reader 1	Tag 1	With	With	Normal
	Reader 2	Tag 2	Without	Without	Slow
	Reader 3				With stop in read-field

- Runs repeated 5 or 10 times
- Due to time constraint and goals of testing, some tests were aborted earlier in the case of consistently insufficient results
- Reader 3 performed similar to reader 1, further testing with reader 3 was aborted due to time constraints

## Test Results (2)

- Performance for the different readers with vertical tags and slow pallet movement:

Reader	Tag	Results per run				
		Run 1	Run 2	Run 3	Run 4	Run 5
Reader 3	Tag 1	89.0%	88.7%	90.0%	83.7%	88.0%
Reader 1	Tag 1	90.7%	92.7%	92.7%	92.7%	92.7%
Reader 1	Tag 2	98.3%	97.7%	98.3%	96.7%	96.7%
Reader 2	Tag 1	99.7%	99.3%	98.7%	99.7%	99.0%
Reader 2	Tag 2	100.0%	99.7%	100.0%	100.0%	99.7%

- Highest readability was achieved with reader 2 and tag 2
- In this configuration only 1 of 300 tags was missed (in 2 out of 5 runs), always the same tag. A slightly reduced quality of this one single tag is most likely the cause, but this is difficult to prove unambiguously

## Test Results (3)

- Performance for reader 2, in combination with tag 1 and tag 2 and either waveguides or reflective walls:

Reader 2		Results per run				
Change	Tag	Run 1	Run 2	Run 3	Run 4	Run 5
No additions	Tag 1	99.7%	99.3%	98.7%	99.7%	99.0%
No additions	Tag 2	100.0%	99.7%	100.0%	100.0%	99.7%
Waveguides	Tag 1	99.7%	98.3%	100.0%	99.7%	99.3%
Waveguides	Tag 2	100.0%	100.0%	100.0%	100.0%	100.0%
M&A RFID Tunnel	Tag 1	99.7%	100.0%	100.0%	99.3%	99.7%
M&A RFID Tunnel	Tag 2	100.0%	100.0%	100.0%	100.0%	100.0%

## Test Results (4)

- Reader 2 with current firmware gives best performance
- Tag 2 shows more consistent performance than tag 1
- Addition of waveguides helps radio-waves to penetrate the pallet structure
- Reflective wall simulation of Mieloo & Alexander RFID Performance Enhancement Tunnel increases readability
- Vertical tag position with an air gap behind and in front of the tag gives optimal results
- Missed tags were always located in centre of the pallet  
➔ RF penetration lowest in centre of pallet

## Conclusions

- Latest generation of readers and tags makes reading of 300 camcorders on one pallet possible!
- Current tag technology allows for consistent reading of 300 camcorders on a full pallet
- Continuing reader development will result in higher performance in the near future, especially firmware is developing at a high pace. This will enable the operator to move faster through the portal and enables RFID to be integrated into standard logistics processes
- Extra measures like reflective walls or waveguides are easy to implement and increase the performance and reliability of a RFID system

## Next Steps

- Mieloo & Alexander will continue to test and validate the readability performance of UHF EPC Gen2 RFID technology for its use in the (Consumer) Electronics Supply Chain
- The readability results achieved so far have already resulted in a first full scale deployment of the technology (integrated with IP Video) at Sony Europe's European Distribution Centre in Tilburg the Netherlands, also by Mieloo & Alexander
- For more information on performance testing, feasibility analysis/business case assessments or the Sony implementation, please contact Mieloo & Alexander:

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