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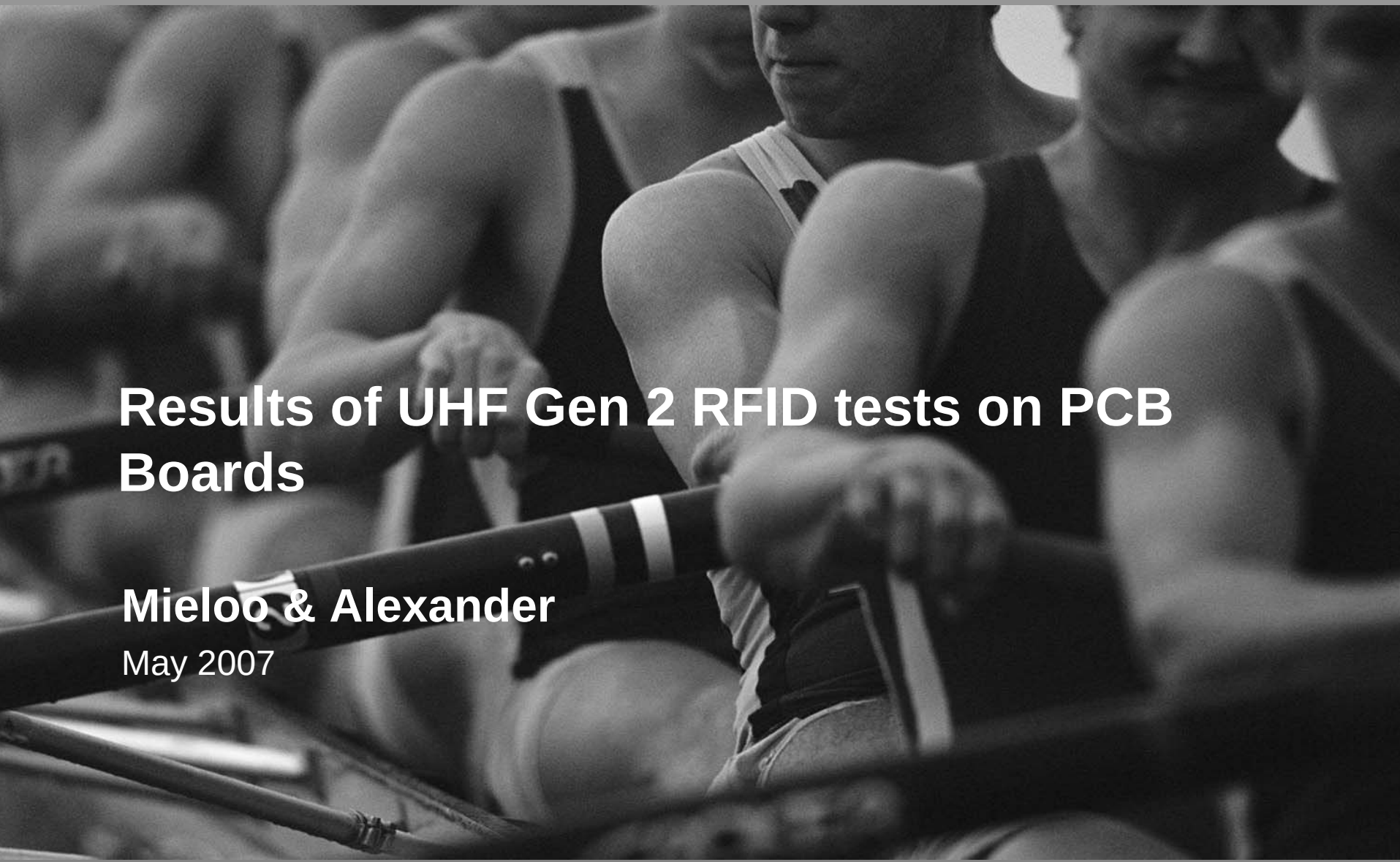

Results of UHF Gen 2 RFID tests on PCB Boards

Mieloo & Alexander

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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 CE and High-Tech industry, for utilisation in the supply chain.

- Next to being able to read all items on densely stacked pallets of (Consumer) Electronic goods, there is also a keen interest from CE and High Tech manufactures to be able to track components during the manufacturing process, for example for route cause analysis. Component tagging will also enable paperless warranty schemes, extended quality management in service and repair, product and process design and engineering improvements, etc.

- Arguably, the most important components in CE or High Tech products are Printed Circuit Boards (PCB's), as they are vulnerable and failure easily leads to malfunctioning of the entire device. However, metal density and high manufacturing speeds and temperatures make the PCB not an ideal candidate for RFID tag application. Nevertheless, the benefits if this could be achieved are manifold.

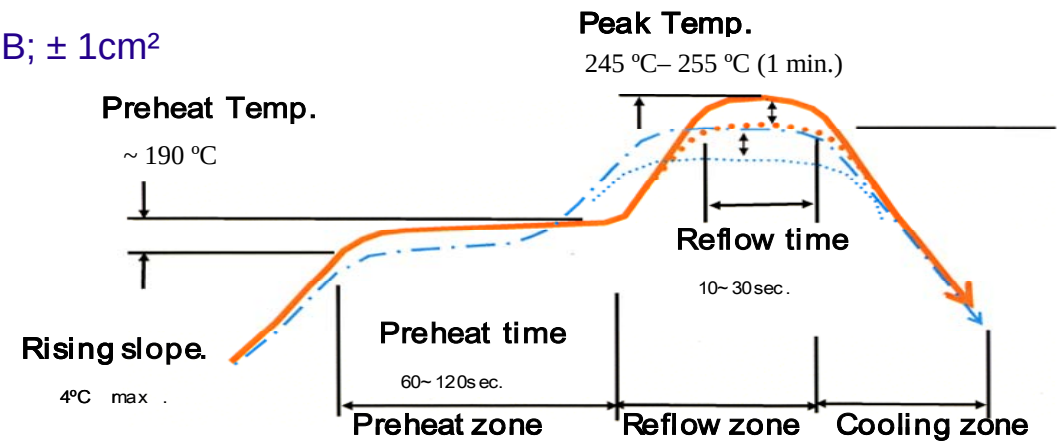
- This report documents the results of tests conducted by Mieloo & Alexander for a CRT/LCD manufacturer, and is structured as follows:

The Challenge: Metal, Speed and Heat

- Main challenges
  - Readability in metal environment; PCB sheets and components
  - Minimum reading distance of tags;
    - Minimum of ± 10 cm from above the PCB, concerning PCB components
    - Minimum of ± 2 cm from underneath the PCB
  - Available read time depending on conveyor speed;
    - 0.15 – 0.30 cm/s

- Other process requirements
  - Available mounting space on PCB; ± 1cm²
  - High temperature resistance;
    - 2 minutes at 190°C
    - ~2 minute increasing to 255°C
    - 1 minute at 255°C
    - Placed in a refrigerator of 4°C
  - Read multiple tags

Reflow oven



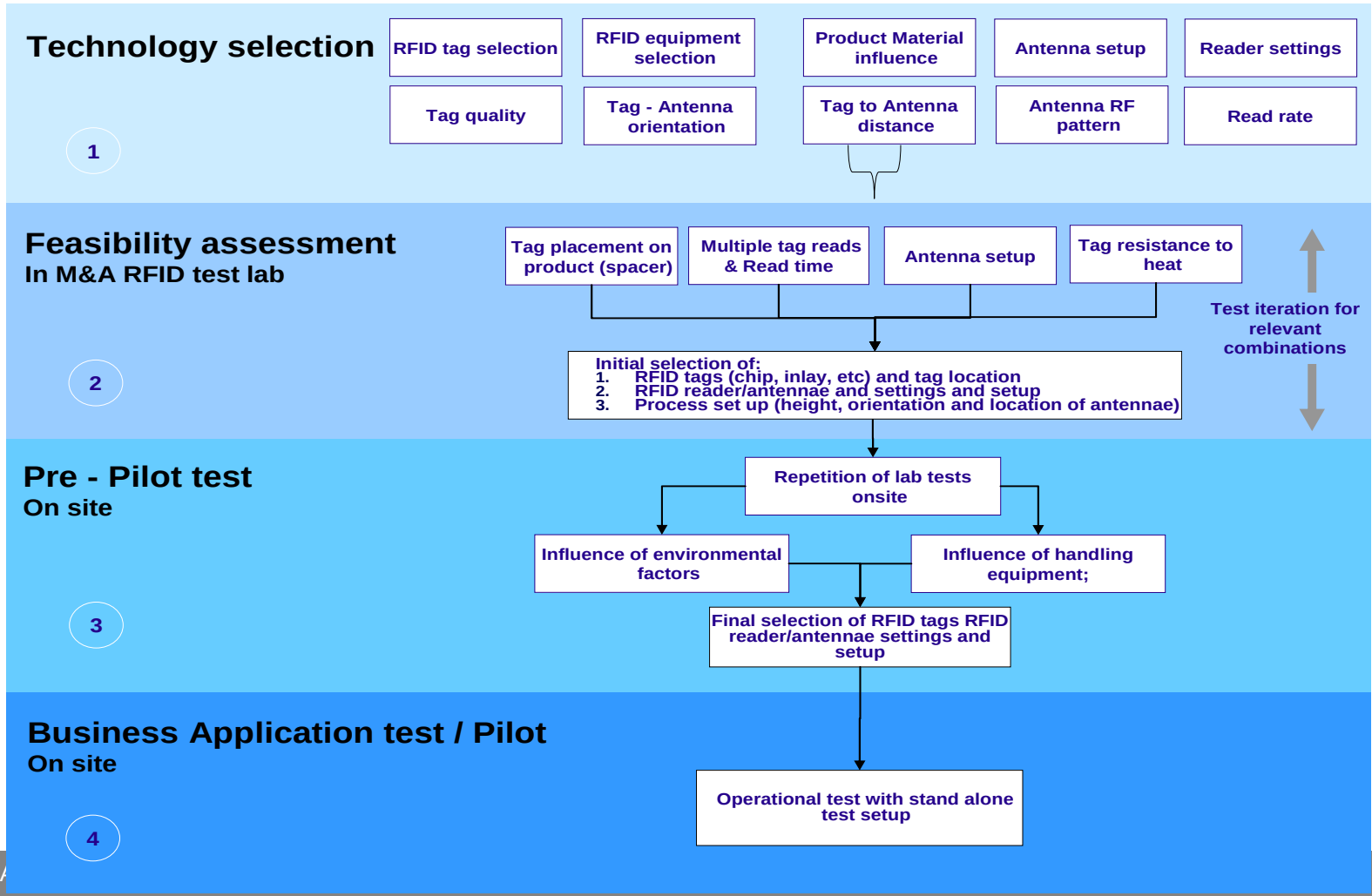
Test Objectives & Approach

- The objective of this test is to determine the feasibility of tagging Printed Circuit Boards with RFID.

- The tests focuses on 4 aspects:
  1. Tag placement on PCB
  2. Multiple tag reads vs. available read time
  3. Antenna setup
  4. Heat resistance of the tag

Generic M&A RFID test approach

Step 1 and 2 in scope for this test



Step 1: RFID technology selection (1)

Initial considerations

- The initial technology scope at the start of the test aims at passive RFID technology in general, because the solution requirements do not give direct clarity on which technology to choose.

- Passive RFID technology can be subdivided in:
  - Low Frequency
  - High Frequency
  - Ultra High Frequency
  - Near Field Ultra High Frequency

- In the first step an assessment of the characteristics, potential applications and benefits of these different technologies ➔ next slide

Step 1: RFID technology selection (2)

Characteristics of different passive RFID technologies

- Low Frequency 125 kHz:
  - Works good in metal environment, inductive field
  - Doesn't support anti-collision for reading multiple tags
  - Short read range
  - Relatively high cost
- High Frequency 13,56 MHz:
  - Works good in metal environment
  - High cost, larger tags, doesn't support anti-collision
  - Short read range
- Ultra High Frequency 868 MHz:
  - Readability is influenced by metal environment through reflections
  - Low cost, good protocol: anti-collision, fast data transfer, international standards
  - Large read range
- Near Field UHF 868 MHz:
  - Works good in metal environment
  - Low cost, good protocol: anti-collision, fast data transfer, international standards
  - Very short read range

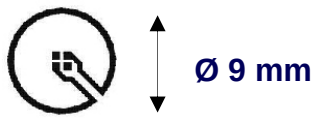
Near field UHF combines the advantages of the 3 other options and is therefore chosen as the technology to start the feasibility assessment with!

Step 1: RFID technology selection (3)

Technology selected for the feasibility test

- Reader (standard UHF GEN 2 reader)
  - UHF Near Field Communication does not require special reader technology. Any GEN2 compatible equipment can be used

- Antenna (Special NFC UHF antenna)
  - Within Near Field Communication, the magnetic part of the electromagnetic wave is used and the tags receive their energy out of the inductive coupling between reader and tag antennae.

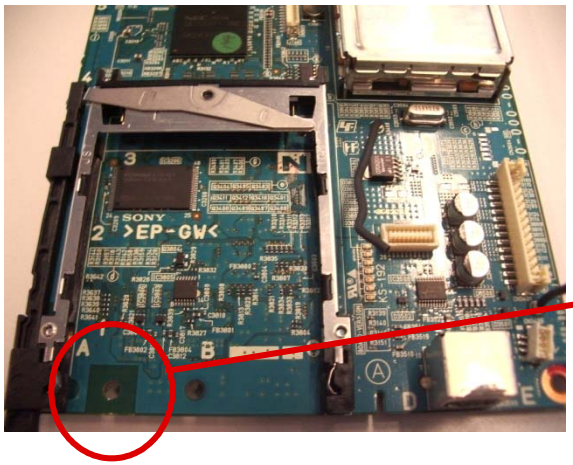


- Tags (Special Gen2 NFC UHF Tags)
  - The tags consist out of the same IC as any other GEN 2 tag, only difference is a special antenna that enables magnetic coupling

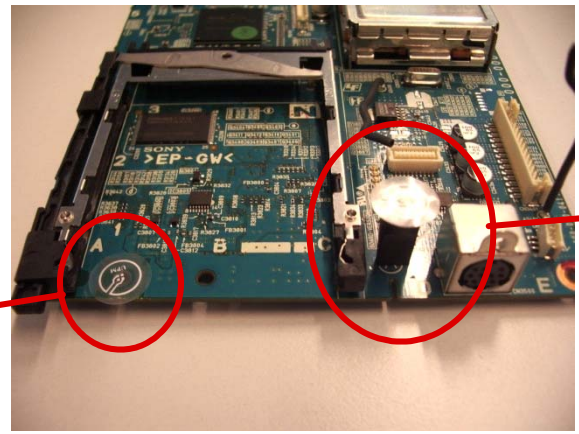
Step 2: Feasibility Assessment (1)

Tag placement

- Even so NFC and magnetic coupling are less sensitive to a metal environment, the tags cannot be placed directly onto metal.
  - Alternative I: Tag placed directly on a metal free location of the PCB
  - Alternative II: Tag placed on a spacer that keeps ± 1 cm distance



Metal free area on the N board



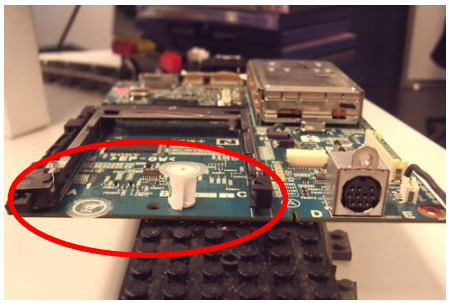
Spacer with small footprint

- Readability tests with PCB boards show positive results for two different alternatives to place RFID tags on boards.

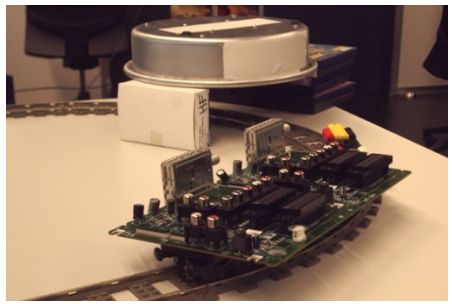
Step 2: Technical Feasibility Assessment (2)

Test conditions

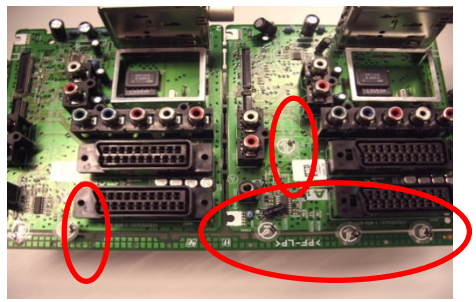
- Two alternatives for tag placement; alternative I & II
- Board speed 30 cm/s (simulated with Lego train)
- Multi tag reads up to 6 tags
- Maximum tag – antenna distance is tested
- Tag – antenna orientation; antenna above or underneath PCB
- All tests are repeated 20 times to ensure test reliability



Alt. I left & Alt. II right



Test setup with Lego train, antenna above the board

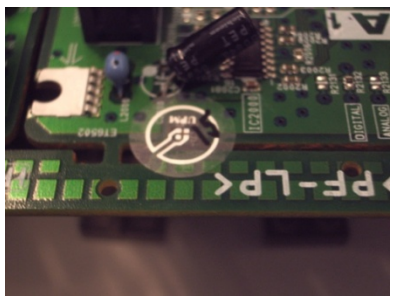


Multiple tags placed on the board

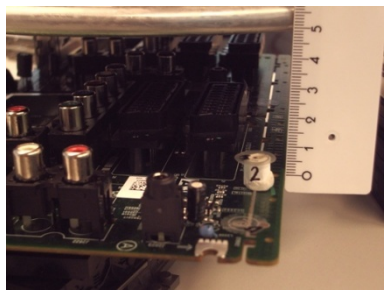
Step 2: Technical Feasibility Assessment (3)

Test results

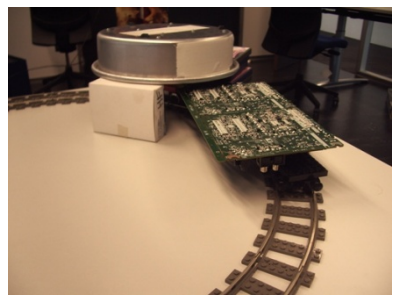
- Alternative I: 100% readability up to 50 cm distance; dynamically and statically tested. The metal around the metal-free spot works as an antenna for the tag! 100% readability up to 15 cm when antenna is placed underneath the board
- Alternative II: 100% readability on distance < 5 cm (dynamically tested)
  - < 50% readability on distance > 5 cm (dynamically tested)
  - 100% readability on distance up to 15 cm (statically tested)
- 70% readability up to 5 cm when antenna is placed underneath the board
- Decreasing the speed increases the readability
- Multiple tags are no difficulty for the NF UHF protocol



Alt. I on little hole on PCB



Minimal antenna distance to A-board

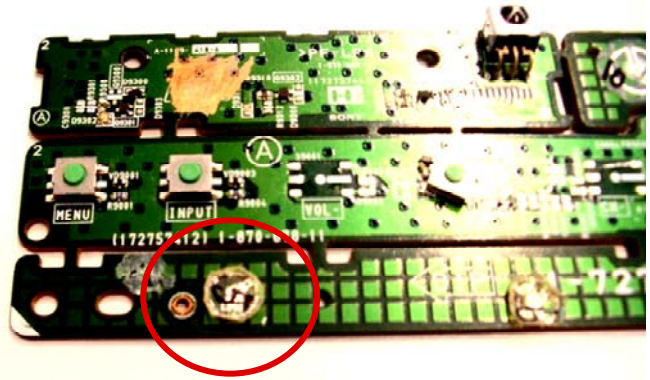


Antenna ‘underneath’ the board

Step 2: Technical Feasibility Assessment

Temperature resistance of tag

- Heat resisting test:
  - Tags are placed in an oven attached to a PCB:
  - 2 minutes at 190°C
  - ~2 minute increasing to 255°C
  - 1 minute at 255°C
  - Placed in a refrigerator of 4°C



- Results:
  - The tags' plastic inlay wrinkled in the oven but the IC and the antenna remain unaffected and the tags were still functioning after the heat treatment.

- Solution options:
  - Tags placed directly on the PCB: paper or other temperature resistant inlays
  - Tags in a spacer: less problematic as the tag can be shielded within the spacer

Summary and Conclusions

Of Step 1 and 2

- Utilize UHF Near field RFID tags and equipment; resolve dense reader and cross read issues with RFID Network architecture

- Two options for tag placement remain:

	Pros	Cons
Alternative I Tag placed directly on a metal free location	Less costs Option to pre-mount tag on raw board before it is fed into the A line	Re-design of PCB with metal free area Special inlay required
Alternative II Tag placed on a spacer	Does not consume board space Provides protection against heat	Cost for spacer

  - A final recommendation depends on the ability to mount the tag itself or the tag with the spacer by robots.
  - Antenna distance must be as close as possible (regarding manufacturing process)
  - The heat resistance question can be resolved, but requires further analysis and discussion

* We disregarded the alternative to mount the IC and to build the antenna onto the board as this adds no cost benefit.