ETSI SR 002 787 V1.1.1 (2009-08)

Special Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Report for CESI-ETSI RFID PlugtestsTM event to investigate the interoperability of interrogators and tags manufactured by different vendors in a postal environment

中国电子技术标准化研究所
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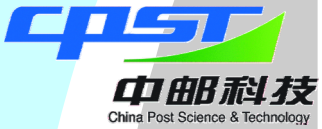

Reference
DSR/ERM-TG34-007

Keywords
radio, SRD, testing

ETSI

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Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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Foreword

This Special Report (SR) has been produced by CESI-ETSI RFID Plugtests™ event cooperation with support from ETSI Technical Committee ERM TG34 and CPST; and with sponsorship from Tektronix.

This and other Plugtests™ events are sponsored by the European Commission.

Executive Summary

The CESI-ETSI RFID Plugtests™ event, to investigate the interoperability of interrogators and tags manufactured by different vendors in a postal environment, was conducted at CPST's premises in Beijing between the 20th to 24th April 2009.

A total of 13 interrogators from 7 manufacturers and 18 different tag types from 9 manufacturers were tested. Among the tags 6 different types of metal tags were used in one of the tests.

The test results revealed that reliable high performance UHF RFID systems can meet the needs of certain operations in the Postal sector using combinations of equipment from different vendors. Further that systems with different UHF air interface protocols (ISO/IEC 18000-6C [i.1], TOTAL [i.1] and IPICO IP-X [i.2]) showed no evidence of interfering with each other. This widens choice for the use of different RFID systems at the same location. Further the test demonstrated the possibility for China to consider a UHF channel plan similar to that deployed in Europe, which would improve the performance and reliability of UHF RFID systems operating in close proximity to each other. Additional late scheduled tests indicated that Chinese tagged goods with tags optimized for Chinese UHF regulations were capable of being read equally well in Europe with interrogators working in compliance with European UHF radio regulations.

The test results showed that there is a need for China to remain vigilant in order to prevent the introduction of non-Chinese compliant UHF RFID devices. There was evidence of partial and complete failure of some equipment to meet Chinese radio regulations with consequential interference to other radio devices and services. Three interrogators were shown not to comply with Chinese radio regulations. These devices participated in the RFID Plugtests™ event where they had no influence on other compliant interrogators and tags. Additionally the results recorded during tests of non Chinese compliant devices have been excluded from the post Plugtest analysis to ensure that the results from these devices did not unfairly reflect upon the general conclusions.

In conclusion the China RFID Plugtests™ event was very successful for all participants. Vendors had the opportunity to gather valuable information on the interoperability of their devices in Postal scenarios. China Post advanced their level of comprehension of the UHF RFID market and their confidence that the performance of passive RFID would meet a number of their favored applications. CESI and ETSI shared a new heightened level of understanding and cooperation with respect to UHF RFID, regional RFID radio spectrum matters, compliance and Plugtests™ event.

Recommended follow-on actions include the repeat testing of some poorly performing metal optimized tags to determine if the results were due to systematic or non systematic failure of the devices under test. All other tests TD_MAIL_2 to 4 should be repeated with representative material in order to establish a higher level of confidence in the appropriate selection of devices . It is recommended to carry out further tests with a view to the introduction of a UHF RFID spectrum channel plan. These spectrum related tests should simulate a dense reader environment in a representative application scenario in order to highlight the possible advantages to Chinese UHF RFID applications. Vendors with devices which were unable to meet Chinese radio regulations are recommended to revise their products and carry out further compliance tests. CESI and ETSI are able to assist vendors with such repeat testing.

Interestingly the series of interference tests highlighted no evidence of any interference between ISO/IEC 18000-6C [i.1] and TOTAL [i.1] or IPICO I-PX [i.2] air interface protocols operating at the same frequency. The only interference demonstrated whether operating at Chinese or European UHF frequencies was between two out of six of the interrogators compliant with ISO/IEC 18000-6C [i.1].

Introduction

This document decribes a RFID Plugtests™ event that was performed at CPST in Beijing, China during the period 20th to 24th April 2009, which was co-organized by European Telecomunication Standards (ETSI) and China Electronic Standardization Institute (CESI). The purpose of the RFID Plugtests™ event was to investigate interoperability when tags and interrogators manufactured by different vendors and complying with different standards were used under different postal scenarios defined by China Post Science & Technology Company (CPST). The RFID Plugtests™ event also explored the capability for any combination of simultaneously operating interrogators (supplied by the participating vendors) when located in the vicinity of each other (referred to 'dense reader mode') to maintain their performance. These interference tests were completed with different combinations of UHF interrogators under both Chinese and also European UHF radio regulations. Other tests investigated if there was any evidence of a reduction in performace when China UHF tags were read by European UHF interrogators.

Since RFID postal applications would be a national or global business, interoperability is crucial. It was therefore considered necessary to carry out a series of tests at the earliest opportunity to determine whether there any problem existed. The tests simulated a number of real life scenarios in which tags and interrogators manufactured by different vendors might be present simultaneously in the same interrogation zone. The tests are described in a test plan which was reviewed and approved by ETSI, CESI and CPST and is available at annex A of the present document.

All of three pre-tests and eight scenario-tests were performed at CPST and comprised the following:

- Determining compliance with the Chinese radio regulation.
- Reading RFID tags in a multi-interrogator environment using just 2 channels at Chinese UHF frequencies.
- Reading RFID tags in a multi-interrogator environment using just 2 channels at European UHF frequencies.
- Reading an RFID tag which is mounted on the top of a metal mail container.
- Reading RFID tags which are attached to 60 mail boxes.
- Reading RFID tags which are attached to mail cases on a conveyor.
- Reading RFID tags which are attached to mail bags on a conveyor.

Tests were carried out with interrogators set to the designated European UHF frequency (865 MHz to 868 MHz). Tests were also carried out with ISO/IEC 18000-6C [i.1] tags mixed with TOTAL [i.1] tags, and ISO/IEC 18000-6C [i.1] tags mixed with IPICO IP-X [i.2] tags. These tests showed that equipment in the EU and China were compatible.

Nine RFID manufacturers (interrogators and tags) took part in the RFID Plugtests™ event. They all participated on the basis that the results of the tests on their equipment would remain confidential. The present document therefore only provides an overall summary of the results recorded for each of the tests. In addition all of the participants in the tests had completed the ETSI Non-disclosure Agreement.

1 Scope

The present document provides a description of the event, the test results, and some technical proposals for Postal applications.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ISO/IEC 18000-6: "Information technology -- Radio frequency identification for item management -- Part 6: Parameters for air interface communications at 860 MHz to 960 MHz".

[i.2] IPICO's IP-X™ RFID Air-interface Protocol

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

inventory mode: mode in which interrogator is configured to re-read the tags in its reading zone continuously

NOTE: Identification of individual tags may be reported multiple times.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CESI	China Electronics Standardization Institution
CPST	China Post Science & Technology Company
CW	Continuous Wave
dBch	Decibels referenced to the integrated power in the reference channel
ERP	Effective Radiated Power
f_c	Frequency of operating field (carrier frequency)
f_o	Offset frequency used in pre-test 1

NOTE: See clause 4.

ID	IDentifier
R_{BW}	Term used to denote 2.5/Tari bandwidth centred at f_c
RFID	Radio Frequency IDentification
RSSI	Received signal strength indicator
S_{BW}	Term used to denote 2.5/Tari bandwidth centred at $(n \times f_o) + f_c$
SMA	Subminiature A
Tari	Reference time interval for a data-0 in interrogator-to-tag signalling
TNC	Threaded Neill-Concelman
TOTAL	Tag only talks after listening
UHF	Ultra High Frequency

4 General

Nine manufactures participated in the RFID Plugtests™ event. They were ZTE, Motorola, Sense, WPG, IPICO, INVENGO, Silion, NXP and Impinj. Seven of them provided the UHF interrogators. They were ZTE, Motorola, Sense, IPICO, INVENGO, Silion and Impinj. All of the nine manufactures provided UHF RFID tags. Also Alien RFID tags that were provided by CPST were tested.

For all of the test scenarios pre-programmed tags were attached to each of the objects under test. Each interrogator was also assigned a reference number as were the tests. The objects were divided into groups with tags assigned by tag type to each group. An electronic record was made of the pre-programmed number in the tag, the object and the test group. In addition there were additional groups comprising items that included tags compliant with different standards. This made it possible to compare the performace of tags by type against the performance of a mixed population of tags.

There were four test scenarios in the original test plan specification (see below) but in fact with the agreement of all parties another four test scenarios were added at the end of the test. These additional tests were selected in order to explore the potential for tags optimized for use under Chinese UHF regulations to operate satisfactorily at European UHF frequencies. These tests included both the fixed frequency mode and FHSS mode. Tests were carried out at both Chinese and European UHF frequencies using FHSS even though this is not permitted under existing European UHF regulations.

Three pre-tests were carried out. Pre-test 1 tested the output power, frequency and spectrum mask of each interrogator to make sure that they are conform to the Chinese 920 MHz to 925 MHz regulations. Pre-test 2 tested a dense interrogator environment under Chinese UHF regulations. Pre-test 3 tested the European 4-channel plan.

4.1 Test schedule

The event was held during 20th to 24th April 2009.

Date	Time	Test	Location	Place
Monday 20 April	09:00 - 18:00	**Pre-test 1:** DRM spectrum mask **TD_MAIL_1:** Tests with Mail Container **TD_MAIL_2:** Tests with Mail Cases on Cart	Testing Hall	CPST
Tuesday 21 April	08:30 - 19:00	**TD_MAIL_2:** Tests with Mail Cases on Cart **TD_MAIL_3:** Conveyor Tests with Mail Cases **TD_MAIL_4:** Conveyor Tests with Mail Bags	Testing Hall	CPST
Wednesday 22 April	08:30 - 19:00	**Pre-test 2:** Multi-interrogator environment **Pre-test 3:** Four channel plan	Basketball Court	CPST
Thursday 23 April	08:30 - 19:30	**TD_MAIL_1:** Tests with Mail Container **TD_MAIL_2:** Tests with Mail Cases on Cart **TD_MAIL_3:** Conveyor Tests with Mail Cases **TD_MAIL_4:** Conveyor Tests with Mail Bags **TD_MAIL_5:** Tests with Mail Cases on Cart **TD_MAIL_6:** Tests with Mail Cases on Cart **TD_MAIL_7:** Tests with Mail Cases on Cart **TD_MAIL_8:** Tests with Mail Cases on Cart	Testing Hall	CPST
Friday 24 April	08:30 - 15:00	**TD_MAIL_8:** Tests with Mail Cases on Cart **Wrap-up meeting**	Testing Hall meeting room	CPST

4.2 Interoperability Test Sessions

The objective of each interoperability test session was to execute for each test pair (1 interrogator vendor and 1 tag group) tests according to "Test Descriptions for CESI-ETSI RFID Plugtests™ event" (see annex A). This meant that one interoperability test session constituted of 5 test-runs of a given test pair, e.g. "interrogator vendor A - tag group C" (1 test session = 5 test-runs = 5 log files).

Prior to each interoperability test session one person from the participating teams was selected to be the test session secretary. For each test-run a log file was captured, and the interoperability result was agreed amongst both vendors. At the end of each interoperability test session, the complete batch of 5 log files was submitted by the test secretary to ETSI and CESI.

The log files were analyzed according to the appropriate evalution formulas (as defined in the respective "Results" sections of clause 5 "Result Summaries"). The results were then entered in the ETSI Test Reporting Tool (https://services.plugtests.net/reporting/index.php) and made available for consultation.

Table 1: Example - Overall Results TD_MAIL_1

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
423 (95,7 %)	19 (4,3 %)	**0 (0,0%)**	38 (7,9%)	442 (92,1 %)	480

The example above shows how the Overall Results per test (Pre-test 2 to TD_MAIL_8) were reported. The "Interoperability" table provided the number of executed test-runs which were recorded as OK and NO (Not OK). The "Not Executed" column indicated why the rest of the test-runs were not executed. This was either because of non applicability (NA) or because of timing constraints (OT). The "Totals" columns showed the total number of test-runs that were executed; and in the "Results" entry it showed the total of all test-runs (sum of executed and not-exectued test-runs).

5 Result Summaries

The Test descriptions for CESI-ETSI Plugtests™ event, defining the three pre-tests and the four scenario tests, is attached in annex A. Where time permitted some additional test were carried out. Details of these additional tests are also included in the present document.

5.1 Pre-test 1: DRM spectrum mask

5.1.1 Summary

The purpose of Pre-test 1 is to verify whether spectrum emissions from the supplied RFID interrogators complied with the requirements critical for successful DRM operation under China RFID UHF regulations.

In the test for the intentional emissions interrogators were set to the maximum value permitted by Chinese RFID UHF regulations, and were measured using a spectrum analyser.

The test was carried out in a normal laboratory. The output port of the interrogator was connected directly to the input of the spectrum analyser through a 10 dB attenuator and an interconnecting cable. The cables had to accommodate the following connector types: TNC, SMA and N. The cables were calibrated before the test. The loss of each cable was recorded and taken into account in the measurements.

In order to determine conformance with the Chinese UHF regulations the interrogators were set to an output power of 27 dBm (assuming a typical 6 dB antenna that would deliver 33 dBm ERP) with the centre frequency set to 921,125 MHz. Inventory mode was activated during the measurements in order to force continuous modulation of the carrier. The interrogator manufacturers were asked to set Tari to the maximum value used in any of the other tests. The tests included measurement of the output power and centre frequency, measurement of the channel bandwidth and measurement of the power in the adjacent channels (i.e. channels -3, -2, -1, 1, 2, 3).

Interrogators did not always transmit at their maximum power since for some application test scenarios the output power had to be reduced. The output power will be adjusted according to the gain required for the application scenario.

5.1.2 Exceptions

All interrogator types participating the RFID Plugtests™ event were tested in Pre-test 1. If multiple devices of the same interrogator type were available only one device was tested.

Tolerances in the actual output power when setting the output power in software to 27 dBm were observed for multiple interrogators. Whenever a deviation of more than 1 dB (< 26 dBm or > 28 dBm) of the measured output power was observed, the software settings of an interrogator were altered in order to fit within the 1 dB tolerance range. Along with the measurement results the actual software settings for the output power were noted. These settings were used for those other tests that also required maximum output power.

One of the interrogators under test did not offer possibilities to select the output power in software. Furthermore this interrogator had a built in antenna with a gain lower than 6 dB. Output power calibration to 29 dBm (allowing for lower antenna gain) had to be done manually.

Two of the interrogators under test were optimized for operation in the European frequency band. These interrogators were tested at frequencies of 865,7 MHz and 866,9 MHz respectively.

One of the interrogators under test was optimized for operation in the US frequency band. This interrogator was tested at a frequency of 902 MHz.

One of the interrogators under test initially did not fulfil the requirements for occupied channel bandwidth and spectrum mask. The reason was found to be a Tari setting of 6,25 µs. As this Tari setting is not permitted under Chinese RFID UHF regulations the setting was changed to a higher value and the test was repeated.

5.1.3 Results

All interrogators under test fulfilled the requirements for centre frequency accuracy and occupied channel bandwidth.

Nine of ten interrogators fulfilled the requirements for the spectrum mask (adjacent channel power ratio) when set to an output power that would deliver 33 dBm ERP when connected to a 6 dB antenna.

One interrogator did not fulfil the requirements for the spectrum mask when its output power was set in software to 27 dBm. This interrogator's actual output power measured for a setting indicating 27 dBm was ~ 22 dBm. This interrogator's software settings were altered in order to achieve ~27 dBm actual measured output power. With the updated settings the requirements for the spectrum mask were met.

5.1.4 Recommendations

Based on the observations in Pre-Test 1 it is recommended not to rely purely on software settings but to use specialized measurement equipment (spectrum analyzer) in order to verify output power and other values critical for conformance with regulations. The fulfilment of spectrum mask requirements is of vital importance especially in dense reader environments.

5.2 Pre-test 2: Multi-interrogator environment

5.2.1 Summary

The purpose of Pre-test 2 is to test the applicability of the European 4 channel-plan for multi-interrogator environments under Chinese regulations.

The test covered the simultaneous operation of multiple interrogators located in close proximity to each other. The actual distance between two interrogators in the circle was chosen to be ~ 7 m. This ensured that no interrogator was able to read tags associated with another interrogator, while the forward link signal power of neighbouring interrogators was still much higher than the return link signal power of tags associated with each interrogator. Three different protocols were used by these interrogators: ISO/IEC 18000-6C [i.1], TOTAL [i.1], IPICO IP-X [i.2]. There were six ISO/IEC 18000-6C [i.1] interrogators, one TOTAL [i.1] interrogator and one IPICO IP-X [i.2] interrogator. The interrogators were setup to use fixed frequencies of 920,625 MHz and 922,125 MHz (fixed frequency settings alternating around the circle of interrogators) - channel spacing = 1,5 MHz.

Each interrogator manufacturer provided 30 tags that were read continuously during the test, The tag population tag geometry and tag orientation were determined by the interrogator manufacturers.

Prior to the tests a spectrum analyzer was used to setup and verify the output power and frequency settings of each interrogator. The radiated output power was adjusted to deliver a level of 33 dBm ERP from the antenna. Furthermore with all interrogators set to inventory mode, a check was made that each one could read a minimum of 20 of the 30 tags in its reading zone .

During the tests a spectrum analyzer was used to ensure that only channels 3 (920,625 MHz) and 9 (922,125 MHz) were occupied.

The test procedure included determining the change of the detection rate (tag identifications per second) of a certain interrogator as the other interrogators in the test were activated one-by-one. The procedure was repeated for each of the interrogators under test. The detection rate was determined by counting the number of identifications over a fixed period of time (20 seconds).

5.2.2 Exceptions

The initial test plan specified a repetition of the tests using a channel spacing of 750 kHz (channels 3 and 6). Due to the poor weather conditions only one day was suitable for outdoor tests, which was used to conduct Pre-test 2 with 1,5 MHz channel spacing and Pre-test 3. It was agreed that Pre-test 2 with 750 kHz channel spacing will be addressed later in a joint endeavour between CESI and ETSI (details not yet fixed).

Later evaluation of the test results showed that an error occurred in recording the figures for one of the interrogators. The results that were recorded incorrectly have been excluded from the final report after consulting the relevant manufacturer.

During the tests on one of the interrogators the corresponding tag population moved due to the wind. As movement of the tag population could affect the detection rate this incident was considered in the evaluation of the results.

5.2.3 Results

Overall, the results of Pre-test 2 show that multiple interrogators may successfully operate in close proximity to each other using just two channels with a spacing of 1,5 MHz (dense reader mode). Furthermore, the test demonstrated effective use of multiple protocols (ISO/IEC 18000-6C [i.1], TOTAL [i.1], IPICO IP-X [i.2]) in the same environment.

The results for six of the seven interrogators in Pre-test 2 did not show any significant drop in detection rate during the tests.

The detection rate of one interrogator under test dropped considerably on being subjected to transmissions by a certain other interrogator. The two interrogators were using the same channel and were placed back to back in the circle at a separation of more than 14 meters. The situation did not change after activating further interrogators. Later investigations showed that the interrogator causing the drop in detection rate was setup with a Tari of 6,25 µs (violating the spectrum mask requirements). Interestingly, other interrogators were not affected by this.

For some interrogators a rather high variation (> 5 %) of the detection rate was observed during the tests. Since the results randomly deviated in both a positive and negative direction, they were considered to be caused by the interrogator's inventory procedure rather than by the influence of other interrogators.

For one interrogator it was observed that the detection rate increased by up to 12 % when switching on other interrogators. A similar behaviour was observed in Pre-test 3 with a device from the same vendor.

Table 2: Overall Results – TD_PREMAIL_2

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
60 (93,8 %)	4 (6,3 %)	**0 (0,0 %)**	0 (0,0 %)	64 (100,0 %)	64

5.2.4 Recommendations

The excellent results in Pre-test 2 showed that the European 4 channel-plan may be successfully applied for multi-interrogator environments under the Chinese UHFregulations. To align with the frequencies most widely used globally for RFID at UHF it would be beneficial to focus on the upper of the two designated frequency bands (920 MHz to 925 MHz) in China. The following transmit channels may be used for RFID interrogators in DRM: CH3, CH6, CH9, CH12, CH15, CH18. This would result in a six channel plan with a channel spacing of 750 kHz. In order to provide a good basis for discussions about changing the Chinese UHF RFID regulations, additional tests should be performed in multi-interrogator environments to compare the current frequency hopping scheme (utilizing all high-power channels) against the proposed new scheme.

Future tests may include investigation into interference between interrogators operating on the same channel. This will likely take a considerable amount of time. In this Pre-Test 2 half the interrogators were operating on one channel and half on another. When interference between two interrogators was witnessed, it was on the same channel. It is impossible to predict if other interrogators would also have been affected if all of them had used the same channel.

Further investigations may be necessary to find out whether the use of multiple interrogators in close proximity might have positive impacts on the detection rate of certain devices (as observed for one of the devices during Pre-test 2 and 3).

5.3 Pre-test 3: Four channel plan

5.3.1 Summary

The purpose of Pre-test 3 was to test the European 4 channel-plan with the interrogators participating in the RFID Plugtests™ event and to validate proper operation in the European UHF frequency band. Furthermore, possible interferences between multiple air interface protocols were tested.

The test covered the simultaneous operation of multiple interrogators located in close proximity to each other. The actual distance between two interrogators in the circle was chosen to be ~ 7 m. This ensured that no interrogator was able to read tags associated with another interrogator, while the forward link signal power of neighbouring interrogators was still much higher than the return link signal power of tags associated with each interrogator. Two different protocols were used by these interrogators: ISO/IEC 18000-6C [i.1], TOTAL [i.1]. There were three 6C interrogators and one TOTAL [i.1] interrogator. The interrogators were setup to use fixed frequencies of 865.7 MHz and 866.9 MHz (fixed frequency setting alternating around the circle of interrogators) - channel spacing = 1,2 MHz.

Each interrogator manufacturer provided 30 tags that should be read continuously during the test. The tag population geometry and orientation were determined by the interrogator manufacturers.

Prior to the tests a spectrum analyzer was used to setup and verify the output power and frequency settings of each interrogator. The radiated output power was adjusted to a level of 33 dBm ERP from the antenna Furthermore with all interrogators set to inventory mode a check was made that each one could read a minimum of 20 of the 30 tags in its reading zone.

During the tests a spectrum analyzer was used to ensure that only channels 4 (865,7 MHz) and 7 (866,9 MHz) were occupied.

The test procedure included determining the change of the detection rate (tag identifications per second) of a certain interrogator as the other interrogators in the test were activated one-by-one. The procedure was repeated for each of the interrogators under test. The detection rate was determined by counting the number of identification over a fixed period of time (20 seconds).

5.3.2 Exceptions

No exceptions were reported for Pre-test 3.

5.3.3 Results

Overall, the results of Pre-test 3 showed successful operation of the interrogators under the European UHF 4 channel-plan. Furthermore, the results do not show any indication of interference between the different air interface protocols used in the test.

The detection rate of one interrogator under test dropped considerably on being subjected to transmissions by a certain other interrogator. The two interrogators were using the same channel and were placed back to back in the circle at a separation of more than 14 meters. The situation did not change after activating further interrogators. Later investigations showed that the interrogator causing the drop of detection rate used a Tari setting of 6,25 µs during the tests (violating the spectrum mask requirements). Interestingly, other interrogators were not affected by this.

The detection rate of another interrogator dropped by about 20 % after being subjected to emissions from a certain interrogator. The interrogators were using different channels and were placed next to each other in the circle at a separation of about 7 meters. It has to be mentioned that the interrogator causing the drop in detection rate was unable to fulfil the requirements of the spectrum mask shown in Pre-test 1.

For one interrogator it was observed that its detection rate increased by up to 6 % when other interrogators were switched on. A similar behaviour was observed in Pre-test 2 with a device from the same vendor.

Table 3: Overall Results – TD_PREMAIL_3

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
14 (87,5 %)	2 (12,5 %)	0 (0,0 %)	0 (0,0 %)	16 (100,0 %)	16

5.3.4 Recommendations

The results in both Pre-test 2 and Pre-test 3 show that for successful operation in close proximity using the dense reader mode, it is important that all interrogators meet the spectrum mask requirements.

5.4 TD_MAIL_1: Tests with Mail Container

5.4.1 Summary

There were 7 interrogators and 5 types of tags in this test whose air interface complied with ISO/IEC 18000-6C [i.1]. There was also one IPICO IP-X [i.2] interrogator and one IPICO IP-X [i.2] tag included in this test. The seven ISO/IEC 18000-6C [i.1] interrogators were each tested with each of the 5 metal optimized ISO/IEC 18000-6C [i.1] tags in 5 test-runs. The IPICO IP-X [i.2] interrogator was tested with the one IPICO IP-X [i.2] tag in a further 5 test-runs.

In accordance with the test specification only one tag was used with each mail container. This tag was placed on the metal top of the mail cage.

The target was 100 % read rate for each test-run and for all TD_MAIL_1 tests.

5.4.2 Exceptions

The placement of the tag on the top surface of the mail cage was left to the judgment of the vendor's representative conducting the tests. While all tags were placed on the top surface of the metal mail cage, the reading performance of some interrogators varied according to whether certain tags were positioned on the metal sheet top panel away from the edge of the mail cage or on the metal box sectioned edges of the top surface.

All 4 antennas fitted to the portal were connected to each of the interrogators under test with one exception. The one exception used only two of the overhead antennas located on the portal.

One of the interrogators under test was optimized for operation in the US frequency band. This interrogator was tested at a frequency of 902 MHz.

One vendor removed a metal optimized tag at the beginning of the test of the third interrogator in order to verify its performance. The same vendor replaced the metal optimized tag with a similar device before the testing of the fourth interrogator. The replacement tag's encoded ID was recorded. Ahead of the sixth interrogator test the replacement tag was encoded with a CESI defined ID.

The analysis of the results takes into account the removed and replaced tags when reporting the overall performance of the TD_MAIL_1 test.

5.4.3 Results

The objective of this test was to achieve 100 % read rate in all tests without any ghost reads.

All interrogators achieved 100 % read performance in all 5 tests with one or more tag groups. Further five of these interrogators achieved 100 % read performance in all tests with four tag groups. Two other interrogators achieved 100 % read performance in all tests with three tag groups.

One tag group achieved 100 % read performance with just over half of the interrogators. Another tag group achieved could not be read at all by five of the ISO/IEC 18000-6C [i.1] interrogators on the five test-runs. Further investigation revealed that the poor tuning of these tags for this application was a likely cause of the lower performance.

No ghost reads recorded in any of the tests.

On the first day, with ISO/IEC 18000-6C [i.1] devices, there were three different interrogators which could not read one kind of tag. A possible reason for these poor results was the air gap between the tag and the mail container. The air gap was due to the peel-off backing covering the adhesive on the lower face of the tag, which was left on to facilitate placement and removal during testing. Tests showed that, when this backing was removed and the tag applied directly to the metal top suface of the mail container, the reading performance improved. At the end of scheduled testing on Thursday these tests were repeated for a limited selection of interrogators and tags.

Table 4: Overall Results – TD_MAIL_1

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
135 (75,0 %)	45 (25,0 %)	**0 (0,0 %)**	0 (0,0 %)	180 (100,0 %)	180

5.4.4 Recommendations

Placement of some metal optimized tags is important although the majority performed well when applied anywhere on the topsurface of the metal mail container.

Further testing of those tag types which showed lower performance is recommended in order to determine whether the de-tuning is a systematic problem or limited to the sample provided for the RFID Plugtests™ event.

5.5 TD_MAIL_2: Tests with Mail cases on a Mail Cart

5.5.1 Summary

Seven interrogators and four types of tags were tested using ISO/IEC 18000-6C [i.1] protocol. One interrogator and one type of tag was tested using TOTAL [i.1] protocol,. The interoperability between interrogators and tags manufactured by different vendors was tested, and the interoperability of mixed populations of tags was also tested.

There were four antennas mounted on the test portal frame for connection to the interrogator under test. Each of the tested interrogators was placed in turn on a wooden board situated on top of the portal frame.

The interrogator tests were divided into 2 kinds. The first kind tested homogenous tag groups, where an interrogator read only one type of tag at a time. Using the same interrogator, the second kind tested a mixed population of tagged mail cases where all tags to be read had a matching air interface protocol.

120 tags were attached to 60 mail cases, that is 2 tags were attached to each mail case. In the mixed case, there were 4 types of ISO/IEC 18000-6C [i.1] tags and one type of IPICO IP-X [i.2] tags (60 tags) making a total 5 tag types. Each mail case had the same type of tag applied to each end. The mail cases were deliberately configured in an arrangement to distribute the ISO/IEC 18000-6C [i.1] and TOTAL [i.1] tags evenly throughout the mail cart. The same tags and mail cases in the same positions on the same mail cart were used for all TD_MAIL_2 interference tests.

5.5.2 Exceptions

All tests were performed with empty small mail cases as there was no suitable material available to fill them.

The interference test set-up was modified from the original proposal which was to have 4 tags on each small mail case, (ie 2 different tags on each end face). This test was actually performed with 2 tags of the same type applied to each mail case and with alternate mail cases having 2 tags of a different type from the adjacent mail case. The reason for the change was due to concern that the proximity of tags was not representative of the application scenario and might negatively influence reading performance. The test specification has been updated to reflect the configuration of tags on each mail case, their positioning and approximate orientations. ISO/IEC 18000-6C [i.1] tags of all tag types entered for this test were used in the interference test.

While all small mail cases were tagged with two tags, one at each end of the mail case, one minor objective of the results evaluation was to determine whether or not one tag on each mail case would suffice. This requirement was introduced after the test specification was finalized and hence it is mentioned here as an exception. The evaluation of the test results against this objective provided a conservative view as to the capabilities of tags and interrogators. This is because it was only possible to set a very demanding pass performance criteria, being the ability to read all tags in each and every test-run.

The recommendation is based on interpreting the two analysis criteria being identification of cases with two tags (100 % of all mail cases) and the potential to identify all mail case using one tag (100 % of all tags).

5.5.3 Result

The objective of this test was to correctly identify all mail cases on every test-run by reading either one or both tags on each mail case. A further lesser objective was to demonstrate that all mail cases could be identified by either one of the two tags on each mail case regardless of whether it was facing out or inwards. Another objective was to avoid the generation of ghost reads.

One interrogator demonstrated 100 % reading performance, meeting both objectives 1 and 2 above.

A further 3 interrogators demonstrated 100 % identification of all mail cases by identifying either one or both of the tags applied to each mail case, thus complying with the first objective.

Any detected ghost reads with a pre-programmed ID belonging to the batch under test indicated a forgotten tag in the test field, and was therefore ignored. Any detected ID not belonging to the batch under test was counted as a genuine ghost read. Through careful selection of the antenna and/or through the addition of shielding in the vicinity of the antennas a reduction or elimination of tag reads can normally be achieved for those tags in the vicinity of the portal antennas but which are not moving through the portal.

There was no apparent evidence from the interference tests to indicate that the prescence of TOTAL [i.1] tags influenced in anyway the reading performance of ISO/IEC 18000-6C [i.1] protocol tags or interrogators. Overall there was less than 1 % variation between the homogenous tag group tests and the mixed tag group tests. The same was true for ISO/IEC 18000-6C [i.1] protocol tags influencing the reading performance of TOTAL [i.1] tags and interrogators.

Table 5: Overall Results – TD_MAIL_2

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
152 (82,2 %)	33 (17,8 %)	**0 (0,0 %)**	0 (0,0 %)	185 (100,0 %)	185

5.5.4 Recommendations

It is recommended that for similar applications where high reading performance is important, each mail case is tagged with 2 similar tags (i.e. one at each end of the mail case).

It is recommended that future tests similar to TD_MAIL_2 include mail containers filled with representative material. This may add to the testing time as handling filled mail cases will be slower. For example it will be challenging to remove columns of five mail cases at a time in order to swap tags.

5.6 TD_MAIL_3: Conveyor Tests with Mail Cases

5.6.1 Summary

This test was to test the interoperability of tagged large mail cases with interrogators connected to antennas fixed to a portal over a powered steel bedded conveyor belt. One tag was attached to the front and and another to the rear of each mail case. Ten tags attached to five mail cases were prepared in advance for each of the tests. The mail cases were placed sequentially on the conveyor before the conveyor was switched-on.

Each interrogator in turn recorded the tags and the sequence in which they were read. Every test was run 5 times.

Seven interrogators and four types of tags were tested using ISO/IEC 18000-6C [i.1] protocol, One interrogator and one type of tag was tested with the IPICO IP-X [i.2] protocol.

Knowing the sequence of mail cases travelling on a conveyor is important where a conveyor is a feed to an automatic sort machine. Identifying a mail case in an incorrect sequence when feeding an automatic sorter can result in considerable costs to a Postal operator. This problem has previously arisen when using bar codes.

5.6.2 Exceptions

This test was divided into two parts with each part comprising of five test-runs. Part two was carried out immediately after Part one. For Part 1 5 mail cases were used, where every mail case had one tag applied on each side. The separation between two mail cases was 105 millimetres and the conveyor speed was 0,5 metres per second.

The Part 2 tests used 6 tags where one tag was applied to each end of of three mail cases, The separation between each mail case in this test was 500 millimetres and the conveyor speed was set to 1 metre per second.

While all large mail cases were tagged with two tags, one at each end of the mail case, an objective was to determine whether the use of only one tag on each mail case would provide an acceptable level of reading performance. The analysis test success criteria are therefore both to identify each mail case and, to read all tags that are in the test.

The requirement to correctly identify the sequence of mail cases as they travelled along the conveyor was applicable to both Parts 1 and 2 of TD_MAIL_3. Considering this requirement together with reading performance there were therefore two success criteria. Firstly it was necessary to identify the correct sequence of the large mail cases by correctly reading at least one tag on each mail case and secondly the tougher task of successfully identifying each and every tag in the correct sequence. The recommendation is based on interpreting these two analysis criteria.

Once an interrogator completed the two parts of the conveyor test, it immediately took part in the TD_MAIL_4 tests This was done solely to reduce the interrogator set-up times. As described in the test specification, there were 3 antennas positioned on a portal over the conveyor. The selection of appropriate antennas during each tag test was decided by the vendor's representative. The vendor's representative was permitted to optimise the settings of the interrogator to match the tag type being tested. All settings and antenna selections were recorded by the organizers.

5.6.3 Results

The objective was to identify all mail cases in the correct sequence. A further objective was to identity all tags in the correct sequence with the purpose of understanding if it was possible to reliably identify the correct sequence of mail cases with only one tag applied to each mail case. No ghost reads was an additional essential objective.

In general reading performance was good with all tags read in many of the tests . The challenge was in identifying the actual sequence of the mail cases and the correct sequence of tags. With two tags per mail case it was possible to identify the mail cases in the correct order provided a minimum number of tags were read in the right sequence.

At the slower conveyor speed and with the five mail cases more closely spaced one of the interrogators, with tags from four tag groups, was able to identify all mail cases in the correct sequence when reading both tags. Further another interrogator with tags from it's one associated tag group was able to identify all mail cases in the correct sequence when reading both tags. Four interrogators with tags from three tag groups, were able to identify all mail cases in the correct sequence when reading both tags. Two interrogators with tags from two tag groups, were able to identify all mail cases in the correct sequence when reading both tags. None of the interrogators were able to determine the correct sequence of tags during all of the five tests with any of the tag groups. This indicates that where mail case sequence is important to the conveyor application it is necessary to have mail cases with two tags, one at each end of the mail case.

At the higher conveyor speed and with three mail cases more widely spaced five interrogators with at least one tag group achieved 100 % correct sequencing of mail cases and tags. Of these two interrogators with all tag groups achieved 100 % correct sequencing of mail cases and tags. One interrogator with two tag groups achieved 100 % correct sequencing of mail cases and tags. Two interrogators with one tag group achieved 100 % correct sequencing of mail cases and tags. This indicates that, with careful selection of interrogators and tags and with a wider spacing between tagged mail cases, it may be possible to achieve the objective of a single tag applied to each mail case. A further 14 interrogator and tag group tests achieved 100 % case level identification from reading both tags. Where possible UHF RFID portals should be placed in a conveyor system anywhere where the distance between mail cases will be consistently large.

No ghost reads recorded.

Table 6: Overall Results – TD_MAIL_3

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
267 (93,7 %)	18 (6,3 %)	0 (0,0 %)	0 (0,0 %)	285 (100,0 %)	285

5.6.4 Recommendations

Based upon analysis of the TD_MAIL_3 test results, the most robust recommendation would be to apply a tag at each end of every mail case. If the application only economically supports the use of one tag, then care should be exercised as to the selection of interrogator systems, antennas and their positioning, together with maximizing the separation between mail cases. Note that depending upon the application environment shielding may also be required. This recommendation is independent of the conveyor speeds used in the tests.

Vendors may need to perform additional tests in order to specify a standard setting for their interrogators and their antenna configuration. This type of application will probably lead to situations where the Postal operator will wish to source tags from different vendors. It will be essantial therefore that interrogators can read all tag types reliably.

The absence of representative material within the mail cases may have favourably influenced the results. It is recommended that future tests include representative material within the mail cases.

5.7 TD_MAIL_4: Conveyor Tests with Mail Bags

5.7.1 Summary

Seven interrogators and 4 types of tags, compliant with ISO/IEC 18000-6C [i.1], participated in this test. One interrogator and one type of tag using IPICO IP-X [i.2] protocol was tested.

Ten tagged mail bags (1 tag per mail bag) with some foam material in each bag were used for the tests. The mail bags were randomly put on the conveyor. The tag orientation was random.

All of the interrogators and tags had a very good interoperability in this conveyor scenario. The results are shown in table 7.

5.7.2 Exceptions

The mail bags were filled with blocks of foam-like material. This enabled the mail bags (with their tags applied to the mail tabs tied around the neck of each bag) to have a representative position with respect to each other and to the antennas and conveyor. It is highly likely that the foam-like material will not have had the same impact on tag detuning and possibly reading performance as truly representative material.

For each interrogator the TD_MAIL_4 test was carried out immediately after TD_MAIL_3 in order to reduce the interrogator set-up times.

As described in the test specification there were three antennas positioned on a portal over the conveyor. The selection of appropriate antennas was decided by the vendor's representative. The vendor's representative was permitted to optimise the setting of the interrogator for the tag type being tested. All settings and antenna selections were recorded by the organizers.

5.7.3 Results

The objective was to read 100 % of all tags in test with no ghost reads.

All tag and interrogator combinations tested demonstrated 100 % read performance with no ghost reads (This statement is based on the fact that a single tag read failure in one test brings the overall result in the table below to 99,3 %. It is therefore justified to consider that this is likely to be a test procedural error).

Table 7: Overall Results – TD_MAIL_4

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
144 (99,3 %)	1 (0,7 %)	0 (0,0 %)	0 (0,0 %)	145 (100,0 %)	145

5.7.4 Recommendations

Vendors may need to perform additional tests in order to specify a standard setting for their interrogators and their antenna configuration. This type of application will probably lead to situations where the Postal operator will wish to source tags from different vendors. It will be essantial therefore that interrogators can read all tag types reliably.

The absence of representative material within the mail bags may have favourably influenced the results. It is recommended that future tests include representative material within the mail bags.

5.8 TD_MAIL_5: Tests with with Mail Cases on a Mail Cart

5.8.1 Summary

For this test interrogators, operating within the Chinese allocated RFID frequency spectrum, were operated at one fixed frequency, which was equivalent to using a single channel of a channel plan. The tag groups tested included only tags optimized for Chinese radio regulations. Analysis of the test results of TD_MAIL_5 and TD_MAIL_8 showed no differences in performances. This indicated that implementing a UHF radio spectrum channel plan in China would have no negative impact upon current performance with the potential advantages in improved performance in dense reader implementations.

This test was used as a basis for comparison between TD_MAIL_5, 6, 7 and 8. The majority of (ISO/IEC 18000-6C [i.1]) tags were common to test TD_MAIL_6, 7 and 8. The only exception was the IPICO IP-X [i.2] and the ISO/IEC 18000-6C [i.1] tags used for the interference tests in TD_MAIL_6.

5.8.2 Exceptions

This test was completed by only one interrogator provider with two types of tags.

5.8.3 Results

The objective was to compare radio regulations by evaluating any differences in reading performance. A further objective was to measure differences in reading performance of tags optimized for use in China when used in combination with interrogators set to Chinese and European frequencies.

Tests TD_MAIL_5, 6, 7 and 8 with the same Chinese optimized tags showed that almost identical performance can be achieved using the same interrogators as tested in TD_MAIL_2.

Tests results for TD_MAIL_5 compare favourably with those of TD_MAIL_7. The results indicate that Chinese optimized UHF tags perform in a similar way in China and Europe when operating within a UHF channel plan. Furthermore the results showed no evidence that either Chinese optimized tags, or operating frequencies or bandwidth affected overall reading performance.

Table 8: Overall Results – TD_MAIL_5

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
10 (100,0 %)	0 (0,0 %)	0 (0,0 %)	0 (0,0 %)	10 (100,0 %)	10

5.8.4 Recommendations

Further tests should be performed building on the success of the comparitive results from TD_MAIL_5 and 7. The next tests should establish a 'dense reader' environment to investigate tag and interrogator performance in the most challenging of known application scenarios.

A channel plan provides very efficient use of the radio spectrum and improves reading performance irrespective of protocol where many interrogators are operating simultaneously in close proximity to one another. Further testing could be useful to demonstrate the full benefits of a channel plan for China. It is recommended that careful consideration is given to implementing a channel plan in China.

The absence of representative material within the mail cases may have favourably influenced the results. It is recommended that future tests include representative material within the mail cases.

5.9 TD_MAIL_6: Tests with with Mail Cases on a Mail Cart

5.9.1 Summary

The specified mode of interrogator operation using frequency hopping as requested by CPST for this test **is not compliant with current European radio regulations**. This test involved interrogators set to operate within the European radio spectrum band of frequencies for UHF. The TD_MAIL_6 test allowed comparison of the performance of ISO/IEC 18000-6C [i.1] interrogators and Chinese optimized tags when using China's wider designated spectrum (TD_MAIL_8) against the performance achieved in the narrower band of RFID spectrum allowed in Europe. In effect this was a practical comparison of the effects of wider spectrum in a multi-tag scenario. Analysis of the results showed no apparent difference in performance between the TD_MAIL_6 and TD_MAIL_8.

This test was used as a basis for comparison between TD_MAIL_5, 7 and 8. The test included a limited test of incompatibility between ISO/IEC 18000-6C [i.1] and IPICO IP-X [i.2]. The test results showed no evidence of interference to ISO/IEC 18000-6C [i.1] interrogators and tags.

5.9.2 Exceptions

There were no exceptions. The test was slightly different to TD_MAIL_2 interference tests because of the limited number of tag and interrogator types tested. The successful test on a sample of 60 of the ISO/IEC 18000-6C [i.1] tags in isolation indicated that all of the tags in the interference test were working correctly.

5.9.3 Results

The objective was to compare radio regulations by evaluating any differences in reading performance. A further objective was to measure differences in reading performance of UHF tags optimized for use in China when used in combination with interrogators set to Chinese and European UHF frequencies. Tests TD_MAIL_5, 6, 7 and 8 with the same China optimized UHF tags showed that almost identical performance can be achieved as in TD_MAIL_2 with the same interrogators.

Results from TD_MAIL_6 compare favourably with those of TD_MAIL_8. The results indicate that Chinese optimized UHF tags perform in a similar way in China and Europe when operating with UHF frequency hopping.

There was no evidence of interference between ISO/IEC 18000-6C [i.1] and IPCO IP-X [i.2] when one ISO/IEC 18000-6C [i.1] interrogator read multiple ISO/IEC 18000-6C [i.1] tags (60) in the prescence of an equal quantity of IPICO IP-X [i.2] tags (60). Also there was no evidence of ISO/IEC 18000-6C [i.1] equipment interfering with TOTAL [i.1].

Table 9: Overall Results – TD_MAIL_6

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
30 (100,0 %)	0 (0,0 %)	**0 (0,0 %)**	0 (0,0 %)	30 (100,0 %)	30

5.9.4 Recommendations

Further interference testing of IPICO IP-X [i.2] and ISO/IEC 18000-6C [i.1] would be useful in a dense reader configuration to fully explore if there is any measureable degradation in the performance of any ISO/IEC 18000-6C [i.1] interrogator systems under test. The same applies where ISO/IEC 18000-6C [i.1] equipement is a potential interferer and TOTAL [i.1] is a victim.

The absence of representative material within the mail cases may have favourably influenced the results. It is recommended that future tests include representative material within the mail cases.

5.10 TD_MAIL_7: Tests with with Mail Cases on a Mail Cart

5.10.1 Summary

This test was used as a basis for comparison with TD_MAIL_5, 6 and 8. The majority of (ISO/IEC 18000-6C [i.1]) tags were common to tests TD_MAIL_5, 6, 7 and 8. The only exception was the IPICO IP-X [i.2] and the ISO/IEC 18000-6C [i.1] tags used for the interference tests in TD_MAIL_6.

5.10.2 Exceptions

None.

5.10.3 Results

The objective was to compare radio regulations by evaluating any differences in reading performance. A further objective was to measure differences in reading performance of UHF tags optimized for use in China when used in combination with interrogators set to Chinese and European radio regulations.

Tests TD_MAIL_5, 6, 7 and 8 with the same China optimized tags showed almost identical reading performance to the results achieved in TD_MAIL_2 using the same interrogators.

TD_MAIL_5 test results compared favourably with those of TD_MAIL_7. The results indicated that Chinese optimized UHF ags performed in a comparable way in both China and Europe when operating within a UHF channel plan. Furthermore the results showed no evidence that either Chinese optimized UHF tags, or differences in operating frequencies or bandwidth affected overall reading performance.

Table 10: Overall Results – TD_MAIL_7

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
20 (100,0 %)	0 (0,0 %)	**0 (0,0 %)**	0 (0,0 %)	20 (100,0 %)	20

5.10.4 Recommendations

The absence of representative material within the mail cases may have favourably influenced the results. It is recommended that future tests include representative material within the mail cases.

5.11 TD_MAIL_8: Tests with with Mail Cases on a Mail Cart

5.11.1 Summary

This test was similar to TD_MAIL_2 as the interrogators were set to operate within Chinese UHF radio regulations with frequency hopping. The difference from TD_MAIL_2 is that TD_MAIL_8 uses only two tag groups with tags optimised for Chinese UHF radio regulations.

This test was used as a basis for comparison with TD_MAIL_5, 6 and 7. The majority of (ISO/IEC 18000-6C [i.1]) tags were common to tests TD_MAIL_5, 6 and 7. The only exception was the IPICO IP-X [i.2] and the ISO/IEC 18000-6C [i.1] tags used for the interference tests in TD_MAIL_6.

5.11.2 Exceptions

No exceptions recorded.

5.11.3 Results

The objective was to compare radio regulations by evaluating any differences in reading performance. A further objective was to measure differences in reading performance of UHF tags optimized for use in China when used in combination with interrogators set to Chinese and European frequencies.

Tests TD_MAIL_5, 6, 7 and 8 with the same China optimized tags showed almostidentical performance to the results achieved in TD_MAIL_2 using the same interrogators.

Tests TD_MAIL_8 results compared favourably with those of TD_MAIL_6. The results indicated that Chinese optimized tags would perform in a comparable way in China and Europe when operating with frequency hopping.

Tags optimized for Chinese radio regulations offered no significant improvement in performance over tags optimized for European radio regulations in this test scenario.

Table 11: Overall Results – TD_MAIL_8

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
20 (100,0 %)	0 (0,0 %)	0 (0,0 %)	0 (0,0 %)	20 (100,0 %)	20

5.11.4 Recommendations

The absence of representative material within the mail cases may have favourably influenced the results. It is recommended that future tests include representative material within the mail cases.

6 Non-interoperbility(NO) reasons resolved during test

6.1 TD_MAIL_1: Tests with Mail Container

In this test all of the tags were designed specifically for this application and with the expectation that they would be mounted directly on the mail container. The introduction of an air gap between the tag and metal surface affected its tuning with a consequent reduction in reading performance.

When the reason for poor reading performance was understood tags were glued directly on the surface of the mail container. Tests with several tags showed a better reading performance.

7 Main non-interoperability reasons during test

7.1 Tari Value

In Pre-Test 2 and Pre-Test 3, there were two interrogators that were adversely affected by other interrogators. On measuring the spectrum of the interfering interrogators with a spectrum analyser, it was found that they were out of specification. The reason for this was that their tari value had been set to 6,25 us.

8 Recommendations to China Post

8.1 Two tags per mail case

Both the result of tests with mail cases on mail carts and with mail cases on a conveyor demonstrated that the use of two tags on mail cases increased the reading performance.

8.2 Dense interrogator mode

To enable multiple interrogators to transmit simultaneously in the same geographic space a 6-channel plan is proposed. When using this arrangement it is recommended that RFID systems should operate in the dense interrogator mode.

In the dense interrogator mode each interrogator may transmit at power levels of up to 2 W e.r.p. while occupying a high power channel of 250 kHz. The two low power channels on each side of the transmit channel are reserved for the backscatter response from the tag. Typically tags will respond at link frequencies of approximately 200 kHz or 300 kHz, which is set by the configuration of the interrogator. The power level of the response from a tag will be -20 dBm e.r.p. or less depending on its distance from the interrogator and the nature of the material to which it is attached. The dense interrogator mode separates the high power transmission of the interrogator from the low power signals of the tags, which improves system performance. It also permits transmissions from multiple interrogators on the same channel. In fact provided that an adequate minimum working distance is maintained between adjacent interrogators, there is no upper limit to the number of interrogators that may simultaneously operate at the same frequency.

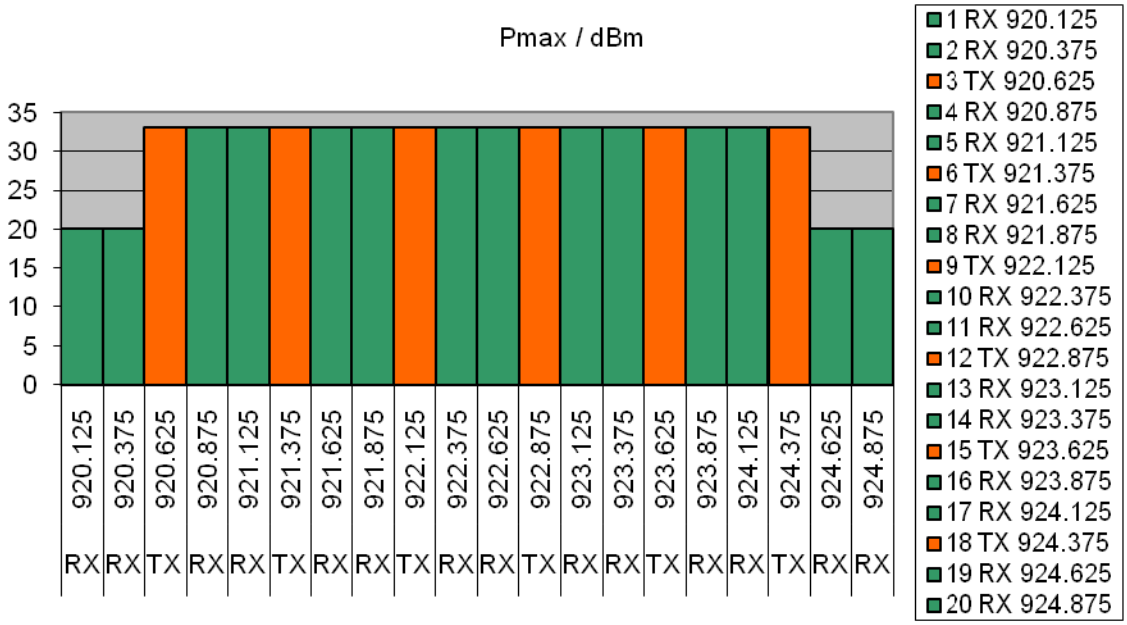

Figure 1: Recommended Channel Allocation

Annex A:
Test Descriptions for CESI-ETSI RFID Plugtests™ event

The document describing the tests executed during CESI-ETSI RFID Plugtests™ event is contained in archive sr_002787v010101p0.zip which accompanies the present document.

Annex B: Bibliography

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- ETSI EN 302 208-1 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W; Part 1: Technical requirements and methods of measurement".

- ETSI TR 102 436 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) intended for operation in the band 865 MHz to 868 MHz;. Guidelines for the installation and commissioning of Radio Frequency Identification (RFID) equipment at UHF".

- ETSI EG 202 237: "Methods for Testing and Specification (MTS); Internet Protocol Testing (IPT); Generic approach to interoperability testing".

- CEPT/ERC/REC 70-03 E: "Relating to the Use of Short Range Devices (SRD)".

- 800/900 MHz Radio Frequency Identification (RFID) Application Regulation (Temporarily) from State Radio Regulation Committee (SRRC), Ministry of Informatics Industry (MII), P.R.China.

NOTE: Available at www.autoid.org/07/UHF_RFID_Freqency_allocation_of_P_R_China%5B1%5D.pdf.

- RFID Interoperability Event.

NOTE: Available at http://www.etsi.org/plugtests/rfid2/RFID.htm and http://www.rfidtest.org.cn.

History

Document history		
V1.1.1	August 2009	Publication