ISO/IEC JTC 1 N 9029

2008-04-16

ISO/IEC JTC 1
Information Technology

Document Type:	**Text for DTR Ballot**
Document Title:	**ISO/IEC DTR 24770, "Information technology, automatic identification and data capture techniques -- RTLS device performance test methods -- Test methods for air interface communication at 2.4 GHz"**
Document Source:	**SC 31 Secretariat**
Reference:	
Document Status:	**This document is circulated to JTC 1 National Bodies for DTR ballot. National Bodies are asked to vote and submit their comments via the on-line balloting system by the due date indicated.**
Action ID:	**VOTE**
Due Date:	**2008-07-17**
No. of Pages:	**21**

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ISO/IEC JTC 1/SC 31

Automatic Identification and Data Capture Techniques

Secretariat: ANSI (USA)

DOC TYPE:	**Text for DTR Ballot**
TITLE:	**ISO/IEC DTR 24770, "Information technology, automatic identification and data capture techniques -- RTLS device performance test methods -- Test methods for air interface communication at 2.4 GHz"**
SOURCE:	**ISO/IEC JTC 1/SC 31/WG 3/SG 1**
PROJECT:	**24770**
STATUS:	**ISO/IEC 24770 BRM requests the convener of the BRM, Mr. Josef Preishuber-Pflügl to forward the reviewed and updated document according to N2474 to SC 31 Secretariat for a 3 month DTR ballot.** **JTC 1/SC 31 forwards the DTR to JTC 1 for DTR balloting.**
ACTION ID:	**JTC 1**
DUE DATE:	**2008-07-16**
DISTRIBUTION:	**ISO/IEC JTC 1/SC 31 members**
MEDIUM:	**ISO TC Portal (LiveLink)**
NO. OF PAGES:	**20 (including this cover)**

ISO/IEC JTC 1/SC 31 N 2474

Date: 2008-04-16

N/A

ISO/IEC JTC 1/SC 31/WG 3

Secretariat: ANSI

Information technology, automatic identification and data capture techniques — RTLS device performance test methods — Test methods for air interface communication at 2.4 GHz

Document type: Technical Report
Document subtype:
Document stage: (50) Approval
Document language: E

Contents

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Foreword

http://isotc.iso.org/livelink/livelink/fetch/2000/2122/3770791/JTC1_Patents_database.html?nodeid=3777806&vernum=0

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, the joint technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard (“state of the art”, for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC TR 24770, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

Introduction

ISO/IEC 24730 defines the air interfaces and an application programming interface for Real Time Locating Systems (RTLS) devices used in asset management applications. Part 2 of ISO/IEC 24730 defines the air interface for these devices operating at frequencies from 2.4-2.483 GHz.

The purpose of Technical Report 24770 is to provide test methods for performance with the various parts of ISO/IEC 24730.

TR 24769 contains all measurements required to be made on a product in order to establish whether it conforms to the corresponding part of ISO/IEC 24730.

1 Scope

This document defines the test methods for determining the performance characteristics of 2.4 GHz real time location system (RTLS) equipment including tags, readers, and exciters which are applicable to the selection of equipment that conforms to ISO/IEC 24730-2 for specific applications. This document does not apply to the testing in relation to regulatory or similar requirements.

The RTLS equipment performance parameters included in this document include the mandatory direct sequence spread spectrum (DSSS) 2.4 GHz radio frequency beacon link between tags and readers. It includes the optional on-off keyed, frequency shift keyed (OOK/FSK) short range radio frequency link between tags and programmers. It also includes the optional magnetic air interface between exciters and tags and between programmers and tags.

Unless otherwise specified, the tests in the document shall be applied exclusively to RTLS equipment defined in ISO/IEC 24730-2.

2 Normative references

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

- ISO/IEC 24730-1 *Information technology automatic identification and data capture techniques – Real Time Locating Systems (RTLS) – Part 1: Application Program Interface (API)*

- ISO/IEC 24730-2 *Information technology – Real time location systems (RTLS) – Part 2: 2,4 GHz air interface protocol*

- ISO/IEC 24769 *Information technology, automatic identification and data capture techniques – RTLS device conformance test methods – Test methods for air interface communication at 2.4 GHz*

- ISO/IEC 18000-4 *Information technology -- Radio frequency identification for item management -- Part 4: Parameters for air interface communications at 2,45 GHz*

- ISO/IEC 19762-1 *Information technology -- Automatic identification and data capture (AIDC) techniques -- Harmonized vocabulary -- Part 1: General terms relating to AIDC*

- ISO/IEC 19762-3 *Information technology -- Automatic identification and data capture (AIDC) techniques -- Harmonized vocabulary -- Part 3: Radio frequency identification (RFID)*

- ISO/IEC 15963 *Information technology -- Radio frequency identification for item management -- Unique identification for RF tags*

3 Terms, definitions, symbols and abbreviated terms

3.1 General

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1, ISO/IEC 19762-3 and the following apply.

3.2 Terms and definitions

All terms and definitions used in this document are specified in ISO/IEC 19762-3.

3.3 Symbols

For the purposes of this document the following symbols apply.

3.4 Abbreviated terms

ARB Arbitrary waveform generator

BPSK Binary phase shift keying

DSSS Direct sequence spread spectrum

DUT Device under test

EIRP Effective isotropic radiated power

EVM Error vector magnitude

FSK Frequency shift keying

OOK On-off keying

PPM Parts per million

RBW Resolution bandwidth

RTLS Real time location system

TIB Timed interval blink

VBW Video bandwidth

4 General

4.1 Performance Requirements

This Technical Report specifies a series of tests to determine the performance characteristics of RTLS equipment relative to the ISO/IEC 24730-2 air interfaces. The results of these tests can be used to determine the suitability of RTLS equipment for applications.

4.1.1 Location Accuracy

The primary function of RTLS equipment is to locate tags within the area covered by the readers. Location accuracy determines the primary performance criteria of an RTLS. Location accuracy can be characterized by comparing the system's calculated location for a given set of tags to the actual location of the tags. The system must be able to locate tags to within the applications allowable error.

4.1.2 Tag Capacity

A RTLS must typically locate a large number of tags. The number of tag blinks per second that can be processed and located through the readers can be used to determine a systems tag capacity. The system must be able to provide location information for an applications peak tag blink density.

4.1.3 Location Latency

The latency between when the tag blink is transmitted and when the RTLS equipment can provide accurate location information determines the suitability of the equipment for the application.

4.1.4 Tag Orientation

The ability of an RTLS to provide real time location information should be independent of the orientation of the tag. The location reported by the RTLS should not change as the tag is rotated in any orientation relative to the readers.

4.1.5 System Range and Packet Error Rates

The range of the tag-reader 2.4 GHz DSSS link determines the reader density requirements and also effects system capacity. The packet error rate will determine how often the equipment can successfully provide accurate location information for the tag.

The range, packet error rate, and orientation requirements of the optional air interfaces between the tags and exciters, and between the tags and programmers, determine the usability of the system in meeting the applications requirements.

4.2 Default conditions applicable to the test methods

These conditions apply to all tests.

4.2.1 Test environment

Testing shall take place in an environment typical to that of the desired application. Testing can be performed indoors or outdoors with temperature and humidity profiles similar to that expected in the desired application. The RF noise floor at the test location should also represent typical conditions expected within the desired application.

4.2.2 Default tolerance

Unless otherwise specified, a default tolerance of + 5 % shall be applied to the quantity values given to specify the characteristics of the test equipment and the test method procedures.

N/A

4.2.3 System Logging

The RTLS should provide sufficient data logging to allow determination of the number of packets received and sent, but this is not absolutely required.

5 Performance tests for ISO/IEC 24730

5.1 System Locate Performance

5.1.1 Test objective

The objective of this test is evaluate the system locate performance characteristics of the ISO/IEC 24730 equipment.

5.1.2 Test set up

The readers shall be connected to omni-directional antennas. It is preferred that the RTLS locate performance characteristics be evaluated with the system installed as it would for the desired application. If that is not possible, then the equipment shall be configured as shown in figure 1, with 4 readers at the corners of a square measuring 300 m across the diagonal (outdoor applications) or 200 m across the diagonal (indoor applications). In addition to standalone tags, several tags mounted on the application's locatable assets (or items of comparable size and composition) shall be used to evaluate locate performance.

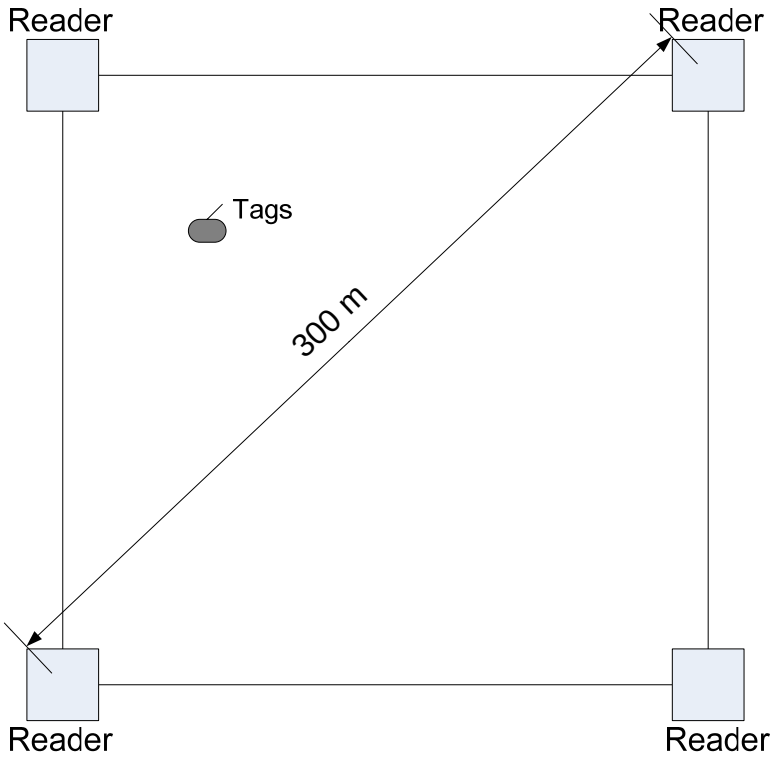

Figure 1 — Setup of Equipment for RTLS Locate Accuracy Test

5.1.3 Test procedure

The tag shall be configured to transmit 72-bit DSSS blinks as defined in clause 6.4.2.2 of ISO-24730-2. Unless otherwise indicated, the tags shall be configured at a blink interval such that the number of tags in the test divided by the blink interval used during test is equal to or greater than the planned number of assets tagged in the application (within range of a given set of readers) divided by the planned blink interval of application tags. Each blink shall be configured with at least 2 sub-blinks. The tag shall be configured to transmit at the extremes of class 1 power: of 0 dBm and +10 dBm EIRP. The tag shall be attached to assets such as to reproduce the conditions of the desired application. Additional procedures specific to individual test are outlines in the test measurement and requirements.

5.1.4 Test measurements and requirements

5.1.4.1 Location accuracy

Tags, or sets of tags shall be distributed throughout the area of coverage at about a 20 m spacing as shown in figure 2. The actual location of all tags shall be recorded. The test shall be run long enough to capture a minimum of 250 tag blinks from each tag. This will typically be several hours minimum. The total number of tag locates calculated during the test shall be divided by expected number of blinks from all the tags included in the test for the duration of the test using the formula ((N tags) * (test duration) / (tag blink interval)). Each location calculation shall be compared to appropriate tag's actual location to produce the location error. The location accuracy shall be represented as a percentage of all locations calculated by the system in which the errors fall within the specified maximum error divided by the total number of locations calculated. The radius of acceptable error shall be determined by the requirements of the application.

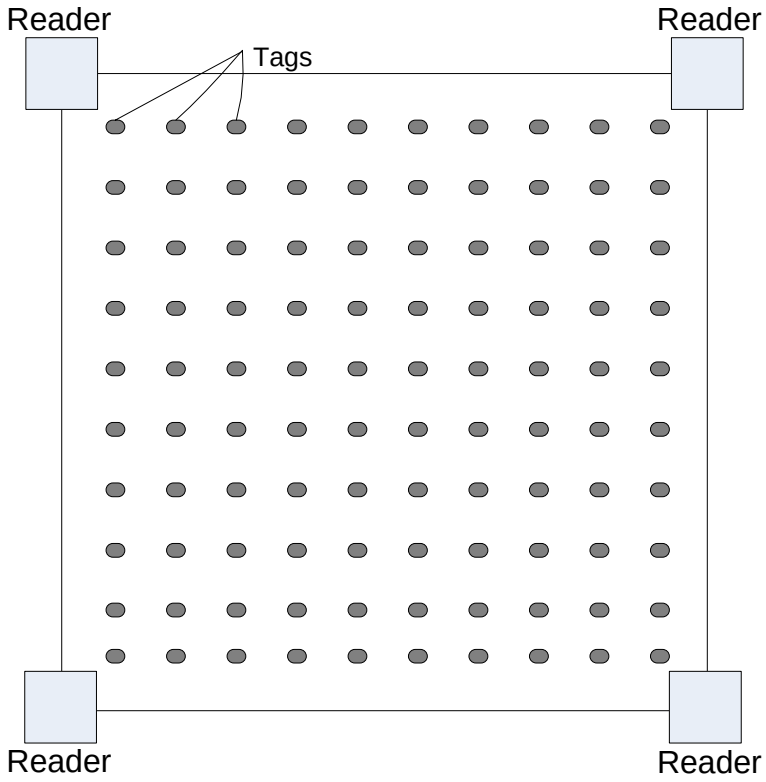

Figure 2 — Setup of Equipment Illustrating Tag Spacing

N/A

5.1.4.2 Location reporting latency

The test shall include at least 50 tag location changes to capture a statistically significant number of tag blinks. Tags, or groups of tags, shall be moved from one known location to another known location throughout the test. The exact time of each actual move shall be logged, as well as the exact time of reported location change. Record the difference between the time of reception and the time of the location report which location is within the maximum error allowed by the application.

5.1.4.3 Tag capacity

The tags shall be configured at a blink interval such that the total number of blinks per second during the test is at least 2.5 times the expected blinks per second in the application. This ensures that the system will continue to perform at times when tag blinks cluster in time. The location accuracy and locate latency shall be compared to the results from test results at the expected number of blinks per second to determine performance degradation.

5.1.4.4 Tag orientation

This test is required only for applications where the tag orientation when attached to the asset is not predicable. For the duration of the test, compare the errors in the calculated location as the tag is rotated through all three axes. Changes in location accuracy as a result of orientation should be noted in the test report quantitatively.

5.1.5 Test report

The test report shall contain location accuracy statistics evaluating the percentage of tag blinks located to within the applications required locate error radius. The report shall also contain the maximum tag blinks per second the system can handle and still meet the required location accuracy and locate latency. The report shall also include the average latency of location information as a tagged asset is move. If relevant to the application, the report shall also provide location variations based on tag orientation.

5.2 Tests for mandatory DSSS tag to reader air interface

5.2.1 Test objective

The objective of this test is to evaluate the performance characteristics of the 2.4 GHz air interface between the RTLS tags and the RTLS readers.

5.2.2 Test set up

The reader(s) shall be connected to omni-directional antennas. Ideally the performance characteristics of the tag to reader interface would be evaluated with the system installed as it would for the desired application. If that is not possible, then the equipment shall be conducted with at least one reader and several tags mounted on the application's locatable assets (or items of comparable size and composition) shall. Unless otherwise stated, the tags shall be placed at a distance from the reader comparable to the maximum distance likely to be required by the application.

5.2.3 Test procedure

The tag shall be configured to transmit a 72-bit or 152-bit DSSS blinks as defined in clause 6.4.2.2 or clause 6.4.2.4 of ISO-24730-2, depending on the requirements of the application. The tags shall be configured at a blink interval such that the number of tags in the test divided by the blink interval

used during test is equal to or greater than the number of assets tagged in the application (within range of a given set of readers) divided by the blink interval of application tags. Each blink shall be configured with at least 2 sub-blinks. The tag shall be configured to transmit at a class 1 power between 0 dBm and +10 dBm EIRP. The tag shall be attached to assets such as to reproduce the conditions of the desired application.

5.2.4 Test measurements and requirements

5.2.4.1 Packet error rate

The packet error rate is defined as the total number of tag blinks successfully received by the reader divided by the total number of tag blinks expected (i.e. number of blinks transmitted by the tag), for the duration of the test ((N tags) * (test duration) / (tag blink interval)) and the result subtracted from 1 to give the packet error rate. The distance at which the initial packet error rate specified in ISO/IEC 24730-2 is met is the initial distance which should be used for subsequent range tests.

5.2.4.2 Tag range

Tag range is measured by increasing the distance between the tag and the reader until the packet error rate doubles as tested in clause 5.2.4.1.

5.2.4.3 Tag orientation

This test is required only for applications where the tag orientation when attached to the asset is not predicable. For the duration of the test, compare the error in the calculated location as the tag is rotated through all three axes. No tag orientation shall result in significant changes to packet error rate or tag range.

5.2.5 Test report

The test report shall contain the percentage of blinks anticipated during the test that were successfully received by the reader. The report shall also contain data to evaluate the tag's range from a particular reader at which the reader no longer sees the tag or at which the packet error rate begins to exceed the applications acceptable limits. If relevant to the application, the report shall also provide packet error rate and range variations based on tag orientation.

5.3 Tests for optional tag to exciter air interface

5.3.1 Test objective

The objective of this test is to evaluate the performance characteristics of the 2.4 GHz air interface between the RTLS tags and the RTLS readers.

5.3.2 Test set up

It is preferred that the performance characteristics of the tag to exciter interface be evaluated with the system installed as it would for the desired application. If that is not possible, then the equipment shall be configured as shown in figure 3, with the exciter(s) mounted to surfaces of comparable size and composition, and at an orientation and distances relative to the exciter, as expected in the application. Several tags mounted on the application's locatable assets (or items of comparable size and composition) shall be used to evaluate tag to reader interface performance. A minimum of one (1) reader is required for this test.

N/A

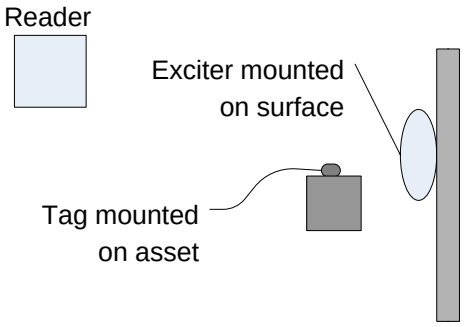

Figure 3 — Exciter Test Configuration

5.3.3 Test procedure

The tag shall be configured to transmit a 72-bit or 152-bit DSSS exciter blinks as defined in clause 6.4.2.2 or clause 6.4.2.4 of ISO-24730-2, depending on the requirements of the application. The tags shall be configured transmit one or more exciter blinks in response to exciter messages at and interval and retrigger time matching the requirements of the application. Each exciter blink shall be configured with at least 2 sub-blinks. The tag shall be configured to transmit at a class 1 power between 0 dBm and +10 dBm EIRP. The tag shall be attached to assets such as to reproduce the conditions of the desired application.

5.3.4 Test measurements and requirements

5.3.4.1 Packet error rate

The packet error rate test assumes the tag has sufficient logging to count magnetic messages and that the count can be either transmitted to the system or read with a programmer device. Record the magnetic message count of all the tags involved in the test. Place all the tag in the field of an exciter for a period of time equal to 1000 times the tag's magnetic receiver wake up interval. Record the magnetic message count of all the tags. The packet error rate is given by the formula

PER = 1 - ((final magnetic message count - starting magnetic message count) / 1000)

5.3.4.2 Exciter capture time

The minimum time the tags must be within the exciter field to ensure they transmit exciter blinks determines the exciter capture time. The tags will be moved through the field of an exciter at a controlled speed and distance both representative of the conditions of the application. All tags shall respond with exciter blinks as they pass through the exciter field.

5.3.4.3 Exciter capture range

The tags will be moved slowly from a distance far outside the exciter range to well within the exciter range. The distance at which each tag first transmits exciter blinks shall be recorded.

5.3.4.4 Exciter release range

The tags will be moved slowly from a distance well within the exciter range to far outside the exciter range. The distance at which each tag last transmits exciter blinks shall be recorded.

5.3.4.5 Exciter latency through the system

The tags will be moved rapidly from outside the exciter range to inside the excite range and the time of the move logged. This time will be compared to the time at which system reports the exciter blink to determine the exciter latency

5.3.4.6 Exciter separation

Two exciters shall be placed at the minimum distance as defined by the application as shown in figure 4. The tags shall be moved through fields of both exciters with the direction, speed, distance and orientation as defined by the application. The system exciter blink reports shall accurately reflect the exciter closest to the tag.

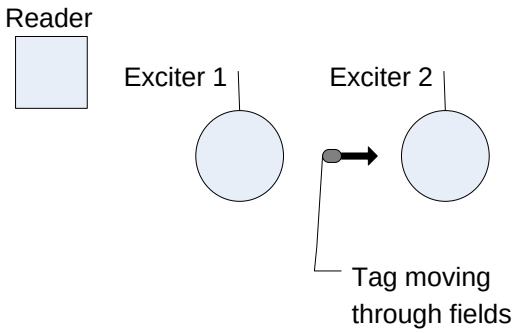

Figure 4 — Exciter Separation Test

5.3.5 Test report

The test report shall contain data summarizing the packet error rate, capture/release range, capture time, exciter separation, and system latency.

5.4 Tests for optional tag to programmer air interfaces

5.4.1 Test objective

The objective of this test is to evaluate the performance characteristics of the 2.4 GHz air interface between the RTLS tags and the programmer.

5.4.2 Test set up

The RTLS tag to programmer test shall be conducted with the tags mounted on application assets (or items of comparable size and composition) as shown in figure 5. The programmer shall be handled by a user as expected in the application. The operating power of the programmer shall not exceed the power allowed by local regulatory authorities.

N/A

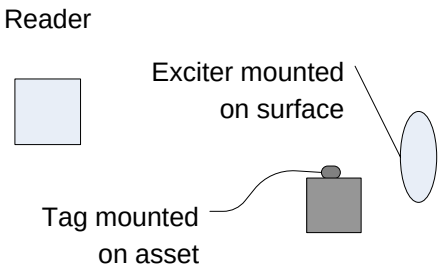

Figure 5 — Programmer Interface Test

5.4.3 Test procedure

The programmer shall write data to the tag using the protocol defined in clause 7.2.3 of ISO/IEC 24730-2 and verify successful completion, the read the tag data using the protocol defined in clause 7.2.7, and sub-clause 7.2.7.2 of ISO/IEC 24730-2. Unless otherwise noted, the tests shall be conducted with a one to two foot distance between the tag and the programmer.

5.4.4 Test measurements and requirements

5.4.4.1 Packet error rate

The data write / data read cycle shall be performed a minimum of 100 times with 10 tags to provide a statically significant data set. The total number of write / read failures divided by the total number of attempts provides the packet error rate.

5.4.4.2 Programmer to tag range

The data write / data read range shall be increased until the packet error rate doubles; this distance is considered to be the maximum range.

5.4.4.3 Transaction response time

The average time for each data write and for each data read shall be logged to evaluate performance.

5.4.5 Test report

The test report shall contain the enough transaction results to effectively evaluate the packet error rate of the programmer to tag interface. The report shall also contain data to evaluate the maximum range at which the interface will reliably work. The report shall also provide the average write data time and read data time.

Template for comments and secretariat observations

Date: 07.02.08	Document: **ISO/IEC PDTR 24770**

1	2	(3)	4	5	(6)	(7)
MB[1]	**Clause No./ Subclause No./ Annex** (e.g. 3.1)	**Paragraph/ Figure/Table/ Note** (e.g. Table 1)	**Type of com-ment**[2]	**Comment (justification for change) by the MB**	**Proposed change by the MB**	**Secretariat observations** on each comment submitted
DE	Introduction		ge	The statement “ISO/IEC 24730 defines the air interfaces for…” Is not correct. E.g. 24730-1 defines an API not an air interface	Change to “ISO/IEC 24730 defines components for…”	Resolved: Change to air interfaces and an application programming interfaces (API)
AT1	3.4		Ed	Abbreviation should not contain another abbreviation	Change to " BPSK Binary phase shift keying"	Accept
AT2	4.1.1		Te	The distance error is not well defined.	The distance error should mention the Euclidean distance error, which is well defined in the literature	Resolved: Reword to state " Location accuracy can be characterized by comparing tag location calculated by the system, with the actual location of the tags."
AT3	5.1.4.1		Te	The last sentence describes the circular error probability	Add sentence by “(circular error probability)”	Rejected
DE	5.1.4.1		te	How exactly is the location error defined?	Add definition or reference to definition of location error.	Resolved: Reworded in document.
AT4	5.1.4.2		Te	… a statistically significant number…	Is unclear, a more precise example should be given	Resolved: Specify 50 location changes, and reword portion of paragraph to clarify.
AT5	5.1.4.4		Te	The distance between the tags and the reader shall be increased until the packet error rate doubles as tested in paragraph 5.2.4.1	Test 5.2.4.1 is not specified for a specific distance, only for the maximal expected distance in the application. There a specific PER occurs. If I use this as reference and at the double PER, what can I say about the Tag range? Allows a lot room to interpret.	Resolved: Reworded and now references the ISO/IEC 24730-2 standard.
AT6	5.3.2		Ed	First sentence is very complicated and not in good English	Change appropriately	Resolved: Reword to state: "Ideally the performance characteristics of the exciter interface should be measured in the same

1 **MB** = Member body (enter the ISO 3166 two-letter country code, e.g. CN for China; comments from the ISO/CS editing unit are identified by ******)

2 **Type of comment:** **ge** = general **te** = technical **ed** = editorial

NOTE Columns 1, 2, 4, 5 are compulsory.

1	2	(3)	4	5	(6)	(7)
MB[1]	**Clause No./ Subclause No./ Annex** (e.g. 3.1)	**Paragraph/ Figure/Table/ Note** (e.g. Table 1)	**Type of com-ment**[2]	**Comment (justification for change) by the MB**	**Proposed change by the MB**	**Secretariat observations** on each comment submitted
						configuration as the target application."
At7	5.4.2		Ed	Illustration missing	Add drawing or an appropriate reference to another figure	Accept. Add figure 5 and modify verbiage.
DE			ge	It is confusing that some tests yield relative performance numbers (e.g. location accuracy) other tests yield absolute performance numbers (packet error rate).	Either define only tests which yield absolute performance numbers or explain why both types are needed and classify each test correspondingly.	Rejected as each test is defined to provide data that is useful for the intended application and that measured parameter. Location accuracy can only be measured as a percentage within a defined area. Packet error rate is a directly measureable value.

1 **MB** = Member body (enter the ISO 3166 two-letter country code, e.g. CN for China; comments from the ISO/CS editing unit are identified by ******)

2 **Type of comment:** **ge** = general **te** = technical **ed** = editorial

NOTE Columns 1, 2, 4, 5 are compulsory.

Resolutions from the ISO/IEC PDTR 24770 BRM meeting of Vienna, Austria, 9th of April 2008

Resolution 1:
ISO/IEC 24770 BRM approves the resolution of comments on PDTR 24770 according document N0371 done by the ballot resolution group.
UNANIMOUS

Resolution 2:
ISO/IEC 24770 BRM requests the project editor Tim Harrington of WI 24770 to update PDTR 24770 according to N0371 on or before 30.04.2008 and issue it to the convener of the BRM Josef Preishuber-Pfuegl.
UNANIMOUS

Resolution 3:
ISO/IEC 24770 BRM requests the convener of the BRM Josef Preishuber-Pflügl to forward the reviewed and updated document according to N0371 to SC31 Secretariat for a 3 month DTR ballot.
UNANIMOUS