ETSI TR 102 021-4 V1.3.1 (2006-05)

Technical Report

Terrestrial Trunked Radio (TETRA);
User Requirement Specification TETRA Release 2;
Part 4: Air Interface Enhancements

Reference

RTR/TETRA-01168

Keywords

TETRA, user

ETSI

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Sous-Préfecture de Grasse (06) N° 7803/88

Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Terrestrial Trunked Radio (TETRA).

The present document is part 4 of a multi-part deliverable covering the User Requirement Specifications (URSs) for TETRA Release 2, as identified below:

Part 1: "General Overview";

Part 2: "High Speed Data";

Part 3: "Codec";

Part 4: "Air Interface Enhancements";

Part 5: "Interworking and Roaming";

Part 6: "Subscriber Identity Module (SIM)";

Part 7: "Security";

Part 8: "Air - Ground - Air services".

Introduction

The TETRA Release 2 suite of standards was mandated in the new Terms of Reference (ToR) for ETSI Project TETRA approved at ETSI Board meeting number 28 (Board 28) on 6th September 2000 (see bibliography). Its aim was to enhance the services and facilities of TETRA in order to meet the emerging user requirements, utilize new technologies and, by maintaining the competitiveness with other wireless technologies, increase the future proofness of TETRA as the standard for PMR and PAMR worldwide.

The approved programme for TETRA Release 2 covers five work areas, namely:

- high speed data;
- speech coding;
- air interface enhancements;
- interworking and roaming;
- SIM.

The present document provides the User Requirement Specification for the TETRA air interface enhancements.

The URS is required by Working Groups 2 and 3 of EPT to supplement the feasibility study TR 101 987 [7] produced by EPT/Task Group 23.

1 Scope

The present document provides the User Requirement Specifications (URS) for the TETRA air interface enhancements translated into terms of:

- network performance aspects;
- terminal performance aspects;
- location information aspects;
- requirements not anticipated in the TETRA Release 2 work programme.

The present document is applicable to the specification of TETRA Release 2 equipment.

The user requirements contained in the present document are described in non-technical terms and are based on discussions in EPT WG1 and on an analysis of the results for air interface enhancements from the TETRA Release 2 Market Questionnaire (see bibliography), described in TR 102 021-1 [1], clauses 4.2 and 4.3.

2 References

For the purposes of this Technical Report (TR) the following references apply:

[1] ETSI TR 102 021-1: "Terrestrial Trunked Radio (TETRA); User Requirement Specification TETRA Release 2; Part 1: General Overview".

[2] ETSI TR 102 021-2: "Terrestrial Trunked Radio (TETRA); User Requirement Specification TETRA Release 2; Part 2: High Speed Data".

[3] ETSI TR 102 021-3: "Terrestrial Trunked Radio (TETRA); User Requirement Specification TETRA Release 2; Part 3: Codec".

[4] ETSI TR 102 021-5: "Terrestrial Trunked Radio (TETRA); User Requirement Specification TETRA Release 2; Part 5: Interworking and Roaming".

[5] ETSI TR 102 021-6: "Terrestrial Trunked Radio (TETRA); User Requirement Specification TETRA Release 2; Part 6: Subscriber Identity Module (SIM)".

[6] ETSI TR 102 021-7: "Terrestrial Trunked Radio (TETRA); User Requirement Specification TETRA Release 2; Part 7: Security".

[7] ETSI TR 101 987: "Terrestrial Trunked Radio (TETRA); Proposed Air Interface Enhancements for TETRA Release 2; Analysis and Feasibility Assessment".

[8] EPT/WG1(01)046v9: "ETSI Project TETRA (EPT) TETRA Release 2 Questionnaire".

[9] EPT13(00)17r1: "TETRA Release 2 Work Programme".

[10] ETSI Board B28 (00)12: "Extension of EPT Terms of Reference to Enable TETRA Release 2".

[11] ETSI Board B28 (00)24 Rev 2: "Summary minutes, decisions and actions from 28th ETSI Board Meeting" Sophia Antipolis, 5-6 September 2000.

3 Definitions and abbreviations

3.1 Definitions

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

TETRA Release 2: Work Programme with new terms of reference within ETSI Project TETRA to enhance the services and facilities of TETRA in order to meet new user requirements, utilize new technology and increase the longevity of TETRA within the traditional market domains of PMR and PAMR

3.2 Abbreviations

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

AGA	Air Ground Air
AI	Air Interface
APL	Automatic Person Location
AVL	Automatic Vehicle Location
BS	Base Station
DTX	Discontinuous Transmission
EPT	ETSI Project TETRA
ETSI	European Telecommunications Standards Institute
GTSI	Group TETRA Subscriber Identity
ITSI	Individual TETRA Subscriber Identity
MS	Mobile Station
PAMR	Public Access Mobile Radio
PMR	Private Mobile Radio
PTT	Press To Talk
RF	Radio Frequency
SDS	Short Data Service
TA	Timing Advance
TETRA	TErrestrial Trunked RAdio
TR	Technical Report
URS	User Requirement Specification
V+D	Voice plus Data
WGS 84	World Geodetic System 1984

4 User Requirement Specification

4.1 Introduction

The enhancements of the TETRA air interface standard aim at providing increased benefits and optimization in terms of spectrum efficiency, network capacity, system performance, quality of service, size and cost of terminals, battery life, and other relevant parameters. Other possible air interface enhancements are providing increased coverage range and low cost deployments for applications such as airborne public safety, maritime, rural telephony and "linear utilities" (e.g. pipelines). Provisioning of location information is another service that could be provided by enhancements of the TETRA air interface standard.

4.2 Network performance aspects

4.2.1 Overview of network performance aspects

The network performance aspects to be enhanced or supported in TETRA Release 2 are listed below:

- improved spectrum efficiency;
- enhanced network capacity;
- improved end-to-end time delay performance;
- Base Station site RF coverage beyond the current 58 km radius limitation of TETRA Release 1;
- location positioning accuracy better than base station site location (Cell ID);
- improved cell hand-over decision and management.

Most of these elements are difficult to quantify by users. The user requirements can generally be expressed as the more improvement the better. Some of these elements require substantial standardization effort. These requirements will compete for standardization resources and, as such, compromise each other. In the Questionnaire responses, users have indicated how they judge the relative importance of these elements. This gives an indication which items deserve most standardization effort. Some enhancements may be satisfied by implementation rather than standardization.

The different aspects are listed in clauses 4.2.2 to 4.2.7 in descending order of TETRA user market importance.

4.2.2 Enhanced network capacity

Enhanced network capacity is the most important requirement for the general TETRA market and also in all market segments.

Most of the respondents (users/operators) are still starting up their TETRA networks. These networks are not under normal or full load. Most respondents can only estimate the capacity load of their systems. Today the majority of those users have traditional analogue private open channel PMR systems. It is very difficult (depending on the individual user/organization behaviour) to estimate how effective the statistical multiplexing of TETRA trunking will be. It is likely that the capacity gain of trunking has been underestimated.

As a result of underestimating the trunking effect, enhancing network capacity could be too high on the list of the general user requirements.

4.2.3 Location positioning accuracy better than base station site location

Location positioning accuracy better than base station site location (Cell ID) is also a very important requirement for the general TETRA market. It is required in both Public Safety and PAMR market segments.

The requirements for location positioning are handled in detail in clause 4.4.

4.2.4 Improved cell hand-over decision and management

Improved cell hand-over decision and management is an important requirement for the general TETRA market. It is required in both the Public Safety and PAMR market segments.

User/operators responsible for more mature TETRA networks tend to judge this item more important than users/operators with limited TETRA experience. This could indicate that the importance of this item is underestimated by the TETRA users/operators starting up their TETRA networks.

The relative importance of this item is probably higher than its current ranking suggests.

Some problems experienced in the networks today are:

- cell dragging by an MS;
- handover to a wrong cell.

User requirements important for the future (networks under normal or full load) include:

- load management;
- need for consistent behaviour from all MS suppliers;
- need for (future) flexibility in the handover methodology.

When the networks will be under normal or full load, improved cell selection will also be part of the solution for enhancing network capacity.

Most networks can be considered as built in two layers; a macro layer and a micro layer.

The macro layer provides the general network coverage. This layer delivers coverage mainly in low to average user density zones; mostly rural areas. This macro layer generally uses very high (hilltop) sites, with antennas substantially above clutter height.

The micro layer fulfils an additional requirement, depending on the type of network. In PAMR networks the microcells deliver extra capacity in high user-density zones; mostly urban areas. In Public Safety networks this micro layer delivers mainly extra coverage (including indoor for hand portables) in urban areas. The Public Safety microcells differ from the macro cells mainly by their location (city centre instead of hilltop), not by their RF parameters, and as such these cells are not really small.

In both types of networks there is need for a cell selection mechanism to prevent too much traffic going via the macrocells. Macrocells should only be used when no other cell can be used because of bad signals or high speed.

4.2.5 Improving end to end time delay performance

Improving end-to-end time delay is required in both the Public Safety and PAMR market segments.

4.2.6 Improved spectrum efficiency

Improved spectrum efficiency is important for the PAMR market segment and required by some Public Safety users.

As stated above, since most of the respondents (users/operators) are still starting up their TETRA networks, the TETRA network capacity could be underestimated. If this is the case, spectrum problems could also be overestimated.

4.2.7 Base station site RF coverage beyond the current 58 km radius limitation of TETRA Release 1

Base station site RF coverage beyond the current 58 km radius limitation of TETRA Release 1 is required by Public Safety, the military and utilities.

Requirement scenarios include aeronautical and maritime use, "linear cells" (e.g. pipelines, railways) and large rural cells (large low-traffic areas).

User organizations/operators dealing with very low user densities require larger cells in order to be able to deploy base stations in a cost efficient way.

The user density for AGA communications is very low (maximum user density will very rarely exceed 0,01 users per square kilometre and on average it will be below 0,001 user per square kilometre). To minimize interference and optimize frequency reuse cell sizes should be in line with maximum achievable distance for AGA. Propagation studies show that at 400 MHz a range of 200 km is feasible (based on free space path loss which applies instead of the modified Hata model) for an MS (aircraft) at 10 000 feet. As operational flights normally stay below 10 000 feet, 200 km range (BS-MS) is sufficient for normal AGA operation.

User density in linear cells is one user in five linear kilometres. A range of 120 km (BS-MS) is required with no change to the RF power classes and receiver sensitivity.

4.3 Terminal performance aspects

4.3.1 Overview of terminal performance aspects

The terminal performance aspects to be enhanced in TETRA Release 2 are listed below:

- size reduction;
- weight reduction;
- improved battery operating life for daily PMR shift use;
- improved battery-operating life for Telephony use.

The majority of these elements are difficult to quantify by users. The user requirements can generally be expressed as the more reduction or improvement the better. Some of these requirements are compromising others. Users have indicated how they judge the relative importance of these elements. This gives an indication what terminal aspects could be compromised when it is not possible to improve all aspects.

The different aspects are listed in clauses 4.3.2 to 4.3.5 in order of TETRA user market importance (descending).

4.3.2 Improved battery operating life for daily PMR shift use

Improved battery operating life is very important user requirement in all market segments and in all user organizations. Improved battery operating life for daily PMR shift use is the most important user requirement in the general TETRA market.

In PMR, the majority of the calls are group calls. These calls happen at a high frequency and are very short (compared with individual calls).

Increasing call setup time or losing fragments of speech is unacceptable for Public Safety users. The network should in the first place be always available and reliable. "Sleeping" terminals would probably not meet those requirements.

Discontinuous Transmission (DTX) will probably bring almost no improvement for PMR users since they release the PTT when not talking. It would probably also be unacceptable for Public Safety users because it could compromise the use of "ambience listening" (used in emergency calls).

Note that, even if it is found that techniques such as DTX and energy economy mode are not beneficial for some types of PMR users, it should be straightforward for these features to be disabled for these users. The function could potentially even be de/activated according to the profile of the individual user.

4.3.3 Improved battery operating life for telephony use

Improved battery operating life for telephony use is the second most important user requirement in the general TETRA market. For utility and PAMR type users it is seen as more or equal important to improved battery operating life for daily PMR shift use. For Public Safety users this aspect has the lowest priority.

For telephony use (calls are longer and less frequent compared with PTT type calls) increased call setup is less noticeable and as such not considered as a problem.

For this type of use "sleeping" terminals and DTX could be very beneficial and acceptable for all users.

4.3.4 Weight reduction

In the general TETRA market this requirement is far less important than improved battery operating life. For Public Safety users however this is requirement is second on the requirement list, not so far behind the requirement for improved battery operating life for daily PMR shift use.

4.3.5 Size reduction

In the general TETRA market this requirement has the lowest priority. For Public Safety users however this requirement is more important than improved battery operating life for telephony use.

4.4 Location information aspects

4.4.1 Location positioning applications

A survey of user requirements highlighted the need for multiple applications. Those can be categorized in two types of applications with similar requirements:

- location positioning of vehicles using TETRA mobiles. This is called Automatic Vehicle Location or AVL;
- location positioning of persons using TETRA portables. This is called Automatic Person Location or APL.

4.4.2 Location positioning accuracy and resolution

Accuracy is defined as the precision of the acquiring location positioning system whereas resolution is the precision of the transferred information.

The general requirement for location accuracy is a few metres. In urban environments it should be possible to know in what building the person has entered. In big buildings (e.g. factories) it should be possible to know where in the building (on what floor and where on that floor) the person is situated. Using routing applications (for public safety) is only possible when this accuracy requirement is met. Time to incident is critical in public safety and ending up in the wrong (one way) street is not acceptable. Public safety uses dedicated routing applications where traffic jams, temporary closed roads and incidents are introduced in real time.

From the requirements above it can be seen that base station site location (Cell ID) is insufficient for location positioning.

4.4.3 Location positioning update rate

The required location positioning update rate is in the order of a few tens of seconds. This is however a maximum value, which is only needed during limited periods when special attention to that particular person or vehicle is needed. In general a much lower update rate is acceptable (in the order of a few minutes) if a mechanism allows for changing the update rate when needed. This mechanism could be by polling over the TETRA network by another system or operator. This mechanism could also be a rule-based system that decides autonomously (without instructions over the TETRA network) to change the update rate. A mixture of both could also be possible.

The update rate also depends on the location positioning accuracy. If the positioning accuracy is lower then the update rate could be lowered accordingly.

4.4.4 Location positioning availability

As more and more user- and organization-critical applications will depend on having location positioning, the requirements for availability are very high, especially in the public safety sector. Location positioning is needed in all locations where users may operate. These locations include inside buildings, tunnels, underground parking, forests, rural areas, urban areas (narrow streets between high buildings in city centres).

It should be noted that having communication is even more user- and organization-critical (life-critical in public safety). It can therefore be assumed that the locations mentioned above will have TETRA coverage in well implemented TETRA networks.

4.4.5 Location positioning reliability

Users and organizations will start using more and more applications based on location positioning. These applications will become critical to fulfil their task. Control rooms and/or dispatchers will be so used to having location positioning that they will have great difficulties continuing their work when the location positioning fails (they become blind). The reliability of the location positioning system is a very important requirement and users should have knowledge about its reliability. They should be able to verify and preferably influence this reliability (service level agreements). Not only technical reliability is important but considerations should also be given to the long term availability of the location positioning system provider. Having the location positioning system as an integrated part of the TETRA system would be a great advantage in this respect.

4.4.6 Location positioning terminal impact

The general requirements for terminals are increased battery life, weight reduction and reduction in size. Adding location positioning functionality should also respect these requirements. Especially for APL the equipment volume, the equipment weight and the battery consumption should not increase substantially.

4.4.7 Location positioning air interface enhancement

The analysis and feasibility assessment of TG23 [7] has shown that it is very difficult to add an integrated location positioning service in TETRA 1 V+D because of the modulation (symbol length/channel bandwidth) and the lack of timing systems (e.g. TA).

Having an "enhancement" changing the modulation (physical layer) would cause compatibility problems. Having an enhancement introducing a timing mechanism (e.g. TA which would also be useful for long range) may involve significant and unjustifiable implementation costs.

If work in TETRA Release 2 leads to evolutions of TETRA where the modulation is changed (e.g. high speed data), these location positioning requirements should be considered from the beginning. If this is not done, it may again be impossible to integrate the location positioning service afterwards.

4.4.8 Location information transfer to support APL/AVL applications

In the following a preferred technical solution for the "Emergency Services" is described. It should however be noted that there are several other solutions currently in use and others will continue to be developed, which may or may not necessarily meet the requirements of the "Emergency Services".

The location information transfer method should be open, standardized and optimized for the TETRA air interface.

The standardized location information transfer method should allow application providers/developers to make interoperable applications based purely and only on the information in the standard. (There should be no options or possibilities that require further agreements; profiles and/or information exchange between TETRA providers and/or application providers/developers).

The transfer method and information should be valid worldwide and not depend on parameters which are location specific. Any conversion to or from local grids should be done before and/or after transfer. (The transferred information should be in a globally recognized standard e.g. WGS 84). In special situations (decided by the sending station) the base station site identifier may be used instead of WGS 84-based location information.

The location information content and format should be TETRA-bearer independent (possibility to use SDS, IP, etc.).

The transfer method should be independent of the system used to acquire the location information, e.g. GPS, Galileo, proprietary non-satellite-based systems, manual input.

There could be multiple recipients for the location information. The multiple recipients could be all the members of a group. (It is expected that when SDS is used and when there are multiple recipients that are all member of the same group, group SDS will be the optimized method for the AI).

There could be multiple applications in the same network using the same location information transfer method or even using the same location information message from the same source at the same time.

It is expected that the service will have the same reliability/performance as SDS type 4 at basic link.

The location information transfer elements needed to support APL/AVL are listed in tables 1 and 2. The standard should support both types but users may wish to only use either the short message or the long message for their applications. Some users may use a long message initially with short messages being sent subsequently as updates from the same mobile station.

Note that all AVL messages are applicable to both the uplink and downlink.

Table 1: Short message location information transfer elements

Information element	Mandatory resolution/range	Useful resolution/range	Comment
Latitude	2,5 m	1,25 m	
Longitude	2,5 m	1,25 m	
Time elapsed (time between acquiring and sending the location information)	5 s to 1 h at least 4 steps		
Speed	instantaneous speed in the direction of travel, range = 0 km/h to 500 km/h, resolution 1 km/h or 10 % whichever is greater	to 1 000 km/h	
Heading/Direction of travel	instantaneous heading resolution 22,5°		
User defined data	8 bits minimum	all left over bits	e.g. sensor status
Position accuracy	at least 4 steps, < 3m minimum to > 3km	< 3 m, < 30 m, < 300 m, < 3 km, < 30 km, > 30 km	

Table 2: Long message location information transfer elements

Information element	Mandatory resolution/range	Useful resolution/range	Comment
Latitude	2,5 m	1,25 m	
Longitude	2,5 m	1,25 m	
Altitude	From -200 m to 10 000 m 1,25 m up to 5 000 m nice to have 200 m above 5 000 m		
Speed	instantaneous speed in the direction of travel, range = 0 km/h to 500 km/h, resolution 1 km/h or 10 % whichever is greater	to 1 000 km/h	
Heading/Direction of Travel	instantaneous heading resolution 5°	1°	
Position accuracy	4 steps, < 3 m minimum		
Message reference (consecutive numbering)	range 1 to 10	range 1 to 1 000	
Time of position	range = 1 day, resolution = 1 s (in UTC)	1 month or 1 year (unless time-date stamp is included in AVL message) - 1 s resolution in UTC	unknown time indication should also be available
Time elapsed (time between acquiring and sending the location information)	5 s to 1 h at least 4 steps		especially useful if time of position is unknown
Terminal or location ID	should support at least any TETRA identifier		or any identity used by the location application (not necessarily TETRA Identity)
Acknowledgement request			should not be used with group addressing
User defined data	8 bits minimum	all left over bits	e.g. sensor status

The information elements are not dependant on the method used to acquire the location information (type of system, technical solution). This means that the status of (elements in) the acquiring system, if needed, can only be placed in the "user defined data" element because the used acquiring system will be user-specific There could even be no "technical" acquisition system at all, just a person entering information based on his knowledge.

It may be useful that a short message is part of a long message.

When SDS is used to transfer the information, the short message should fit into 0,5 + 0,5 timeslots and the long message should fit into 0,5 + 1,0 timeslots (using the Random Access method).

It is expected that a standardized control message will be needed to configure and control the transfer application.

With the control message it should be possible to initialize and update the transfer application. Parameters that should be initialized/updated/adapted via these control messages are listed in table 3.

Table 3: AVL control message elements

Information element	Comment
Transfer initialization configuration request	This could be used to contact a server that will deliver the needed initialization parameters to start the APL/AVL application.
Information destination	This could be an ITSI, GTSI, external subscriber number or IP-address.
Minimum time elapsed between messages	Minimum time elapsed takes precedence over the maximum time elapsed and maximum distance travelled to prevent excessive resource usage.
Maximum time elapsed between messages	
Maximum distance travelled between messages	
Specific location	This could be used to send the location information when the sender is at that specific location.
Location message request	The location message transfer is initiated after reception of this message.

There should be no mechanism which prevents the sender from initiating an information transfer at any time. This decision could be based on a manual (personal) intervention or based on a local system asking the sender to do so.

4.4.9 Location positioning security issues

The location information transfer method should be available during temporary disable. However this functionality should only be available if no external devices are needed to provide location information as no external communication should be allowed during temporary disable, neither should there be any indication of terminal activity to the user.

It should be noted that the message format described in the present document does not take into account many of the security issues. These should be considered before the implementation of a location positioning system, especially one with remote activation possibilities. To reach an acceptable level of privacy and security, the system might use methods such as pre-configured destination address lists, end-to-end encryption, end-to-end authentication, or manual user confirmation.

However, these solutions are not in the scope of the present document.

4.5 Requirements identified that were not initially anticipated in the TETRA Release 2 work programme

4.5.1 Requirements resulting from the questionnaire

The requirements below are individual remarks from users/organizations answering the questionnaire. As other users/organizations could not judge the importance of these remarks, they cannot be ranked against the requirements specified in the questionnaire.

There is a requirement for the user to be aware at all times of who is in the call (by their alias) and their affiliation. To satisfy this requirement there is a need to easily, quickly and efficiently dynamically update and change aliases network wide on a regular basis.

Some examples are:

- individual call aliases;
- group membership, e.g. table with radio aliases in the first column and group affiliation in the second column;
- more information about the ongoing communication (talking party, new group members, etc.).

Preferably there should be only one place (database) in the system where the one-to-one relation between ITSI (or GTSI) and the "alias" (name) is made. If a subscriber receives a call within a group and/or from a user for whom it does not know the aliases, these should be delivered over the air-interface.

4.5.2 User requirements emerging after the questionnaire

4.5.2.1 Co-existence of terminals (MSs) and/or base stations (BSs)

Recent user experience with TETRA terminals (MSs) has shown that some TETRA terminals have difficulties to operate in close vicinity of each other. These terminals however comply with the current TETRA specifications. TETRA specifications should be tightened to allow closer co-existence between MSs.

Transmitting terminals in close vicinity of some receiving terminals seem to degrade the reception of those receiving terminals, sometimes to the extent that the connection with the network is lost. These terminals could operate in uncorrelated communication, e.g. they do not communicate with each other but with third parties not in close vicinity. The degraded receiving terminal could also be in idle mode.

The behaviour of those degrading receiving terminals is a problem for the users in the public safety community. They need reliable terminals in all of their normal operational conditions. The current terminal behaviour could cause loss of lives in critical situations.

Typical scenarios of these normal operational conditions are given as examples.

Scenario 1: radio users in the same car

Two or more policemen (uniformed or secret) often operate while they are in the same car using portable radios. Each of them needs the possibility to communicate independently of the others, at the same time, in a group call, individual call, simplex call or duplex call.

Scenario 2: radio users at the same table

Two or more radio users (commanding officers of different organizations) meet during crisis management around the same table. They have put their portable radios in front of themselves on the meeting table. Their radios are involved in uncorrelated communication, e.g. they normally do not communicate with each other using their radios but communicate with third parties not in close vicinity. Their radios could also be in idle mode. At any moment all of them should be able to communicate independently of the others, at the same time, in a group call, individual call, simplex call or duplex call.

There is therefore a user requirement for calls to be capable of being transmitted and received by terminals located in close proximity to each other (e.g. when the terminal users are sitting next to each other) without any differentiation or degradation of service. This requirement applies to group calls, individual calls, simplex calls or duplex calls.

History

Document history		
V1.1.1	December 2001	Publication
V1.2.1	May 2004	Publication
V1.3.1	May 2006	Publication