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TECHNICAL REPORT

Terrestrial Trunked Radio (TETRA);
Voice plus Data (V+D);
Designers' guide;
Part 6: Air-Ground-Air

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee TETRA and Critical Communications Evolution (TCCE).

The present document is part 6 of a multi-part deliverable covering Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Designers' guide, as identified below:

ETSI ETR 300-1: "Overview, technical description and radio aspects";

ETSI TR 102 300-2: "Radio channels, network protocols and service performance";

ETSI TR 102 300-3: "Direct Mode Operation (DMO)";

ETSI ETR 300-4: "Network management";

ETSI TR 102 300-5: "Guidance on numbering and addressing";

ETSI TR 102 300-6: "Air-Ground-Air".

Modal verbs terminology

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1 Scope

The present document is written as a "Read-me-first" manual or "Getting started with TETRA Air-Ground-Air". It is not intended to be a guide to the TETRA Air-Ground-Air standard nor an authoritative interpretation of the standard. If any conflict is found between the present document and the corresponding sections in the TETRA standard then the standard takes precedence.

The reader of the present document is assumed to have a working knowledge TETRA technology. The guidance provided in the present document is prepared with the experience of implementing an Air-Ground-Air to an existing national network.

The aims of the present document are:

- to introduce and detail the different aspects of Air-to-Ground communication in a TETRA network;
- to show the reader that Air-Ground-Air is an integral part of a TETRA network when required;
- to provide the reader with sufficient knowledge to engage in qualified discussions with the equipment and service suppliers;
- to expose the reader to the specific language and technical terminology used in the present document;
- to enable the reader to understand the flexibility in system design, system network topography, system availability, various modes of operation and security features;
- to provide basic guidance on optimizing a TETRA network when including an Air-Ground-Air element.

The present document provides guidance on the requirements for an Air-Ground-Air service and how best to implement an AGA service.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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

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The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ECC/DEC/(06)05: "ECC Decision of 7 July 2006 on the harmonised frequency bands to be designated for Air-Ground-Air operation (AGA) of the Digital Land Mobile Systems for the Emergency Services".

[i.2] ETSI EN 300 392-2: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".

[i.3] ETSI EN 300 392-7: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 7: Security".

[i.4] TETRA MoU - TTR 001-16: "TETRA Interoperability Profile - Part 16 (Air to Ground)".

[i.5] Recommendation ITU-R P.528-2: "Propagation curves for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands".

3 Definitions and abbreviations

3.1 Definitions

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

path delay function: cell reselection initiated by path delay

NOTE: The time taken for signal to perform a round-trip between the MS and Cell is known as the "Path Delay". When this time exceeds a preset value the SwMI informs the MS that maximum path delay is exceeded and causes the MS to initiate cell reselection.

Preferred Location Area (PLA): set of cells MS prefers against other cells

NOTE: A number of Location Area Codes may be programmed into the MS. The MS on receiving one or more of these LAs in the neighbour list of the cell it is affiliated to will "prefer" to use the cell associated with one of those LAs. Mobility to and away from such cells is defined in ETSI EN 300 392-2, clause 18 [i.2] and TETRA Interoperability Profile 16 [i.4]. PLAs may also be known as "Home Location Areas".

RF carrier: distinct radio frequency on which radio channel may be active

Subscriber Class (SC): subdivision of the subscriber population

NOTE: There are 16 subscriber classes defined for use on TETRA networks. Those 16 classes are divided into 3 groups, Highly Preferred Subscriber Class, Preferred Subscriber Class and (Basic) Subscriber Class. Mobility between the 3 groups of subscriber class is defined in ETSI EN 300 392-2 [i.2] and TETRA Interoperability Profile 16 [i.4].

V+D operation: mode of operation for communication via the TETRA V+D air interface which is controlled by the TETRA Switching and Management Infrastructure (SwMI)

3.2 Abbreviations

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

AGA	Air-Ground-Air
AGA_MS	Air-Ground-Air Mobile Station
AGL	Above Ground Level
ATG	Air To Ground (Also A2G)
BS	Base Station
DC	Direct Current
DMO	Direct Mode Operation
ECC	Electronic Communications Committee
EIRP	Equivalent Isotropic Radiated Power
EMC	ElectroMagnetic Compatibility
HF	High Frequency
HPSC	Highly Preferred Subscriber Class
LA	Location Area
MCCH	Main Control CHannel
MMI	Man Machine Interface
MS	Mobile Station
PD	Packet Data
PLA	Preferred Location Area
PSC	Preferred Subscriber Class
PSS	Public Safety Spectrum
PTT	Press To Talk switch, otherwise known as pressel
RF	Radio Frequency
RSSI	Radio Signal Strength Indication
RX	Receive
SC	Subscriber Class
SwMI	Switching and Management Infrastructure
SWR	Standing Wave Ratio
TMO	Trunked Mode Operation
TX	Transmit
TX/RX	Transmit/Receive
V+D	Voice plus Data (trunked infrastructure)
VHF	Very High Frequency

4 What is different about Air-Ground-Air operation and why is it needed?

4.1 General

TETRA radio networks are, in the main, built to provide communications where most subscribers are operating terminal equipment at sea or at ground level. There are a number of users, however, whose communication needs require operation at thousands of feet above ground level.

Air-Ground-Air (AGA) operation, also known as Air-To-Ground (ATG or A2G) is a TETRA radio service designed to provide communication between radio users operating from airborne assets and ground based operatives including radio users and dispatchers. The airborne assets typically will be comparatively small in number operating comparatively infrequently. However once they are operational their effectiveness is highly valued.

Most TETRA radio networks are primarily designed as a cellular network providing a land-mobile radio service, so significant design changes have to be implemented to service the requirements for effective AGA use.

The AGA service is provided by deploying an overlay network of Radio Cells or "Air Cells" that provide the user with communications typically from 500 feet (150 m) upwards.

4.2 Spectrum

The spectrum for AGA use is reserved solely for AGA purposes. There are several reasons for this, including:

- Radio channels are a scarce resource. Fortunately they can be re-used at a distance. This is possible due to the path loss caused by distance, landscape and buildings. In land-mobile networks the re-use distance is typically 50 km due to the high path loss of landscape and buildings. Path Loss at altitude is much less than at ground level. Transmitting at altitude on a land mobile network would result in interference on several land-mobile Base Stations that re-use the same radio channel. The EU-wide network plan, see annex A, if followed closely will minimize co-channel interference to acceptable levels. An internationally agreed frequency allocation is easier to implement to minimize interference between networks, refer to ECC/DEC/(06)05 [i.1].
- A small number of widely spaced radio cells supplying service for AGA purposes.
- The cells will radiate at lower power than cells used in the ground network.

5 Technical Design

5.1 Concept of Overlay Network

Due to the limited range of RF signals radio networks normally have a cellular structure where channels are re-used at a regular distance. If the terrestrial network with typical cell sizes of 8 km radius were planned in such a way that it allowed aircraft communications at normal operational attitudes for public safety or private mobile radio users, more than 1 000 channels would be required to avoid co-channel interference. As the available spectrum will support many fewer channels, this is clearly a non-viable technical solution. An efficient means of using the available spectrum is outlined in the following paragraphs.

Operators should answer this by deploying two networks - one optimized for terrestrial use and a second network designed for airborne radios.

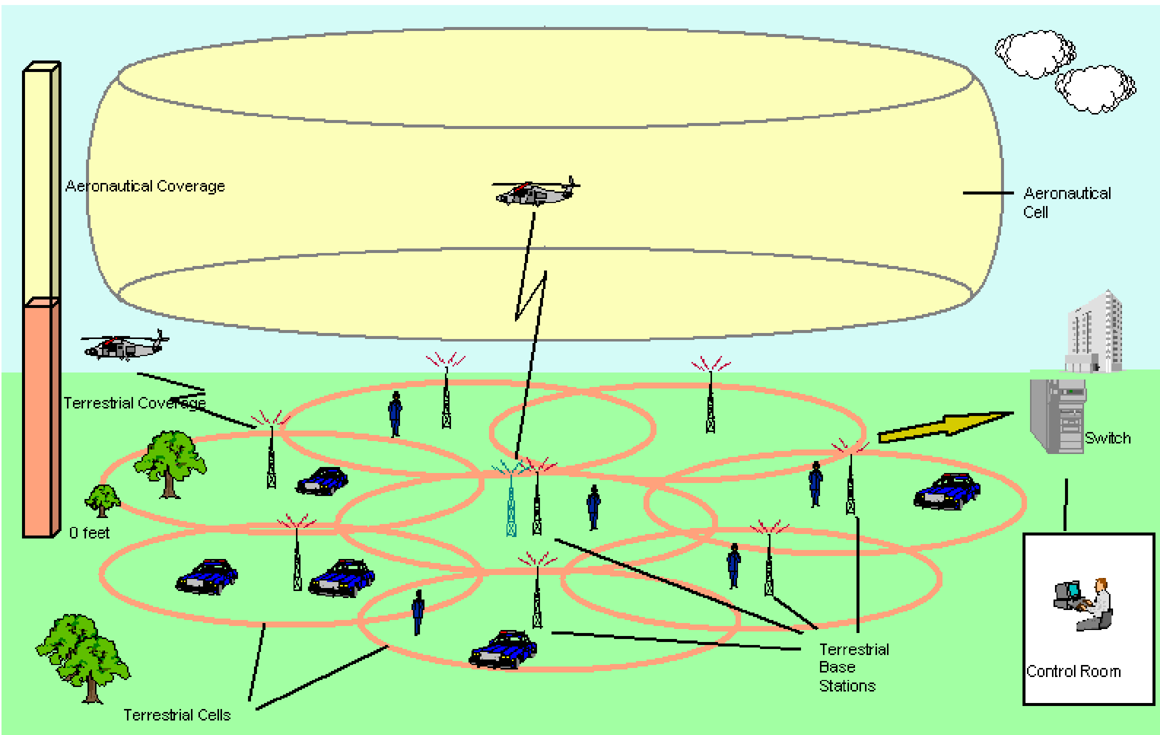

Figure 1: Terrestrial and Air-Ground-Air network

The terrestrial network is planned to the normal guidelines, whilst the AGA network is frequency planned specifically to allow for long frequency re-use distances. In order to maintain spectral efficiency, the AGA cells, here after referred to as "Air Cells" are spaced wide apart and typically have only a single RF carrier at each radio cell.

AGA terminals will roam seamlessly across the two networks without user intervention. The terminals design for use in the AGA service will additionally prefer to use the AGA network, utilizing mobility management techniques described later. Similarly, terrestrial terminals will be restricted to the ground network using the same techniques. As both networks will offer the same services and facilities, the user (either ground or Air-Ground-Air) is not expected to be aware of which network they are using.

The operational design is that the aircraft radio(s) will use the terrestrial network from ground level to an altitude where the AGA signal is received at the value "Radio Usable"; to prevent co-channel interference to ground cells the handover to an air cell should occur before an altitude of 500 feet (150 m) is achieved.

On descent, the operational design is that the aircraft radio(s) will use the AGA to an altitude where the AGA signal is received at the value "Radio Relinquishable" and a ground cell signal is received at a stronger level; this design ensures the aircraft radios are most likely to select the local ground cell. Again, this is to prevent co-channel interference to ground cells the handover from an air cell should occur at a low altitude, considerably less than 500 feet (150 m).

All radio cells are configured to broadcast information that allows suitably configured terminals to identify the network type that they belong to them and to handover to the appropriate radio cell. This assumes that certain other conditions are met; for instance, minimum received signal strength.

5.2 Spectrum Allocation

With ECC/DEC/(06)05 [i.1] a quantity of spectrum has been reserved for public safety AGA operational purposes in the PSS allocation. This reserved sub-band is the upper end of the PSS allocation. It consists of 8 channels reserved exclusively for AGA operations and an additional 2 optional ones to be utilized on the operators needs.

Figure 2 illustrates the European-wide harmonised spectrum layout for public safety networks.

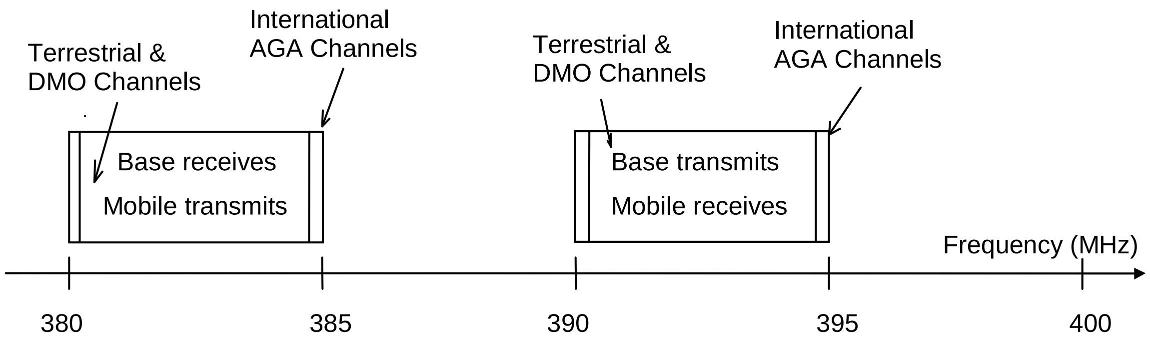

Figure 2: European Harmonised Spectrum Allocation in the 380 MHz to 400 MHz frequency range for Public Safety

5.3 Non-Harmonised Frequencies

Where the service requirements of individual operator or country calls for extra AGA RF carriers are required these additional carriers for AGA use, these carriers will have to be allocated from the terrestrial sub-band then consideration to exported interference to neighbour authorities and operators be undertaken as part of the planning process. It is worthwhile reviewing those frequencies when setting up bilateral agreements between countries.

5.4 Cell Operational Size

Clause 4.2 describes why the operational footprint of an air cell is much larger than a ground cell as in "free space" the path loss is much less. Due to line-of-sight propagation the usable signal from an air cell can extend hundreds of kilometres, depending on altitude; such distances will take the signal a finite time to cover those distances. It is important that the round-trip time of the signal taken to transit between the BS and MS should not exceed the guard time between timeslots.

5.5 Neighbouring

To allow smooth cell reselection in the AGA network and smooth switching between the terrestrial and the AGA network neighbour cell relations have to be defined in the TETRA network.

The neighbouring for AGA purposes needs to be considered in 3 ways.

Unlike the neighbouring for terrestrial cells where the cell to cell neighbouring is normally limited to the immediate, contiguous, neighbouring cells and is reciprocal this is not true of neighbouring to and from air cells. This is due to there being many more ground cells compared to air cells in any network.

Cell neighbouring type 1 - Ground cell to air cell (as known as "Upwards" neighbouring):

- All ground cells that are under the operational area of an air cell should list that air cell in its neighbour list broadcast. If a ground cell is located where more than one air cell may provide service then all these air cells may be included in the neighbour list.

Cell neighbouring type 2 - Air cell to air cell (as known as "Sidewards" neighbouring):

- Neighbouring air cell to air cell should list the immediate or contiguous neighbours only, typically no more than eight dependent upon frequency reuse pattern, ground terrain and the number of air cells.
- In mountainous regions air cells may be located below the level of the surrounding hills and so may not have truly circular coverage.

Cell neighbouring type 3 - Air cell to ground cell (as known as "Downwards" neighbouring):

- Neighbouring from air cell to ground cell should use the following recommended priority order:
  1) The ground cell that serves the operating or home location (air field, helipad) of aircraft that operate within the air cells area.
  2) Any other regularly used airfields or helipads within the air cells area.
  3) A selection of ground cells using different frequencies to the above sites dispersed at intervals within the air cells area. This will allow a better transition to the ground network throughout the air cells operating area. Typically the operating authority will chose no more than 20 ground cells for inclusion in the broadcast neighbour list.

5.6 Subscriber Class

The following information explains how Highly Preferred Subscriber Class operation can be used to aid aircraft communications.

Subscriber class 2 has been adopted and documented in ETSI EN 300 392-2 [i.2] and TETRA Interoperability Profile 16 [i.4] as the recommended subscriber class value for AGA operations therefore AGA radios should be configured to be member of Subscriber Class 2, which is defined in ETSI EN 300 392-2 [i.2] and TETRA Interoperability Profile 16 [i.4] as a Highly Preferred Subscriber Class (HPSC). Ground radios should be configured not to be member of Subscriber Class 2. Subscriber class 1 is also a HPSC value; typically this subscriber class value will be used for other purposes.

Ground cells should normally be configured to broadcast that they do not support HPSC or PSC classes of subscriber class, but only normal Subscriber Classes, typically SC14 or SC16 only. Air Cells should be configured to broadcast support for the Highly Preferred Subscriber Class SC2.

When an aircraft departs, the AGA radio will most probably be registered to a Ground cell. The Ground cells broadcast neighbour list will contain at least one air cell identity including its subscriber class (flag 2, HPSC). The AGA radio monitoring the neighbour cells will, once the received signal of the air cell has reached "Radio Useable" for over 5 s, roam to the air cell even if, or when, the present serving ground cell is received at higher signal strength. For full guidance refer to ETSI EN 300 392-2 [i.2].

Air cell to ground cell reselection, i.e. as the aircraft lands, should take place when the air cell received signal strength falls below "Radio Relinquishable" for more than 5 s. The radio should select one of the cells specified in the received neighbour list and select the strongest received signal. If the neighbour list contains a PSC cell then the radio terminal should select that cell provided the received signal strength is over Radio Useable in preference to lower priority subscriber class cells that may be received at higher signal strengths.

The selection of Subscriber Class methodology will require the operator to cause the air cell to broadcast SC2 only and ground cells to not broadcast SC2. The aircraft MSs will only require the appropriate subscriber class values, SC2 and the terrestrial cell subscriber class value(s) setting in the MS configuration. There is no limit to the number of cells, due to constraints in MS design that may be used for AGA purposes within a network.

Additional air cells added to a network will not require commensurate programming work to the MSs.

5.7 Preferred Location Area

The following information explains how Preferred Location Area operation may be used to aid aircraft communications.

Aircraft MSs, if capable in the MS design, may be programmed with a number of LAs; these LAs are known as PLAs. In this case the PLAs programmed into the MSs will be those LAs of air cells.

The number of PLAs that can be programmed into a MS is limited to, typically, between 20 and 32 LAs.

When an aircraft departs, the AGA radio will most probably be registered to a Ground cell. The Ground cells broadcast neighbour list will contain at least one air cell LA. The AGA radio monitoring the neighbour cells will, once the received signal of the PLA cell has reached "Radio Useable" for over 5 s, roam to the air cell even if, or when, the present serving ground cell is received at higher signal strength. For full guidance refer to ETSI EN 300 392-2 [i.2].

Air cell to ground cell reselection, i.e. as the aircraft lands, should take place when the air cell received signal strength falls below "Radio Relinquishable" for more than 5 s. The radio should select one of the cells specified in the received neighbour list and select the strongest received signal.

The selection of Preferred Location Area methodology does not require the network operator to cause the air cell to broadcast differing (subscriber class) values to ground cells. The limited number of PLAs that may be loaded into a MS will limit either the total number of air cells in an operator's network or limit the operational area of aircraft MSs within a network; should an aircraft venture outside of that area with working radios it should be expected that the aircraft radios will attach to terrestrial cells with the likelihood of causing interference to terrestrial cells over a wide area.

However, should additional air cells be added to an operators network then all MSs used in aircraft will have to be re-programmed to add the additional PLAs to the MS programmed configuration.

5.8 Subscriber Class or Preferred Location Area

The previous 2 clauses describe two different means of identifying the air network from the ground network; a choice of HPSC or PLA, one or the other should be employed only. Both methods offer the same MS roaming performance from terrestrial cell to air cell and air cell to terrestrial cell.

Whilst the choice of air cell selection is left to the discretion of the operator the choice of using subscriber class methodology has benefits with the ease of implementation, network expansion and MS programming. The use of PLA methodology may have a benefit in a small network.

5.9 Radio Handovers

In the terrestrial network, handovers take place when the RSSI on the radio's serving cell drops to a pre-determined level, coupled with a neighbouring cell that has a RSSI that is stronger than the serving cell by a specified margin.

Handovers between the ground network and the AGA "overlay" network will occur, in accordance with the operating description for HPSC or PLA in references ETSI EN 300 392-2 [i.2] and TETRA Interoperability Profile 16 [i.4].

Once affiliated to the air cell, there are few obstructions to the signals from AGA radio cells so two unusual characteristics appear:

- Normal RSSI based handovers are less likely to occur in air cells when compare to the ground based network due to the limited effects of terrain and clutter on the radio path and the likelihood of hitting the maximum Path Delay criteria before finding an adjacent air cell of sufficient signal to perform a handover to.
- Roaming to other air cells is expected to be by Path Delay functionality. In this case the radio upon transmitting, when over the defined distance from the serving cell, will receive a "Maximum Path Delay Exceeded" message from the network causing the radio to initiate cell reselection procedures. The "Path Delay Factor" is the TETRA parameter which defines when the Maximum Path Delay Exceeded message is sent and it is this that, for timing reasons, dictates the maximum size of a TETRA cell.

This means that the typical method of cell handover between AGA cells is not by normal terminal reselection but by the action of forced rejection from the serving cell and subsequent attachment to the highest ranking neighbour cell.

It is possible that the aircraft radio may not receive a suitable signal from a ground cell as helicopters can land anywhere and there are a limited number of neighbours available in the broadcast neighbour list of the serving air cell. If, exceptionally, no suitable frequency is received then the radio should remain affiliated to the serving air cell until "radio link failure" is encountered upon which the radio should perform a scan for a suitable cell.

5.10 AGA Cell Aspects

5.10.1 Antenna Type

It is recommended that the antennas for AGA service use are zero downtilt colinears with 6 dBi gain.

Typically AGA radio cells will have a single TX/RX antenna. However it is recommended that the site should be equipped with a second antenna for use as a "Hot Spare" for added resilience. (This may also be helpful to site performance if it can be used for receive diversity).

Some collinear antennas are of such a design that they have built in lightning protection and can replace lightening protectors; consideration should be given to the use of them for replacing the lightening protector where this improves the antenna location on the mast.

5.10.2 Shared Antennas

It is strongly recommended that antennas used for terrestrial radio cells are not shared with AGA sites.

In exceptional circumstances it may not be possible to add an additional antenna to the existing mast. In this case the preferred solution is to replace one of the diversity receive antennas on the site (assuming the site has these) with a zero downtilt antenna recommended above and use this antenna for the AGA radio cell. The effect of this on the terrestrial site clearly needs to be taken into account, however depending on the design of the radio cells it may still be possible to use this antenna for diversity use by connections at the appropriate places in the receivers. If the existing antenna of the terrestrial site has downtilt, removal may give coverage or interference problems and the likely impact of this change assessed before implementation.

5.10.3 Antenna location on masts

To enable cell reselection in the large AGA cells great care should be taken to create a circular radiation pattern for the AGA cell. Wherever possible the AGA antenna should be located at the top of the mast and ideally be the only one. If sole use of the mast top is not possible then the minimum number of other antennas may be allowed with the greatest possible separation.

Where the antenna has to be located on the side of a mast then the maximum stand-off should be utilized for installation and preferably be located in its own aperture. Where the mast is of closed construction, or has wide flat sheet type cable tray risers or many feeder cables within the mast construction then another location should be sought. If not, degradation in system performance should be expected on the sides away from the one which the antenna is mounted on.

5.10.4 Feeder Types and Design Rules vs. Length

Feeder types will match the types already in use by the network operator's design.

5.10.5 Antenna Mounting Arrangement

It is expected that the radio cell antenna mounting arrangements are specified by the operators in co-ordination with the mast manufacturers and site owners.

The mounting design should provide a stable, secure attachment to the mast or mast head which takes into account the prevailing wind speed and direction at the site.

Antenna mounting should be as vertical as possible (i.e. ±1 degree error).

5.10.6 Base Radio RF Parameters

The signal between a radio cell and an aircraft mobile station is not subject to the same degree of attenuation as between a radio cell and a terrestrial mobile station. This may usefully allow the network operator to run the radio cell at a lower transmit power level than might be used in a terrestrial cell. A maximum transmit power of 10 W (+40 dBm) into the antenna is recommended.

5.10.7 Reselection Parameters

The reselection parameters used on an AGA network are likely to be different to those used on the terrestrial network. Clause 5.10.6 discusses that the signal is subject less attenuation in the air and the Base Station operates at a lower transmitter output power. To compensate for that lower transmit power the TETRA parameter "Minimum Receive Access Level" may be usefully be set to a lower value than is used on the operators terrestrial network.

Similarly the parameter "Maximum Mobile Station Transmit power" can be set to a lower value, typically +30 dBm. This reduction in these values will reduce interference to other mobile stations and Base Stations.

By setting the "ACCESS_PARAMETER" a value greater than that broadcast by the operators' terrestrial cells will aid in reducing interference.

Also affected by the reduced attenuation is the ability of the aircraft mobile station to roam between AGA cells by received signal strengths is inhibited. The solution described in TETRA Interoperability Profile 16 [i.4] handover between AGA cells is caused by the "round trip time" for the signal to travel the distance from the radio cell to mobile station and back. Once this time exceeds the "Path Delay Factor" value BS informs it to the MS and the mobile station will initiate a cell handover. The value is set to align with the mobile station capabilities and typically corresponds to a distance from radio cell to mobile station of 83 km.

A guide to determining the "Fast Reselection Threshold" parameter value is to select a value that sets the "Radio Relinquishable" value at the coverage reliability planning level. The intention of that is to ensure the radios can roam at the appropriate signal level to the terrestrial network.

When selecting values for the "Fast Reselection Hysteresis" and "Slow Reselection Hysteresis" parameters it is suggested that consideration is given to the effects on the signal caused by the aircraft body in shadowing the signal path between Base Station and mobile station as the aircraft, particularly helicopters, perform turns and the manoeuvre. Such effects may be particularly apparent with multiple radio installations in aircraft.

As previously discussed, handover between air cells is normally initiated by Path Delay Function the "Slow Reselection Threshold" parameter value does not need to be a large value and may be selected such that roaming to a ground cell occurs at a similar level to "Radio Relinquishable".

5.11 AGA network planning

5.11.1 General design considerations for an AGA network

The design for an AGA network plan should consider the following factors:

1) When an aircraft is at operational altitude the signal path is normally, "line of sight", therefore path losses due to "clutter" can be disregarded. At large distances from the Base Station and/or at lower altitudes the situation is different. There the signal path extends beyond the horizon where path loss quickly increases.

2) The radio cell used for AGA operations can operate at a lower transmit output power than terrestrial cells.

3) Few frequencies are available for AGA operations hence a frequency re-use plan of 7 channels is normal.

4) The flying speeds of the aircraft of up to 300 km/h.

5) The operating area of an AGA radio cell is large, typically 50 km radius.

6) Affects of antenna "Cross Polarization" due to the aircraft changing attitude whilst climbing, banking and descending.

Due to the low number of available channels minimizing interference caused by co-channel noise requires greater consideration than the possibility of exceeding the reference sensitivity level at the edge of coverage of a cell. The larger cell operational radius has a benefit in reducing such interference.

Additionally the Uplink (aircraft MS to radio cell) link budget includes:

1) The mobile stations when attached to an AGA cell will be operating at a maximum MS transmit power of 30 dBm.

2) The radio cell may not have diversity on the antenna system.

5.11.2 International Frequency Co-ordination

Due to line-of-sight propagation the signal from an AGA user can extend hundreds of kilometres. Therefore a careful, internationally coordinated, planning of AGA channels is necessary. The ECC has harmonised 8 channels with another two preferred extension channels for AGA purposes, refer to ECC/DEC/(06)05 [i.1].

Due to the large signal range and the limited number of available channels it is not possible to plan AGA networks on a national basis. Therefore international agreement is also needed on how and where to use the channels.

Belgium, The Netherlands and UK collaborated on behalf of the TETRA Association and prepared a pan-Europe AGA radio plan using a seven-cell frequency reuse pattern. In this way the 8^{th} channel (plus the two preferred extension channels) are available for cross or close border use or for additional capacity as required.

The operator or licensing authority should negotiate a Memorandum of Understanding with neighbouring countries to minimize the risk of mutual interference.

5.11.3 Design of the pan-European AGA radio plan

The goal was to:

- Design an AGA network based on a 7-cell frequency reuse pattern.
- Allow switching between terrestrial network and AGA network at altitudes of 500 feet.
- Allow interference-free communications (i.e. $Carrier/Interference_{Static} > 10$ dB) at flying altitudes as high as possible.

The typical link budget calculation for an AGA network is in table 1.

Table 1: Typical AGA link budget

Link budget AGA			
BS antenna: 5 dBi omnidirectional		**AGA MS antenna: 0 dBi omnidirectional**	
Downlink BS - AGA_MS		Uplink AGA_MS - BS	
BS TX power	40 dBm	AGA_MS TX power	30 dBm
Combiner loss	0 dB	Body loss	0 dB
Duplexer and directional coupler loss	0 dB		
Feeder and connector losses	2 dB	Cable and connector losses	1 dB
BS TX antenna gain	5 dBi	AGA_MS antenna gain	0 dBi
BS TX EIRP (20 W)	43 dBm	AGA_MS TX EIRP	29 dBm
AGA_MS sensitivity (dynamic)	-103 dBm	BS sensitivity (dynamic)	-106 dBm
		Duplexor and Splitter loss	0 dB
Cable and connector losses	1 dB	Feeder and connector losses	2 dB
Body loss	0 dB	Diversity gain	0 dB
Margin due to reflection and obstructions	0 dB	Margin due to reflection and obstructions	0 dB
Man-made noise margins	0 dB	Man-made noise margins	0 dB
AGA_MS RX antenna gain (at edge)	0 dBi	BS antenna gain (at edge)	5 dBi
Nominal signal at AGA_MS antenna	-102 dBm	Nominal signal into BS RX antenna	-109 dBm
Maximum allowed downlink path loss	145 dB	Maximum allowed downlink path loss	138 dB
NOTE: There is 7 dB difference between down and uplink. The extra power in the downlink will ease handover from the landmobile to the air layer.			

The calculation shows that the allowable path loss in the AGA network is 138 dB.

Recommendation ITU-R 528-2 [i.5] and simulations using the Longley-Rice Irregular Terrain Model, see below, predict that at 500 feet the combination of propagation beyond the horizon and terrestrial clutter between Base Station and the AGA user limit the reliable radio range to 50 km. This was confirmed by measurements.

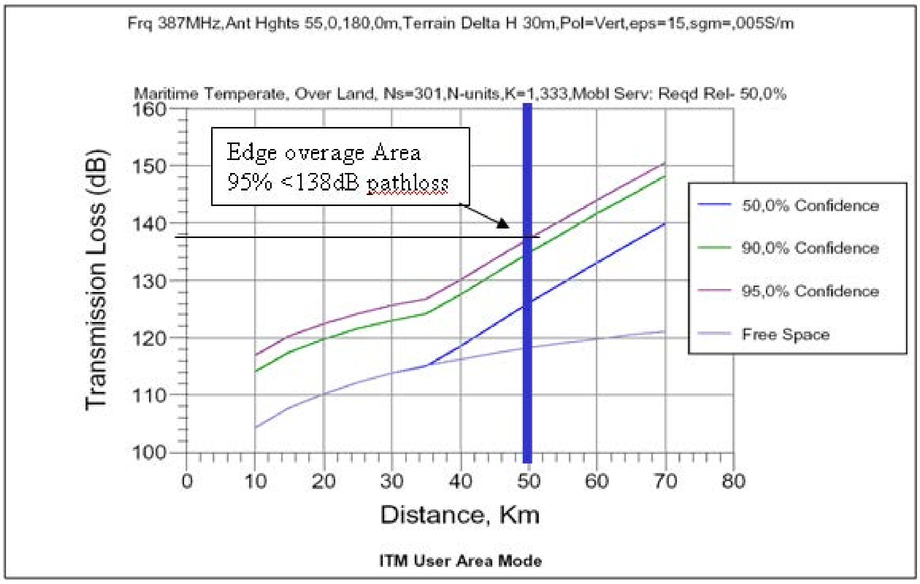

Figure 3: Path loss

The re-use distance in a seven-cell pattern with 50 km cell radius is 50 x √(3 x 7) = 229 km.

ITU528-2 and simulations using the Irregular Terrain Model (Longley-Rice) predict that in a cellular network with a re-use distance of 229 km at the cell edge of the serving cell the C/I protection will drop below 10 dB at altitudes above 4 000 feet AGL.

Annex A provides the resulting pan-European AGA radio plan, listing the WGS84 coordinates of centres of the AGA cells. To allow co-location of AGA Base Stations with existing terrestrial Base Stations an implementation circle of 20 km around the centre is available.

The coverage may include operation over the sea up to the international limit out from the coast.

The coverage limit is controlled by timing constraints that are a feature of the TETRA protocol. For AGA use the TETRA Air Interface standard ETSI EN 300 392-2 [i.2] specifies extended range with an operating distance from the radio cell to 83 km. Extended range allows for the combination of 50 km cell radius, sufficient room and time for cell reselection and the 20 km implementation room described above.

5.11.4 Characteristics of the pan-European AGA radio plan

The pan-European AGA radio plan is based on the following:

- channels 3 793 to 3 799 are used in a 7-channel pan-European re-use pattern with 50 km cell radius, detailed in annex A;
- channels 3 790, 3 791 and 3 792 are available for coordination along borders and use in special areas;
- co-location of AGA Base Stations with existing terrestrial Base Stations within a 20 km implementation circle around the centre listed in annex A;
- effective antenna height of the AGA site: 55 m to 100 m;
- transmitted power of the AGA site: 20 Watt EIRP;
- support of extended range in the AGA mobile and Base Station.

The AGA network based on the plan has the following characteristics:

- service on the AGA cell from 500 feet at the cell edge, to a lower altitude at the centre of the AGA cell;
- service on the AGA cell up to 4 000 feet at the cell edge, up to a higher altitude closer to the centre of the AGA cell.

6 Configuration

6.1 Capacity Planning

Capacity planning for the AGA network does not follow the normal planning rules associated with the terrestrial network. Due to the likelihood of limited spectrum availability for air-ground communications, there may be no limits on the queuing allowed at any one radio cell. Instead, radio cell capacity will have to be agreed between network operator and users or user's representatives.

In the frequency plan described in clause 6.1.1 the spare channels may be available to add capacity to a limited number of cells.

6.2 System Restriction Control

The network operator should configure the network such that the SwMI should reject attachment attempts from terrestrial MSs to air cells. Attachment by a terrestrial MS originating an Emergency Call to an air cell when no other cell is available may be permissible.

6.3 User Priority

User priority may be a useful facility when a talkgroup suffers from high levels of activity and the Air borne user take control of the talk group to impart command intelligence. However, it does not necessarily offer pre-emptive priority.

Emergency call function should use pre-emptive priority.

6.4 Security

The AGA network should comply with the operators security standards. Operators should refer to their own requirements, standards, documentation and ETSI EN 300 392-7 [i.3].

6.5 Packet Data

Packet data services may be supported on all AGA sites. It is recommended that the service is supported using dynamic Packet Data channel allocation. The dynamic PD functionality may be selected to give priority to either voice or PD depending upon the requirements of the network operator or user.

It is unlikely that Multi-slot data will be supported on AGA cells due to capacity constraints.

You need a policy - either use AGA throughout the doc or AGA but not both!

6.6 Resilience

The AGA network normally uses one carrier in each radio cell. Therefore the network cannot have a resilient or second carrier available to maintain service should the active radio cell transceiver fail. It may be possible that the radio cell transceiver equipment can be duplicated, using the same frequency, with the second transceiver maintained in a standby state to be brought into service when the main transceiver fails.

6.7 Radio Cell Fallback Strategy

AGA sites will be configured so that if the connection between the SwMI and the cell is disconnected the cell will reject attachment attempts or alternatively stop radiating to ensure communications are possible via operational terrestrial radio cells. Such service should be regarded as "Incidental" as aircraft may receive signals from more than one radio cell using the same frequency.

In the event of a wide area network failure, AGA terminals will move to the terrestrial network. This will allow airborne users to have limited communication with units on the ground.

6.8 Exception Conditions

There will be occasions where an AGA terminal can only receive signals from AGA sites that are greater than the min Rx access level but all exceed the path delay threshold. This might happen when the most appropriate serving cell is shadowed or if the radio cell fails.

Under this condition, the radio will search around all of the neighbouring AGA radio cells. Once it has been rejected by the AGA sites, the terminal will attach to a terrestrial radio cell. The radio will remain attached to the terrestrial network until service is restored at the local air cell, or the aircraft moves into the footprint of a neighbouring AGA cell where the radio will receive a new neighbour list from a ground cell containing a new air cell identity. The neighbour list broadcast of the terrestrial cell that the aircraft MS is attached to contains detail on the service state of the air cell(s).

This method of working requires careful selection of the following parameters:

- Subscriber Class information.
- Site adjacency information.
- Min Rx access level for each cell.
- Path Delay threshold of both the AGA and terrestrial cells.

7 Airframe considerations

7.0 General

The environment in an aircraft may be considered to be very harsh to radio equipment both physically and electrically. The airframe is likely to have limited space for antennas to be located. The actual antenna positions are likely to be closer than is optimal to prevent interference between equipments. Radiation patterns are often altered from the ideal or expected on airframes to the detriment of the service.

It should be expected that there will be considerable vibration therefore a larger than normal MMI is of value to the aircrew for ease of operation. Integration of the audio output and inputs with the aircraft communication system is essential.

7.1 Mobile Stations

7.1.0 General

Radio terminals for use in aircraft may vary from handhelds in car cradles to specifically designed units. All MSs for airborne use should support adaptive and system specified power control, Subscriber Class functionality or Preferred Location Area functionality.

7.1.1 Mobile Stations - Aircraft specific MSs

MSs specifically designed to appropriate standards for installation in aircraft are available.

Aircraft specific MSs have the following characteristics to improve usability in aircraft:

- Large MMIs.
- Night Vision Goggles capable.
- Large button keypad with positive action and "de-bounce".
- Duplicate controllers.
- Multiple radio control availability.
- DO160 D/E environmental qualification.
- Standard Aircraft cockpit mounting compatibility.
- Easily integrates aircraft audio system.
- Quick and easy exchange of components.
- Extra filtering to reduce the possibility of interference to and from other aircraft radio equipment.

MSs of this type should be the preferred radios for use in aircraft.

7.1.2 Multiple Mobile Stations

Aircraft may have several TETRA radios installed for role specific purposes along with (HF & VHF) analogue radios for aircraft operational purposes. Whilst audio from all radios should be available to all members of the aircrew the controls may not be. Purpose designed aircraft TETRA radio terminals may have multiple control facilities to allow control of individual radios from two or more locations within the aircraft.

Using several mobile stations with their antennas in close proximity can be a problem due to the possibility of one mobile transmitting in the same time slot as another is receiving. Some extra filtering may be provided in custom aircraft radio equipments but this will not help with interference between the radio equipments on the same frequency band. The high levels of RF from a transmitting mobile may exceed the blocking level defined in ETSI EN 300 392-2 [i.2] of the other mobile's receivers and the wideband noise from the transmitter defined in ETSI EN 300 392-2 [i.2] may cause co-channel interference. Both effects will cause receiver desensitization. To bring both these effects to the level where they are not causing receiver desensitization can typically require 50 dB to 60 dB of isolation which is difficult to obtain using the antenna spacing likely on an airframe. One solution to this is to use a single antenna with an isolating RF combiner to reduce the number of antennas required. This will add losses into the RF signal path and these are to be accounted for in the link budget calculations. These losses may not be as big an issue in the AGA service as they might be in the terrestrial service due to the lower propagation losses. The mobile transmitter power may also be increased to compensate for the loss. Some loss in the AGA receiver input may also be beneficial in reducing the large signal levels that may be obtained from nearby terrestrial sites and the resultant receiver blocking and intermodulation problems that may result. A problem with these RF combiners can be their weight and sensitivity to vibration.

Where individual antennas have to be used for each radio they should be placed as far apart as possible to achieve the best possible isolation. This may not be enough to bring the isolation up to the required levels, some problems with receiver desensitization may be expected. This is likely to take the form of a receiving radio losing the control channel or dropping a call under low signal level conditions such as at a cell edge or when the aircraft turns, tilting the airframe so that the antenna is on the side of the aircraft distant from the cell site when another radio is transmitting.

7.1.3 Mobile Stations - Hand Held equipments

Although not recommended (for mechanical and MMI reasons) hand-Held MSs used in car mounting cradles may be an option for installation into aircraft. Where this practice is adopted the cradles should be installed where all the principle (primary) users of the aircrew can access the MMI easily. The car cradle should be suitable for the aircraft DC power circuit (typically 28 volts) or a DC to DC converter, to supply power at the correct voltage for the car cradle, will need to be installed as part of the TETRA radio system. The audio inputs and outputs from the car cradle breakout box should be connected to the aircraft communication system at appropriate levels; corrective or matching circuitry should be employed as necessary.

The car cradle should supply an antenna connection to an antenna which radiates on the outside of the aircraft body. The integral antenna of the hand held mobile station should, where possible be removed and replaced by a blanking plug. The installed handheld MS + cradle should not allow any RF radiation from the handheld antenna and/or connector circuitry during a transmission within the cockpit/cabin area. The ideal system should disconnect the handheld antenna automatically when the handheld MS is fitted to the cradle and automatically connect to the aircraft external antenna.

If this installation practice is adopted then it should be expected that each aircraft requires certification (see clause 7.2.5).

The use of Hand Held MSs in aircraft without connection to an external antenna should not be practiced under any circumstances.

7.1.4 Mobile Stations - Vehicle MSs

MSs designed for use in car vehicles may also be an option for installation into aircraft. To enable vibration-proof installation of the radio unit and easy access to the MMI it is recommended to employ a version with a remote control head. Where this practice is adopted the MMI should be installed where all the principle (primary) users of the aircrew can access it easily. The installation will require a DC to DC converter to be installed as part of the TETRA radio system. The audio inputs and outputs from the vehicle MS should be connected to the aircraft communication system at appropriate levels; corrective or matching circuitry should be employed as necessary.

If this installation practice is adopted then it should be expected that each aircraft requires certification (see clause 7.2.5).

7.1.5 Emergency Call Operation

MSs installed in aircraft should be capable of originating Emergency Calls, however the function will have operating differences to terrestrial MSs. Those differences are no "hot mike" function; requiring the aircraft operator to operate the PTT to talk to others in the talkgroup.

7.2 Mobile Station Configuration

7.2.0 General

The MS should meet the TETRA conformance specification for a maximum of Mobile Power Class 3 (i.e. 3 Watt nominal) and, at least, Receiver Class B when operational in TMO.

In countries or regions where the licensing authorities allow DMO operation from aircraft the MS should be capable of having the DMO TX power configured by the programming tool; the DMO TX power for DMO TGs used from a flying aircraft should be set at +15 dBm.

Configuration of the AGA Mobile Stations will usually be the terrestrial radio parameter set but with the following exceptions or additions.

7.2.1 Subscriber Class operating methodology configuration

- AGA subscriber class should be used - identified as subscriber class 2.
- Subscriber class 2 should be provisioned into the MS as an additional subscriber class value where the radios will operate on both terrestrial and air service layer and switch between the layers.
- Subscriber class 2 should be solely provisioned where the MS will only operate on the air service layer.

7.2.2 Preferred Location Area operating methodology configuration

- Subscriber class setting not needed.
- The Location Area Codes of the network's air cells should be provisioned into the MS where the radios will operate on both terrestrial and air service layer and switch between the layers.

7.2.3 Common operating methodology configuration

- Support of extended range up to 83 km.
- It is advantageous to be able to program the MCCH frequencies of the operator's air cells into the MSs in addition to the operators downlink frequency band.

NOTE: This procedure expedites service recovery if an AGA MS is restarted when at operational height.

7.2.4 Aircraft Antenna Configuration

Antenna type recommended: Vertically polarized $\lambda/4$.

Cable/connector losses = 2 dB.

The antennas should be mounted on recommended aircraft manufacturers antenna fixing points as these points should have a suitable "ground plane" designed into the bodywork. Where the bodywork is a non-conductive composite a suitable "ground plane" should be affixed to the inner of the body panels and correctly bonded to the airframe ground.

Antennas on aircraft with multiple radio installations should have the antennas widely dispersed around the aircraft body to minimize the possibility of mutual interference. Consideration should be given as to the use of the radios as communications will be necessary both on the ground and in the air. Therefore antennas on both the upper-side and lower-side of the body will be needed to enable good communications from different MSs that may be selectively used in the air and on the ground.

7.2.5 Certification

Operation of TETRA MSs in aircraft will require some form of EMC testing once the installation is complete. Such testing requirement will be guided by the country the aircraft are operational in, aviation safety requirements, the aircraft manufacturers' requirements and the type of MSs installed.

For guidance, any type of MS installed will require aircraft EMC testing to comply with airworthiness certification after the installation work has been completed. The testing will normally take place in a specific order:

1) The installed antennas will be tested for performance and connectivity, e.g. SWR and Isolation.
2) The aircraft will be connected to a "ground power" source and the aircraft powered up. The radios will be switched on and the aircraft systems tested with the MSs firstly in idle, then receiving and finally transmitting.
3) The transmitting tests will take place at least 3 frequencies, bottom, top and mid-point of the frequency band; normally with the MSs operating in DMO and Transmitting at +35 dBm or higher if the licensing authority allows. Post testing and before the aircraft is allowed to become operational the programming of the radio will be changed to reduce the DMO TX power.
4) If the tests in paragraph 2 above are successful and observed not to affect the aircraft systems then they will be repeated on aircraft power i.e. engines running at operational speed but on the ground.
5) If the tests in paragraph 4 are successful and observed not to affect the aircraft systems then they should be repeated with the aircraft airborne; with rotary wing aircraft (helicopters) the airborne tests should take place with the aircraft about 1 metre off the ground; with fixed wing aircraft the tests will take place at a safe operational altitude.

Failure i.e. an unexpected deviation of any aircraft function during any of the tests will require the tests to be stopped and the aircraft systems investigated for the causes. The testing should not restart until causes have been identified and rectification has taken place.

Certification should be provided on successful completion of tests.

7.3 Mobile Station Upgrades

It is normal practice in aviation that any changes to any system in an aircraft of any type should have a detailed change documentation and recording system. TETRA MSs and radio assemblies will be subject to the same rules and recording system. The maintenance companies for the respective aircraft will supply in detail the requirements or advice on request. It is to be expected that a qualified engineer will be required to be present to oversee the MS manufacturer's engineer perform the upgrade process. If the aircraft MS equipment has aircraft equipment approval granted under an airworthiness authority a "Release to Service" certificate may be required to be issued after completion of the upgrade and the equipment may also require a "mod strike" to be entered on the unit ID label in accordance with the upgrade procedure. The release certificate would be issued under the terms of the manufacturer's approval authority as granted by an airworthiness authority in the country of origin.

Changes to the MSs user or operator configuration may also be subject to the same rules.

Annex A: Europe wide AGA frequency plan

The following pages document the pan Europe AGA network frequency plan prepared in 2008.

This plan is based around a seven cell reuse pattern from the designated AGA channels, the unused additional 1 + 2 channels may be used to add capacity over major conurbations or flexibility on border areas. The plan is designed grant an equitable capacity allocation to all users.

It is recommended that the plan is followed aligning the suggested cell locations with the operators site locations. The plan allows some flexibility in the site locations of up to 20 km.

A MoU preferably is implemented between user countries defining "Super Preferential" and "Preferential" channels for each country.

More details on the backgrounds of the plan can be found in clause 5.11.

Figure A.1 presents a pictorial overview of the cell pattern in Europe.

Table A.1 lists the WGS84 coordinates of the centres of the AGA cells of the pan-European AGA network plan.

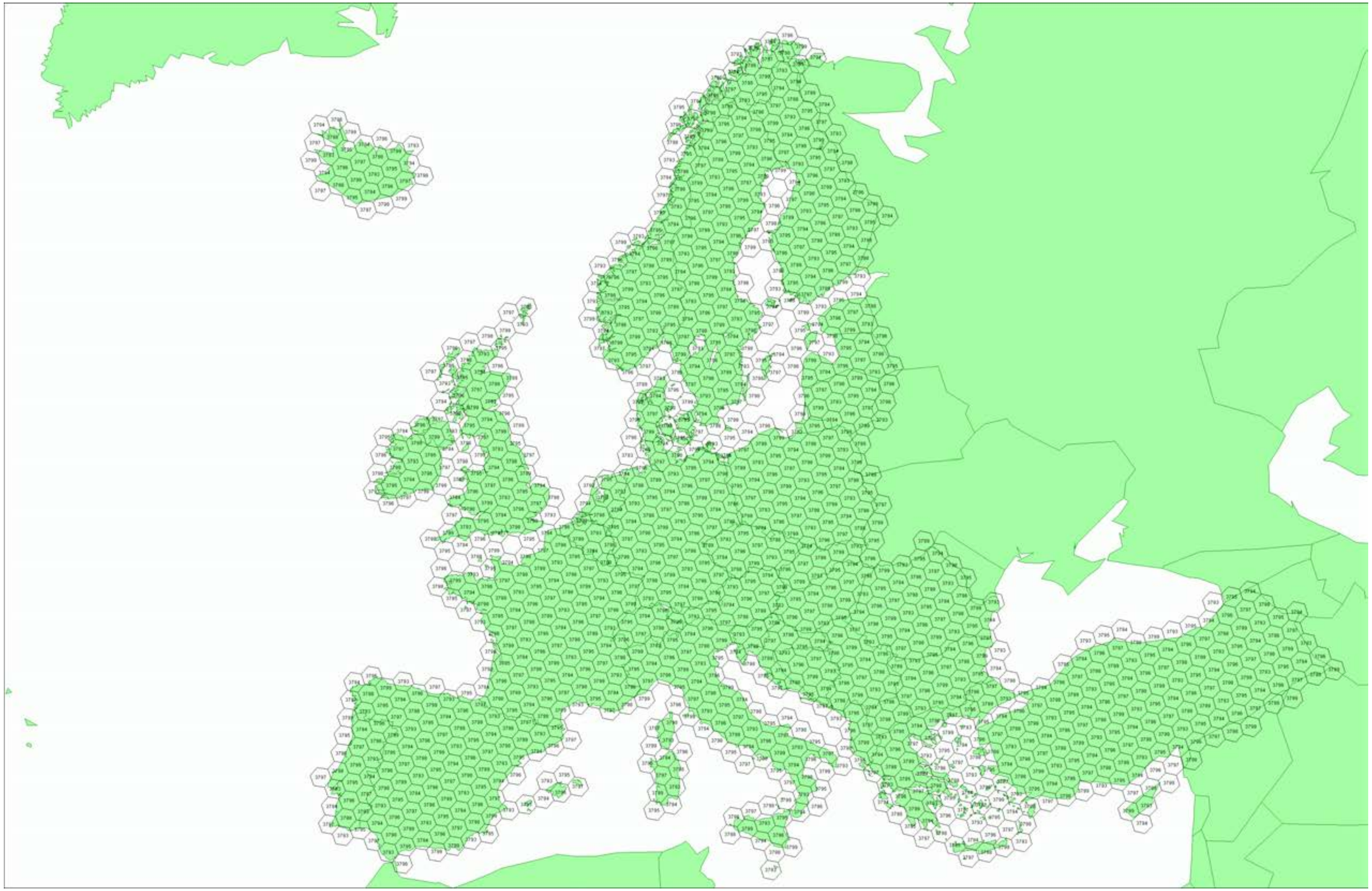

Figure A.1: Overview of the cell pattern in Europe

Table A.1: Pan-Europe AGA cell locations

Channel	Latitude	Longitude
3 793	34.944648	33.523981
3 794	34.306819	33.016826
3 793	35.030420	27.019467
3 797	35.628938	33.105179
3 795	36.313280	32.676458
3 793	36.346311	31.726731
3 799	34.986633	32.596705
3 796	36.216727	34.571840
3 797	36.153268	35.516838
3 795	36.850613	35.113175
3 793	36.909865	34.156304
3 794	36.270075	33.624938
3 798	35.581344	34.042215
3 799	35.523764	34.977568
3 796	36.701455	37.020174
3 797	36.611646	37.969645
3 795	37.321182	37.592936
3 793	37.407152	36.631106
3 794	36.781128	36.067909
3 798	36.079742	36.459610
3 796	37.118558	39.507093
3 797	37.002038	40.458772
3 795	37.722874	40.110799
3 793	37.835948	39.146347
3 794	37.224963	38.551707
3 798	36.511761	38.916001
3 799	36.401865	39.858929
3 796	37.466154	42.02739
3 797	37.322678	42.978899
3 795	38.053848	42.661297
3 793	38.194291	41.696683
3 794	37.599583	41.071253
3 798	36.875479	41.406432
3 799	36.738963	42.349770
3 796	37.742644	44.575388
3 793	38.480512	44.276268
3 794	37.903265	43.620967
3 798	37.169248	43.925483
3 799	37.005963	44.866851
3 797	34.918454	24.236185
3 795	35.552133	23.712873
3 796	35.647890	25.586776
3 797	35.680741	26.525710
3 795	36.330109	26.020847
3 793	36.291695	25.071740
3 794	35.605012	24.649057
3 798	34.965658	25.162719
3 799	35.002988	26.090583
3 796	36.376367	27.922006
3 797	36.384180	28.873390
3 795	37.048728	28.389201
3 793	37.035620	27.426923
3 794	36.358340	26.971047
3 798	35.703542	27.465538
3 796	37.043844	30.314206
3 797	37.025855	31.276239
3 795	37.704981	30.814959
3 793	37.717975	29.841344
3 794	37.051470	29.351744
3 798	36.381772	29.824863

Channel	Latitude	Longitude
3 799	36.369146	30.776089
3 796	37.647484	32.759961
3 797	37.603021	33.730632
3 795	38.296033	33.294476
3 793	38.335835	32.311577
3 794	37.681479	31.787951
3 798	36.997514	32.237496
3 799	36.958842	33.197631
3 796	38.184644	35.255202
3 797	38.113135	36.232305
3 795	38.819246	35.823426
3 793	38.886459	34.833509
3 794	38.245624	34.275805
3 798	37.548118	34.699612
3 799	37.482814	35.666551
3 796	38.652903	37.795217
3 797	38.553887	38.776368
3 795	39.272223	38.396820
3 793	39.367335	37.402342
3 794	38.741376	36.810783
3 798	38.031144	37.206761
3 799	37.938727	38.178222
3 796	39.050096	40.374672
3 797	38.923234	41.357340
3 795	39.652835	41.009036
3 793	39.776211	40.012616
3 794	39.166452	39.387717
3 798	38.444395	39.753890
3 799	38.324503	40.727440
3 796	39.374347	42.987665
3 797	39.219428	43.969196
3 795	39.959256	43.653866
3 793	40.111130	42.658256
3 794	39.518850	42.000834
3 798	38.785952	42.335380
3 799	38.638345	43.308462
3 794	39.796875	44.643814
3 797	36.115633	22.234260
3 795	36.740255	21.678137
3 796	36.879805	23.587386
3 797	36.934221	24.545148
3 795	37.575281	24.006667
3 793	37.514872	23.038724
3 794	36.815135	22.631605
3 798	36.184422	23.178120
3 796	37.664805	25.947833
3 797	37.693859	26.920349
3 795	38.350903	26.401929
3 793	38.316106	25.418418
3 794	37.625270	24.976487
3 798	36.978347	25.504552
3 799	37.012154	26.465259
3 796	38.388546	28.371666
3 797	38.391368	29.357148
3 795	39.063842	28.861251
3 793	39.055565	27.863984
3 794	38.375055	27.386469
3 798	37.712413	27.893679
3 799	37.720454	28.867463
3 796	39.047916	30.855706
3 797	39.023725	31.852121

Channel	Latitude	Longitude
3 795	39.710978	31.381213
3 793	39.730038	30.372261
3 794	39.061292	29.858621
3 798	38.383519	30.342541
3 799	38.365004	31.327475
3 796	39.639980	33.396033
3 797	39.588092	34.401109
3 795	40.289375	33.957624
3 793	40.336488	32.939313
3 794	39.680952	32.389269
3 798	38.988734	32.847479
3 799	38.942968	33.841402
3 796	40.162017	35.987985
3 797	40.081864	36.999237
3 795	40.796327	36.585525
3 793	40.872096	35.560413
3 794	40.231204	34.973983
3 798	39.525325	35.404110
3 799	39.451722	36.404647
3 796	40.611562	38.626171
3 797	40.502698	39.640914
3 795	41.229396	39.259201
3 793	41.334296	38.230060
3 794	40.709461	37.607578
3 798	39.990801	38.007346
3 799	39.888893	39.011931
3 796	40.986434	41.304503
3 797	40.848547	42.319894
3 795	41.586448	41.972228
3 793	41.720817	40.942006
3 794	41.113414	40.284144
3 798	40.382947	40.651423
3 799	40.252393	41.657324
3 794	41.441068	42.997105
3 798	40.699851	43.329949
3 793	35.780912	14.171754
3 796	38.071071	21.501981
3 797	38.148131	22.477728
3 795	38.779383	21.904046
3 793	38.695898	20.918191
3 794	37.983558	20.529067
3 798	37.362963	21.109851
3 799	37.444083	22.073005
3 796	38.914415	23.883648
3 797	38.965868	24.876657
3 795	39.613892	24.322171
3 793	39.556245	23.318145
3 794	38.852239	22.892654
3 798	38.214686	23.455955
3 799	38.270690	24.436305
3 796	39.696461	26.335513
3 797	39.721324	27.344039
3 795	40.385628	26.811440
3 793	40.354840	25.790997
3 794	39.660642	25.328091
3 798	39.006561	25.871302
3 799	39.036467	26.867206
3 796	40.413812	28.854732
3 797	40.411186	29.876750
3 795	41.091172	29.368766
3 793	41.088180	28.333962

Channel	Latitude	Longitude
3 794	40.405290	27.832823
3 798	39.735213	28.353273
3 799	39.738119	29.362814
3 796	41.063229	31.437635
3 797	41.032315	32.470840
3 795	41.727275	31.990199
3 794	41.082853	30.403468
3 798	40.397416	30.898463
3 799	40.372511	31.919455
3 796	41.641676	34.079708
3 797	41.581785	35.121526
3 795	42.290907	34.670907
3 793	42.345912	33.614728
3 794	41.690185	33.035786
3 798	40.990132	33.502654
3 799	40.936713	34.532651
3 794	42.224374	35.724673
3 798	41.510555	36.160808
3 799	41.428038	37.197125
3 796	37.242761	14.769860
3 795	37.975459	15.080537
3 793	37.819554	14.123608
3 794	37.084106	13.826001
3 798	36.511202	14.467026
3 799	36.662765	15.403185
3 796	38.256911	17.009405
3 795	38.984297	17.355072
3 793	38.851913	16.374812
3 794	38.121277	16.042572
3 797	39.318359	20.321284
3 795	39.938244	19.710895
3 793	39.830628	18.708329
3 796	40.120983	21.726823
3 797	40.195976	22.739417
3 795	40.833402	22.147075
3 793	40.751756	21.123532
3 794	40.035052	20.717186
3 798	39.408426	21.317321
3 799	39.487740	22.316400
3 796	40.963273	24.202351
3 797	41.011403	25.233254
3 795	41.665945	24.661870
3 793	41.611410	23.619007
3 794	40.903925	23.173485
3 798	40.259980	23.754579
3 799	40.312947	24.771907
3 796	41.740781	26.752848
3 797	41.761027	27.800081
3 795	42.432149	27.252652
3 793	42.405789	26.192466
3 794	41.709079	25.706631
3 798	41.048281	26.265776
3 799	41.073880	27.299488
3 793	43.131226	28.840675
3 794	42.446875	28.313657
3 798	41.769801	28.847881
3 796	38.219668	12.504997
3 797	38.392930	13.464142
3 798	37.477904	12.226253
3 799	37.653667	13.172084
3 797	39.443721	15.726628

Channel	Latitude	Longitude
3 795	40.032113	15.064519
3 798	38.556130	14.429028
3 799	38.709159	15.399356
3 796	40.315231	17.065992
3 797	40.440706	18.074107
3 795	41.047612	17.425623
3 793	40.914851	16.407848
3 794	40.179001	16.062677
3 798	39.583281	16.715839
3 799	39.712279	17.709856
3 796	41.280192	19.475157
3 797	41.379845	20.506134
3 795	42.005027	19.874226
3 793	41.898265	18.832482
3 798	40.555339	19.086656
3 799	40.659047	20.103260
3 796	42.184533	21.969139
3 797	42.257145	23.021449
3 795	42.900256	22.409241
3 793	42.820757	21.345037
3 794	42.100473	20.919921
3 798	41.468308	21.540713
3 799	41.545515	22.578478
3 796	43.024271	24.546131
3 797	43.068691	25.617886
3 795	43.729272	25.028638
3 793	43.678230	23.943864
3 794	42.968111	23.476425
3 798	42.318254	24.076408
3 799	42.367814	25.133565
3 796	43.795534	27.203347
3 797	43.810702	28.292284
3 795	44.488170	27.729356
3 793	44.466692	26.626294
3 794	43.768384	26.115299
3 798	43.101339	26.691215
3 799	43.122190	27.765639
3 793	45.182307	29.388546
3 794	44.497479	28.833082
3 795	38.714816	8.249195
3 793	39.687710	9.447390
3 794	38.933110	9.202311
3 797	40.451846	13.386942
3 795	41.025000	12.687468
3 796	41.359751	14.713162
3 797	41.510913	15.735058
3 795	42.103179	15.047253
3 793	41.944315	14.016100
3 794	41.197742	13.697182
3 798	40.616864	14.388151
3 799	40.771235	15.395236
3 797	42.513036	18.174826
3 795	43.124270	17.501776
3 794	42.250992	16.084351
3 798	41.651117	16.762499
3 796	43.355677	19.633328
3 797	43.453957	20.705723
3 795	44.083901	20.050743
3 793	43.978249	18.966647
3 794	43.245754	18.565196
3 798	42.627074	19.227388

Channel	Latitude	Longitude
3 799	42.729673	20.284270
3 796	44.259577	22.231047
3 797	44.329464	23.326281
3 795	44.977743	22.692887
3 793	44.900721	21.584687
3 794	44.177701	21.139037
3 798	43.540519	21.781925
3 799	43.615296	22.861464
3 796	45.095151	24.918053
3 797	45.135442	26.033964
3 795	45.801556	25.425829
3 793	45.754416	24.295689
3 794	45.042570	23.804184
3 798	44.387308	24.424240
3 799	44.433063	25.524415
3 796	45.858333	27.691085
3 795	46.551237	28.245970
3 793	46.535135	27.096519
3 794	45.836204	26.557814
3 798	45.163412	27.151378
3 799	45.179038	28.269754
3 797	40.229231	8.717855
3 795	40.765913	7.973850
3 799	39.471310	8.480329
3 796	41.200725	9.958176
3 793	41.748839	9.213157
3 794	40.988452	8.962039
3 798	40.443626	9.699252
3 796	42.346932	12.270054
3 797	42.524685	13.303682
3 795	43.100619	12.575545
3 793	42.914757	11.533199
3 794	42.158281	11.243531
3 798	41.593892	11.973108
3 799	41.774511	12.991266
3 797	43.591045	15.744164
3 795	44.186578	15.028584
3 794	43.275373	13.625077
3 798	42.691414	14.344053
3 796	44.472052	17.192998
3 797	44.597147	18.283768
3 795	45.212122	17.584222
3 793	45.079176	16.482090
3 794	44.335160	16.107786
3 798	43.731727	16.812907
3 799	43.860828	17.887216
3 796	45.441869	19.804618
3 797	45.538487	20.921883
3 795	46.172627	20.242113
3 793	46.068360	19.112084
3 794	45.333051	18.691895
3 798	44.710348	19.379629
3 799	44.811566	20.480100
3 796	46.343828	22.515013
3 797	46.410621	23.656781
3 795	47.063520	23.000761
3 793	46.989334	21.844805
3 794	46.264475	21.376605
3 798	45.622828	22.043172
3 799	45.694824	23.167955
3 796	47.173506	25.321698

Channel	Latitude	Longitude
3 797	47.209213	26.485479
3 795	47.880327	25.857360
3 793	47.837536	24.677972
3 794	47.124928	24.159924
3 798	46.464798	24.801340
3 799	46.506313	25.948112
3 794	47.910033	27.038525
3 798	47.232019	27.650654
3 795	37.557908	-0.628318
3 793	37.241742	-1.511961
3 795	38.934007	1.300227
3 793	38.635176	0.384178
3 796	39.504697	3.161239
3 797	39.776198	4.105868
3 795	40.274281	3.324752
3 793	39.994334	2.375562
3 794	39.223907	2.225968
3 797	42.291909	8.452823
3 799	41.528337	8.209942
3 796	43.272563	9.737383
3 797	43.477737	10.780341
3 795	44.035616	10.011129
3 798	42.510257	9.471501
3 799	42.717921	10.498402
3 796	44.429456	12.138245
3 795	45.187372	12.454375
3 793	44.999065	11.369603
3 794	44.238169	11.070620
3 798	43.671865	11.831315
3 799	43.854805	12.889939
3 796	45.528945	14.647026
3 797	45.681943	15.754029
3 795	46.280093	15.008339
3 793	46.118775	13.890482
3 794	45.364044	13.546992
3 798	44.777664	14.296338
3 799	44.934319	15.385976
3 796	46.566214	17.264593
3 797	46.690785	18.401983
3 795	47.308879	17.673779
3 793	47.176150	16.524001
3 794	46.429280	16.133207
3 798	45.822919	16.867533
3 799	45.951760	17.987051
3 796	47.536444	19.990727
3 797	47.631088	21.156761
3 795	48.268828	20.450288
3 793	48.166244	19.270278
3 794	47.429010	18.829541
3 798	46.802888	19.544849
3 799	46.902432	20.692643
3 796	48.434856	22.823937
3 795	49.155101	23.336090
3 793	49.084138	22.128121
3 794	48.358392	21.635048
3 798	47.712863	22.327050
3 799	47.781699	23.500993
3 799	48.585038	26.408949
3 796	35.896946	-4.947378
3 795	36.665052	-4.901620
3 793	36.308951	-5.746655

Channel	Latitude	Longitude
3 796	37.354239	-3.180459
3 797	37.686940	-2.304459
3 795	38.125836	-3.109362
3 793	37.784719	-3.987291
3 794	37.013545	-4.046202
3 798	36.584996	-3.249666
3 799	36.917375	-2.385775
3 796	38.783382	-1.322026
3 797	39.099423	-0.412808
3 795	39.557414	-1.223073
3 793	39.232817	-2.135038
3 794	38.458788	-2.220911
3 798	38.011455	-1.418285
3 799	38.327597	-0.522035
3 796	40.180213	0.632518
3 795	40.955539	0.762015
3 793	40.649050	-0.185020
3 794	39.873278	-0.300512
3 796	41.540387	2.687677
3 797	41.818365	3.665948
3 795	42.315773	2.850574
3 793	42.029030	1.867583
3 794	41.252716	1.719636
3 797	43.115869	5.861519
3 795	43.633493	5.047073
3 793	43.368177	4.027435
3 796	44.132495	7.116811
3 797	44.365821	8.166335
3 795	44.903913	7.355635
3 793	44.661736	6.298922
3 794	43.888327	6.076957
3 798	43.361909	6.885020
3 799	43.597326	7.917995
3 796	45.354899	9.498335
3 797	45.563367	10.583618
3 795	46.122092	9.779887
3 793	45.904789	8.685992
3 794	45.135025	8.422220
3 798	44.588134	9.225208
3 799	44.799268	10.293086
3 796	46.521625	11.995256
3 797	46.703540	13.115885
3 795	47.282965	12.322766
3 793	47.092279	11.191980
3 794	46.327757	10.883112
3 798	45.760270	11.677680
3 799	45.945455	12.780111
3 796	47.627616	14.609649
3 797	47.781297	15.764752
3 795	48.381377	14.986306
3 793	48.219040	13.819391
3 794	47.461459	13.462151
3 798	46.873357	14.244543
3 799	47.030936	15.380747
3 796	48.667760	17.342538
3 797	48.791561	18.530706
3 795	49.412120	17.771406
3 793	49.279836	16.569678
3 794	48.530993	16.160876
3 798	47.922373	16.926928
3 799	48.050725	18.095628

Channel	Latitude	Longitude
3 796	49.636941	20.193662
3 797	49.729276	21.412892
3 795	50.369994	20.677577
3 793	50.269410	19.442980
3 794	49.531191	18.979614
3 798	48.902288	19.724780
3 799	48.999842	20.924132
3 796	50.530093	23.161245
3 797	50.589460	24.408871
3 795	51.249856	23.702700
3 793	51.182539	22.437871
3 794	50.456916	21.917238
3 798	49.808112	22.636625
3 799	49.873377	23.864170
3 797	36.714355	-6.557282
3 795	37.112949	-7.379289
3 793	36.732807	-8.214888
3 796	37.851047	-5.674990
3 797	38.208596	-4.806343
3 795	38.625651	-5.637672
3 793	38.259567	-6.507342
3 794	37.485764	-6.532649
3 798	37.078780	-5.711303
3 799	37.435635	-4.854625
3 796	39.333909	-3.864534
3 797	39.675671	-2.961180
3 795	40.111716	-3.800545
3 793	39.761244	-4.705698
3 794	38.983834	-4.756720
3 798	38.558208	-3.926758
3 799	38.899682	-3.036297
3 796	40.786979	-1.955919
3 797	41.111356	-1.016634
3 795	41.566890	-1.862459
3 793	41.233647	-2.804436
3 794	40.453697	-2.883925
3 798	40.008917	-2.046742
3 799	40.333443	-1.121317
3 796	42.205884	0.056119
3 797	42.511221	1.032440
3 795	42.986708	0.182066
3 793	42.672371	-0.797971
3 794	41.891038	-0.908897
3 798	41.426624	-0.066192
3 799	41.732582	0.895267
3 796	43.586043	2.176775
3 797	43.870635	3.191066
3 795	44.366489	2.338424
3 793	44.072793	1.319256
3 794	43.291334	1.173708
3 798	42.806848	2.019896
3 799	43.092565	3.018299
3 796	44.922683	4.411058
3 797	45.184781	5.464022
3 795	45.701357	4.611807
3 793	45.430083	3.552657
3 794	44.649853	3.369104
3 798	44.144910	4.216356
3 799	44.408674	5.252399
3 796	46.210840	6.763639
3 797	46.448664	7.855685

Channel	Latitude	Longitude
3 795	46.986242	7.007038
3 793	46.739209	5.907347
3 794	45.961675	5.682236
3 798	45.435956	6.527712
3 799	45.676019	7.601813
3 796	47.445388	9.238677
3 797	47.657135	10.369839
3 795	48.215906	9.528381
3 793	47.994961	8.387964
3 794	47.221697	8.117608
3 798	46.674962	8.958016
3 799	46.889557	10.070251
3 796	48.621056	11.839603
3 797	48.804922	13.009454
3 795	49.384971	12.179309
3 793	49.191970	10.998444
3 794	48.424662	10.679081
3 798	47.856768	11.510656
3 799	48.044121	12.660670
3 796	49.732469	14.568876
3 797	49.886663	15.776449
3 795	50.487948	14.962239
3 793	50.324740	13.741764
3 794	49.565188	13.369637
3 798	48.976104	14.188119
3 799	49.134454	15.375051
3 796	50.774189	17.427716
3 797	50.896960	18.671406
3 795	51.519298	17.878244
3 793	51.387697	16.619654
3 794	50.637810	16.191103
3 798	50.027634	16.991750
3 799	50.155255	18.214145
3 796	51.740770	20.415811
3 797	51.830430	21.693293
3 795	52.473475	20.926735
3 793	52.375237	19.632281
3 794	51.637026	19.143874
3 798	51.006008	19.921477
3 799	51.101231	21.177211
3 796	52.626823	23.531024
3 795	53.345007	24.105160
3 793	53.281797	22.777923
3 794	52.557364	22.226592
3 798	51.905920	22.975538
3 799	51.967166	24.261746
3 793	54.101935	26.052662
3 797	37.115984	-9.048358
3 796	38.278644	-8.210453
3 797	38.660978	-7.351719
3 795	39.055062	-8.208143
3 793	38.664115	-9.066939
3 794	37.888874	-9.057522
3 798	37.504526	-8.212700
3 799	37.885790	-7.365692
3 796	39.813948	-6.454586
3 797	40.181455	-5.559861
3 795	40.594315	-6.427076
3793	40.217986	-7.322581
3 794	39.438412	-7.337355
3 798	39.035664	-6.481331

Channel	Latitude	Longitude
3 799	39.402489	-5.599311
3 796	41.322144	-4.599222
3 797	41.673206	-3.666977
3 795	42.105413	-4.543636
3 793	41.745335	-5.477502
3 794	40.962441	-5.519275
3 798	40.540717	-4.653220
3 799	40.891519	-3.734721
3 796	42.798862	-2.638369
3 797	43.131792	-1.667155
3 795	43.583889	-2.551575
3 793	43.241770	-3.525390
3 794	42.456662	-3.597230
3 798	42.015408	-2.722619
3 799	42.348534	-1.766244
3 796	44.239501	-0.565969
3 797	44.552550	0.445537
3 795	45.025047	-0.444582
3 793	44.702657	-1.459817
3 794	43.916540	-1.565058
3 798	43.455234	-0.683712
3 799	43.768971	0.311815
3 796	45.639237	1.623992
3 797	45.930599	2.676928
3 795	46.423953	1.783608
3 793	46.123130	0.725652
3 794	45.337314	0.583417
3 798	44.855472	1.469283
3 799	45.148053	2.505064
3 796	46.993024	3.937354
3 797	47.260842	5.032599
3 795	47.775449	4.139063
3 793	47.498084	3.037329
3 794	46.713990	2.854262
3 798	46.211187	3.741982
3 799	46.480791	4.818887
3 796	48.295607	6.379598
3 797	48.537986	7.517695
3 795	49.074163	6.627455
3 793	48.822194	5.481219
3 794	48.041360	5.253264
3 798	47.517237	6.139685
3 799	47.762009	7.258264
3 796	49.541545	8.955629
3 797	49.756563	10.136689
3 795	50.314532	9.253832
3 793	50.089928	8.062804
3 794	49.314014	7.785734
3 798	48.768299	8.667161
3 799	48.986354	9.827564
3 796	50.725232	11.669527
3 797	50.910963	12.893115
3 795	51.490828	12.022329
3 793	51.295573	10.786762
3 794	50.526362	10.456246
3 798	49.958885	11.328418
3 799	50.148333	12.530295
3 796	51.840941	14.524226
3 797	51.995472	15.789263
3 795	52.597200	14.935841
3 793	52.433272	13.656655

Channel	Latitude	Longitude
3 794	51.672673	13.268359
3 798	51.083388	14.126420
3 799	51.242349	15.368818
3 796	52.882868	17.521188
3 797	53.004327	18.825832
3 795	53.627726	17.995660
3 793	53.497067	16.674563
3 794	52.747114	16.224266
3 798	52.136119	17.062775
3 799	52.262749	18.344032
3 796	53.845198	20.660034
3 797	53.931787	22.001574
3 795	54.576483	21.201073
3 793	54.480968	19.840688
3 794	53.743810	19.324435
3 798	53.111371	20.137394
3 799	53.203892	21.455043
3 796	54.722182	23.938175
3 797	54.772212	25.312945
3 795	55.437626	24.548973
3 793	55.379027	23.152936
3 794	54.656916	22.567223
3 798	54.003487	23.348148
3 799	54.060223	24.698826
3 796	55.508234	27.350459
3 795	56.205500	28.033490
3 793	56.185443	26.606528
3 794	55.480711	25.948500
3 798	54.806951	26.690533
3 797	39.041988	-9.935149
3 796	40.221229	-9.086579
3 797	40.614376	-8.203324
3 795	41.002890	-9.096824
3 798	39.441602	-9.076621
3 799	39.833675	-8.205766
3 796	41.783120	-7.291739
3 797	42.160852	-6.369622
3 795	42.568454	-7.275632
3 793	42.181602	-8.198223
3 794	41.397055	-8.200810
3 798	40.999592	-7.307382
3 799	41.376654	-6.398765
3 796	43.316391	-5.390184
3 797	43.677005	-4.427410
3 793	43.734364	-6.308682
3 794	42.946795	-6.339608
3 798	42.530024	-5.434490
3 799	42.890406	-4.486391
3 796	46.278480	-1.239299
3 797	46.599452	-0.190177
3 795	47.067922	-1.123700
3 793	46.737250	-2.176525
3 798	45.490014	-1.351283
3 799	45.811742	-0.319379
3 796	47.697373	1.024033
3 797	47.995681	2.118517
3 795	48.485520	1.180639
3 793	48.177372	0.081012
3 794	47.388042	-0.056781
3 798	46.909862	0.872450
3 799	47.209482	1.948366

Channel	Latitude	Longitude
3 796	49.067799	3.421803
3 797	49.341467	4.562752
3 795	49.853121	3.623829
3 793	49.569510	2.476084
3 794	48.782407	2.294329
3 798	48.282736	3.226410
3 799	48.558314	4.347419
3 796	50.384185	5.960480
3 797	50.631192	7.148611
3 795	51.165021	6.212585
3 793	50.908016	5.015789
3 794	50.124755	4.785416
3 798	49.603189	5.716829
3 799	49.852746	6.883652
3 796	51.640746	8.645898
3 797	51.859039	9.881420
3 795	52.415302	8.952927
3 793	52.187008	7.706644
3 794	51.409337	7.422781
3 798	50.865562	8.349363
3 799	51.087089	9.562254
3 796	52.831504	11.482931
3 797	53.019017	12.765417
3 795	53.597846	11.849819
3 793	53.400391	10.554256
3 794	52.630201	10.211889
3 798	52.064016	11.128791
3 799	52.255487	12.387414
3 796	53.950337	14.475116
3 797	54.105019	15.803360
3 795	54.706392	14.906759
3 793	54.541899	13.562927
3 794	53.781222	13.157014
3 798	53.192560	14.058669
3 799	53.351963	15.361970
3 796	54.991031	17.624223
3 794	54.856155	16.260811
3 798	54.245113	17.140938
3 799	54.370472	18.487005
3 796	55.947355	20.929786
3 797	56.030440	22.342098
3 795	56.676089	21.504601
3 798	55.215563	20.375488
3 799	55.304979	21.761433
3 796	56.813156	24.388635
3 797	56.857682	25.837031
3 795	57.524628	25.040815
3 793	57.471198	23.568570
3 794	56.752602	22.944106
3 798	56.097864	23.759718
3 799	56.149551	25.181564
3 796	57.582467	27.994451
3 793	58.261407	27.221255
3 794	57.561732	26.516524
3 798	56.886127	27.288125
3 797	42.571866	-9.118227
3 799	41.786473	-9.107369
3 796	43.755833	-8.192810
3 794	43.358949	-9.129412
3 798	42.967901	-8.195558
3 799	43.355480	-7.259039

Channel	Latitude	Longitude
3 797	47.187770	-3.131219
3 795	47.629759	-4.103523
3 796	48.320054	-1.970337
3 797	48.649184	-0.880937
3 795	49.112510	-1.862026
3 793	48.773300	-2.955048
3 794	47.980161	-3.044585
3 798	47.528254	-2.075113
3 799	47.858203	-1.004309
3 796	49.757684	0.370689
3 797	50.063139	1.509938
3 795	50.548371	0.523060
3 794	49.440723	-0.753380
3 798	48.967301	0.223423
3 799	49.274158	1.342517
3 796	51.144243	2.858667
3 797	51.423917	4.049154
3 793	51.641523	1.862579
3 794	50.852311	1.683189
3 798	50.356840	2.664089
3 799	50.638545	3.832824
3 796	52.473814	5.501286
3 797	52.725544	6.743954
3 795	53.256013	5.757303
3 793	52.993847	4.505397
3 794	52.209072	4.273206
3 798	51.691091	5.254268
3 799	51.945531	6.473587
3 796	53.740225	8.305532
3 797	53.961809	9.600733
3 795	54.515408	8.621698
3 793	54.283375	7.314848
3 794	53.504884	7.024194
3 798	52.964031	8.000710
3 799	53.189052	9.271009
3 796	54.937087	11.277286
3 797	55.126304	12.624611
3 795	55.703197	11.659362
3 793	55.503587	10.297707
3 794	54.733386	9.942738
3 798	54.169418	10.909162
3 799	54.362847	12.230135
3 796	56.057832	14.420845
3 797	56.212473	15.818942
3 795	56.812652	14.874560
3 793	56.647754	13.459205
3 794	55.888011	13.034021
3 798	55.300840	13.983930
3 799	55.460511	15.354409
3 796	57.095780	17.738368
3 797	57.213688	19.184756
3 795	57.836944	18.269209
3 793	57.709009	16.802434
3 794	56.962051	16.301284
3 798	56.351767	17.227371
3 796	58.044233	21.229278
3 797	58.123338	22.720180
3 795	58.769225	21.842226
3 794	57.948729	19.745217
3 798	57.315636	20.639352
3 799	57.401507	22.101015

Channel	Latitude	Longitude
3 796	58.896570	24.889657
3 797	58.934952	26.419849
3 795	59.602759	25.588875
3 793	59.555118	24.031769
3 794	58.841305	23.363330
3 798	58.185950	24.216669
3 799	58.231992	25.717461
3 793	60.326413	27.907350
3 794	59.633198	27.149331
3 798	58.956400	27.952514
3 796	48.857538	-5.038308
3 795	49.652791	-4.981160
3 798	48.062930	-5.093565
3 799	48.423353	-4.032273
3 796	50.361264	-2.766659
3 797	50.698818	-1.634070
3 795	51.155798	-2.667478
3 793	50.807760	-3.803534
3 794	50.012496	-3.882408
3 798	49.567049	-2.862459
3 799	49.905481	-1.750003
3 796	51.817221	-0.343374
3 797	52.130057	0.844211
3 795	52.609511	-0.196770
3 793	52.286005	-1.389634
3 794	51.492377	-1.514021
3 798	51.024891	-0.484837
3 799	51.339214	0.680806
3 794	52.920742	1.013587
3 798	52.430614	2.048438
3 796	55.837071	7.929770
3 797	56.061981	9.290643
3 795	56.611896	8.255332
3 798	55.060833	7.616497
3 799	55.289391	8.949841
3 796	57.039059	11.049524
3 797	57.229909	12.468570
3 795	57.803916	11.448005
3 793	57.602181	10.013186
3 794	56.832978	9.644829
3 798	56.272213	10.666372
3 799	56.467542	12.056175
3 796	58.160468	14.360550
3 797	58.314870	15.836256
3 795	58.912981	14.838716
3 793	58.747838	13.343800
3 794	57.990083	12.897454
3 798	57.405315	13.901060
3 799	57.565077	15.346024
3 796	59.194089	17.865520
3 797	59.309706	19.394973
3 795	59.931701	18.429840
3 793	59.805592	16.877487
3 794	59.061792	16.346353
3 798	58.453105	17.323463
3 796	60.132674	21.563709
3 797	60.207274	23.142380
3 795	60.852665	22.220016
3 793	60.767937	20.614607
3 794	60.040776	19.992379
3 799	59.490336	22.479470

Channel	Latitude	Longitude
3 796	60.969075	25.450209
3 797	61.000597	27.071764
3 795	61.668583	26.203295
3 793	61.627425	24.551144
3 794	60.919742	23.832416
3 798	60.264478	24.726898
3 799	60.304209	26.315738
3 796	61.696403	29.515186
3 795	62.372474	30.368349
3 793	62.376836	28.677853
3 794	61.691587	27.858563
3 798	61.014262	28.695426
3 794	62.349594	32.057462
3 797	51.244660	-4.860790
3 798	50.078437	-6.022815
3 799	50.448546	-4.922021
3 796	52.398948	-3.637192
3 797	52.745233	-2.458233
3 795	53.194569	-3.549407
3 793	52.837376	-4.731583
3 794	52.040987	-4.797351
3 798	51.603295	-3.721846
3 799	51.950506	-2.564733
3 796	53.872848	-1.126870
3 797	54.193335	0.113023
3 795	54.665746	-0.987962
3 793	54.334130	-2.233108
3 794	53.539827	-2.347767
3 798	53.079548	-1.260668
3 799	53.401602	-0.044740
3 796	57.928218	7.512809
3 797	58.156516	8.946286
3 795	58.701660	7.847948
3 793	58.461898	6.400720
3 799	57.385111	8.593911
3 796	59.134361	10.795875
3 797	59.326786	12.294685
3 795	59.896902	11.212112
3 793	59.693057	9.695867
3 794	58.925902	9.313300
3 799	58.566566	11.862731
3 796	60.255158	14.293176
3 797	60.409113	15.855612
3 795	61.004238	14.798567
3 793	60.839013	13.214620
3 794	60.084348	12.744931
3 798	59.502943	13.808663
3 799	59.662612	15.336668
3 796	61.282785	18.008041
3 793	61.891693	16.961774
3 794	61.152229	16.396847
3 798	60.546012	17.430928
3 796	62.209363	21.939553
3 797	62.278872	23.616858
3 795	62.923017	22.645571
3 793	62.842916	20.937779
3 798	61.490900	21.263135
3 799	61.568169	22.903855
3 796	63.027130	26.081484
3 797	63.050984	27.805708
3 795	63.718463	26.896803

Channel	Latitude	Longitude
3 793	63.684570	25.137515
3 794	62.984453	24.360783
3 798	62.330000	25.300238
3 799	62.362670	26.987858
3 796	63.728634	30.421331
3 793	64.408813	29.549154
3 794	63.733159	28.658784
3 798	63.055977	29.531463
3 799	63.042103	31.256744
3 796	51.295354	-9.263132
3 797	51.697232	-8.159956
3 795	52.092606	-9.279165
3 793	51.679978	-10.381766
3 796	52.885662	-7.012300
3 797	53.265457	-5.848055
3 795	53.682857	-6.986730
3 793	53.291994	-8.151925
3 794	52.494606	-8.156013
3 798	52.088401	-7.036947
3 799	52.468551	-5.894134
3 796	54.429730	-4.592523
3 797	54.785093	-3.363722
3 795	55.225381	-4.518941
3 793	54.858656	-5.750574
3 794	54.062210	-5.800236
3 798	53.633675	-4.663354
3 799	53.990003	-3.458314
3 796	55.921218	-1.990224
3 795	56.713674	-1.861456
3 793	56.373595	-3.163204
3 794	55.579678	-3.265424
3 798	55.127981	-2.114015
3 799	55.458077	-0.843647
3 797	58.985738	5.256847
3 796	60.010450	7.047519
3 797	60.242228	8.561674
3 795	60.781438	7.392276
3 793	60.537616	5.863129
3 794	59.762713	5.553476
3 798	59.237200	6.717296
3 799	59.473067	8.197268
3 796	61.219787	10.511675
3 797	61.413744	12.099711
3 795	61.978904	10.947150
3 793	61.772937	9.339743
3 794	61.008926	8.942144
3 798	60.457760	10.094968
3 799	60.656774	11.646336
3 796	62.338669	14.217395
3 797	62.491962	15.877392
3 795	63.083144	14.753295
3 793	62.917997	13.069041
3 794	62.167568	12.573490
3 798	61.590538	13.704991
3 799	61.749928	15.326162
3 796	63.358551	18.168892
3 797	63.468398	19.896726
3 795	64.085362	18.814497
3 793	63.963961	17.057115
3 794	63.230067	16.453814
3 798	62.627229	17.551910

Channel	Latitude	Longitude
3 799	62.744271	19.239288
3 796	64.270819	22.364982
3 797	64.334576	24.153915
3 793	64.901861	21.304525
3 794	64.187703	20.584468
3 798	63.559440	21.635428
3 799	63.631535	23.383031
3 796	65.066983	26.797649
3 797	65.082245	28.638013
3 795	65.748520	27.685556
3 793	65.722793	25.804640
3 794	65.031786	24.960351
3 798	64.378870	25.949078
3 799	64.403629	27.748246
3 793	66.418191	30.542096
3 794	65.753907	29.568459
3 798	65.077547	30.479024
3 796	53.274098	-10.456255
3 797	53.687219	-9.313034
3 795	54.071012	-10.495614
3 798	52.477036	-10.418333
3 799	52.889945	-9.295788
3 796	54.886195	-8.143274
3 797	55.276429	-6.932602
3 794	54.484275	-9.330939
3 798	54.089241	-8.147681
3 799	54.479831	-6.960183
3 796	56.449985	-5.645280
3 797	56.814831	-4.362855
3 795	57.244544	-5.589400
3 793	56.867853	-6.874086
3 794	56.072490	-6.903924
3 798	55.654634	-5.698961
3 799	56.020469	-4.442444
3 796	57.958756	-2.946008
3 795	58.749660	-2.830494
3 793	58.400703	-4.193617
3 794	57.608297	-4.279982
3 798	57.166678	-3.056818
3 799	57.505179	-1.727403
3 793	59.872256	-1.290083
3 797	61.054119	4.643179
3 799	60.277766	4.355651
3 796	62.080370	6.525026
3 797	62.315764	8.129333
3 795	62.847791	6.879242
3 793	62.599714	5.258545
3 794	61.828172	4.943841
3 798	61.310239	6.186664
3 799	61.549950	7.752532
3 796	63.291972	10.191058
3 797	63.487439	11.879567
3 795	64.046511	10.647410
3 793	63.838380	8.937260
3 794	63.078653	8.523826
3 798	62.534032	9.755629
3 799	62.734871	11.402654
3 796	64.407616	14.131531
3 797	64.560027	15.902082
3 795	65.146259	14.701850
3 793	64.981348	12.903738

Channel	Latitude	Longitude
3 794	64.236354	12.379381
3 798	63.664768	13.587851
3 799	63.823690	15.314280
3 796	65.417912	18.351851
3 797	65.524196	20.199451
3 795	66.137338	19.047448
3 793	66.018885	17.165835
3 794	65.291861	16.518581
3 798	64.693345	17.689128
3 799	64.807352	19.490653
3 796	66.313361	22.850465
3 797	66.370613	24.766729
3 795	67.009974	23.681269
3 793	66.941076	21.724266
3 794	66.235556	20.943166
3 798	65.610532	22.059071
3 799	65.676770	23.928296
3 796	67.084620	27.616881
3 797	67.090224	29.589602
3 795	67.754599	28.590384
3 793	67.738077	26.570290
3 794	67.057852	25.646449
3 798	66.407207	26.689260
3 799	66.423077	28.615309
3 794	67.749513	30.611326
3 797	57.273696	-8.128970
3 796	58.455819	-6.810628
3 797	58.830616	-5.470497
3 798	57.662351	-6.843013
3 799	58.038144	-5.531189
3 797	60.327237	-2.584098
3 798	59.191874	-4.103539
3 799	59.539213	-2.709966
3 798	60.658205	-1.131282
3 799	63.612276	7.250433
3 797	65.544369	11.629045
3 799	64.797398	11.126189
3 796	66.458454	14.033422
3 797	66.609755	15.930304
3 795	67.189980	14.642876
3 793	67.025456	12.714407
3 794	66.287149	12.157790
3 798	65.722144	13.454430
3 799	65.880407	15.300737
3 796	67.457209	18.561806
3 797	67.559407	20.546960
3 795	68.167821	19.315675
3 793	68.052771	17.290962
3 794	67.333988	16.592867
3 798	66.740780	17.846091
3 799	66.851288	19.778290
3 796	68.333086	23.409633
3 797	68.382964	25.472440
3 795	69.018769	24.320031
3 793	68.956644	22.209350
3 794	68.261323	21.356283
3 798	67.640384	22.545444
3 799	67.699979	24.554254
3 796	69.075716	28.562893
3 795	69.732190	29.638579
3 793	69.726096	27.457808

Channel	Latitude	Longitude
3 794	69.058489	26.439104
3 798	68.410851	27.541330
3 799	68.416689	29.612866
3 794	69.715263	31.818400
3 796	68.487449	13.920259
3 797	68.637402	15.962881
3 795	69.210500	14.574587
3 798	67.758992	13.301091
3 799	67.916405	15.285156
3 796	69.472578	18.805213
3 797	69.570092	20.949963
3 795	70.172843	19.627837
3 794	69.352626	16.678936
3 798	68.765757	18.027385
3 799	68.872246	20.110645
3 796	70.325819	24.060551
3 797	70.367300	26.293728
3 795	70.998770	25.066459
3 793	70.944376	22.776262
3 794	70.260949	21.837193
3 798	69.644955	23.109536
3 799	69.696995	25.280128
3 796	71.035561	29.667158
3 794	71.029190	27.364993
3 798	70.385294	28.532426
3 799	70.379755	30.772283
3 797	63.345238	-17.153207
3 795	63.642315	-18.771494
3 796	64.585076	-15.928380
3 797	65.036055	-14.441836
3 795	65.357654	-16.123954
3 793	64.892626	-17.600538
3 794	64.120318	-17.371344
3 798	63.809685	-15.742403
3 799	64.260655	-14.290203
3 793	66.578062	-14.769625
3 794	65.808594	-14.601429
3 798	65.472713	-12.911047
3 797	63.418493	-21.763612
3 796	64.690499	-20.723587
3 797	65.182858	-19.305872
3 795	65.455336	-21.043385
3 793	64.949216	-22.444920
3 794	64.185423	-22.095916
3 798	63.922509	-20.419389
3 799	64.414064	-19.032037
3 796	66.428069	-18.095626
3 794	65.948477	-19.594034
3 798	65.661949	-17.841650
3 799	66.127209	-16.329880
3 797	65.189819	-24.194789
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3 794	65.945358	-24.610026
3 798	65.709638	-22.811894
3 799	66.216789	-21.380003

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