ENGLISH ONLY

APPENDIX B

FUTURE COMMUNICATIONS INFRASTRUCTURE — TECHNOLOGY INVESTIGATIONS

EVALUATION SCENARIOS

VERSION 1.0

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ACRONYMS TABLE

A/A	Air/Air
A/G	Air/Ground
A_P	Availability of Provision
A_u	Availability of Use
ACL	ATC Clearance
ADS-B	Automatic Dependent Surveillance – Broadcast
AIRSEP	Air-to-Air Self-Separation
AOA	Autonomous Operation Area
AOC	Aeronautical Operational Control
APT	Airport
ATC	Air Traffic Control
ATS	Air Traffic Services
CAT	Capacity Analysis Tool
COCR	Communication Operating Concept and Requirements document
CoS	Class of Service
DL	Downlink
DOC	Designated Operational Coverage
E2E	End-to-end
ECAC	European Civil Aviation Conference
ENR	En Route
FCS	Future Communications Study
FH	Flight Hour
FL	Flight Level
FRS	Future Radio System
$I_{UCT\text{-}FRS}$	Integrity (Undetected Corrupted Transaction – Future Radio System)
kbps	kilobytes per second
LAV	Large Area Volumes
MLM	Mid-Level Model
NAS	National Airspace System
NM	Nautical Mile
ORP	Oceanic, Remote and Polar
PAIRAPP	Paired Approach
PIAC	Peak Instantaneous Aircraft Count
QoS	Quality of Service
RCTP	Required Communication Technical Performance
SAAM	System for traffic Assignment and Analysis at a Macroscopic level
SESAR	Single European Sky ATM Research
SV	Service Volume
TMA	Terminal Manoeuvring Area
TD_{95}	Technical Delay (95% value)
TT_{95}	Transaction Time (95% value)
TV	Test Volume
UL	Uplink

1 INTRODUCTION

The Future Communication Study (FCS) consists of two main activities:

1. Identification of future communication requirements based on emerging global future Air Traffic Management concepts. This activity is covered by the Communication Operating Concept Requirements (COCR) document. (see COCR version 2.0 – April 2007)
2. A technology assessment to identify the most appropriate technologies to support these communication requirements.

This purpose of this document is to aid the technology assessment. It extrapolates the Phase 2 requirements from the COCR and generates a set of general operational environments (referred to in the document as test scenarios). Due to the timeframe of a rollout of future technologies only Phase 2 requirements have been considered. Phase 1 is seen as out of scope for the technology assessment and so not considered here.

The test scenarios comprise of three main elements:

- Test volumes (dimensions)
- Aircraft traffic
- Communications

Test volumes describe the airspace volumes for typical aeronautical scenarios at airports and differing flight levels. Peak aircraft counts obtained for each test volume have been calculated by an air traffic growth-predicting tool, e.g. MLM for US or SAAM for Europe. From this information, capacity data requirements are then extrapolated.

Each of the elements is described in the sections that follow.

2 TEST VOLUMES

2.1 COCR Service Volumes

Note - The COCR defines a term 'Operational Volume' which is a generic volume covering both air/ground and air/air communications volumes. Section 2.3 describes the requirements for Service Volumes which is related to air/ground addressed communications. Section 2.4 covers broadcast requirements which are referred to as Transmission Volumes in the COCR.

This section defines a set of example test volumes against which the performance requirements are later mapped. The test volumes are based initially on the COCR service volumes or extensions of them.

The COCR has defined the following categories of airspace in the Phase 2 timeframe:

- Airport (APT) – a 10 NM cylindrical volume centred on an airport extending from ground to 5000 ft. This covers aircraft on approach, climb out and also aircraft and vehicles on the surface. This has been based upon the operations in a cylinder of airspace around the airport. (Note: that test volumes generated within this document shall break this airspace down to enable generation of an airport surface requirement.)
- Terminal Manoeuvring Area (TMA) – a typical sector within a TMA handles aircraft departing or landing, bridging upper airspace and the airport airspace. This has been defined as extending from FL050 to FL245.
- En-route (ENR) – an upper sector where aircraft are typically cruising; defined as extending from FL245 to FL450.
- Oceanic, Remote and Polar (ORP) – this is airspace in regions away from high-density core regions of the world e.g. over oceans or remote areas.
- Autonomous Operations Areas (AOA) – this is a volume of airspace where Conflict Management is delegated to the aircrew.

Communication exchanges that take place within these airspace categories are documented within the COCR. The service volume associated with each category of airspace depends upon the airspace organisation and lateral sector size. Some performance figures presented in the COCR were derived using 'service' volumes which are based on actual airspace sectors e.g. TMA, ENR. However, it is unlikely that the future technology will support only the requirements for one sector but will offer a service in a DOC area that could be much larger than a single current sector.

Consequently a set of generic Test Volumes that are larger than a single sector have been defined. These Test Volumes are detached from the structure of operational sectors and are not as complex in shape as current airspace sectors. As a further development of the COCR, Test Volumes have been generated for the following airspace types:

- Airport excluding Surface
- Airport Surface

- TMA (terminal manoeuvring area)
- ENR (en-route)

In addition Large Area Volumes (LAVs) have been defined which are representative of a core large region in the world. This is to assist in matching requirements to technologies that have a very wide coverage volume such as satellite-based systems.

The ORP and AOA volumes are assumed to have the same performance requirements as identified in the COCR.

2.2 Test Volume Normalisation

As mentioned above, the service volumes used in COCR are based on actual sectors of complex 3-dimensional shapes. In order to define a set of generic Test Volumes a series of various sized cuboids have been defined for each airspace category except for the airport, which has been retained as a cylinder.

The smallest cuboid in the set is based on the COCR service volume but normalised to a cuboid but retaining the same volume.

(Note: COCR uses sector sizes that are three times larger than their current construction at present.)

By transforming the COCR complex Phase 2 service volumes into geometric shapes of equivalent volume it is possible to normalise the set of COCR sector volumes into generic Test Volumes. These are given in Table 2-1. This facilitates the generation of an aircraft count for each Test Volume.

Service Volume	Shape	Dimensions	Height Range	Volume (NM^3)
Airport	Cylinder	10 NM diameter	0 – FL050	64.6
TMA	Cuboid	48.95 x 48.95 NM	FL050 – FL245	7,691
ENR	Cuboid	54.8 x 54.8 NM	FL245 – FL450	10,132

Table 2-1 Phase 2 Generic Test Volumes based on COCR Phase 2 sectors

2.3 Test Volumes

It is recognised that some technologies will have the capability to provide services in larger airspace volumes than the generic Test Volumes described above and this leads to the generation of additional Test Volumes.

Use of these technologies would be an advantage as the amount of ground/space segment infrastructure, and hence cost would be reduced.

Additional generic Test Volumes are:

- TMA Large sector that is 75 x 75 NM cuboid (between FL50 and FL245)
- ENR Medium sector that is 100 x 100 NM cuboid (between FL245 and FL450)
- ENR Large sector that is 200 x 200 NM cuboid (between FL245 and FL450)

- ENR Super Large sector that is 400 x 400 NM cuboid (between FL245 and FL450)
- Core Test Volumes covering terrestrial areas
- Core Test Volumes covering terrestrial and oceanic areas

There is also a need to divide the airport service volume into two new Test Volumes. The airport service volume defined in the COCR is made up of three components – runway/tower, ground and clearance/ramp. As these scenarios shall be used for the technology assessment it was deemed necessary to identify an airport surface requirement for technologies with only surface capability.

The Airport Zone Test Volume is equated to the dimensions for COCR airport service volume but shall not include the airport surface requirements. The Airport Surface Test Volume has been assumed to be a combination of clearance/ramp and ground components. Thus Airport Zone TV comprises just of the runway/tower component.

Based on the above considerations the complete set of generic Test Volumes is summarised in Table 2-2 below:

Reference	**Volume Type**
TV 1.1	Airport Zone
TV 1.2	Airport Surface
TV 2.1	TMA Small
TV 2.2	TMA Large
TV 3.1	ENR Small
TV 3.2	ENR Medium
TV 3.3	ENR Large
TV 3.4	ENR Super Large
TV 4.1	Core Regional FL050 – FL245 [TMA]
TV 4.2	Core Regional FL245 – FL450 [ENR]
TV 4.3	Core Regional + Oceanic FL050 – FL245 [TMA]
TV 4.4	Core Regional + Oceanic FL245 – FL450 [ENR]

Table 2-2 Summary of Test Volumes

These test volumes are described in detail of notation, dimensions and volumes in the following sections, which also include an explanation of how the Core Regional TV differs from the Core Regional + Oceanic TV.

2.3.1 TV 1 - Airport Test Volumes

Ref.	**Type**	**Dimensions**	**Height Range**	**Volume (NM^3)**
TV 1.1	Airport Zone	10 NM diameter	0 – FL50	64.6
TV 1.2	Airport Surface	5 NM diameter	0	Area = 19.6 NM^2

Table 2-3 Airport Test Volumes

The airport service volume defined in the COCR is made up of three components – runway/tower, ground and clearance/ramp.

As these scenarios shall be used for the technology assessment it was deemed necessary to identify an airport surface requirement for technologies with only surface capability. The Airport zone Test Volume is equated to the dimensions of the COCR but shall not include the airport surface requirements. For the purposes of this document Airport Surface has been assumed to be the combination of clearance/ramp and ground components. Thus airport zone TV comprises just of the runway/tower component.

Within this context the Airport Surface Test Volume is assumed to be a 5 NM circle centered on the bottom of the cylinder displayed in fig.2-1 below. This assumption has been made, as it is indicative of a typical large airport.

2.3.2 TV 2 - TMA Test Volumes

The TMA test volumes have been generated from the normalized COCR service volume (TV 2.1) and also generated a larger cuboid volume. In the event that a larger/different test volume is required see section 5. This may be necessary if the technology is capable of larger volumes of airspace.

Ref.	Type	Dimensions	Height Range	Volume (NM^3)
TV 2.1	TMA Small	49 x 49 NM	FL50 – FL245	7,691
TV 2.2	TMA Large	75.0 x 75.0 NM	FL50 – FL245	18,056

Table 2-4 TMA Test Volumes

2.3.3 TV 3 - ENR Test Volumes

Ref.	Type	Dimensions	Height Range	Volume (NM^3)
TV3.1	ENR Small	55 x 55 NM	FL245 – FL450	10,132
TV3.2	ENR Medium	100.0 x 100.0 NM	FL245 – FL450	33,739
TV3.3	ENR Large	200.0 x 200.0 NM	FL245 – FL450	134,957
TV3.4	ENR Super Large	400.0 x 400.0 NM	FL245 – FL450	539,829

Table 2-5 ENR Test Volumes

2.3.4 TV 4 – Core Regional Test Volume

Two Core Regional Test Volumes have been defined specifically so that the capabilities of wide area space based communications technologies may be assessed. Examples of such wide area volumes can be found in appendix A

Ref.	Type	Height Range	Volume (NM^3)
TV 4.1	Core Regional (TMA)	FL050 – FL245	12,465,077
TV 4.2	Core Regional (ENR)	FL245 – FL450	13,129,336
TV 4.3	Core Regional + Oceanic (TMA)	FL050 – FL245	21,558,633
TV 4.4	Core Regional + Oceanic (ENR)	FL245 – FL450	22,707,512

Table 2-6 Regional Test Volumes

Core Regional is based upon a large volume of airspace such as NAS or ECAC. TV4.3 and 4.4 are extended out to include some oceanic airspace sectors that extend from the regional core.

The differing flight levels have been used in order to include TMA and ENR airspace types for the region. This is necessary as a space based system may not only have to meet capacity and quality of service requirements for a particular airspace type but potentially for all TMA and ENR sectors within the region. The diagram that follows illustrates the above Test Volumes.

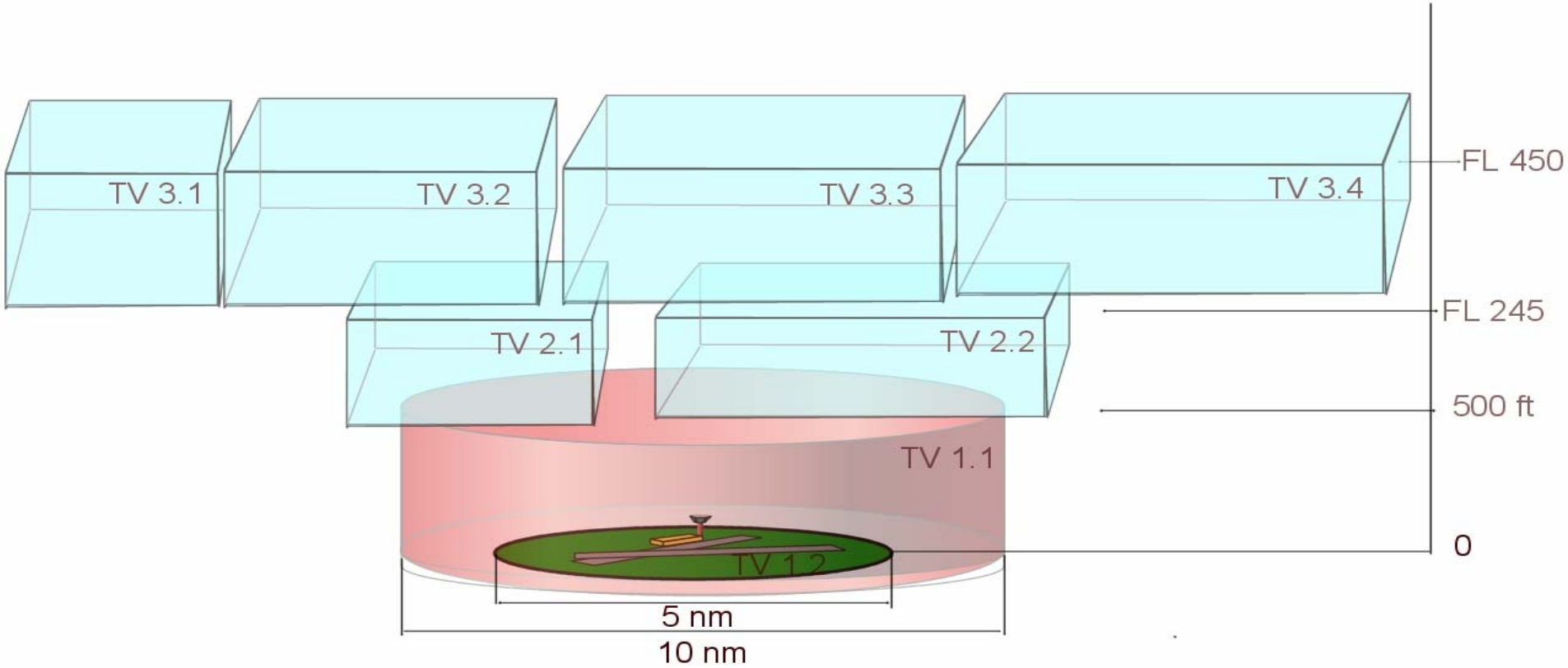


Figure 2-1: Test Volumes Illustration

2.4 Broadcast Transmission volume

In the COCR during Phase 2 the only broadcast requirements are for air-air services within Transmission Volumes. These requirements have been calculated by considering the peak number of aircraft within a given radius, independently of the coverage of ATC sectors. This is necessary because transactions between aircraft are necessary for separation and flight efficiency, and exchanges are not restricted to aircraft within the same ATC sector. For TMA a range of 60 NM has been defined in the COCR for a/a broadcast. The COCR also defines an en-route range of 100MN and the airport range of 5NM.

It follows therefore, that the requirement for air-air capacity within the total communications system capacity will remain constant, regardless of the physical size of the test scenario as described in section 2.3. However if a common technology is used then both the a/g and a/a communication must be supported simultaneously.

When using the scenarios to evaluate candidate technologies it will be necessary to demonstrate how both the air-ground and air-air user capacity requirements would be met. The figure below illustrates the a/a broadcast requirement within the larger 'test volume'.

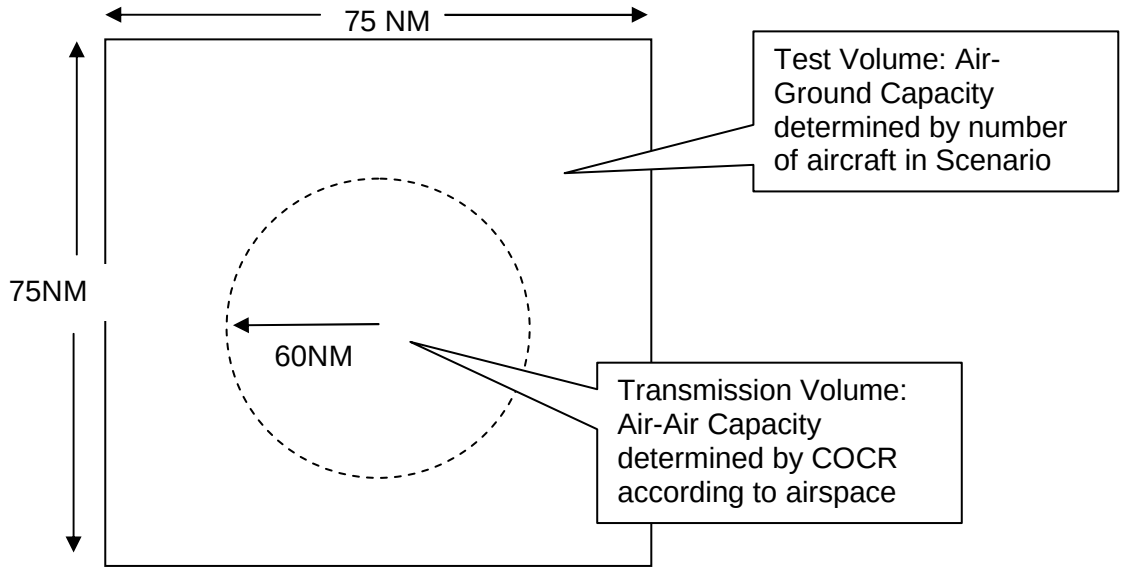


Figure 2-2 Illustrative Air/air test volume within the a/g volume

3 AIRCRAFT TRAFFIC

A traffic growth-modelling tool has used to obtain data for aircraft counts for the Test Volumes defined in Section 2.3 for the COCR Phase 2 timeframe (2025). This is the next element to be mapped onto the Test Volumes, which will eventually form part of the test scenario. It should be noted that the COCR has determined PIACs for the Transmission Volumes for a/a requirements.

In the case of the Core Regional Test Volume, the scenario comprises a set of identical sub-scenarios to represent the total TMA and ENR airspace volumes within the region. Whilst this may not provide a total accurate model of the service volumes within the region, it will provide a consistent and repeatable means of conducting simulations.

The number of aircraft in the COCR service volumes is already known; these values have been assumed to also exist in the equivalent geometric Test Volumes (TV1, TV2.1 and TV3.1). In order to determine the PIAC for the additional test volumes, the associated boundary co-ordinates have been entered into SAAM (centred on the respective positions of the TMA and En-route sectors). The results are given in Table 3-1.

Ref.	**Volume Type**	**No. Aircraft (PIAC)**
TV1.1	Airport Zone	26
TV1.2	Airport Surface	264
TV2.1	TMA Small	44
TV2.2	TMA Large	53
TV3.1	ENR Small	45
TV3.2	ENR Medium	62
TV3.3	ENR Large	204
TV3.4	ENR Super Large	522
TV4.1	Core Regional FL050 – FL245 [TMA]	1733
TV4.2	Core Regional FL245 – FL450 [ENR]	2908
TV4.3	Core Regional + Oceanic FL050 – FL245 [TMA]	1753
TV4.4	Core Regional + Oceanic FL245 – FL450 [ENR]	3415

Table 3-1: Number of aircraft per Test Volume

The PIAC has been extracted from the aircraft quantity data for each TV to simulate a worst and most demanding case. Technologies must be able to provide communication services with the required QoS to all aircraft particularly in busier periods.

4 COMMUNICATION REQUIREMENTS

4.1 Methodology

This section details the final element of the test scenario. Communication requirements are derived using the information in the previous section as inputs to the queuing model defined in the COCR. Figure 4-1 shows the general process and inputs and outputs used to calculate the data capacity requirement.

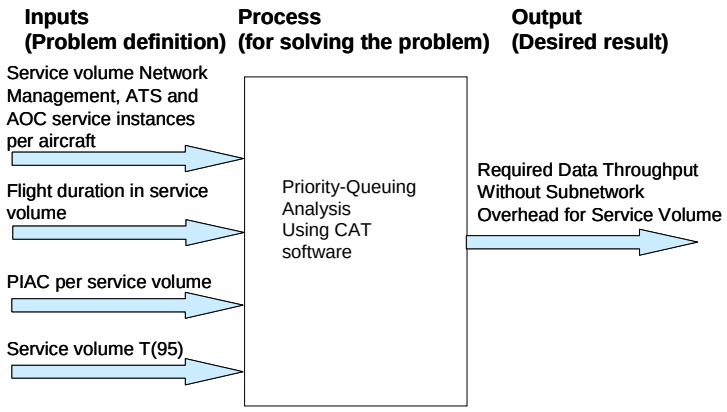


Figure 4-1 Overview of Service Volume Data Channel Requirement Analysis Process

For this analysis, existing values in the queuing model for delay statistics, instances and duration within the service volume have been used. The PIAC values have been updated to reflect the Test Volumes that have been defined. The aircraft count is part of the traffic model that feeds into the queuing model in order to generate new data capacity requirements, and the new values have been used.

The priority queuing analysis process shown in fig 4-1 is shown in more detailed form in fig 4-2. There are different classes of arrivals (class A-K), each with their own separate queues waiting to be serviced by a single server. The different classes A-K have different arrival rates, λ_A - λ_K, and different priorities. A has the highest priority and K the lowest; higher priority queues are served ahead of lower priority. The messages in each class are serviced at rates of μ_A - μ_K.

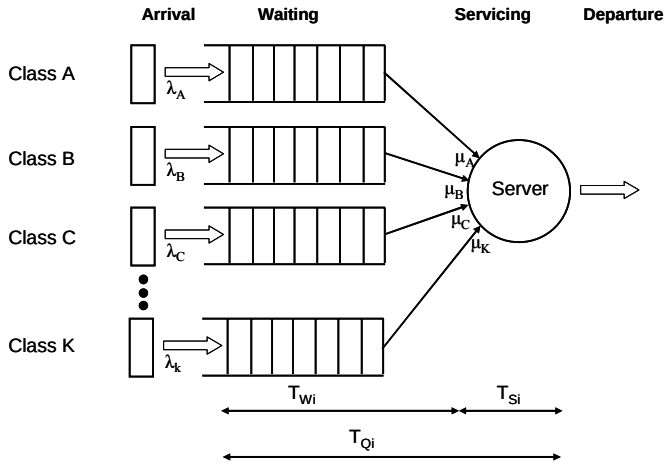


Figure 4-2 Delay Analysis by Priority Queuing Model

More detail of the mechanics and equations of the model can be sought from the COCR v2.0 Appendix 3.

4.2 Limitations and assumptions

The COCR specifies uplink and downlink rates using a single channel queuing model, and these are split by service (i.e. ATS or AOC). The model provides the throughput required to satisfy the communication traffic for a variety of Classes of Service (CoS); that can be seen in fig. 4-2. It is important to recognise that this is essentially the user data rate and does not represent the radio channel data rate which will inevitably be much greater to account for overheads such as addressing, framing or error correction/detection etc.

For air-ground requirements, there is a need to provide services to each aircraft within the test volumes defined in the earlier sections. In order to derive the equivalent capacity requirements for these larger test volumes, the queuing model used within the COCR it utilised altering the PIAC value. The COCR provides the total air-ground data capacity for service volumes.

There are a few requirements defined within the COCR that should be noted here:

- Most ATS A/A messages are broadcast (there are only two addressed ATS messages between aircraft – PAIRAPP and AIRSEP.)
- All ATS A/G messages are addressed (there are no broadcast messages – all ATS messages are sent on demand)
- All AOC messages are A/G addressed (there are no AOC A/A messages)

4.3 Air-Ground Capacity Requirements

4.3.1 COCR Service Volumes

Using data from the COCR, the requirements in this category have already been defined. To avoid over-complicating the assessment process, the high density (HD)

value will be used in the Step 2 simulation. The tables below are Phase 2 capacity figures in the timeframe under analysis in the technology assessment. They have been categorised into with and without A-EXEC as this is a demanding service so the comparison between them can be seen. The figures of interest in this document are those for the worst case shown in the Tables below i.e. high density (HD) airspace and AOA.

Note: The figures in the tables below have been rounded up to the nearest whole number or to the nearest 5 or 10 kHz values for values above 10kHz.

PHASE 2		APT SV		TMA SV		ENR SV			ORP SV		AOA
		HD	LD	HD	LD	HD EU	HD US	LD	HD	LD	
Separate ATS	UL	30	20	30	30	30	30	30	15	15	20
	DL	30	30	30	30	30	30	30	20	20	30
	UL&DL	40	30	40	40	30	40	30	20	20	30
Separate AOC	UL	150	40	2	2	60	100	70	30	30	70
	DL	7	2	3	3	2	3	2	1	1	2
	UL&DL	200	40	4	4	60	150	80	30	30	80
Combined ATS&AOC	UL	150	40	30	30	150	200	150	40	30	100
	DL	30	30	30	30	30	30	30	20	20	30
	UL&DL	200	40	40	40	150	200	150	40	30	100

Table 4-1 Addressed Communication Load (kbps) – Phase 2 with A-EXEC from COCR v2.0

PHASE 2		APT SV		TMA SV		ENR SV			ORP SV		AOA
		HD	LD	HD	LD	HD EU	HD US	LD	HD	LD	
Separate ATS	UL	30	20	30	30	30	30	30	15	15	20
	DL	30	30	30	30	30	30	30	20	20	30
	UL&DL	40	30	40	40	30	40	30	20	20	30
Separate AOC	UL	150	40	2	2	60	100	70	30	30	70
	DL	7	2	3	3	2	3	2	1	1	2
	UL&DL	200	40	4	4	60	150	80	30	30	80
Combined ATS&AOC	UL	150	40	30	30	80	150	90	40	30	100
	DL	30	30	30	30	30	30	30	20	20	30
	UL&DL	200	40	40	40	80	150	90	40	30	100

Table 4-2 Addressed Communication Load (kbps) – Phase 2 without A-EXEC

4.4 Broadcast Capacity Requirements

In a similar manner, the COCR defines the Phase 2 capacity requirements for Broadcast communications. These are based on the peak number of aircraft within a designated radius as shown in the Table below.

The capacity values in the COCR have not been re-interpreted as they can only be serviced by the airborne FRS.

Services	Update rate (s)					Range (NM)					Latency FRS (s) TD[95]					PIAC					Msg Size bytes	Information Transfer Rate (kbps)				
	APT	TMA	ENR	ORP	AOA	APT	TMA	ENR	ORP	AOA	APT	TMA	ENR	ORP	AOA	APT	TMA	ENR	ORP	AOA	ALL	APT	TMA	ENR	ORP	AOA
C&P SURV	-	-	3	3	-		-	100	100	-	-	-	1.2	1.2	-	-	-	320	14	-	34	-	-	73	3.2	-
ITP SURV	-	3	3	3	-		60	100	100	-	-	1.2	1.2	1.2	-	-	160	320	14	-	34	-	36	73	3.2	-
M&S SURV	-	3	3	-	-		60	100	-	-	-	1.2	1.2	-	-	-	160	320	-	-	34	-	36	73	-	-
PAIRAPP SURV	2	2	-	-	-	5	60	-	-	-	0.4	0.4	-	-	-	4	10	-	-	-	-	3	7	-	-	-
AIRSEP	-	-	-	-	-	-	-	-	-	100	-	-	-	-	2.4	-	-	-	-	12	497	-	-	-	-	20
AIRSEP SURV	-	-	-	-	5	-	-	-	-	100	-	-	-	-	1.2	-	-	-	-	36	34	-	-	-	-	8
SURV	2	5	5	5	-	5	100	200	200	-	0.4	1.2	1.2	1.2	-	322	400	1100	34	-	34	219	91	249	7.7	-
TIS-B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WAKE	2	5	5	-	-	5	100	200	-	-	0.4	0.4	1.2	-	-	26	400	1100		-	34	18	272	249	-	-
TOTAL (kbps)																						239	370	498	7.7	28

Table 4-3 Phase 2 Broadcast Information Transfer Rate – Separate Domains

4.5 Air-Ground Capacity Requirements in the Test Scenarios

Section 2, 3 and 4 have been amalgamated to form generic test scenarios that should be used in simulations and measurement of technology performance capabilities as identified in the Step 2: Technology Assessment Methodology document. This will allow comparative assessment of technologies operating within the same airspace.

4.5.1 Scenario Assumptions

In order to generate the scenarios that follow some assumptions have been defined as follows:

- TV1 is assumed to have the dimension of the COCR airport volume.
- Airport combined capacity requirements, as featured in the COCR, are complied by three types of operations – clearance/ramp, ground position and runway/tower. To generate surface capacity requirements for this document it has been assumed that the operational areas of clearance/ramp and ground position combined will generate the surface capacity. (The capacity of the airport zone test volume shall be the runway/tower component.)
- TMA Small/ENR small are assumed to be the same as the COCR in terms of their volume and capacity requirement figures. As detailed in prior section the test volume shape is merely assumed to be regular.
- TV 4.4 ECAC extended FL245-FL450 has been approximated to use ENR model even though part of the test volume overlays the ocean. This is because a large proportion of the volume is covering the ECAC region and distribution of specific traffic is unknown.
- All aircraft are assumed to be uniformly distributed within the TV.

The following sections describe the capacity requirements in each of the Test Volumes that were output from the queuing model.

4.5.2 Scenario 1.1 and 1.2 - Airport Zone and Airport Surface

4.5.2.1 Air-Ground Addressed

		No. Aircraft in surface area	Airport Surface Capacity (kbps)	No. Aircraft in total airport volume	Airport Zone Capacity (kbps)
ATS	UL	264	30	26	3
	DL	264	30	26	10
	UL + DL	264	40	26	10
AOC	UL	264	150	26	0.3
	DL	264	5	26	2
	UL + DL	264	150	26	2
Combined	UL	264	150	26	3
	DL	264	30	26	15
	UL + DL	264	200	26	15

Table 4-3 Airport A/G capacity requirements (kbps)

4.5.3 Scenario 2.1 – TMA Small

4.5.3.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	44	30	30
	DL	44	30	30
	UL + DL	44	40	40
AOC	UL	44	2	2
	DL	44	3	3
	UL + DL	44	4	4
Combined	UL	44	30	30
	DL	44	30	30
	UL + DL	44	40	40

Table 4-4 TMA small A/G capacity requirements (kbps)

4.5.4 Scenario 2.2 – TMA Large

4.5.4.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	53	30	30
	DL	53	30	30
	UL + DL	53	40	40
AOC	UL	53	2	2
	DL	53	3	3
	UL + DL	53	4	4
Combined	UL	53	30	30
	DL	53	30	30
	UL + DL	53	40	40

Table 4-5 TMA Large A/G capacity requirements (kbps)

4.5.5 Scenario 3.1 – ENR SMALL

4.5.5.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	45	30	30
	DL	45	30	30
	UL + DL	45	30	30
AOC	UL	45	60	60
	DL	45	2	2
	UL + DL	45	60	60
Combined	UL	45	150	80
	DL	45	30	30
	UL + DL	45	150	80

Table 4-6 ENR Small A/G capacity requirements (kbps)

4.5.6 Scenario 3.2 – ENR Medium

4.5.6.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	62	30	30
	DL	62	30	30
	UL + DL	62	30	30
AOC	UL	62	70	70
	DL	62	2	2
	UL + DL	62	80	80
Combined	UL	62	150	100
	DL	62	30	30
	UL + DL	62	150	100

Table 4-7 ENR Medium A/G capacity requirements (kbps)

4.5.7 Scenario 3.3 – ENR Large

4.5.7.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	204	30	30
	DL	204	40	40
	UL + DL	204	40	40
AOC	UL	204	200	200
	DL	204	6	6
	UL + DL	204	300	300
Combined	UL	204	300	200
	DL	204	40	40
	UL + DL	204	300	300

Table 4-8 ENR Large A/G capacity requirements (kbps)

4.5.8 Scenario 3.4 – ENR Super Large

4.5.8.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	522	40	40
	DL	522	50	50
	UL + DL	522	70	70
AOC	UL	522	500	500
	DL	522	20	20
	UL + DL	522	500	500
Combined	UL	522	500	500
	DL	522	50	50
	UL + DL	522	600	600

Table 4-9 ENR Super Large A/G capacity requirements (kbps)

4.5.9 Scenario 4.1 – Core Regional FL050 – FL245

4.5.9.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	1733	200	200
	DL	1733	300	300
	UL + DL	1733	400	400
AOC	UL	1733	30	30
	DL	1733	90	90
	UL + DL	1733	150	150
Combined	UL	1733	300	300
	DL	1733	300	300
	UL + DL	1733	500	500

Table 4-10 Core Regional (TMA) A/G capacity requirements (kbps)

4.5.10 Scenario 4.2 –Core Regional FL245 – FL450

4.5.10.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	2908	150	150
	DL	2908	200	200
	UL + DL	2908	300	300
AOC	UL	2908	3000	3000
	DL	2908	80	80
	UL + DL	2908	3000	3000
Combined	UL	2908	3000	3000
	DL	2908	300	300
	UL + DL	2908	3000	3000

Table 4-11 Core Regional (ENR) A/G capacity requirements (kbps)

4.5.11 Scenario 4.3 – Core Regional + Oceanic FL050 – FL245

4.5.11.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	1753	200	200
	DL	1753	300	300
	UL + DL	1753	400	400
AOC	UL	1753	30	30
	DL	1753	90	90
	UL + DL	1753	150	150
Combined	UL	1753	300	300
	DL	1753	300	300
	UL + DL	1753	500	500

Table 4-12 Core Regional + Oceanic (TMA) A/G capacity requirements (kbps)

4.5.12 Scenario 4.4 – Core Regional + Oceanic FL245 – FL450

4.5.12.1 Air-Ground Addressed

			With Auto Exec	Without Auto Exec
		No. Aircraft in Scenario	Total Capacity (kbps)	Total Capacity (kbps)
ATS	UL	3415	400	400
	DL	3415	500	500
	UL + DL	3415	800	800
AOC	UL	3415	60	60
	DL	3415	200	200
	UL + DL	3415	300	300
Combined	UL	3415	400	400
	DL	3415	600	600
	UL + DL	3415	1000	1000

Table 4-13 Regional Core + Oceanic (TMA) A/G capacity requirements (kbps)

4.5.13 Summary of the Scenario Data

The tables above show for each scenario ATS, AOC, ATS & AOC combined in terms of UL, DL and UL+DL. The results have been summarised in Table 4-14 below for the combined ATS and AOC UL and DL capacities.

	With A-EXEC	**Without A-EXEC**
SCENARIO	**ATS & AOC combined UL&DL Capacity Requirement (kbps)**	**ATS & AOC combined UL&DL Capacity Requirement (kbps)**
1.1	15	15
1.2	200	200
2.1	40	40
2.2	40	40
3.1	150	80
3.2	150	100
3.3	300	300
3.4	600	600
4.1	500	500
4.2	3000	3000
4.3	500	500
4.4	1000	1000
ORP	40	40
AOA	100	100

Table 4-14 Summary of the capacity results

As previously mentioned ORP and AOA are assumed to have the same performance requirements as the COCR. These results are shown in the table above, for full reference of all their requirements refer to tables 4-1 and 4-2.

4.6 Quality of Service Requirements

In addition to the capacity requirements, the COCR contains other Quality of Service (QoS) requirements, which the FRS must meet.

Review of the COCR (Phase 2) suggests the most demanding application is ACL, which operates in all domains and has similar requirements in each domain except ORP. The A-EXEC service has even more demanding requirements but only operates in ENR and ORP domains.

The QoS requirements are the same for all test scenarios generated and have been summarise in the tables below. Figures are provided for the Required Communication Technical Performance (RCTP) for Latency (one way), Continuity and Integrity per instance[1], and Availability per flight hour.

Latency RCTP (TT_{95}- 1 way)					**Continuity RCTP (per inst)**	**Integrity RCTP (per inst)**	**Availability RCTP (pFH)**	
APT	**TMA**	**ENR**	**ORP**	**AOA**	**C_{UIT}**	**I_{UCT}**	**A_P**	**A_U**
1.4	1.4	1.4	5.9	1.4	0.9996	5.0E-8	0.99 9995	0.9995

Table 4-15 Quality of Service Requirements without A-EXEC

Latency RCTP (TT_{95}- 1 way)					**Continuity RCTP (per inst)**	**Integrity RCTP (per inst)**	**Availability RCTP (pFH)**	
APT	**TMA**	**ENR**	**ORP**	**AOA**	**C_{UIT}**	**I_{UCT}**	**A_P**	**A_U**
-	0.74	0.74	-	-	0.99999992	5.0E-10	0.9999 99999 5	0.99999 995

Table 4-16 Quality of Service Requirements with A-EXEC

[1] An instance is a sequence of uplink and downlink messages that fulfil an operational objective.

5 SCENARIO METHOD OF APPLICATION

Test scenarios have been generated in order to have some generic test volumes that are of simple construction to use for simulation or measurement purposes. Each scenario consists of a simple geometric shape with an associated aircraft count and communication requirements for air/ground addressed and air/air broadcast services. In addition QoS requirements have been identified for integrity and availability of provision.

In carrying out the technology assessment the appropriate scenario can be used depending on the capability of the technology. For example -

Technology X (max range = 200NM) is intending to supply communication services to the En Route airspace category.

Technology X generating a simulation of a potential configuration of their system would model it around TV3.3 ENR Large or TV3.4 ENR Super Large. The technology can then specify whether it has the ability to provide the required capacity and QoS values for that TV. In the assessment phase it will be ranked as to whether it meets the requirement or not for a particular scenario. Details of the European assessment criteria can be found in Step 2: Technology Assessment report.

Each scenario provides a comparative test bed that technologies can actively show through simulation or by other means, that they can meet the requirements of future types of airspace. They are generic and can therefore be simulated in any global area.

6 CONCLUSION

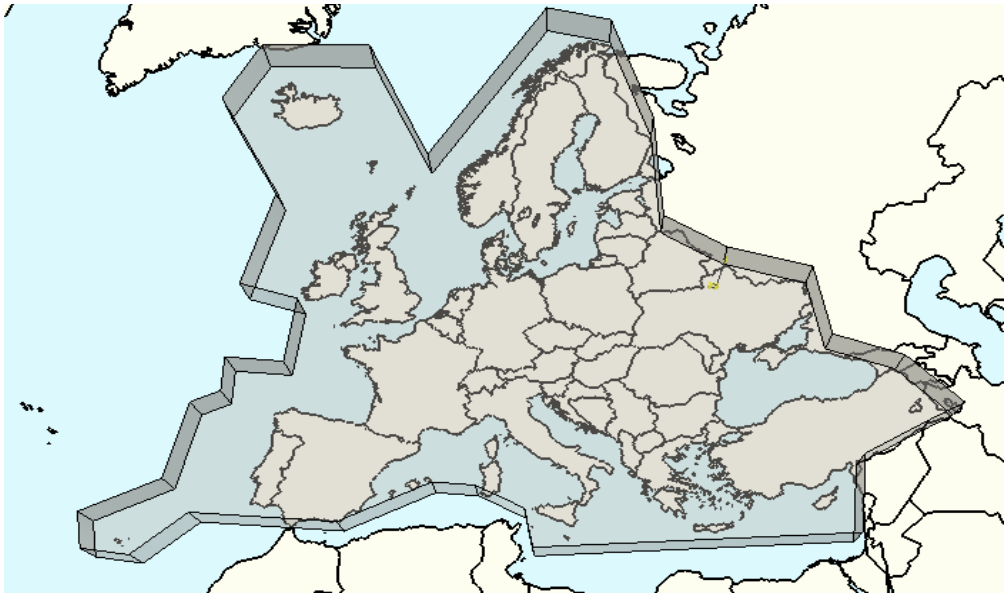
This document provides one way of interpreting the a/g and a/a requirements in the COCR in a way that can be used in technology assessments.

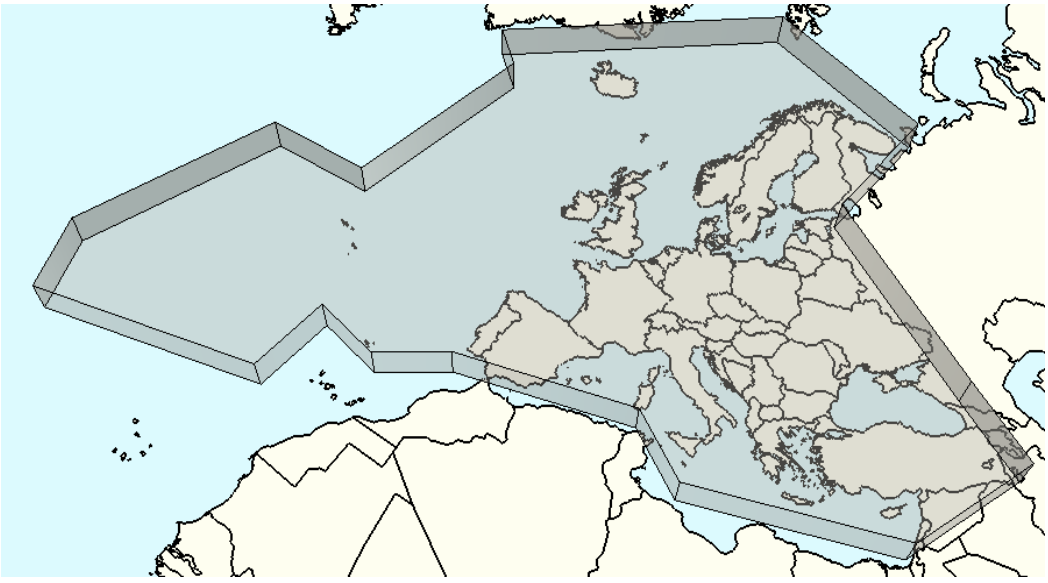
The requirements are described in a series of ways that are equivalent but expressed in a way that can be understood in the context of technology specific solutions.

APPENDIX A

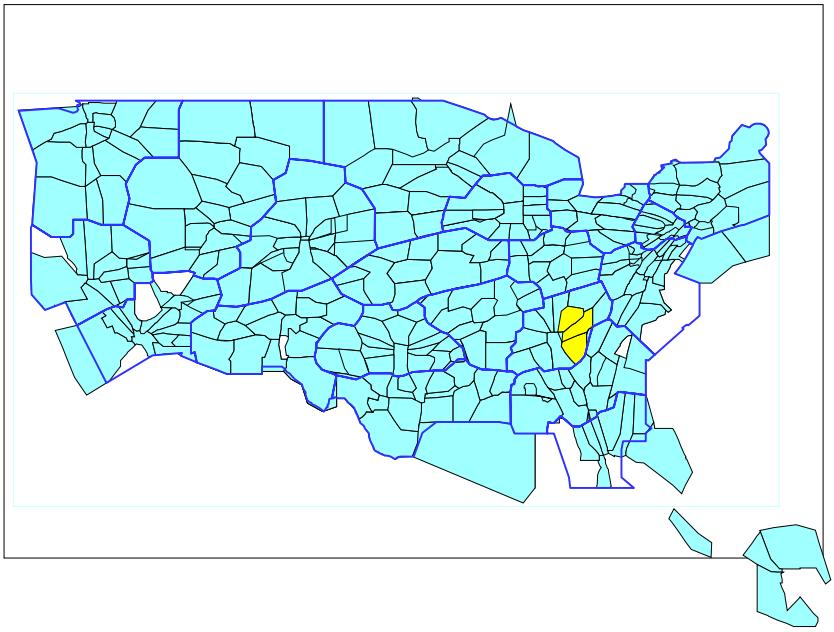
Regional Airspace

The following three figures illustrate the airspace considered in the development of the core regional test volumes. The first shows the boundary of ECAC airspace within coverage of terrestrial communication coverage. The second figure illustrates ECAC airspace including surrounding oceanic airspace.





The third figure illustrates the airspace considered as the core regional test volume for the US NAS.



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