White
Young
Green

SEStran

RTPI SYSTEM - FEASIBILITY STUDY

Report

RT/ A035560 / 01

SEStran

RTPI SYSTEM - FEASIBILITY STUDY

Report

White Young Green	Tel No: 0116 2348000
Executive Park	
Avalon Way	Fax No: 0116 2348001
Anstey	
Leicester	Project No: A035560
LE7 7GR	
	Report No. RT/ A035560 / 01

ISSUE No.	1					
DATE	27/06/07					
PREPARED	SMM					
APPROVED	CS					

Table of Contents

APPENDIX C –

Bus Operational Areas

Major Operators

Legend:
- Lothian Buses depot
- Stagecoach outstation
- Stagecoach depot
- First outstation
- First depot

MINOR BUS OPERATORS

Moffat & Williamson

Mackie

Waverley

Horsburgh

Perryman

MacEwan

Munro
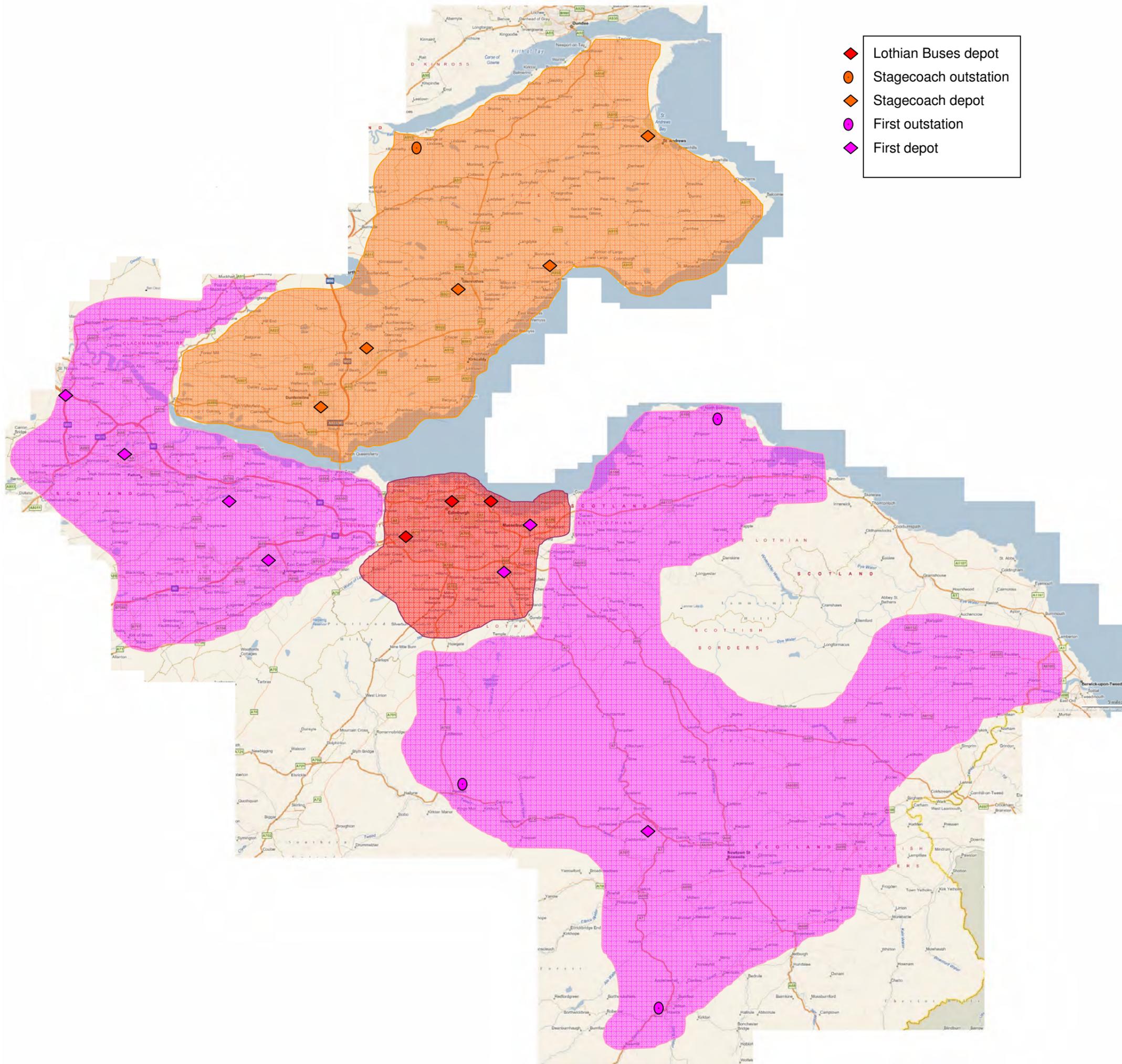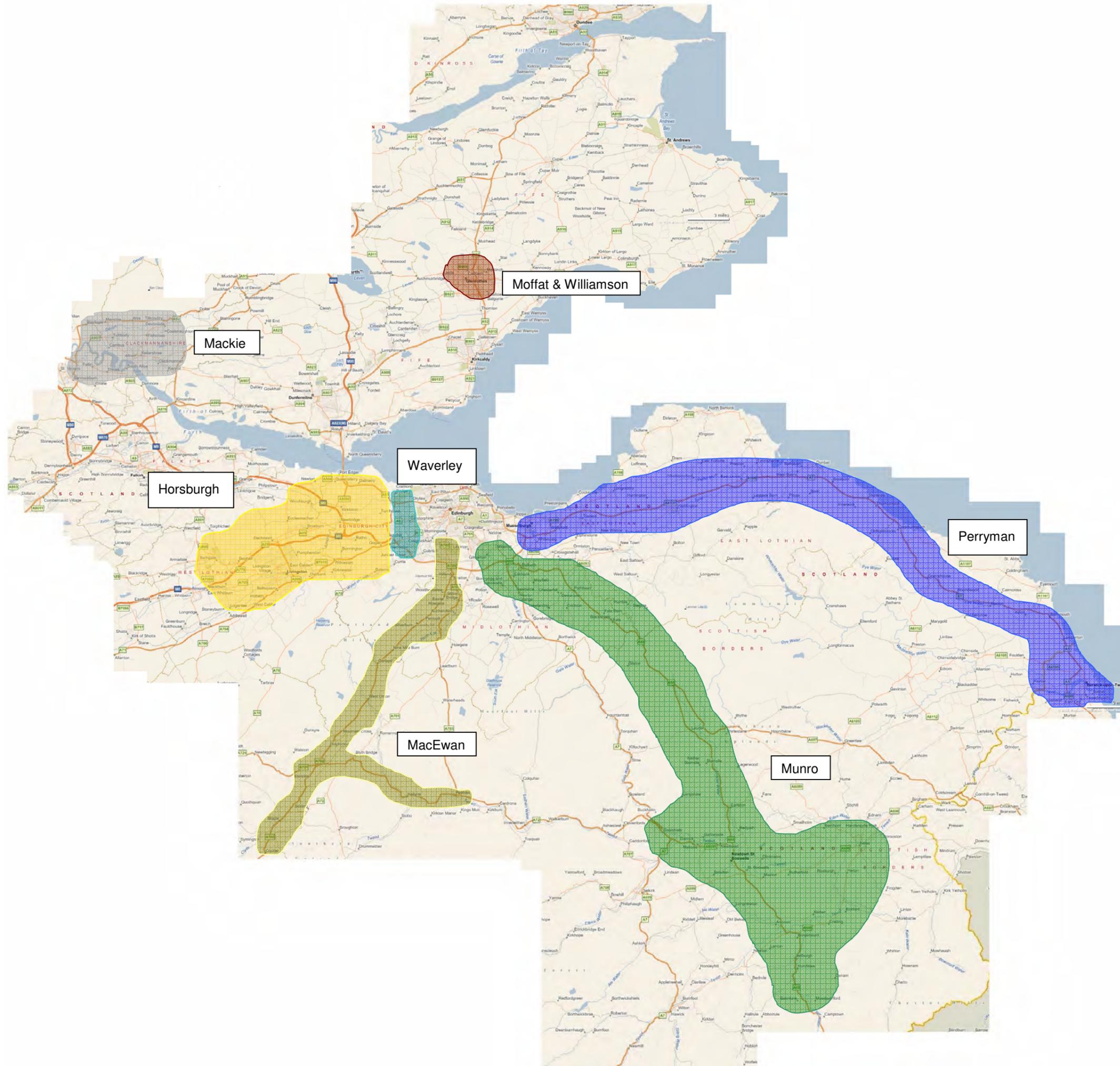
APPENDIX D –

Fife Radio Network

1 Appendix 2 – Mast locations

* Location of mast

1

Appendix 10 – O2 coverage

On-street coverage prediction for O2 services
■ **High** - Video Calls / News
■ **Standard** - Voice/SMS/MMS/ Music, O2 Active. Approximately 2 bars on Mobile minimum.
  Variable - Voice calls, SMS (quality of service may vary) Approx. 1 bar on Mobile.
□ **No Coverage** - No services available
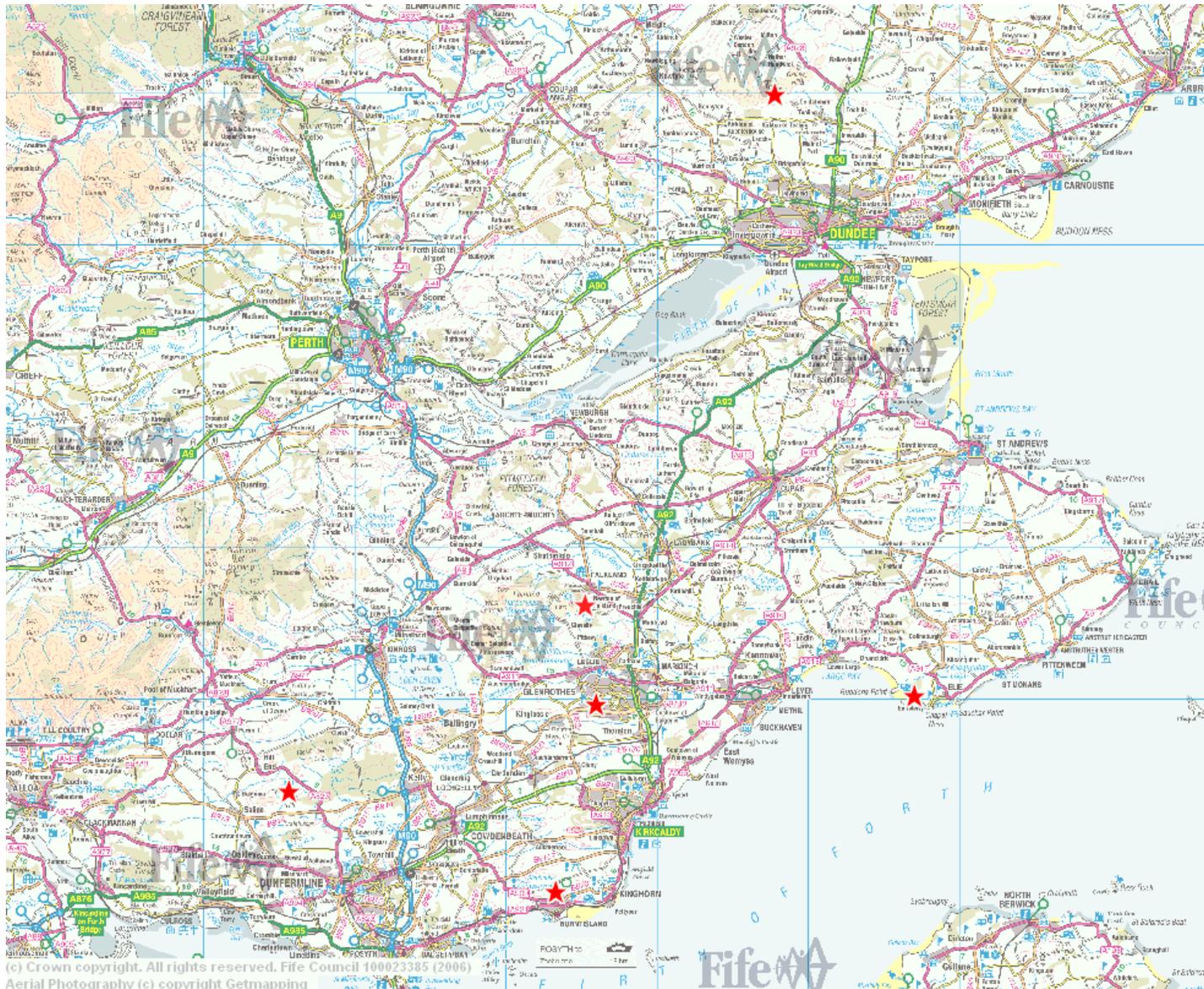
2 Appendix 11 - Projected MPT1327 Coverage

ST 3481 FIFE COUNCIL Composite of Five Sites, Base to Mobile
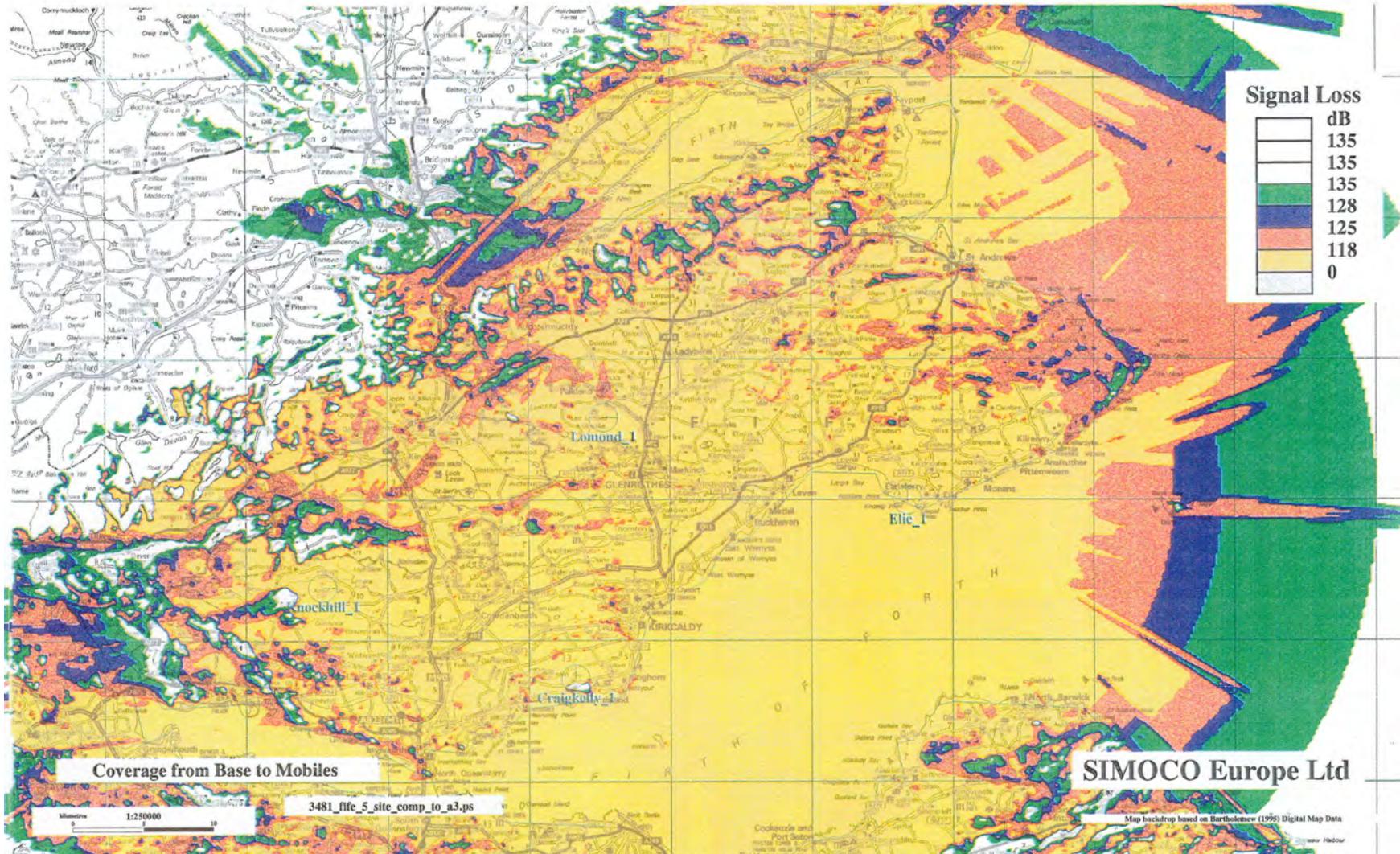
APPENDIX E –

PMR Radio & GPRS Coverage Plots

Indicative Band III coverage plot of northern SEStran area
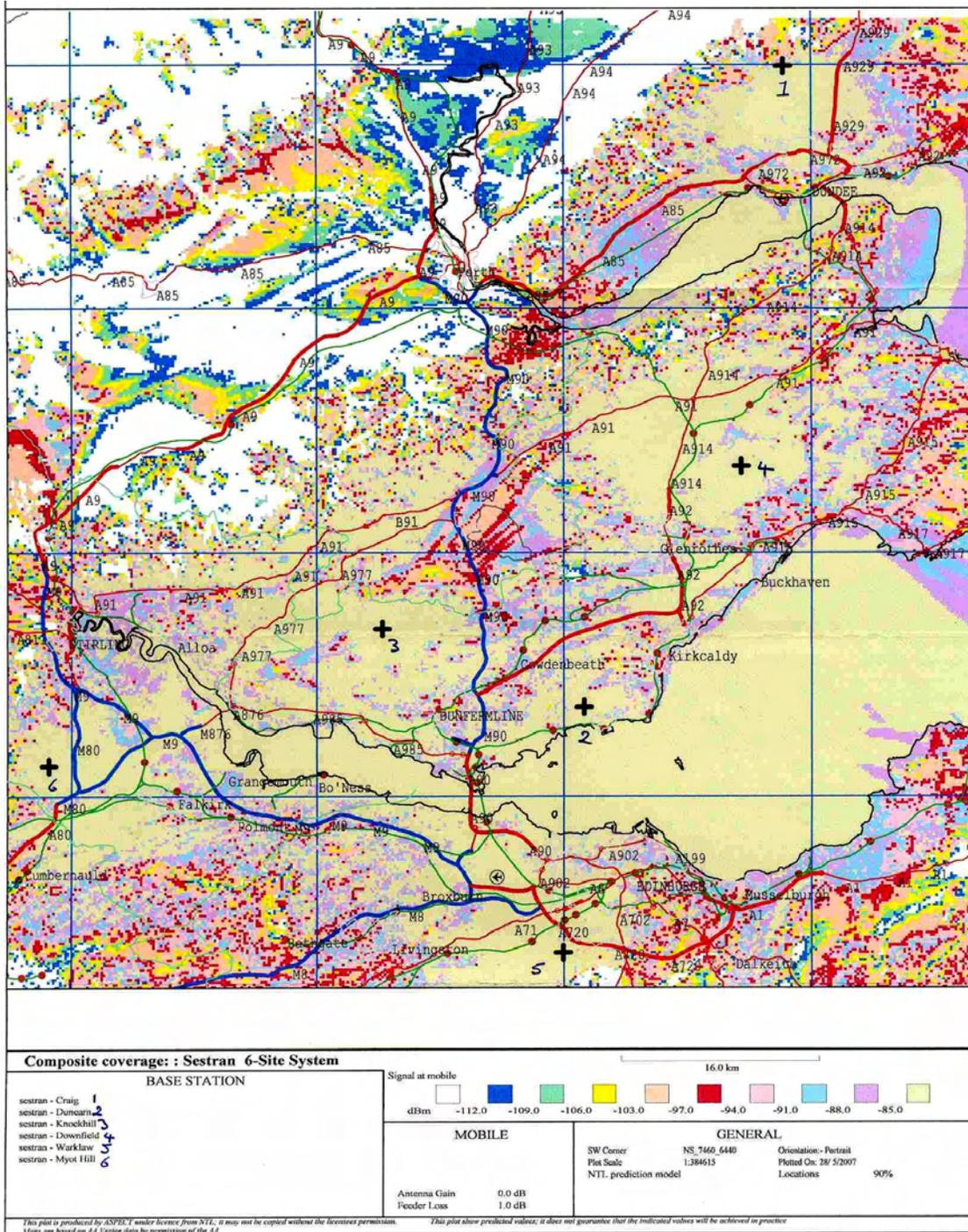
Internet derived Cellular coverage plots

O₂
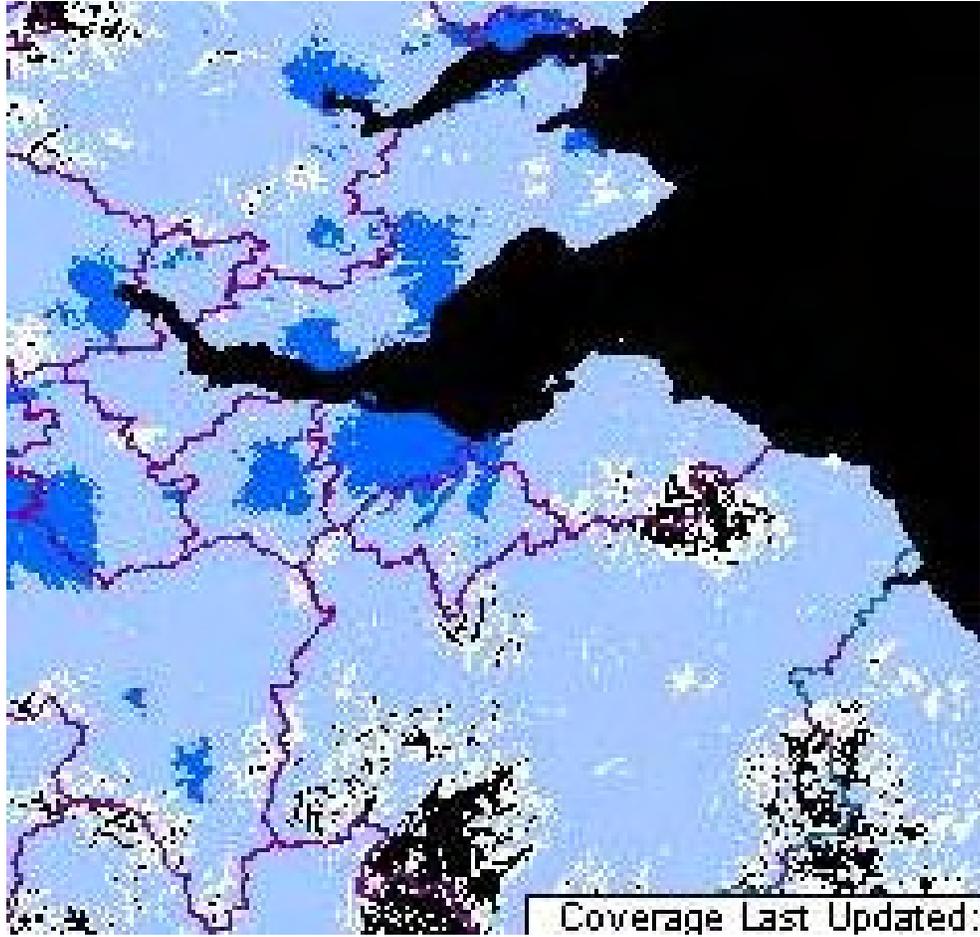
Vodafone
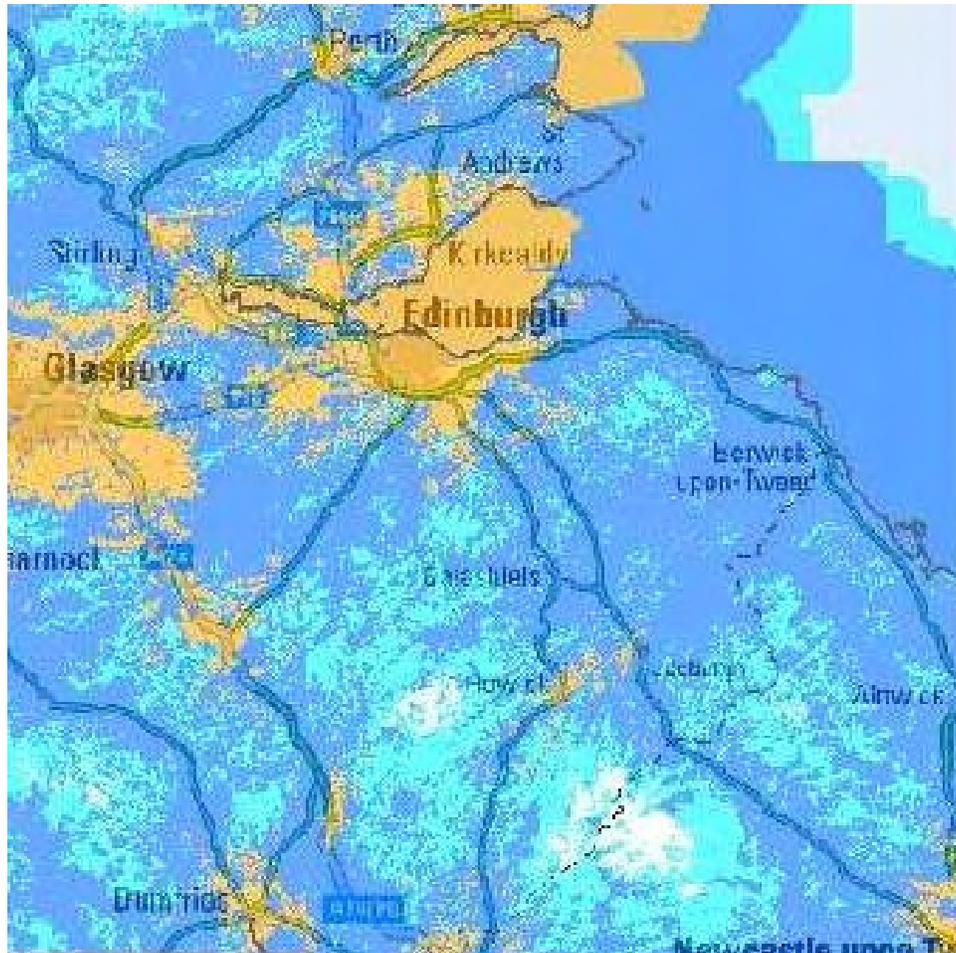
Orange Coverage
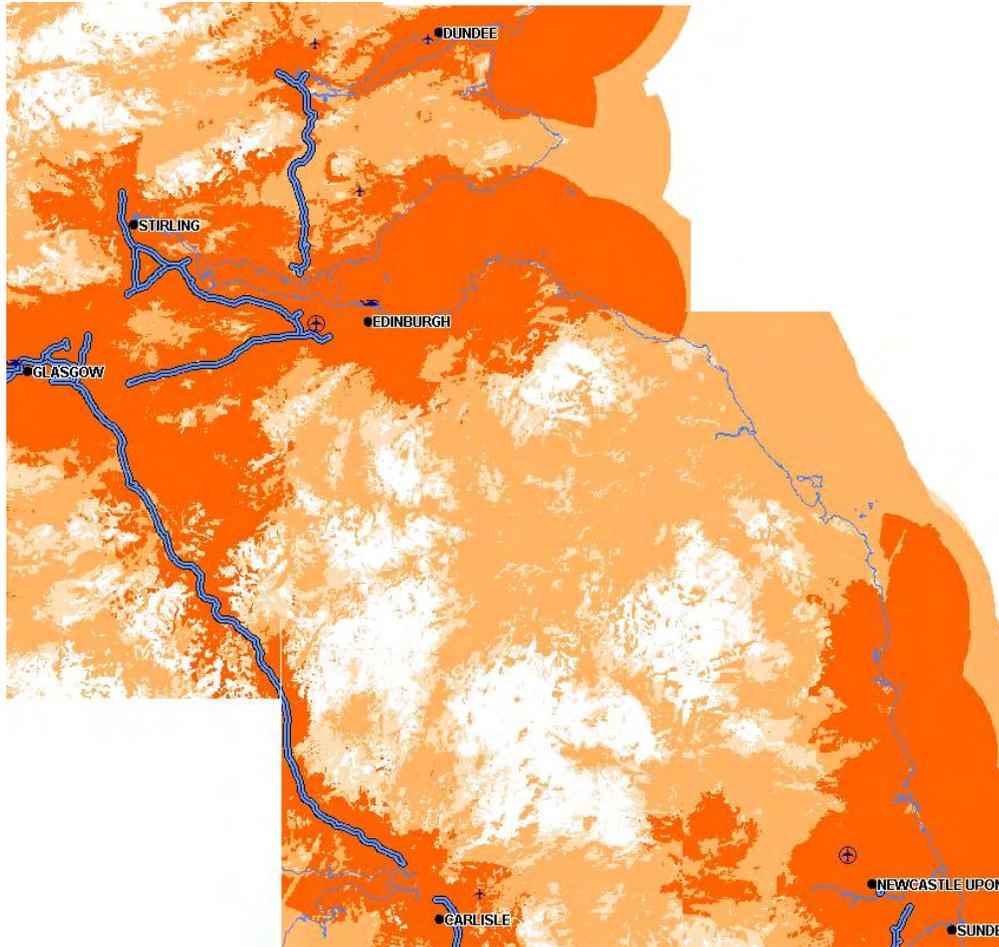
T-Mobile

APPENDIX F –

List of Small Bus Operators

Small bus operators

It should be pointed out that this list, generated from the data supplied by local councils to traveline in Scotland, is comprehensive and includes all operators of registered bus services including those solely operating school bus services, and those who have registered excursions as local services.

Borders

Buskers
IDM Travel
MacEwan's Coach Services
Peter Hogg
Telford's Coaches
Travelsure
Wardlaw Jackson

East Lothian

Don Prentice
Eves Coaches
PostBus

Edinburgh

Bulldog Travel
Dodds of Troon
Edinburgh Tours
Lothian Community Transport
Waverley Travel

Clackmannanshire

Aberfoyle Motors
Addison News
Caber Coaches
Coles Coaches
Crieff Travel
Dochertys Midland Coaches
Goosecroft Coaches
Hamilton Coaches
Harlequin Coaches
Hunters Executive Coaches
John Ferguson
Kingshouse Travel
McGill's Bus Service
Mitchells of Plean
Morrison Travel
Prestige Tours
Sweeneys Garage
Wheelchair Access Vehicle Enterprises

Falkirk

Bo'ness and Kinneil Rail
Bryans of Denny
Davidson Buses
First Glasgow
Goosecroft Coaches
Hamilton Coaches
Myles Minibus

Fife

A1
Hamish Gordon
Rennies

Cross-border operators

Megabus
Scottish Citylink
Silver Choice
Superfast Ferries

Midlothian

None not already listed above

West Lothian

Blue Bus
E + M Horsburgh
Henderson Travel
Passenger Travel
Prentice Westwood
SD Travel

APPENDIX G –

Workshop Details & List of Consultees

List of representatives who attended the AVL/RTPI Workshop sessions

Name	Organisation	March 6th	March 20th
Gary Moyes	Fife CC	✓	
Ian Forbes	Scottish Borders		✓
David Kerr	East Lothian		✓
Dorothy Walker	Stirling (Clacks)	✓	
Karl Vanters	Midlothian		✓
Stuart Lowrie	City of Edinburgh	✓	
Billy Thompson	West Lothian		✓
Roy Mitchell	West Lothian		✓
Stephen Bloomfield	Falkirk CC	✓	
Steve Walker	Stagecoach (East Scotland Ops Dir)		✓
Roy Jeffries	Stagecoach (Technology Projects)		✓
Bill Johnson	Lothian Buses	✓	✓
Ian Craig	Lothian Buses		✓
Jim Freeland	First Edinburgh	✓	
Marc Horsburgh	E&M Horsburgh		✓
John Elliot	Traveline Scotland	Met after workshops	
Marjory Rodger	CPT	Met after workshops	

Complete list of all consultees

Name	Organisation	Responded?	Attended?
John Cockburn	Alexander Wait & Son	×	×
Deborah Law	Blue Bus	×	×
William Bryans	Bryans Coaches	×	×
William Bryans	Bryans Coaches	×	×
Kenneth Nicoll	Bulldog Travel	×	×
John Methven	Buskers	×	×
Ewan Kennedy	City of Edinburgh	✓	×
Max Thomson	City of Edinburgh	✓	×
Stuart Lowrie	City of Edinburgh	✓	✓
Mac West	Clackmannanshire	✓	×
Marjory Rodger	CPT-Scotland	✓	×
Ian Davison	Davidson Buses	×	×
Don Prentice	Don Prentice Coaches	×	×
Marc Horsburgh	E&M Horsburgh	✓	✓
David Kerr	East Lothian	✓	✓
Pete Collins	East Lothian	✓	×
Gary Scougall	EVE Cars and Coaches	×	×
John Angell	Falkirk CC	✓	×
Stephen Bloomfield	Falkirk CC	✓	✓
Bob Mclellan	Fife CC	✓	×

Gary Moyes	Fife CC	✓	✓
Brian Juffs	First in Edinburgh	✓	×
Jim Freeland	First in Edinburgh	✓	✓
James Frame	Goosecroft Coaches	×	×
Ian Horsburgh	Houstoun Travel	×	×
Bill Johnson	Lothian Buses	✓	✓
Neil Renilson	Lothian Buses	✓	×
Ian Craig	Lothian Buses	✓	✓
John MacEwan	MacEwan' Coaches	×	×
James Mackie	Mackie's Coaches	×	×
Douglas Muir	Midlothian	✓	×
Karl Vanters	Midlothian	✓	✓
John Williamson	Moffat & Williamson	✓	×
Donald Cameron	Munro's of Jedburgh	✓	×
Mike Lambden	National Express	✓	×
Linda Perryman	Perryman's	✓	×
R Perryman	Perryman's	✓	×
Gordon Menzies	Rennies	×	×
Brian Young	Scottish Borders	✓	×
Ian Forbes	Scottish Borders	✓	✓
Tom Wileman	Scottish Citylink	✓	×
Samuel Douglas	SD Travel	×	×
Ian Mathie	SEStran	✓	✓
Robert Andrew	Stagecoach	✓	×

Steve Walker	Stagecoach	✓	✓
Roy Jefferies	Stagecoach (Technology Projects)	✓	✓
Dorothy Walker	Stirling (Clacks)	✓	✓
John Elliot	traveline Scotland	✓	×
	W.A.V.E.	×	×
Robert Jack	Waverley Travel	×	×
Billy Thompson	West Lothian	✓	✓
Graeme Malcolm	West Lothian	✓	×
Roy Mitchell	West Lothian	✓	✓

SEStran

AVL/RTPI Workshop Programme

1000	1. Welcome and Introductions	Ian Mathie
1005	2. Aims and Objectives of Workshop	Stuart Maxwell
1015	3. Existing systems – examples of successful systems from around the UK	Stuart Maxwell
1035	4. AVL/RTPI System Overview	Stuart Maxwell
1100	5. Existing Systems and Bus Operators	Andrew Norman
1130	6. Refreshment Break	
1200	7. Including Contracted Services in the system	Andrew Norman
1210	8. Future organisation and Funding	Stuart Maxwell
1220	10. Marketing and branding	Stuart Maxwell
1230	11. The Way Forward	Andrew Norman
1240	Q & A	
1300	Lunch	

APPENDIX H –

MPT 1327 Trunked Radio Details

Reliable • Customised • Cost-Effective

TaitNet MPT 1327
trunked networks

Flexible, dependable trunked radio networks from the world's largest supplier of MPT 1327 systems

MPT 1327 as an Open Standard

In today's market, choice means competition. Greater choice leads to more competitive pricing and superior features. If you choose a proprietary trunked radio system you can be locked into buying from one supplier. But if you choose an open standard MPT 1327 system you have the choice of buying equipment from more than 20 suppliers.

MPT 1327 is the most widely used trunked radio open protocol in the world. Tait alone has installed hundreds of MPT 1327 networks, covering frequencies between 60 and 960 MHz, in over 80 countries.

MPT 1327 offers digital signalling and many advanced features including a wide range of call types - such as private one-to-one, conference and broadcast group calls and emergency calling. You can place and receive telephone calls through a PABX or PSTN, or connect with an existing conventional network, directly or through a despatcher.

TAIT radio communications

TaitNet MPT 1327 benefits

Cost-effective - TaitNet MPT 1327 networks are competitively priced communications solutions, with all the features you need.

Proven reliability and quality performance give Tait trunked radio equipment the leading edge.

Modular design enables you to have a range of features in a system of any size. The system can be expanded from a single channel to a countrywide network. The modular design makes it easier to service and minimises downtime.

Efficient networks make maximum use of spectrum and allow larger customer bases to improve profitability.

Digital interfaces are achieved through the use of a digital audio switch providing the clearest possible audio. Inter-site and inter-node links can be either digital or analogue circuits using either E1/T1 or 4 wire audio links. Digital end-to-end connectivity is available for multi-site networks, reducing the need for a third party multiplexer.

Distributed processing gives individual TaitNet sites the intelligence to process single-site calls making the system more robust, and overcoming the need for an expensive central switch. This reduces the initial purchase price for smaller systems.

Interfacing to other networks, such as PSTN, PABX and private data systems are popular options and may be customised to integrate with your communications system.

Data facilities include short or long data messages, status messaging, automatic vehicle location (AVL) and two-way e-mail gateways.

Call queuing means that even during your busiest times, calls are completed, as they are queued until system resources become available.

Priority calling gives priority access to channels for users with more urgent requirements.

Gradual degradation means that in the unlikely event of a malfunction the system will continue to provide the best level of service. Advanced alarm monitoring with e-mail notification provides the ability to control your network and users on a regional basis or from a single point.

A comprehensive network management package that includes statistical reporting and a flexible call record and billing system.

User validation prohibits unauthorised use of the system, manages access to some or all radio sites and can enable calls to other work groups.

Intelligent group calling means users are connected with minimum amount of system resource.

Control channel reversion handles peak traffic loading without requiring extra channels or hardware by using the control channel for voice traffic when required.

Channel back-up automatically substitutes a traffic channel for the control channel, should the need arise, to ensure continuity of service.

Dynamic call allocation allows more calls during peak loading hours by dynamically adjusting the call time limit to balance traffic flow.

High specification – Tait T800 and the new TB8100 base station equipment provide the backbone of TaitNet systems for both analogue and digital systems.

Emergency calls are given priority over other calls to protect life and property.

Over-the-air regrouping means the composition of call groups can be changed over the network to enable individuals to be quickly connected to work on a particular project.

Gateways – we provide you with direct connection to our central node for e-mail, third party data applications (MAP 27 protocol), or for connection to a despatcher. We have a published despatcher interface protocol.

After Sales Support – having customised a solution for your requirement we ensure it continues to meet your needs with a range of service and maintenance options, including regular remote monitoring of your system by Tait specialists.

Why choose TaitNet MPT 1327?

Choose a TaitNet MPT 1327 trunked radio system with confidence. It's the world's most widely used open protocol technology, and Tait is the largest supplier.

Tait was involved in determining the original MPT 1327 standard in the early 1980s. Our equipment was used in the world's first MPT 1327 system, provided to British Telecom in London, and we also supplied the first multi-site system in Northern England.

We have remained at the forefront of the technology's development, pioneering many new features as MPT 1327 equipment has evolved to continue to meet the voice and data needs of the modern mobile radio user.

Compare advanced trunked radio technologies and you'll find TaitNet MPT 1327 offers the best combination of features and cost-effectiveness - both for the system manager and radio user.

At Tait, we have the commitment, experience and product range to tailor a communications system for any mobile organisation.

Utilities
- Control of your own radio communications network
- Fast call connection and smart features like call back to connect you with people you have been trying to reach
- Exceptional communications with different levels of priority including emergency calling

Transport Organisations
- Efficient radio communications over a large geographic area
- Cost-effective infrastructure allows both voice and data on the same system
- Efficient management of your people with the ability to organise radios into private one-to-one, fleet and groups calls
- The option of advanced voice and data despatching programmes

Service Provider
- A greater source of income as more radios can be connected to the system
- Lower operational costs as fewer channels are required to accommodate users
- Greater customer satisfaction through improved quality of service

Small Organisations
- The ability to place and receive telephone calls through connection to the local PABX or public telephone network
- Free calling means low operational costs
- Improved efficiency with smart calling features such as call back, to connect you with people you have been trying to reach

TaitNet MPT 1327 trunked networks

Features by network tier

Feature	TN1100	TN2100	TN3100	TN5100
Coverage over a small area like a mall, factory campus or town	•	•	•	•
The ability to be organised into fleets, groups or individual units, giving virtual private networks	•	•	•	•
The ability to have calls connected automatically when the called party becomes available	•	•	•	•
The ability to have calls connected automatically as system resources become available	•	•	•	•
The ability to change radio groups on demand and over the air from a despatcher	•	•	•	•
Private, one-to-one calls	•	•	•	•
Group calls, even between different fleets	•	•	•	•
Late entry to group calls	•	•	•	•
Broadcast calls	•	•	•	•
Emergency calls	•	•	•	•
Status messages	•	•	•	•
Up to 5 levels of priority access	•	•	•	•
Short data messages (up to 25 Characters)	•	•	•	•
Long data messages (more than 100 characters)	•	•	•	•
The ability to support Automatic Vehicle Location (AVL) on the network (radio connected)	•	•	•	•
Radio to PABX or PSTN access	•	•	•	•
PABX or PSTN to radio access	•	•	•	•
Easy 2 or 3 digit short form dialling	•	•	•	•
Automatic redial with a single PTT push	•	•	•	•
Caller ID	•	•	•	•
The ability to connect to a conventional network	•	•	•	•
Coverage over an entire city		•	•	•
The ability to monitor the performance of your radio network		•	•	•
The ability to remotely detect and diagnose system failures		•	•	•
The ability to log all call and billing records		•	•	•
The ability to define a range of billing options		•	•	•
The ability to manage the level of access of any user to your radio network		•	•	•
Mobile E-mail connection		•	•	•
Mobile access to a database		•	•	•
Dedicated resources for special users		•	•	•
Coverage over an area like a state or province		•	•	•
The ability to support Automatic Vehicle Location (AVL) on the network (line connected)		•	•	•
The ability to divert radio calls to another radio or a telephone number (for all calls, or on busy)		•	•	•
The ability to patch radio calls to one another		•	•	•
When a group call is made, all the radios in the group will be included in the call regardless of whether they are currently involved in other calls (optional configuration)			•	•
An emergency group call will interrupt all calls currently in progress at a site with the exception of emergency calls (optional configuration)			•	•
The ability to detect unauthorised users and disable them from using your radio network	•		•	•
Coverage over an entire country				•
Specialised applications available				•
Lone Worker	•			

TELARC ISO 9001 REGISTERED
TELARC CERTIFIED ENVIRONMENTAL MANAGEMENT SYSTEM

www.taitworld.com

BNA-1500-01

BUS RADIO CONNECTIVITY

WWW.TAITEUROPE.COM

GPS ANTENNA

MPT1327 VOICE
& DATA SYSTEM

City Square

SIGN CLEARDOWN

IN-BUS TAIT MOBILE

BUS COMPUTER

TRAFFIC LIGHT
PRE-EMPTION

DIGITAL I/O
ALARMS

DRIVER INTERFACE

radio
communications

radio
communications

SOLUTIONS FOR: BUS TRANSPORT

Tait has been designing, manufacturing, installing and supporting effective and reliable radio solutions for the bus transport sector for nearly 40 years. Large bus organisations around the world have put their trust in Tait to supply radio networks that enhance fleet efficiency and deliver improved customer service.

Tait's strength is in its radio expertise and ability to customise its products and solutions to the customer's exact requirements. Bus operators and system integrators the world over choose Tait to provide the services and expertise that ensure a reliable radio 'backbone' for their voice and data communications.

Whether it's voice, Automated Vehicle Location, traffic light pre-emption, sign communication, or Real-Time Passenger Information (RTPI), Tait Radio Communications is the flexible partner of choice to provide communication solutions for bus transport providers.

Tait Radio Communications is the right choice as a bus communications partner for System Integrators because of its:

- **Flexibility** - Tait systems provide flexible voice communication with an integrated data transport system.
- **Speed** - A single data channel will support up to 900 buses and a polling rate of up to 15 per second.
- **Ease of Integration** - Tait employs industry standards and open protocols. This ensures ease of integration and maximum compatibility with other systems.
- **Wide range of services** - Tait does not just provide the radio infrastructure – we will provide turnkey solutions when required. Our range of services and consultancy covers design, coverage planning, licence and site acquisition, system build and deployment – and we can also provide migration from legacy systems
- **Reliability** - Fully redundant, fault tolerant systems provide the highest possible levels of reliability and availability – available as a standard feature.
- **Operational understanding** - Our fully integrated remote system management and alarm monitoring can alert support staff automatically. Problems can be identified and resolved before they have an effect on operational performance.
- **Worldwide expertise** - We can offer our services in over 160 countries around the world.

Bus operators will benefit from the quality of the Tait solution and customisation because we can:

- **Reduce cost of ownership** - One radio can perform the functions that previously required two or even three separate radios.
- **Reduce maintenance costs** - The excellent reliability of Tait products means less downtime and lower labour costs.
- **Protect your investment** - Proven communication techniques combined with state of the art Digital Signal Processing provide an upgrade path for future expansion and development.
- **Cater for your future needs** - A trial system operating on a single route could be expanded to a nation-wide RTPI system by adding additional hardware. Upgrading becomes simpler and more cost effective than ever before.

TECHNICAL HIGHLIGHTS

Flexibility
MPT1327/MPT1343 Trunked and conventional systems allow growth from a single site to a national system.

Fast data
Tait TDMA data channel supports up to 15 polls per second, up to 900 buses per channel (depending on reporting rate), IP connections for data.

Expansion
Multiple data and control channels on each radio site.

Dynamic
Flexible talk groups based on routes, location or other operational requirements.

Customisable
Tait solutions are renowned for their ability to be customised. Some of the features that can be used to tailor the system to your needs are:
- message format can be customised to suit user requirements
- dynamic control of reporting rate, for example, increased reporting rate in emergencies
- 16 message types to and from bus, including emergency, status and extended status
- control and monitoring of vehicle based systems via the bus radio.

Please contact Tait for a complete feature list and explanation of the benefits to your bus requirement.

As Tait has worked on large scale projects within the bus market, it understands the needs of both systems solutions providers and bus operators as we have wide experience of working closely with both, identifying requirements and meeting them within a specified framework.

Tait's bus communication systems are the result of intensive research in conjunction with bus operators and fellow technology providers around the world

TDMA Service Infrastructure Diagram

Existing Site Management Module		Backbone Network (if required)	
Existing Trunked Channel			
Existing Trunked Channel	ETHERNET		
TB8100 Data Channel Frequency 1	AUDIO — TCM — TMM	Digi Etherlite Port Server	T1541 Node Controller
TB8100 Data Channel Frequency 2	AUDIO — TCM — TMM	RS232 / 9600 BAUD	DIP IP / Dispatcher Application

KEY

Existing Taitnet Components	DIP - Dispatcher Interface Protocol
TDMA Service Components	TCM - TDMA Channel Module
Third Party Services or Components	TMM - TDMA Management Module

APPENDIX I -

Mesh Information

MESH4G™ Technology

(NOW Wireless web site http://www.nowwireless.com)

MESH4G™ technology is the most widely deployed and powers the largest mobile mesh networks in the world. MESH4G™-Enabled Architecture technology leverages patented and proven routing techniques originally developed for battlefield communications. By pushing intelligence and decision making to the edge of the network, high performance and scalable
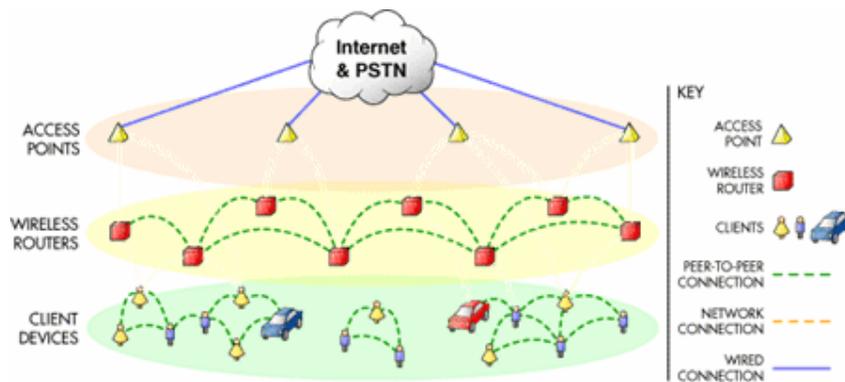
broadband networks can be built at very low cost.

Basics to Mesh Networking

Mesh networking is typically implemented in two basic modes: infrastructure and/or client meshing. To gain the maximum benefit that meshing can offer, both modes need to be supported simultaneously and seamlessly in a single network.

Infrastructure Meshing

Infrastructure meshing creates wireless back-haul mesh among wired Access Points and Wireless Routers. This reduces system back-haul costs while increasing network coverage and reliability.

Client Meshing

Client meshing enables wireless peer-to-peer networks to form between and among client devices (for example, end users) and does not require any network infrastructure to be present. In this case, clients can hop through each other to reach other clients in the network.

MESH4G™ Scalable Routing

At the heart of MESH4G™ ad-hoc networking technology is a highly efficient routing protocol designed specifically for use in Multi-Hopping™ wireless MESH4G™ networks – the MESH4G™ Scalable Routing protocol. This protocol is designed to work efficiently with or without centralised wireless infrastructure equipment (i.e. wired Aps or stations), which enables nodes to seamlessly transition between "infrastructure-enhanced" and client-based "peer-to-peer" networks.

Scalable Routing technology enables dynamic, self-forming, self-healing, Multi-Hopping™ routing between participating nodes in an ad-hoc (mesh) network. This protocol is a hybrid routing approach that leverages proactive and reactive routing techniques via situation-aware networking. With this methodology, network topology dynamics, local RF conditions and degree of node mobility influence the routing metrics used on a moment by moment basis.

The Scalable Routing protocol is self-optimising and delivers ultra-fast route convergence for mobile or RF hostile networks, while minimising overhead on a per node and system wide basis. This unique technique reduces the flooding overhead and latency usually associated with the route discovery process of classical reactive protocols, as well as the high routing overhead usually associated with classical proactive protocols. The situation-aware routing algorithms used in this protocol greatly enhances the scalability of the network, while supporting high mobility in real world, wide area networks. In addition, the algorithms used have been demonstrated to be free of routing loops in all topology and network conditions.

Scalable Routing technology leverages a real-time assessment of connectivity and other environmental factors to determine routes between nodes as well as end-to-end paths through the network. It learns of these conditions via a set of metrics supplied by Adaptive Transmission protocol services (see below). This continuous assessment of network and RF conditions also helps it accomplish "make before break" routing, resulting in smooth handoffs, seamless connectivity, and reliable communications for high speed mobile networks. Strong interaction with Adaptive Transmission protocol services also enables the Scalable Routing protocol to characterise the "bi-directionality" of a link. That is, the extent to which a wireless link can support symmetric data rates to and from a pair of nodes. The ability to characterise and assess asymmetric links is critical for real world wireless routing.

Adaptive Transmission Protocol Service

Many possible environmental conditions can interfere with data transmitted wirelessly, particularly broadband data in high speed mobility situations. Multipath, shadowing, fast fading, and interference (both intentional and unintentional) can all cause excessive packet loss at the receiver.

To deal with these conditions, the transmitter will be instructed to back down its data rate for a period of time. However, these RF conditions can appear on a highly dynamic basis. If the data rate is decreased for longer than the condition exists, link reliability may be satisfactory, but throughput is not maximised. If the data rate is raised too quickly while the condition continues, the resulting packet loss can also lead to poor data throughput. The purpose of Adaptive Transmission protocol services is to enable the Scalable Routing protocol to balance the requirements of a reliable transmission whilst assuring the highest data throughput rate possible on a packet by packet basis.

In addition to providing link quality metrics, these services inform the Scalable Routing protocol of the impact that transmit power level has on network capacity for a given link. For example, the high transmit power required by a particular link may create interference and uses channel resources (i.e. spectrum) unnecessarily. Adaptive Transmission protocol services provide multiple physical layer statistics to the Scalable Routing protocol, which then becomes power-aware. At the same time, these services actively determine the fastest data rate that can be achieved on a packet by packet basis for each link.

Quad-Channel Military Radio (QCMR)

QCMR radio technology uses Direct Sequence Spread Spectrum (DSSS) and operates in the ISM II 2.4 GHz bands. This radio is specifically designed and optimised for wide area, mobile mesh networking systems. It incorporates a multi-channel MAC (3 data channels and one control channel) that enables support for a higher density of meshed users than single channel MAC radios. Position/location technology is built-in to the QCMR radio and does not rely on GPS.

QCMR and the 802.11 Radio Protocol Compared

The question is often asked, "What is the difference between 802.11 and QCMR radio platforms?" The simple answer is that the radios are designed for different applications. The

QCMR radio exists to address markets that 802.11 cannot – specifically wide area & mobile data applications.

802.11 Background

The 802.11 radio protocol was designed to provide a cost effective alternative to the piece of LAN cable between the wall and the user's computer. When 802.11 was being designed, it was expected that the radio would be deployed indoors and the computer would remain relatively immobile. Subsequently, 802.11 was designed to provide very high data rates over short distances to stationary computers using a very low cost, low powered radio.

However, 802.11 has very little immunity from either self-induced or externally generated interference. These and other trade-offs were made to reduce the cost of 802.11. Unfortunately, it also worked to limit radio performance in such a way as to render 802.11 unusable in wide area mobile applications. Current 802.11 technology provides an excellent short range, fixed wireless solution as long as the required level of performance can be supported within the restrictions of these inherent limitations.

QCMR Background

On the other hand, QMCR broadband radios are optimised specifically for wide area, mobile ad-hoc networking applications. With origins based on military specifications and requirements, it was designed to provide reliable communications under the most demanding battlefield conditions.

QMCR radios benefit from having a high performance RF front end that includes capabilities such as multi-tap rake receivers (commonly found in cell phones) and real-time equalisation algorithms to compensate for the rapidly varying RF environments typically encountered in real-world mobile environments.

QMCR mobile broadband radios also incorporate increased error correction capability- again necessary for wide area and mobile communications. While this does limit the overall maximum burst data rate to 6 Mbit/s, it also improves the effective range for mobile users. Rather than the typical maximum of 300 feet for line of sight (LOS) transmissions for 802.11, QMCR radios have a range of 1 mile LOS. Both of these ranges are typical when using omni-direction antennas.

Enhanced interference rejection and signal sensitivity allow QMCR-based networks to provide multi-megabit data rates at speeds up to 250 mph, whereas 802.11 drops the radio link at about 20 mph under real world Multipath conditions.

QMCR also offers additional capabilities not found in the 802.11 standard. One very significant feature is a position location capability that provides better than 10 meter accuracy in a high speed mobile environment which is not reliant on GPS.

Its multi-channel MAC and Physical layers are optimised to meet the scalability and reliability required in mission critical mesh networks. RF challenges encountered in wide area mobile networks such as Doppler shifting, rapid Raleigh fading and Multipath are handled efficiently by the QMCR radio. QMCR solutions have been successfully deployed in Public Safety, transportation and Homeland Security mobile data networks.

MESH4G™ Positioning System

MESH4G™ Positioning System technology offers 3-D position, location and tracking capabilities without the use of GPS Satellites.

Fast and Accurate

Positioning System technology leverages patented position location and determination methods built into our QCMR radio, as well as sophisticated, but CPU efficient, heuristic processing. The core elements of this technology can be added to other radio platforms. Positioning System-enhanced products allow you to determine your own position or the position of any other user without the use of GPS satellites. Position location information, accurate to within +/- 10 meters, is generated in less than one second at mobility speeds of up to 200 mph!

No GPS Required

Since MESH4G™ Positioning System doesn't rely on satellites, it works in both exterior and interior locations where GPS will not. Position location is determined utilising sophisticated time of flight and triangulation information by using other devices in the network as reference points. These features are available in both infrastructure and ad-hoc peer-to-peer networks. Unique and powerful applications for military, public safety, telematics and m-commerce applications can be built with MESH4G™ products and technologies.

Works Where GPS Doesn't

The MESH4G™ Positioning System has been proven to perform in buildings, even collapsed structures. GPS technology can't begin match this level of performance. Precise location within a structure can be displayed via absolute positioning (i.e. geo-referenced co-ordinates) or relative positioning (distance from other nodes or users).

Supports Network and Client Based Applications

The position location of all clients and infrastructure nodes can be monitored in real-time from a network operations centre. Clients can also instantly determine their own location. All position location data is presented in industry standard format – so Positioning System data (absolute location information) works seamlessly with any GPS based application.

APPENDIX J –

System Integration Diagram

Lothian Buses

BusTracker Signs

SEStran Stakeholder Buses

TAndata Bus Station Signs

SEStran Signs

SEStran Stakeholder Buses

Nexus Alpha Bus Station Signs

Lothian Radio

CEC RAdio

SEStran Comms

SEStran Stakeholder Comms

BusTracker web / wap

SEStran web / wap

Tandata Bus Station Systems

Lothian Bus BusTracker

CEC BusTracker

SEStran AVL / RTPI

Nexus Alpha Bus Station Systems

Other 3rd Party RTPI Systems

Other 3rd Party Scheduled Information Systems

Lothian Bus Hastus Scheduling System

SEStran Routwise Bus Registration System

Fiirst Omnitimes Scheduling System

Stagecoach Trapeze Scheduling System

NB: Boxes are only colour coded to identify elements of the same type e.g. scheduling systems, RTPI signs etc.

Small Bus operator Service Registrations

SEStran System

Integration Schematic

APPENDIX K –

Budgetary Costs

SEStran Phase 1 Budget Costs - Capital

Item	Description	Unit price	SEStran	First	Stagecoach	Munro	Qty reqd	Purchase Cost
A1	Supply and installation of In-station hardware inc. processor, colour printer, database server and all necessary monitors and peripherals to meet the requirements of Part 3	£ 25,325.00	1				1	£ 25,325.00
A2	Supply and installation of instation operator terminals	£ 6,355.00		2	2	1	5	£ 31,775.00
A3	Supply and installation of Depot Terminals (for data transfer to vehicles)	£ 4,820.00		4	2	1	7	£ 33,740.00
A4	Supply and installation of Information Terminals	£ 4,315.00		5	3	1	9	£ 38,835.00
A5	Supply and installation of AVL system software for instation	£ 12,895.00	1				1	£ 12,895.00
A6	Supply and installation of bus operations analysis software for instation	£ 2,875.00	3				3	£ 8,625.00
A7	Supply and installation of RTPI system software for instation	Incl in A5					0	
A8	Supply and installation of Web-server and web PC & software (Optional)	£ 4,695.00	1				1	£ 4,695.00
A9	Supply and installation of SMS, WAP server (Optional)	£ 4,695.00	1				1	£ 4,695.00
A10	Supply and installation of TRANSXCHANGE data input/output facility	£ 75,000.00	1				1	£ 75,000.00
	Sub-total							£ 235,585.00

Item	Description	Unit price	SEStran	First	Stagecoach	Munro	Qty reqd	Purchase Cost
B1	Supply and installation of On-Bus Unit (OBU) including differential GPS, schedule database, all necessary peripheral switches, connections, cables etc. Includes necessary input/output ports for optional on-bus facilities detailed below	£ 1,960.00	94	217	146	43	500	£ 980,000.00
B2	Supply and installation of Interface to existing MPT 1327 voice radio system (if required) including all connections, system modifications etc.	£ 50,000.00		1			1	£ 50,000.00
B5	Supply and installation of on-bus data & voice radios	£ 1,035.00	94	217	146	43	500	£ 517,500.00
B6	Supply and installation of driver information unit	£ 565.00	94	217	146	43	500	£ 282,500.00
B7	Supply and installation of wireless LAN transceiver for depot upload downloads of data	£ 135.00	94	217	146	43	500	£ 67,500.00
B8	Supply and installation of Passenger counting facility including all cabling and fittings (optional)	£ 1,345.00		20	20	5	45	£ 60,525.00
B9	Supply and installation of Single line 20 character yellow LED on-bus display (optional)	£ 815.00	94	217	146	43	500	£ 407,500.00
B10	Supply and installation of on-vehicle digital audio stop annunciator system including 6 speakers and all cabling and fittings (optional)	£ 685.00	20	0	0	0	20	£ 13,700.00
B11	Supply and installation of facility to drive existing electronic bus destination boards including all cabling and fittings, hardware / software modifications to the OBU or 3rd party equipment (optional)	£ 145.00	0	0	0	0	0	£ -
B12	Supply and installation of Interface to Wayfarer III ticket machine facility including all software modifications, cabling and fittings	£ 40.00	94	217	146	43	500	£ 20,000.00
	Sub-total							£ 2,399,225.00

Item	Description	Unit price	SEStran	First	Stagecoach	Munro	Qty reqd	Purchase Cost
C3	Supply and installation of 3-line 30 character (29mm) LCD displays	£ 5,440.00	70				70	£ 380,800.00
C8	Supply and installation of 3-line 30 character (29mm) double sided LCD displays	£ 8,125.00	10				10	£ 81,250.00
C9	Supply and installation of 4-line 30 character (29mm) double sided LCD displays	£ 10,525.00					0	£ -
C10	Supply and installation of 5-line 30 character (29mm) double sided LCD displays	£ 11,930.00	10				10	£ 119,300.00
C11	**Description**	**Unit price**						
C12	Supply and installation of 10-line 30 character (29mm) ultra-bright yellow mcd LED displays for interchanges including 24 hr clock	£ 10,510.00	2				2	£ 21,020.00
C13	Supply and installation of 16-line 30 character (29mm) ultra-bright yellow mcd LED displays for interchanges including 24 hr clock	£ 14,750.00	2				2	£ 29,500.00
C16	Supply and installation of double sided 16-line 30 character (29mm) ultra-bright yellow mcd LED displays for interchanges including 24 hr clock	£ 27,630.00	0				0	£ -
C17	Supply and installation of 25-inch CRT monitor for interchanges	£ 4,605.00	4				4	£ 18,420.00
C18	Key Facility Signs: mounted internally						0	£ -
C19	Supply and installation of 25 inch CRT monitor	£ 4,965.00					0	£ -
C20	Supply and installation of 42 inch plasma screen	£ 9,925.00	2				2	£ 19,850.00
C21	Additional Optional Facilities							
C31	Additional cost for supply and installation of synthesised voice announcement facility including speakers, cabling and fittings within any sign	£ 1,085.00	20				20	£ 21,700.00
	Sub-total							£ 691,840.00

D	BUS PRIORITY	Unit price	SEStran	First	Stagecoach	Munro	Qty reqd	Purchase Cost
D2	Supply and installation of radio receiver, associated antenna and priority control unit	£ 1,750.00	50				50	£ 87,500.00
	Sub-total							£ 87,500.00
E	COMMUNICATIONS	Unit price	SEStran	First	Stagecoach	Munro	Qty reqd	Purchase Cost
								£ -
E1a	Control node	£ 60,000.00	1				1	£ 60,000.00
E1b	Base stations	£ 50,000.00	13				13	£ 650,000.00
E1c	Site access fee	£ 5,000.00	13				13	£ 65,000.00
E1e	Microwave back haul links (2 microwave ends)	£ 20,000.00	8				8	£ 160,000.00
	Allowance for leased lines to base stations	£ 5,000.00	3				3	£ 15,000.00
E1f	Leased lines to depots (set up)	£ 5,000.00	12				12	£ 60,000.00
E1g	Information terminal connections	£ 500.00	9				9	£ 4,500.00
	Connection to web hoster	£ 5,000.00	1				1	£ 5,000.00
E2	System for bus priority at traffic signals (include any costs not already in item B13)	inc in on-bus					0	
E3	Wireless LAN hardware and all associated software at bus operators premises	£ 7,860.00	7				7	£ 55,020.00
E4	Licence fees (12 months)	inc in E1					0	
E5	Site rental fees (12 months)	inc in E1					0	
	Sub-total							£ 1,074,520.00
F	System Integration Costs	Unit price	SEStran	First	Stagecoach	Munro	Qty reqd	Purchase Cost
F1	Omnitimes	£ 75,000.00	1				1	£ 75,000.00
F2	Trapeze	£ 75,000.00	1				1	£ 75,000.00
F3	Routewise	£ 75,000.00	1				1	£ 75,000.00
F4	BusTracker - server to server	£ 100,000.00	1				1	£ 100,000.00
	BusTracker - sign issues	£ 100,000.00	1				1	£ 100,000.00
F5	Tandata Bus Station Systems	£ 75,000.00	1				1	£ 75,000.00
F6a	Nexus Alpha Bus Station Systems	£ 75,000.00	1				1	£ 75,000.00
F7a	Web site design	£ 75,000.00	1				1	£ 75,000.00
F8a	Traffic Signals Ancillary costs	£ 2,500.00	50				50	£ 125,000.00
F9a	RTPI Ancillary costs	£ 1,500.00	100				100	£ 150,000.00
F10a							0	
	Sub-total							£ 925,000.00
G	PROJECT DELIVERY, WARRANTY & MAINTENANCE	Unit price					Qty reqd	Purchase Cost
F2	Licences	£ 15,000.00	5				5	£ 75,000.00
F3	Project management	£ 250,000.00	1				1	£ 250,000.00
F4	Training	£ 75,000.00	1				1	£ 75,000.00
F5	Documentation	£ 30,000.00	1				1	£ 30,000.00
							0	£ -
							0	£ -
	Consultancy support	£ 150,000.00	1				1	£ 150,000.00
							0	£ -
							0	£ -
	Sub-total							£ 580,000.00

Total		£	5,993,670.00

SEStran Ultimate Scheme Budget Costs - Capital

Item	Description	Unit price	SEStran	First	Stagecoach	Munro	Qty reqd	Purchase Cost
A1	Supply and installation of In-station hardware inc. processor, colour printer, database server and all necessary monitors and peripherals to meet the requirements of Part 3	£ 25,325.00	1				1	£ 25,325.00
A2	Supply and installation of instation operator terminals	£ 6,355.00		2	2	1	5	£ 31,775.00
A3	Supply and installation of Depot Terminals (for data transfer to vehicles)	£ 4,820.00		4	2	1	7	£ 33,740.00
A4	Supply and installation of Information Terminals	£ 4,315.00		5	3	1	9	£ 38,835.00
A5	Supply and installation of AVL system software for instation	£ 12,895.00	1				1	£ 12,895.00
A6	Supply and installation of bus operations analysis software for instation	£ 2,875.00	3				3	£ 8,625.00
A7	Supply and installation of RTPI system software for instation	Incl in A5					0	
A8	Supply and installation of Web-server and web PC & software (Optional)	£ 4,695.00	1				1	£ 4,695.00
A9	Supply and installation of SMS, WAP server (Optional)	£ 4,695.00	1				1	£ 4,695.00
A10	Supply and installation of TRANSXCHANGE data input/output facility	£ 75,000.00	1				1	£ 75,000.00
	Sub-total							£ 235,585.00
Item	**Description**	**Unit price**	**SEStran**	**First**	**Stagecoach**	**Munro**	**Qty reqd**	**Purchase Cost**
B1	Supply and installation of On-Bus Unit (OBU) including differential GPS, schedule database, all necessary peripheral switches, connections, cables etc. Includes necessary input/output ports for optional on-bus facilities detailed below	£ 1,960.00	1,000	0	0	0	1000	£ 1,960,000.00
B2	Supply and installation of Interface to existing MPT 1327 voice radio system (if required) including all connections, system modifications etc.	£ 50,000.00		0	0	0	0	£ -
B5	Supply and installation of on-bus data & voice radios	£ 1,035.00	1,000	0	0	0	1000	£ 1,035,000.00
B6	Supply and installation of driver information unit	£ 565.00	1,000	0	0	0	1000	£ 565,000.00
B7	Supply and installation of wireless LAN transceiver for depot upload downloads of data	£ 135.00	1,000	0	0	0	1000	£ 135,000.00
B8	Supply and installation of Passenger counting facility including all cabling and fittings (optional)	£ 1,345.00		0	0	0	0	£ -
B9	Supply and installation of Single line 20 character yellow LED on-bus display (optional)	£ 815.00	1,000	0	0	0	1000	£ 815,000.00
B10	Supply and installation of on-vehicle digital audio stop annunciator system including 6 speakers and all cabling and fittings (optional)	£ 685.00	500	0	0	0	500	£ 342,500.00
B11	Supply and installation of facility to drive existing electronic bus destination boards including all cabling and fittings, hardware / software modifications to the OBU or 3rd party equipment (optional)	£ 145.00	0	0	0	0	0	£ -
B12	Supply and installation of Interface to Wayfarer III ticket machine facility including all software modifications, cabling and fittings	£ 40.00	1,000	0	0	0	1000	£ 40,000.00
	Sub-total							£ 4,892,500.00
Item	**Description**	**Unit price**	**SEStran**	**First**	**Stagecoach**	**Munro**	**Qty reqd**	**Purchase Cost**
C3	Supply and installation of 3-line 30 character (29mm) LCD displays	£ 5,440.00	500				500	£ 2,720,000.00
C8	Supply and installation of 3-line 30 character (29mm) double sided LCD displays	£ 8,125.00	20				20	£ 162,500.00
C9	Supply and installation of 4-line 30 character (29mm) double sided LCD displays	£ 10,525.00					0	£ -
C10	Supply and installation of 5-line 30 character (29mm) double sided LCD displays	£ 11,930.00	20				20	£ 238,600.00
C11	**Description**	**Unit price**						
C12	Supply and installation of 10-line 30 character (29mm) ultra-bright yellow mcd LED displays for interchanges including 24 hr clock	£ 10,510.00	20				20	£ 210,200.00
C13	Supply and installation of 16-line 30 character (29mm) ultra-bright yellow mcd LED displays for interchanges including 24 hr clock	£ 14,750.00	10				10	£ 147,500.00
C16	Supply and installation of double sided 16-line 30 character (29mm) ultra-bright yellow mcd LED displays for interchanges including 24 hr clock	£ 27,630.00	10				10	£ 276,300.00
C17	Supply and installation of 25-inch CRT monitor for interchanges	£ 4,605.00	10				10	£ 46,050.00
C18	Key Facility Signs: mounted internally						0	£ -
C19	Supply and installation of 25 inch CRT monitor	£ 4,965.00					0	£ -
C20	Supply and installation of 42 inch plasma screen	£ 9,925.00	10				10	£ 99,250.00

		Unit price		SEStran	First	Stagecoach	Munro	Qty reqd	Purchase Cost	
C21	Additional Optional Facilities									
C31	Additional cost for supply and installation of synthesised voice announcement facility including speakers, cabling and fittings within any sign	£	1,085.00	100				100	£	108,500.00
	Sub-total								£	4,008,900.00
D	**BUS PRIORITY**	**Unit price**		**SEStran**	**First**	**Stagecoach**	**Munro**	**Qty reqd**	**Purchase Cost**	
D2	Supply and installation of radio receiver, associated antenna and priority control unit	£	1,750.00	150				150	£	262,500.00
	Sub-total								£	262,500.00
E	**COMMUNICATIONS**	**Unit price**		**SEStran**	**First**	**Stagecoach**	**Munro**	**Qty reqd**	**Purchase Cost**	
									£	-
E1a	Control node	£	60,000.00	1				1	£	60,000.00
E1b	Base stations	£	50,000.00	13				13	£	650,000.00
E1c	Site access fee	£	5,000.00	13				13	£	65,000.00
E1e	Microwave back haul links (2 microwave ends)	£	20,000.00	8				8	£	160,000.00
	Allowance for leased lines to base stations	£	5,000.00	3				3	£	15,000.00
E1f	Leased lines to depots (set up)	£	5,000.00	20				20	£	100,000.00
E1g	Information terminal connections	£	500.00	20				20	£	10,000.00
	Connection to web hoster	£	5,000.00	1				1	£	5,000.00
E2	System for bus priority at traffic signals (include any costs not already in item B13)	inc in on-bus						0		
E3	Wireless LAN hardware and all associated software at bus operators premises	£	7,860.00	20				20	£	157,200.00
E4	Licence fees (12 months)	inc in E1						0		
E5	Site rental fees (12 months)	inc in E1						0		
	Sub-total								£	1,222,200.00
F	**System Integration Costs**	**Unit price**		**SEStran**	**First**	**Stagecoach**	**Munro**	**Qty reqd**	**Purchase Cost**	
F1	Omnitimes	£	75,000.00	1				1	£	75,000.00
F2	Trapeze	£	75,000.00	1				1	£	75,000.00
F3	Routewise	£	75,000.00	1				1	£	75,000.00
F4	BusTracker - server to server	£	100,000.00	1				1	£	100,000.00
	BusTracker - sign issues	£	100,000.00	1				1	£	100,000.00
F5	Tandata Bus Station Systems	£	75,000.00	1				1	£	75,000.00
F6a	Nexus Alpha Bus Station Systems	£	75,000.00	1				1	£	75,000.00
F7a	Web site design	£	75,000.00	1				1	£	75,000.00
F8a								0	£	-
F9a								0	£	-
F10a								0		
	Sub-total								£	650,000.00
G	**PROJECT DELIVERY, WARRANTY & MAINTENANCE**	**Unit price**						**Qty reqd**	**Purchase Cost**	
F2	Licences	£	15,000.00	5				5	£	75,000.00
F3	Project management	£	250,000.00	1				1	£	250,000.00
F4	Training	£	75,000.00	1				1	£	75,000.00

Ultimate system

F5	Documentation	£	30,000.00	1	1	£	30,000.00
					0	£	-
					0	£	-
	Consultancy support	£	150,000.00	1	2	£	300,000.00
					0	£	-
					0	£	-
	Sub-total					£	730,000.00
	Total					£	**12,001,685.00**