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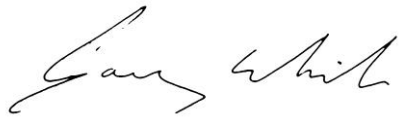
Report

Risk analysis of the Impact of 4G on Breathing Apparatus Telemetry

Prepared for

East Sussex Fire and Rescue Service

Prepared by



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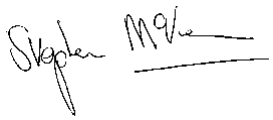

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EXECUTIVE SUMMARY

In support of the BA Telemetry Working Group, Risktec were asked to:

- Review all relevant research and background to this issue, which has informed the BA Telemetry Working Group so far;
- Provide guidance, where needed, on the latest outputs of the BA Telemetry Working Group (analyses, processes and templates). These will include information concerning proposed solutions with their various advantages and disadvantages from a variety of perspectives such as safety, risk, operation, technical etc;
- Review the proposed risk assessment template and assess its suitability to the task as well as review the risk criteria and develop a weighting criteria appropriate to the issue and safety concerns of the Group;
- Facilitate the BA Telemetry Working Group's Workshop in central London challenging the Group's thinking in terms of risk criteria, refine and agree the risk assessment, verifying the thinking on the solutions (both technical and operational) and applying the outcomes against each of the proposed solutions, currently identified.

It was noted that issues relating to finance, investment and solution design were either being dealt with by different Working Groups or would sit as a wider programme risk and thus were not considered in this document. It was also noted that the review of risks and the choice of solution was aimed at managing the risks to those FRSs who have already purchased BA Telemetry and not at FRSs who are currently waiting to procure BA Telemetry (though clearly the ultimate choice of solution will impact on both groups). The risks are therefore identified for existing users only.

The original risk template was reviewed with the qualitative assessment tables for likelihood and impact modified. It was noted that, since BA Telemetry was one of a number of controls that mitigate the risk to a firefighter when using BA, that loss of BA telemetry degrades the safety measures provided to keep the firefighter safe. The potential impact of interference has the effect of reducing the range that the firefighter can travel from the Entry Control Board (ECB) whilst remaining under the protection of BA Telemetry.

The use of the original risk template does not, therefore, allow a direct calculation of the risk affecting a firefighter from each of the options, however the process does allow the likelihood of hazards from each option to be assessed.

It was therefore proposed that, should more detail be required in the assessment of risk, that this would be better achieved using techniques such as fault and event tree analysis which allow for the combination of complicated sequences of events.

In identifying the risks much use was made of the existing SWOT analyses combined with new information provided by the on-going AEGIS research into SRD and LTE (4G) interference. It was recommended that the SWOT analyses should be updated and republished when the AEGIS/ERA research is complete.

There was not enough time available during the workshop on 9th November 2011 (and the AEGIS research into the practical effect of LTE and SRD interference had yet to be completed) for a comprehensive assessment of all the risks and issues that the CFOA Working Group are reviewing. Consequently this report is therefore issued as a framework to allow the Working Group to continue to identify and compare risks across the various options.

ISSUE RECORD

Issue	Date	Revision History
0.1	22-Nov-11	First issue for Client Comment
1.0	09-Dec-11	Formal issue to client
2.0	20-Dec-11	Revised to incorporate comments from the Operational Impact group.
3.0	06-Feb-12	Final issue incorporating further comments

DISTRIBUTION

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1 INTRODUCTION

1.1 Background

All Fire and Rescue Services (FRS) equip their firefighters with respiratory protective equipment in the form of breathing apparatus. This supplies individual firefighters with a self-contained supply of breathable air in order to protect them during fire fighting and other activities at a range of incidents.

Some FRS make use of an additional piece of radio equipment attached to the BA set which provides a data link to continually update officers on their firefighters' remaining air levels. The combination of both is known as BA telemetry.

BA telemetry uses frequencies at 862-863 MHz adjacent to the 800 MHz band (790-862 MHz) which is earmarked for 4G mobile broadband services. 4G is generally used to refer to mobile broadband services delivered using the next generation of mobile broadband technologies including Long Term Evolution (LTE) and WiMAX. There is a possibility that these future services might interfere with the telemetry component of the BA used by some FRS, but not with the breathing apparatus itself.

A study conducted by Thales (Reference 1) provides an initial assessment of the potential interference from LTE into BA telemetry, and further technical studies are underway.

A Working Group, known as the BA Telemetry Working Group, is made up of subject matter experts from the Chief Fire Officers' Association (CFOA), the Department for Communities and Local Government (DCLG) and Ofcom. This Working Group has been tasked with identifying a solution for managing any interference risk.

1.2 Scope and methodology

In support of the Working Group, Risktec were asked to:

- Review all relevant research and background to this issue, which has informed the BA Telemetry Working Group so far;
- Provide guidance, where needed, on the latest outputs of the BA Telemetry Working Group (analyses, processes and templates). These will include information concerning proposed solutions with their various advantages and disadvantages from a variety of perspectives such as safety, risk, operation, technical etc;
- Review the proposed risk assessment template and assess its suitability to the task as well as review the risk criteria and develop a weighting criteria appropriate to the issue and safety concerns of the Group;
- Facilitate the BA Telemetry Working Group's Workshop in central London challenging the Group's thinking in terms of risk criteria, refine and agree the risk assessment, verifying the thinking on the solutions (both technical and operational) and applying the outcomes against each of the proposed solutions, currently identified.

Thus, prior to the workshop, Risktec reviewed all the evidence, processes and templates and proposed modifications to these for discussion at the workshop. This report presents the key findings from the workshop with regard to the agreed risk process and criteria and the identified risks from 4G to each currently proposed option.

There has not been time for a comprehensive assessment of all the risks and issues that the CFOA Working Group are reviewing during the workshop. Consequently this report is issued as a framework to allow the Working Group to continue to identify and compare risks across the various options.

2 RISK ASSESSMENT AND CRITERIA

The workshop reviewed the proposed criteria to ensure the terminology used was appropriate for the hazards arising from 4G and the risk this may place on the FRS users of BA Telemetry. It is recognised that there are other users of BA Telemetry who would face the same impact and therefore the results of this process are applicable to those users.

In discussion of the risks it was identified that there were both operational and project related risks that need to be managed. Operational risks are those risks that impact operationally (e.g. injuries to firefighters) from the failure of BA Telemetry. Project related risks are risks that occur during the project to develop and introduce the agreed solution (e.g. project delays and financial impacts). However all risks are closed (or reduced to "residual" risks on completion of the project and/or the transition to Business as Usual (BAU). Both of these types of risks can affect one or more stakeholders (e.g. existing BA Telemetry FRS users, Government, potential BAT users).

It was noted that issues relating to finance, investment and solution design were either being dealt with by different Working Groups or would sit as a wider programme risk and thus were not considered here. It was also noted that the review of risks and the choice of solution was aimed at managing the risks to those FRSs who have already purchased BA Telemetry and not at FRSs who are currently waiting to procure BA Telemetry (though clearly the ultimate choice of solution will impact on both groups).

2.1 Severity / Impact

The first table that was reviewed was the Severity / Impact table which looks at the range of impacts of a hazard on the FRS. While a number of hazard categories were adopted it was unanimously agreed that any options would be addressed on the basis of Fire Safety; with other impacts (including finance) being of secondary importance.

		Safety	**Internal Organisation**	**Service Delivery**	**Reputation / Legal**
1	Minor	Minor injuries (non Riddor)	Crew loses confidence in equipment	Minor disruption (few mins)	Minor local reputation damage.
2	Moderate	Some Major Injuries (e.g. one BA Team Affected)	FRS loses confidence in equipment	Disruption to service for a few hours	HSE Investigation, Major national reputation damage Damage to reputation from an unrelated issue
3	Medium	Many Major Injuries (e.g. Multiple BA Teams Affected)		Restriction of service for up to 1 day	Prohibition notice, national adverse media coverage over a sustained period
4	High	Single Fatality	UK Wide loss of confidence in equipment	Restriction of service for more than 1 day (impounded equipment)	Work related death protocol leading to Police and HSE Investigation. Individuals investigated for corporate killings, fraud, etc. International adverse media coverage, short term.
5	Catastrophic	Multiple Fatalities		Restriction of service for more than 1 week	Work related death protocol leading to Police and HSE Investigation. Individuals convicted of corporate killing, fraud, etc. International adverse media coverage - >1year

TABLE 1: SEVERITY IMPACT

The original table had an additional consequence related to Financial Impact, however this was not seen to be of direct relevance to the first initial analysis, with financial issues being considered separately by a different group.

2.2 Likelihood

The likelihood table was split into two parts; one to look at the ongoing risks from 4G on BA Telemetry (and thus would be looking at the frequency of an incident, i.e. how many times per year) and the other part to look at project related risks of the development of any options (i.e. during the project what is the chance that?). These are shown in the two tables below.

	Likelihood	**Frequency of interference event sufficient to cause degradation of BA Telemetry Control**
1	Negligible	Once per year
2	Unlikely	1 – 10 times per year
3	likely	10 – 20 times a year
4	Very likely	20 - 50 times a year
5	Probable	➢ 50 times per year

TABLE 2: LIKELIHOOD (FREQUENCY)

	Likelihood	**Description**
1	Negligible	Less than 1% chance
2	Unlikely	Less than 25% chance of occurring
3	likely	25% to 50% chance
4	Very likely	50% to 75% chance
5	Probable	➢ 75% chance

TABLE 3: LIKELIHOOD (PROBABILITY)

2.3 Risk Criteria

The likelihood and impact can then be plotted on the Risk Criteria table (below). In general, where the risk is low then no additional controls are required; however continual assessment of the on-going tasks and processes should be carried out. Where the risk is evaluated to be medium then additional controls should be investigated so long as the cost involved is not disproportionate (i.e. the risk should be controlled to an As Low as Reasonably Practicable (ALARP) state). A high risk is an intolerable risk and either additional controls are required or an alternative means to achieve the task should be considered.

			Impact				
			Minor	Moderate	Medium	High	Catastrophic
			1	2	3	4	5
Likelihood	Negligible	1	1	2	3	4	5
	Unlikely	2	2	4	6	8	10
	Likely	3	3	6	9	12	15
	Very Likely	4	4	8	12	16	20
	Probable	5	5	10	15	20	25

2.4 Applicability

The development of these tables for qualitatively assessing the likelihood and impact of risk is a fairly standard methodology and works very well where hazards are clear and there is a direct relationship between the hazard and the consequential impact.

As was discussed during the workshop, however, it is clear that the consequential impact of interference from 4G (or other sources) on BA telemetry is to ultimately cause the failure of BA Telemetry. This on its own, however, does not have an immediate direct impact on fire-fighter safety since:

- there are a number of other controls already in place;
- the loss of telemetry would have to coincide with a situation where lack of this information would put the fire-fighter at risk.

There are other tools and techniques that would allow for the full capture of the different scenarios that could lead to a safety impact on a fire fighter, including Fault and Event Tree analysis. It may be that, should more detailed analysis of the difference in risk across the various options be required, that a Fault and Event tree study would allow a more accurate comparison of the risks.

3 RISK IDENTIFICATION

The workshop reviewed the SWOT analyses (Appendix 1) previously prepared for each option and looked at the risks associated with each. Although most effort was spent on looking at the steady state risks from 4G (i.e. when both 4G and the proposed options were fully implemented) the potential project related risks were also looked at (such as the effect of project delays etc).

The potential hazards and risks are looked at in the following sections.

3.1 Risk Impact

The initial discussions of the Working Group were that that the majority of fire-fighter injuries occurred through slips, trips or falls. If fatalities were caused where the telemetry had failed, this failure would need to be investigated to ascertain whether it was a root or sole cause. The concern centred on the unknown consequences that would result. An initial suggestion was that the severity rating might be a 3, but this required more detailed discussion.

It was agreed by the Working Group that, due to the difficulty in assigning a safety impact on the fire fighter, each option would take the fire fighter impact to be 'Minor' (i.e. minor injuries) since anything greater would require the failure of additional controls.

3.2 Risk Likelihood

The analysis of the likelihood of the BA Telemetry being affected by other transmissions is based both on the discussions during the workshop which is further supplemented by a 'BA Telemetry Technical Briefing Paper' (Reference 2) produced by OFCOM. This paper introduces the idea of a "protection distance".

To determine the protection distance from a potential source of interference, we look at signal strength, distance and objects which are in the way (clutter) and work out the minimum distance devices can be apart to ensure there is no significant effect of interference.

When there is a clear line of sight and a free path with no objects in the way (known as free space) the signal will travel further before it reduces to a level below the required Signal to Noise Ration (SNR). However conversely the greater the distance the more likely it is that there will be objects in the way. This is taken into consideration by modelling the "clutter" statistically into any calculations.

Putting this into an Operational context; if the protection distance can be maintained (perhaps via a cordon or by operational procedures) then there will be no impact to the telemetry system. Whilst in theory this ratio is helpful, in practice it might not be possible to maintain the recommended separation distance because excluding devices from the area may not be achievable.

As an illustration, if the required protection distance is quite short, say <10m, then provided the fire-fighters (users) are not carrying LTE equipment then there is a lower likelihood of interference than if the protection distance is larger. This is because in a larger protection distance there is more chance of LTE equipment being used in the larger 3-dimensional space.

Protection distances are designed with worst case scenarios/ranges in mind, so that they can give performance security above the noise floor in the vast majority of circumstances. Consequently they are likely to be more pessimistic than most real-life circumstances.

3.3 Option 1: Remain at 862.9625 MHz

This is the existing situation. The introduction of 4G has the potential for an interference effect on BA Telemetry. The Thales research (Reference 1) shows that the distance from a 4G user to the BA Telemetry ECB where interference will not be a problem is of the order of 3.5km in rural areas and 340m in urban areas. There is also on-going research from Aegis that shows this can be shown to be reduced further in practice by a factor of around 3.

The Working Group discussed this information and assigned a likelihood of 'Very Likely' (i.e. up to 50 times a year) that BA Telemetry would be sufficiently affected by 4G to cause operational problems.

No project risks are relevant for this option

3.4 Option 2: Move to 869.5 MHz (SRD Band)

There is still a hazard in this band from 4G interference, however due to the increased separation from 4G this means the effect is lower. The on-going Aegis research suggests that there is a factor of ten reductions in the distance that 4G will have an effect on BA Telemetry. Reference 2 looks at the effect of interference from LTE in this band by looking at protection distance. Taking a pessimistic protection ratio of 10 (higher values are more likely) this means that for LTE to have an effect on the BA Telemetry, then the BA Telemetry user must be 10x further away from the ECB than the LTE device.

For example, given a maximum distance of 70m (constrained by hoses, although this may not always be the case), this suggests LTE devices must be within 7m of the ECB. There is additional mitigation needed regarding the duty cycle of the different equipment and hence the chance of them both transmitting at the same time.

The Working Group therefore decided to assign this a likelihood of 'Unlikely' (i.e. 1 to 10 times per year) or even 'negligible'.

There is an additional risk in this band from SRD (Short Range Devices) interference. It was noted that:

- The SRD band is licensed (i.e. only approved devices can be used therefore the characteristics of these devices are known)
- The SRD devices are not found everywhere, many are of low power or use limited duty cycles thus will have limited impact on BA Telemetry. The most likely situation for interference being radio modems used industrially.

This was discussed by the Working Group. Although there are a number of unknowns (such as the potential for illegally used devices, etc) it was agreed that it was much less likely for these to have an impact on BA Telemetry than 4G in the current option (862.9 MHz) and was therefore assigned a likelihood of 'Unlikely'.

There are few project risks in this option since it is believed that the current equipment can be re-tuned to work in this band therefore no new technology is required. An on-going risk remains of the licensing of additional compliant devices in this band, however this is not expected to be any worse than interference from existing SRDs

3.5 Option 3: Move to 870-876 MHz

Since this band is even further away from 4G the chance of interference is reduced still further, however the Working Group agreed to keep the likelihood at 'Unlikely'.

There are, however, many unknowns about operating in this band. These include the potential for other devices to be introduced which may have more effect on the BA telemetry than either SRD or 4G in the previous options. While OFCOM may be able to influence the debate at the EU level, the outcome could not be guaranteed.

There are also significant potential project risks for this option:

- No existing commercial equipment exists – development and licensing may take several years (and the costs may be high if its use becomes UK only). During this time, the risks of option 1 continue
- The future of the band is not known till 2015

3.6 Option 4: Move to 450 - 470 MHz

There is currently negligible risk of interference from other devices.

The band is, however, heavily congested and negotiations would be required with other users (e.g. MoD, Home Office) to identify / allocate a frequency for FRS use. There were less out of band emissions but it was still a congested band. It was reiterated that arrangements could be considered between the emergency services and the MOD over this spectrum. If pursued as an option, OFCOM would assist with the co-ordination between the Working Group and the MOD.

On current understanding it was estimated that the likelihood of interference would be 'negligible'.

The Emergency Services Mobile Communications Programme requirements might mean that this band may not be available from 2016 onwards. This might result in the need for alternative options in the 400 MHz band to be considered

There are also significant potential project risks for this option:

- No existing commercial equipment exists – development and licensing may take several years (and the costs may be high if its use becomes UK only). During this time, the risks of option 1 continue.

3.7 Option 5: Convergence with Radio

This was a new option introduced at the workshop which involved linking the BA Telemetry to the fireground radio (would require digital fireground radio).

It was estimated that the likelihood rating, based on provisional research results, could probably be managed to be nil. While the severity rating would be consistent across all the options, it was suggested that given the long development time associated with this option, it should not be considered further as part of this assessment.

It was also noted that OFCOM has ongoing business-as-usual relationships with all its stakeholders. For this option, it could mean OFCOM giving ongoing technical and other input, if required, in the future. It was suggested to keep this development in mind for current strategic future thinking/roadmap for FRS operational communications.

4 RISK EVALUATION

The following table summarises the risks discussed in the workshop. It is noted that some of these are not quantified as no information was available. However it is not considered likely that they will be much (if at all) greater than those identified. The table below takes the agreed impact of 'minor'. However for comparison, to look at the effect of 'medium' impact the table is replicated with this information.

Hazard	Impact	Likelihood	Impact	Risk
Current Band (862.9 MHz)				
4G Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	4	1	4 (low)
SRD Band (869.5 MHz)				
4G Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	2	1	2 (low)
SRD Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	2	1	2 (low)
Higher Band (870 - 876 MHz)				
4G Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	2	1	2 (low)
Other device Interference	Loss of BA Telemetry resulting in minor injuries to firefighter			
Lower Band (450 – 470 MHz)				
Other device Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	1	1	1 (low)

The key effect on the overall risk is the selection of the impact as being minor injuries. Any increase in this would lead to the risk in the current band being at least 'medium' as shown below.

Hazard	Impact	Likelihood	Impact	Risk
Current Band (862.9 MHz)				
4G Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	4	3	12 (medium)
SRD Band (869.5 MHz)				
4G Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	2	3	6 (medium)
SRD Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	2	3	6 (medium)
Higher Band (870 - 876 MHz)				
4G Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	2	3	6 (medium)
Other device Interference	Loss of BA Telemetry resulting in minor injuries to firefighter			
Lower Band (450 – 470 MHz)				
Other device Interference	Loss of BA Telemetry resulting in minor injuries to firefighter	1	3	3 (low)

It is also noted that the other risk categories were not particularly reviewed. However discussion did take place regarding the internal effect on morale and confidence in the system. In these cases, should any interference on the BA Telemetry lead to it being unable to be used on a frequent basis this could lead to FRS across the UK losing all confidence in

the system. This could ultimately lead to a reluctance of firefighters to place reliance on BA Telemetry and thus removing its effectiveness as an additional control. It is recommended that this impact is investigated further.

5 CONCLUSIONS

The workshop involving the BA Telemetry Working Group reviewed the risks identified with each of the options regarding the impact of 4G on BA Telemetry.

The original risk template was reviewed with the qualitative assessment tables for likelihood and impact and were modified. It was noted that, since BA Telemetry was one of a number of controls that mitigate the risk to a firefighter when using BA, that loss of BA telemetry does not have a direct and immediate impact on the safety of a firefighter. It does, however, degrade the safety measures provided to keep the firefighter safe.

The use of the risk template does not, therefore, allow a direct calculation of the risk affecting a firefighter from each of the options, however the process does allow the likelihood of hazards from each option to be assessed.

It was therefore proposed that, should more detail be required in the assessment of risk, that this would be better achieved using techniques such as fault and event tree analysis which allow for the combination of complicated sequences of events.

In identifying the risks much use was made of the existing SWOT analyses combined with new information provided by the on-going AEGIS/ERA research into SRD and LTE (4G) interference. It was recommended that the SWOT analyses should be updated and republished when the AEGIS/ERA research is complete.

This report therefore should be used as a template to allow all risks to be identified and captured using a similar process and thus allow the risk to firefighters from each option to be compared.

6 REFERENCES

Ref Title

1 THALES Research and Technology (UK), *862 - 863 MHz Breathing Apparatus Telemetry System Interference Study*
P7784-10-003, Issue 2, December 2010

2 OFCOM, *BA Telemetry Briefing Paper*

APPENDIX 1

SWOT ANALYSIS

SWOT analysis - Current 862.9625 MHz

Strengths	Weaknesses
• Dedicated Emergency Services Band (fully licensed) • No hardware change required • Understand propagation environment (building penetration) • No co-existence issues with other FRS radio equipment • Minimal change required (cost and timescales) • Understood coexistence with adjacent SRDs • Good experience and robust operation over the last 10 years • Known upgrade path and confidence in the band • Industry standard and known costs	• No EU harmonisation (UK only) • Possible existing radio mic interference
Opportunities	**Threats**
• Less demand for band so easier to harmonise if technical solution found • Increase Tx power possible to improve • signal to interference	• Interference from LTE will limit range

SWOT analysis - 869.5 MHz (SRD)

Strengths	Weaknesses
• Various commercial products are available now • Minimal change required (cost and timescales) • Reduced costs • EU harmonisation (economies of scale) • No requirement for licence • EU/Republic of Ireland use this band – compatibility • Understand propagation environment (building penetration)	• Shared band with licence-exempt devices • Minimal regulatory protection • Public/FRS perception that licence-exempt bands are less safe than licensed bands • Device - no scope for increased power • No operational experience
Opportunities	**Threats**

• Use this as interim or permanent solution
• Suppliers:
  ○ Easy to provide in existing range of products
  ○ Commercially attractive
	• Possible interference from LTE
	• Possible interference from SRD
	• New compliant devices in this band increase band utilisation

SWOT analysis - 870 – 876 MHz

Strengths	Weaknesses
• Currently vacant spectrum (mostly) • Close to current allocation • Understand propagation environment (building penetration)	• No commercial off-the-shelf equipment known for this band • Future of band is not fully known until 2015 • EU pushing for smart metering (SRDs) or GSM-R in this band therefore no EU harmonisation
Opportunities	**Threats**
• May become shared band (all licensed) – reduced spectrum costs • Usage is not defined at all for this band • Scope for new power/technology • Possibility of licensing alongside other compatible technologies in this band	• Remains some possible interference from LTE • Band becomes completely licence- exempt • LTE for railways in part of this band? • Introduction of new LTE technology brings innovation in devices; increased complexity in band • It is unclear what the future may bring to this band

SWOT analysis - 450 - 470 MHz

Strengths	Weaknesses
• Dedicated Emergency Services band • Established licence costs under current structure	• No EU harmonisation • No UK/EU certified equipment (2 year development cycle) • Power • May need to change appliance storage options • Requires UK Certification
Opportunities	**Threats**
• Combining fireground radio and telemetry in one application • Range could be improved in this band • Existing US equipment in this band (cannot be used in the UK)	• Potential blocking by fireground radio on fire-fighter • Emergency Services Mobile Communications Programme (ESMCP) makes this band unavailable – 2016-2020?