Communications Working Group

Communications Technology Enhancement Committee

INTERIM REPORT

STAGE 1 – Breathing Apparatus &

HAZMAT Communications Solution

1. Introduction

As part of an ongoing Operational Review in the Queensland Fire & Emergency Services – Fire & Rescue Division a number of issues associated with the rollout of the Digital P25 Radio Network for Emergency Services known as the Government Wireless Network (GWN) in South East Queensland were identified, one of which is the no *hands fee* communication capability for Operational Crews when using Breathing Apparatus, particularly when conducting high risk internal operations, combatting Structure Fires. Instances are regularly encountered were Fire Fighting crews find it difficult to clearly understand communication messages when in noisy environments as well as operating restrictions when using of the current RSM while wearing full PPC.

QFES in partnership with the UFUQ formed the Communications Technology Enhancement Committee "CTE". The scope of the CTE Committee was to identify, test then implement any solution that could increase Firefighter Safety and enhance the ability to communicate with crews operating internally in noisy environments whilst wearing Breathing Apparatus. The scope was also extended to cover use of communication accessories across all streams in Fire & Rescue (QFES) including Hazardous Materials, Technical Rescue and in Command and Control.

The culmination of over twelve months navigating procurement and suitability issues led to the pragmatic test week for in mask or in helmet communications solutions that would help alleviate some of the real issues being faced by Officers and Firefighters. The testing conducted over three full days at the Tactical Training Unit (Live Fire Campus) revealed some potential enhancements that will require further testing and modification to ensure suitability as an interim solution for communications in noisy environments. It emphasised that any future acquisition must incorporate a coordinated and complementary acquisition process for the new Breathing Apparatus Solution on the expiration of the current Standing Offer Arrangement.

The pragmatic testing also identified the current RSM used by Fire Fighting crews had wind porting capability, but no specific noise cancelling capability which reduceS the ability for Fire Fighting crews to communicate while working in internal noisy emoluments. The CTE Committee formed the opinion that this issue must be addressed as a priority.

NOTE: the phrase "Critical Safety Issues" not in this version and the phrase "absolute priority" amended to "priority".

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2. Background

With the implementation of the Government Wireless Network (GWN) into Operations in South East Queensland in 2015 came the need to conduct a complete overhaul of Radio Communication procedures, equipment and training.

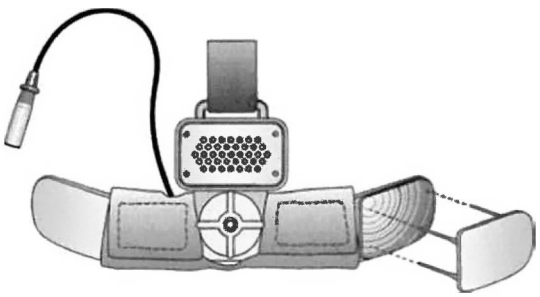
As part of the digital transformation the in-mask communication system that was used by Firefighters was found to be commercially unavailable and unable to be adapted to the new technology and was removed from service. The in-mask system was known as the "Guardian" communication system which consisted of a proprietary Radio Speaker Microphone (RSM) that connected to the analog UHF Radio designated the Motorola GP339.

Motorola GP339 & RSM

Guardian RSM with large red PTT

The RSM is unique in that was specifically built to work in extreme firefighting environments and had a large tactile Push to Talk (PTT) button on the front that was both easy to locate and operate with full level 2 Structural PPE, with the ability to plug in two different accessories.

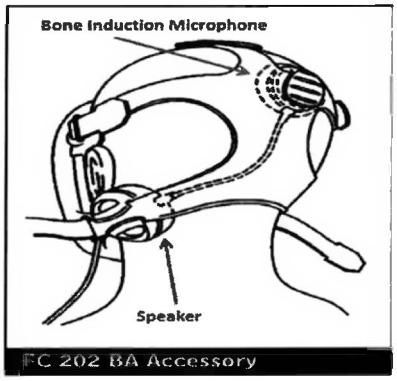
The first was an in helmet accessory that was issued to all Fire & Rescue Station Officers and fitted into to the helmet harness at the rear of the helmet, where a bone induction microphone and ruggedised speaker were collocated with a cable that connected to the accessory port in the RSM.



Drawing showing large speaker & connector *Photo (fitted) of in helmet comms*

The second accessory was fitted to all Self Contained Breathing Apparatus Facemask straps, consisting of a speaker connected by cable to a bone induction microphone, which was subsequently connected by cable to the RSM. With the Firefighter in Breathing Apparatus, operating in extreme environments regularly encountered in Structural Firefighting, the Guardian SCBA Accessory allowed clear communications in both transmission and reception.

Photo of accessory off mask



Drawing of accessory fitted to SCBA Facemask

The Guardian system (including accessories) was designed for the Queensland Fire & Rescue Service in partnership with the manufacturer to specifically address the outcomes of a 1997 Coronial Inquest into the deaths of two Queensland firefighters operating in Breathing Apparatus in a fire that is now known as the Southport Honda Fire, where lack of reliable communications (amongst other things such as accountability, lack of procedure & training) were seen to be contributing factors in the tragic incident. Whilst it took many years to design, test, train and integrate the Guardian system into Operations in Queensland it was a big step forward in firefighter safety as a reliable communications system that worked very well, particularly in noisy environments (and could be used across most streams of Fire & Rescue).

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3. Government Wireless Network Rollout

With the then QFRS as an active participant agency rolling out the Government Wireless Network in preparedness for the G20 conference, a QFRS Concept of Operations was promulgated to ensure that the new technology was fit for purpose and would not compromise Operational outcomes that had been building for fireground communications. It was identified in the QFRS GWN Concept of Operations clearly that Fireground Communications would rely on

portable radios and as such, these radios would ***"..... provide greater levels of safety for all users by introducing Duress, Automatic Resource Location (ARL), Intrinsically safe and Ruggedised equipment that has been manufactured for fire industry requirements"*** [1]

To achieve this operational concept the GWN Concept of Operations also identified the solution on page 22 of the document as the APX6000XE Radio combined with the APX XE RSM, clearly identified in the following pictures:

Figure 8 Motorola APX6000 XE

Picture from QFRS GWN ConOps page 21 (APX XE RSM)

APX XE (Extreme Environment) RSM

The Motorola APX XE (Extreme Environment) Radio Speaker Microphone accessory used with the APX series of digital radios is certainly built for firefighters for extreme environments, but has a simple drawback – it cannot be used with any accessories other than Bluetooth™ through the radio itself.

It has the following features:

- ***"The XE RSM is the first accessory from Motorola with dual microphones that helps suppress interfering background noise. It suppresses noise so effectively, you can be heard in some of the loudest environments; over pumper trucks, crowd noise and wailing sirens.***
- ***This high-visibility, bright green XE RSM features an asymmetrical shape to help you find the controls without looking, even while wearing bulky gloves.***

[1] 2014, QFES Concept of Operations, Government Wireless Network. QFES GWN Unit. Document ID: QFES QWN – 001. (Page 21 & 22)

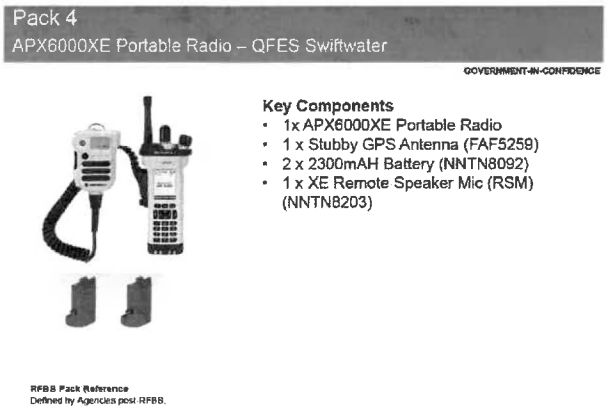
- ***The XE RSM features a large push-to-talk button and an extra-large emergency button that are both easy to locate, but shielded so they're not set off accidentally when running, crawling or climbing.***
- ***Easily accessible programmable buttons and a volume switch that ramps up and down make the microphone intuitive to use even in the most demanding conditions.***
- ***A large d-ring and sturdy clamping clip ensure your APX XE RSM stays attached to your turnout gear.***
- ***The XE RSM features a strobe light that activates when the emergency button is pressed, casting light up to 10 feet in thick smoke. And if the RSM gets sprayed with a hose or dropped in a pool of water, you'll see what rugged specs (IP68 submergibility) and a unique water-draining speaker design really mean."*** [2]

This combination of the APX6000 XE radio with Active Noise cancelling APX XE RSM was tested in the operational environment and, whilst not giving the same capability as the Guardian Communications unit, provided the ability to communicate in extreme environments provided adequate training was given to the user.

What followed prior to rollout of equipment into operations in South East Queensland is not fully understood and outside the scope of the CTE Committee, however the decision was made to rollout the APX6000 XE portable radios in conjunction with the Black RSM (HMN4103B). The CTE Committee now understands that Black RSM (HMN4103B) was selected for implementation due to having a connection port to enable hands free communication capability to be added at a later date, which seems like a sound decision, however selection of the Black RSM (HMN4103B) meant that radio end users have less noise cancelling capability. To date no suitable hands free communications devices have been identified to connect to the Black RSM (HMN4103B).

NOTE: the phrase "of great concern to all CTE Committee Members" is not in this version and neither is "significantly less capable". Paragraph added (underlined).

[2] 2017. NNTN8203 APX™ XE REMOTE SPEAKER MICROPHONE. Motorola Solutions. Accessed online @ https://www.motorolasolutions.com/en_xu/products/two-way-radio-accessories/audio-accessories/remote-speaker-microphones/nntn8203-apx-xe-rsm.html#tabaccessoryinfo



PACK 4 for Swiftwater use only

Pack 4A – Operational Firefighter use

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4. CTE Committee Pragmatic Test Days

After completing the rigorous procurement process, five vendors were able to meet the criteria set out for the acquisition of equipment to enhance SCBA communications. All five of these vendors were given half a day to allow the CTE Committee to put them through a basic course to test capability and performance against the following criteria:

1. Deployment, Connectivity and Mounting tests
2. Radio Transmission/Reception
3. Range of Motion testing
4. General Suitability
5. Pragmatic Testers Comments

With the resources consisting of Operational Staff and Committee members available on day one of Pragmatic tests, it was decided that to accurately assess the performance of communication solutions offered by vendors that baseline testing of existing equipment would be completed by the Operational Officers.

The baseline tests for Fire Fighting operations , completed with the Operational Combinations (Radio/RSM) as follows:

APX XE500 RSM + APX6000 XE Radio

Black RSM (HMN4103B) + APX6000 XE Radio

The results of the baseline testing revealed that the Black RSM (HMN4103B) when coupled with the APX6000XE Radio in a number of transmission and reception tests, even when used with the retractable lanyard (a device that allows placement of the RSM at the speech port of the SCBA), crews were unable to communicate when subjected to background noise of a positive pressure ventilation fan and two operating sprinkler heads. The APX XE 500 RSM coupled with the APX6000XE Radio did not perform favourably in a number of tests, but this was due to the fact that the RSM has five microphones for Active Noise Cancelling and required software configuration changes within the Radio itself, and was set aside for further investigation, although it also had no accessory ports.

NOTE: the phrase "non-compliant" is not in this version. Neither is "total communication failure" or "non-compliant" on a second occasion.

Consultation with the industry representative from Motorola Solutions revealed that there was no Active Noise Cancelling present in the Black RSM (HMN4103B), and that it had a rudimentary form of noise cancelling described as 'Windporting or Noise Cancelling', a proprietary Motorola RSM feature that consists of a membrane behind the microphone grill that cuts out wind noise and prevents water ingress.

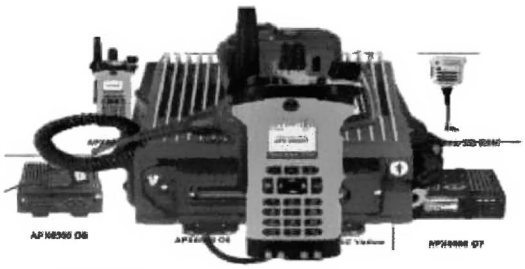
The use and understanding of the term Active Noise Cancelling and other variants of Noise Cancelling or Windporting is critical when the CTE Committee commenced operational testing

of Stage 1 - Breathing Apparatus and HAZMAT Communications Solution in February 2018. This was explained fully by the Motorola Representative and further explained in a redacted email attached as Appendix A. It is important in the context of this report to have a full understanding of the different forms of 'Noise Cancelling' as described by Motorola.

The CTE Committee sought audience with a representative of the QFES GWN Unit and received the explanation of the selection of the Black RSM (HMN4103B) that concurs with the following extract from the Recruit Training Course PUAOPE013A Operate Communications Systems and Equipment (Analogue and Digital). It states on page 81 that the Black RSM was selected as a result of pragmatic testing that showed the Black RSM (HMN4103B) had slightly better audio quality than the APX XE RSM (NNTN8375) and the Black RSM's ability to plug in accessories through the Motorola proprietary 8 pin plug (no fit for purpose accessory has been purchased or is available for use with the Black RSM in extreme environments).

2.9 GWN Subscriber Radios

APX6000XE hi-visibility yellow with eXtended Ergonomics (XE) for use with gloves. XE portables can be used with the IP68-rated black display-type remote speaker microphone which incorporates a speaker, microphone, volume up/down control, duress button and 2 programmable side buttons.



Note: The choice of black RSM was made due to its ability to accept plug in accessories and slightly higher clarity of transmission. Regions can choose to purchase an adapter to attach to the black RSM to enable the Guardian feature to be utilised.

At the next CTE Committee meeting is was unanimously resolved that an urgent SAFETY BULLITEN should be drafted. The CTE Committee approved final draft was endorsed and submitted to QFES GWN Unit as a priority via the committee . The SAFETY BULLITEN contained critical information on the identified reduced communication capabilities of the current RSM/Radio combinations when used in noisy environments. A Safety Bulletin has not been released, further consultation with the QFES GWN Unit identified that a release of a training note with the same detailed information would be sufficient communication and the training note would be developed by the CTE Committee and released by the QFES GWN Unit. (notes next page)

NOTE: the phrase "non-compliance" is not in this version. Neither is "complete failure" or the section related to minimizing impact. The CTE Committee was tasked outside of scope to conduct some

further testing to see if the results could be duplicated, and to conduct baseline testing on the Motorola ANC RSM (PMMN4102BGRN) that was only tested on Pragmatic test day using any accessory plugged in to the nexus connector (the accessory port on top of the ANC RSM, which also allows connection of a 3.5mm jack). The Motorola ANC RSM (PMMN4102BGRN) was not available when the GWN Concept of Operations was being developed and contains Active Noise Cancelling (although with a single microphone as source) and was critical during the Pragmatic Test as it allowed Third Party Accessories to be tested with the APX6000 XE radios. The additional baseline testing that was completed at Roma Street Fire Station on the 22nd February 2018 with Operational Crews, including a complete crew that had participated in the Pragmatic testing days at the Tactical Training Unit (Live Fire Campus).

Pictured below, the Motorola ANC RSM (PMMN4102BGRN) has been pivotal to testing and was chosen by the CTE Committee as a preferred option to replace the Non-Compliant Black RSM HMN4103B as it gave consistent audio performance in both transmission and reception audio clarity when used with the APX6000 XE radios as a Radio Speaker Microphone.

ANC RSM (PMMN4102BGRN) as used by FENZ

ANC RSM showing exaggerated controls and Nexus

The additional baseline tests conducted at Roma Street Fire Station were video and audio recorded, and the results have been uploaded to the CTE Committee Vimeo Channel and can be viewed at the following links. The audio was recorded remotely inside Roma Street Fire Station to give an independent awareness of RSM/Radio performance and can be accessed at the following links.

Access to the videos requires the following password:

Pragmatic Test 1: APX6000 XE + Black RSM (HMN4103B)

https://vimeo.com/259651018

Pragmatic Test 2: APX6000 XE + APX XE RSM (NNTN8375)

https://vimeo.com/259751917

Pragmatic Test 3: APX6000 XE + ANC RSM (PMMN4102BGRN)

https://vimeo.com/259805426

As demonstrated, all RSM's tested had difficulty when used in the closed environment with an active Distress Signal Unit (DSU) operating, however, both the APX XE RSM (NNTN8375) and the ANC RSM (PMMN4102BGRN) were Compliant.

All documentation regarding the Pragmatic Testing conducted by the CTE Committee is held by Project Management Office, and is available on request through the QFES Communications Working Group [redacted].

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5. SCBA in Mask/In Helmet Communications Accessory

The primary goal of the CTE Committee was to conduct a full market scan, pragmatically test and trial a solution or accessory that enabled Firefighters in full Structural Level 2 PPE and Self Contained Breathing Apparatus to communicate while conducting Operations in noisy environments. The market scan and subsequent offer delivered five vendors that had passed through desktop evaluation to Pragmatic Testing at the Tactical Training Unit (Live Fire Campus). Each vendor was allocated a half day to have any solutions tested through a process that included a simulated operational environment.

Solutions offered by vendors included In Helmet communications, Bluetooth to the APX600 XE radio solutions, in mask communications and boom style microphones. Vendors were given the opportunity to set up their offered equipment and then brief Operational Crews that participated in the testing. The results were then collated by , QFES Project Management Office and and applied weighting to ensure Operational Needs were identified. The CTE Committee reconvened and selected the most suitable piece of equipment for Operational Trials which are to commence as soon as the equipment is available from the successful vendor.

The Accessory that was selected by the CTE Committee for further testing was the Titan FIRECOMM HUC 5 Helmet Headset that was Compliant during the Pragmatic Test program and is able to be retrofitted to any existing helmet in use with QFES Fire & Rescue. It is personal

issue and able to be removed, cleaned and operated through the provision of a clip that is retrofitted to the helmet.

Titan FIRECOMM HUC 5 Helmet Headset

Nexus connector and speaker clip

The FIRECOMM HUC 5 has a noise cancelling microphone, is waterproof with an IP67 rating and has easily connected to the helmet via an in helmet clip. If the operator has multiple helmets then then supply of additional housing clips are a cheap and reliable way to transfer the personal communication system to all PPE.

It is to be noted that if operational testing and trials find the FIRECOMM HUC 5 to be fit for purpose that it is recognised only as an interim solution for Operational use for communication in noisy environments whilst conducting operations, and that the acquisition process for new SCBA at the expiration of the current Standing Offer Arrangement include in mask communication systems as a priority.

Operational Testing will begin utilising current Motorola APX6000XE radio with Motorola ANC RSM (PMMN4012BGRN) and Titan FIRECOMM HUC5 Helmet Headset and will be;

- Carried out at Kemp Place Station (Brisbane Region) and Surfers Paradise Station (South West Region)
- The equipment is to be tested by all personnel on Alpha Appliance (1x Station Officer, 3x Firefighter)
- Review forms are to be completed by crews at the end of each tour
- Personnel are to be issued own headset
- Additional 16 headsets and 18 helmet harnesses to be purchased through Pac Fire

As previously stated, all documentation regarding the Pragmatic Testing conducted by the CTE Committee is held by Project Management Office, and is available on request through the QFES Communications Working Group Chair .

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6. Findings and Recommendations

The Recommendations from the CTE Committee are divided into three sections, Past, Present and Future and should be read as such.

Findings and Recommendations from the CTE Committee marked in Bold and RED are issues that the CTE Committee have determined be addressed as a priority.

NOTE: the word "critical" is not in this version.

Past

1. Prior to GWN QFES used a Motorola GP339 with a bone conduction (Guardian) interface to allow for hands free communications whilst conducting Operations in SCBA

2. The APX 6000 XE radio was selected for the digital network

3. The Guardian Bone Conduction units were not compatible with GWN and the company ceased trading.

Informant advises that it was later found that Guardian was compatible and company did not go out of business, the ceased that part of their activities due to "a lack of communication from QFES".

4. Two RSM's were selected as suitable as an accessory to the APX 6000 XE radio.
    i. The Black RSM (HMN4103B) for Operational Firefighters
    ii. The Green APX XE (NNTN8203) for Swiftwater Operators

5. There are no suitable accessories available for the Black RSM (HMN4103B) or the Green APX XE (NNTN8203) to use for communications whilst conducting Operations in SCBA (see note above)

Present

1. During baseline testing the CTE Committee noticed a significant difference in intelligibility of radio transmissions between the Black RSM (HMN4103B) and Green APX XE (NNTN8203) when operated in the Simulated Operational Environment

2. **Pragmatic testing has confirmed reduced ability to effectively communicate when using the Black RSM (HMN4103B) with noise levels commonly encountered whilst firefighting.**

3. The Green APX XE (NNTN8203) which is specifically designed for internal firefighting operations and has performed well in the background noise

4. **QFES Firefighting Appliances only carry the Black RSM. Firefighters need to be aware of the limitations of the Black RSM, especially in high risk situations (DSU in Operations/Low Air Whistle Sounding)**

5. **The CTE Committee made two recommendations to manage this risk:**
   i. **Issue a Safety Bulletin to make firefighters aware of the potential risk, and to offer them suggestions on how to manage this issue in the event of a life-threatening situation. (QFES GWN Unit will release a Training Note identify precautions and limitations).**
   ii. **As an interim safety measure locate and place at least 1 Green APX XE (NNTN8203) (ideally 2) onto each frontline appliance to ensure that at least one of the firefighters in a BA Team will be able to transmit and receive messages over the noise of a DSU/Low Air Warning Whistle. (This has been agreed to and being actioned by the QFES GWN Unit).**

NOTE: in point 2, the phrase "non-compliance" is replaced with "reduced ability to effectively communicate"critical" is not in this version.

In point 4, the phrase "life threatening" is replaced with "high risk"

In point 5 (i) the bracketed sentence has been added
In point 5 (ii) the bracketed sentence has been added
Point 6 from the original has been deleted.

The Future

1. **Acquisition of a Radio Speaker Microphone to replace the Black RSM (HMN4103B) be prioritized.**

2. **The recommended replacement is the Motorola ANC RSM (PMMN4012BGRN)**

   to provide the following features;

a. Active Noise Cancelling
b. IP67 Rating
c. Large Tactile Push to Talk on front and side
d. Exaggerated Controls such as high/low volume
e. Nexus connector for the use of third party accessories
f. 3.5mm jack for additional accessories as required
g. Ability to adapt RSM/Accessory for use across all Fire & Rescue streams

3. **Continue acquisition and Operational Trial for SCBA Communications solution that has been determined by the CTE Committee as Titan FIRECOMM HUC 5**

4. Proceed to Stage 2 of the CTE Committee (including Tech Rescue, HAZMAT & Command and Control) Communication solutions

5. **Ensure that future procurement of Personal Protective Equipment (PPE) , Self-Contained Breathing Apparatus (SCBA), Personal Protective Clothing (PPC) and any other item for use in Operations are coordinated and integrated with communication solutions and not 'standalone' acquisitions**

NOTE: in point 1, the phrase "Critical Firefighter Safety Issue" has been deleted.

Appendix A.

Subject: Noise Cancelling in Motorola Remote Speaker Microphones

Hi [redacted]

As requested, here's some additional information on how the various different Motorola Remote Speaker Microphones (RSMs) apply noise cancellation to the sound that they hear before it is transmitted over the radio channel through an APX radio. There are effectively 3 different RSM configurations that we offer:

1. APX radio only (without any RSM):
In this configuration, the user speaks directly into either side of the radio. All APX portable radios have two embedded microphones, one on each side, and when the PTT button is pressed, the signal from both microphones is sent to a Digital Signal Processor (DSP) in the radio, where a sophisticated noise cancellation algorithm is used to determine which microphone is hearing nearby human voice, and therefore which microphone is hearing mainly background noise. The DSP then uses this information to intelligently cut out background noise from the audio containing the human voice and send the "cleaned up" audio to the radio transmitter. The DSP in the radio has a number of parameters (like noise cancellation level, microphone gain, etc) which can be configured using the radio programming software to optimise the noise cancellation for the intended environments in which the radio will be used.

2. APX radio with passive RSM (such as the HMN4103 Display RSM):
A lot of Motorola RSMs utilise a passive noise cancellation design called Windporting, where the mechanical design of the RSM is optimised to reduce the impact of wind on the internal microphone in the RSM. This functions in a similar way to the fluffy cover often seen on boom microphones used by TV crews, and is an effective way to minimise wind noise. When using one of these RSMs, the audio that the microphone hears is passed directly to the radio, where the radio's DSP then removes additional background noise (as per configuration 1 above, but taking input from a single microphone only).

3. APX radio with an Active Noise Cancellation RSM (such as the ANC RSM used by FENZ, the XE RSM and the XE500 RSM):
Our most advanced RSMs contain their own DSP chip within the head of the RSM and apply similar noise suppression algorithms to the audio before it is even sent to the radio. When these RSMs are used, the radio assumes that the audio has already been 'cleaned up' when it receives it, so it bypasses the DSP in the radio (as applying the same algorithm twice will generally make the audio sound worse). Also, as these RSMs were designed specifically for firefighting applications, the DSP parameters have been optimised for these environments, and are not alterable by the radio programmer.
The level of noise cancellation available depends on the number of microphones embedded in the RSM. The ANC RSM has a single microphone, the XE RSM has two microphones, and the XE500 RSM has five microphones. Furthermore, because of the issue of applying noise cancellation algorithms more than once, the ANC RSM does NOT apply any noise cancellation to audio that it receives through its NEXUS connector, as it makes the assumption that the upstream audio accessory has applied noise cancellation before passing the audio to the RSM.

I hope this provides more clarity on how Motorola's APX radios are able to provide active noise cancellation across the range of RSM configurations, but if you would like any further information, please don't hesitate to ask.

Regards,

[redacted]

MOTOROLA SOLUTIONS

Communications Technology Enhancement Committee

INTERIM REPORT

STAGE 1 – Breathing Apparatus &

HAZMAT Communications Solution

1. Introduction

As part of an ongoing Operational Review in the Queensland Fire & Emergency Services – Fire & Rescue Division a number of issues associated with the rollout of the Digital P25 Radio Network for Emergency Services known as the Government Wireless Network (GWN) in South East Queensland were identified, one of which was the inability to communicate effectively with Operational Crews when using Breathing Apparatus, particularly when conducting high risk internal operations when combatting Structure Fires. Instances of difficulty in execution of communications plans (changing channels), audio latency, loss of coverage, lack of accessories and partial or even total communications loss were regularly encountered operationally.

As a result, a Communications Working Group was formed in 2016 to address these issues as identified. One Sub-Committee of the Communications Working Group that formed as result of the Communication issues was to be known as the Communications Technology Enhancement Committee "CTE". The scope of the CTE Committee was to identify, test then implement any solution that could increase Firefighter Safety and enhance the ability to communicate with crews operating internally in noisy environments whilst wearing Breathing Apparatus. The scope was also extended to cover use of communication accessories across all streams in Fire & Rescue including Hazardous Materials, Technical Rescue and in Command and Control.

The culmination of over twelve months navigating procurement and suitability issues led to the pragmatic test week for in mask or in helmet communications solutions that would help alleviate some of the real issues being faced by Officers and Firefighters every day. The testing conducted over three full days at the Tactical Training Unit (Live Fire Campus) revealed some potential enhancements that will require further testing and modification to ensure suitability as an interim solution for communications in noisy environments. It emphasised that any future acquisition must incorporate a coordinated and complementary acquisition process for the new Breathing Apparatus Solution on the expiration of the current Standing Offer Arrangement.

The pragmatic testing also uncovered some Critical Safety Issues with the Digital Radio hardware and configuration of both Radios and Accessories currently in use in operations. The CTE Committee formed the opinion that these issues must be addressed as an absolute priority.

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2. Background

With the implementation of the Government Wireless Network (GWN) into Operations in South East Queensland in 2015 came the need to conduct a complete overhaul of Radio Communication procedures, equipment and training.

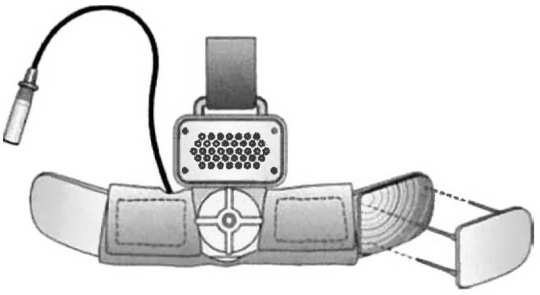
As part of the digital transformation the in-mask communication system that was used by Firefighters was found to be commercially unavailable and unable to be adapted to the new technology and was removed from service. The in-mask system was known as the "Guardian" communication system which consisted of a proprietary Radio Speaker Microphone (RSM) that connected to the analog UHF Radio designated the Motorola GP339.

Motorola GP339 & RSM

Guardian RSM with large red PTT

The RSM is unique in that was specifically built to work in extreme firefighting environments and had a large tactile Push to Talk (PTT) button on the front that was both easy to locate and operate with full level 2 Structural PPE, with the ability to plug in two different accessories.

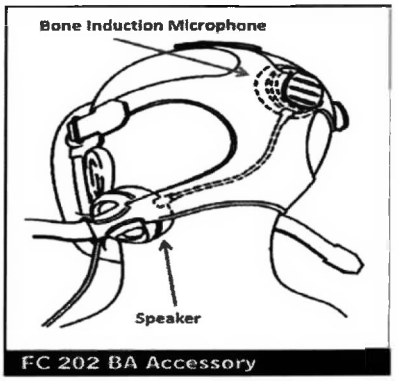
The first was an in helmet accessory that was issued to all Fire & Rescue Station Officers and fitted into to the helmet harness at the rear of the helmet, where a bone induction microphone and ruggedised speaker were collocated with a cable that connected to the accessory port in the RSM.



Drawing showing large speaker & connector *Photo (fitted) of in helmet comms*

The second accessory was fitted to all Self Contained Breathing Apparatus Facemask straps, consisting of a speaker connected by cable to a bone induction microphone, which was subsequently connected by cable to the RSM. With the Firefighter in Breathing Apparatus, operating in extreme environments regularly encountered in Structural Firefighting, the Guardian SCBA Accessory allowed clear communications in both transmission and reception.

Photo of accessory off mask



Drawing of accessory fitted to SCBA Facemask

The Guardian system (including accessories) was designed for the Queensland Fire & Rescue Service in partnership with the manufacturer to specifically address the outcomes of a 1997 Coronial Inquest into the deaths of two Queensland firefighters operating in Breathing Apparatus in a fire that is now known as the Southport Honda Fire, where lack of reliable communications (amongst other things such as accountability, lack of procedure & training) were seen to be contributing factors in the tragic incident. Whilst it took many years to design, test, train and integrate the Guardian system into Operations in Queensland it was a big step forward in firefighter safety as a reliable communications system that worked very well, particularly in noisy environments (and could be used across most streams of Fire & Rescue).

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3. Government Wireless Network Rollout

With the then QFRS as an active participant agency rolling out the Government Wireless Network in preparedness for the G20 conference, a QFRS Concept of Operations was promulgated to ensure that the new technology was fit for purpose and would not compromise Operational outcomes that had been building for fireground communications. It was identified in the QFRS GWN Concept of Operations clearly that Fireground Communications would rely on

portable radios and as such, these radios would ***"..... provide greater levels of safety for all users by introducing Duress, Automatic Resource Location (ARL), Intrinsically safe and Ruggedised equipment that has been manufactured for fire industry requirements"*** [1]

To achieve this operational concept the GWN Concept of Operations also evidently identified the solution on page 22 of the document as the APX6000XE Radio combined with the APX XE RSM, clearly identified in the following pictures:

Figure 8 Motorola APX6000 XE

Picture from QFRS GWN ConOps page 21 (APX XE RSM)

APX XE (Extreme Environment) RSM

The Motorola APX XE (Extreme Environment) Radio Speaker Microphone accessory used with the APX series of digital radios is certainly built for firefighters for extreme environments, but has a simple drawback – it cannot be used with any accessories other than Bluetooth™ through the radio itself.

It has the following features:

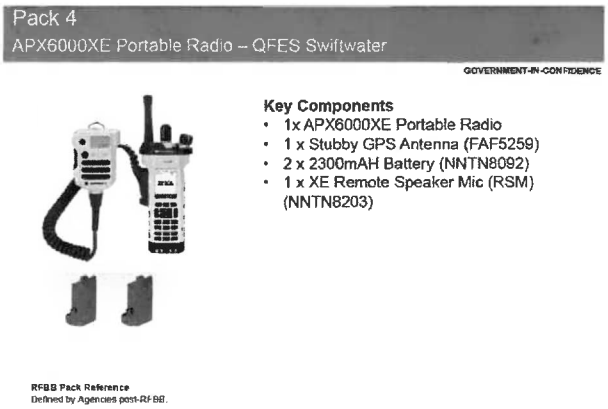
- ***"The XE RSM is the first accessory from Motorola with dual microphones that helps suppress interfering background noise. It suppresses noise so effectively, you can be heard in some of the loudest environments; over pumper trucks, crowd noise and wailing sirens.***
- ***This high-visibility, bright green XE RSM features an asymmetrical shape to help you find the controls without looking, even while wearing bulky gloves.***

[1] 2014, QFES Concept of Operations, Government Wireless Network. QFES GWN Unit. Document ID: QFES QWN – 001. (Page 21 & 22)

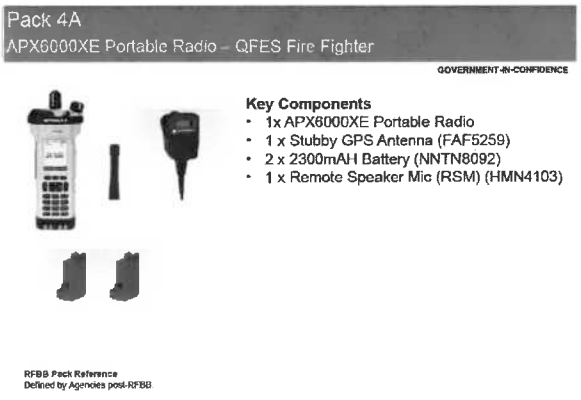
- ***The XE RSM features a large push-to-talk button and an extra-large emergency button that are both easy to locate, but shielded so they're not set off accidentally when running, crawling or climbing.***
- ***Easily accessible programmable buttons and a volume switch that ramps up and down make the microphone intuitive to use even in the most demanding conditions.***
- ***A large d-ring and sturdy clamping clip ensure your APX XE RSM stays attached to your turnout gear.***
- ***The XE RSM features a strobe light that activates when the emergency button is pressed, casting light up to 10 feet in thick smoke. And if the RSM gets sprayed with a hose or dropped in a pool of water, you'll see what rugged specs (IP68 submergibility) and a unique water-draining speaker design really mean."*** [2]

This combination of the APX6000 XE radio with Active Noise cancelling APX XE RSM was tested in the operational environment and, whilst not giving the same capability as the Guardian Communications unit, provided the ability to communicate in extreme environments provided adequate training was given to the user.

What followed prior to rollout of equipment into operations in South East Queensland is not fully understood and outside the scope of the CTE Committee, however, what is of great concern to all CTE Committee Members is the ultimate decision to rollout the APX6000 XE portable radios with the significantly less capable Black RSM (HMN4103B) to operational staff as part of the Product Catalogue – SEQ Project Portable Radio Equipment Packs PowerPoint for agencies.



PACK 4 for Swiftwater use only



Pack 4A – Operational Firefighter use

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[2] 2017. NNTN8203 APX™ XE REMOTE SPEAKER MICROPHONE. Motorola Solutions. Accessed online @ https://www.motorolasolutions.com/en_xu/products/two-way-radio-accessories/audio-accessories/remote-speaker-microphones/nntn8203-apx-xe-rsm.html#tabaccessoryinfo

4. CTE Committee Pragmatic Test Days

After completing the rigorous procurement process, five vendors were able to meet the criteria set out for the acquisition of equipment to enhance SCBA communications. All five of these vendors were given half a day to allow the CTE Committee to put them through a basic course to test capability and performance against the following criteria:

1. Deployment, Connectivity and Mounting tests
2. Radio Transmission/Reception
3. Range of Motion testing
4. General Suitability
5. Pragmatic Testers Comments

With the resources consisting of Operational Staff and Committee members available on day one of Pragmatic tests, it was decided that to accurately assess the performance of communication solutions offered by vendors that baseline testing of existing equipment would be completed by the Operational Officers.

The baseline tests, completed with the Operational Combinations (Radio/RSM) as follows:

APX XE500 RSM + APX6000 XE Radio

Black RSM (HMN4103B) + APX6000 XE Radio

The results of the baseline testing revealed that the Black RSM (HMN4103B) when coupled with the APX6000XE Radio was Non-Compliant in a number of transmission and reception tests, even when used with the retractable lanyard (a device that allows placement of the RSM at the

speech port of the SCBA), and had total communication failure when subjected to background noise of a positive pressure ventilation fan and two operating sprinkler heads.

The APX XE 500 RSM coupled with the APX6000XE Radio was also Non-Compliant in a number of tests, but this was due to the fact that the RSM has five microphones for Active Noise Cancelling and required software configuration changes within the Radio itself, and was set aside for further investigation, although it also had no accessory ports.

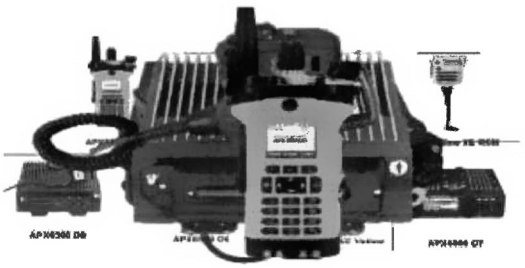
Consultation with the industry representative from Motorola Solutions revealed that there was no Active Noise Cancelling present in the Black RSM (HMN4103B), and that it had a rudimentary form of noise cancelling described as 'Windporting or Noise Cancelling', a proprietary Motorola RSM feature that consists of a membrane behind the microphone grill that cuts out wind noise and prevents water ingress.

The use and understanding of the term Active Noise Cancelling and other variants of Noise Cancelling or Windporting is critical when the CTE Committee commenced operational testing of Stage 1 - Breathing Apparatus and HAZMAT Communications Solution in February 2018. This was explained fully by the Motorola Representative and further explained in a redacted email attached as Appendix A. It is important in the context of this report to have a full understanding of the different forms of 'Noise Cancelling' as described by Motorola.

The CTE Committee sought audience with a representative of the QFES GWN Unit and received the explanation of the selection of the Black RSM (HMN4103B) that concurs with the following extract from the Recruit Training Course PUAOPE013A Operate Communications Systems and Equipment (Analogue and Digital). It states on page 81 that the Black RSM was selected as a result of pragmatic testing that showed the Black RSM (HMN4103B) had slightly better audio quality than the APX XE RSM (NNTN8375) and the Black RSM's ability to plug in accessories through the Motorola proprietary 8 pin plug (no fit for purpose accessory has been purchased or is available for use with the Black RSM in extreme environments).

2.9 GWN Subscriber Radios

APX6000XE hi-visibility yellow with eXagerated Ergonomics (XE) for use with gloves. XE portables can be used with the IP68-rated black display-type remote speaker microphone which incorporates a speaker, microphone, volume up/down control, duress button and 2 programmable side buttons.



Note: The choice of black RSM was made due to its ability to accept plug in accessories and slightly higher clarity of transmission. Regions can choose to purchase an adapter to attach to the black RSM to enable the Guardian feature to be utilised.

The Non-Compliance of the Black RSM (HMN4103B) and complete failure of both transmission and reception of same has raised serious safety concerns. At the next CTE Committee meeting is was unanimously resolved that an urgent SAFETY BULLITEN should be drafted as soon as possible. The CTE Committee approved final draft was endorsed and submitted to QFES GWN Unit as a priority via the committee [redacted]. The SAFETY BULLiTEN contained critical information on the identified deficiencies of the GWN RSM/Radio combinations currently in use by Operational Firefighters. Furthermore, information was included that could minimise the impact of these deficiencies. At the time of writing the Safety Bulletin has not been released by the QFES GWN unit.

The CTE Committee was tasked outside of scope to conduct some further testing to see if the results could be duplicated, and to conduct baseline testing on the Motorola ANC RSM (PMMN4102BGRN) that was only tested on Pragmatic test day using any accessory plugged in to the nexus connector (the accessory port on top of the ANC RSM, which also allows connection of a 3.5mm jack). The Motorola ANC RSM (PMMN4102BGRN) was not available when the GWN Concept of Operations was being developed and contains Active Noise Cancelling (although with a single microphone as source) and was critical during the Pragmatic Test as it allowed Third Party Accessories to be tested with the APX6000 XE radios. The additional baseline testing that was completed at Roma Street Fire Station on the 22nd February 2018 with Operational Crews, including a complete crew that had participated in the Pragmatic testing days at the Tactical Training Unit (Live Fire Campus).

Pictured below, the Motorola ANC RSM (PMMN4102BGRN) has been pivotal to testing and was chosen by the CTE Committee as a preferred option to replace the Non-Compliant Black RSM HMN4103B as it gave consistent audio performance in both transmission and reception audio clarity when used with the APX6000 XE radios as a Radio Speaker Microphone.

ANC RSM (PMMN4102BGRN) as used by FENZ

ANC RSM showing exaggerated controls and Nexus

The additional baseline tests conducted at Roma Street Fire Station were video and audio recorded, and the results have been uploaded to the CTE Committee Vimeo Channel and can be viewed at the following links. The audio was recorded remotely inside Roma Street Fire Station to give an independent awareness of RSM/Radio performance and can be accessed at the following links.

Access to the videos requires the following password:

Pragmatic Test 1: APX6000 XE + Black RSM (HMN4103B)

https://vimeo.com/259651018

Pragmatic Test 2: APX6000 XE + APX XE RSM (NNTN8375)

https://vimeo.com/259751917

Pragmatic Test 3: APX6000 XE + ANC RSM (PMMN4102BGRN)

https://vimeo.com/259805426

As demonstrated, all RSM's tested had difficulty when used in the closed environment with an active Distress Signal Unit (DSU) operating, however, both the APX XE RSM (NNTN8375) and the ANC RSM (PMMN4102BGRN) were Compliant.

All documentation regarding the Pragmatic Testing conducted by the CTE Committee is held by Project Management Office, and is available on request through the QFES Communications Working Group .

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5. SCBA in Mask/In Helmet Communications Accessory

The primary goal of the CTE Committee was to conduct a full market scan, pragmatically test and trial a solution or accessory that enabled Firefighters in full Structural Level 2 PPE and Self Contained Breathing Apparatus to communicate while conducting Operations in noisy environments. The market scan and subsequent offer delivered five vendors that had passed through desktop evaluation to Pragmatic Testing at the Tactical Training Unit (Live Fire Campus). Each vendor was allocated a half day to have any solutions tested through a process that included a simulated operational environment.

Solutions offered by vendors included In Helmet communications, Bluetooth to the APX600 XE radio solutions, in mask communications and boom style microphones. Vendors were given the

opportunity to set up their offered equipment and then brief Operational Crews that participated in the testing. The results were then collated by , QFES Project Management Office and and applied weighting to ensure Operational Needs were identified. The CTE Committee reconvened and selected the most suitable piece of equipment for Operational Trials which are to commence as soon as the equipment is available from the successful vendor.

The Accessory that was selected by the CTE Committee for further testing was the Titan FIRECOMM HUC 5 Helmet Headset that was Compliant during the Pragmatic Test program and is able to be retrofitted to any existing helmet in use with QFES Fire & Rescue. It is personal issue and able to be removed, cleaned and operated through the provision of a clip that is retrofitted to the helmet.

Titan FIRECOMM HUC 5 Helmet Headset

Nexus connector and speaker clip

The FIRECOMM HUC 5 has a noise cancelling microphone, is waterproof with an IP67 rating and has easily connected to the helmet via an in helmet clip. If the operator has multiple helmets then then supply of additional housing clips are a cheap and reliable way to transfer the personal communication system to all PPE.

It is to be noted that if operational testing and trials find the FIRECOMM HUC 5 to be fit for purpose that it is recognised only as an interim solution for Operational use for communication in noisy environments whilst conducting operations, and that the acquisition process for new SCBA at the expiration of the current Standing Offer Arrangement include in mask communication systems as a priority.

Operational Testing will begin utilising current Motorola APX6000XE radio with Motorola ANC RSM (PMMN4012BGRN) and Titan FIRECOMM HUC5 Helmet Headset and will be;

- Carried out at Kemp Place Station (Brisbane Region) and Surfers Paradise Station (South East Region)
- The equipment is to be tested by all personnel on Alpha Appliance (1x Station Officer, 3x Firefighter)
- Review forms are to be completed by crews at the end of each tour
- Personnel are to be issued own headset
- Additional 16 headsets and 18 helmet harnesses to be purchased through Pac Fire

As previously stated, all documentation regarding the Pragmatic Testing conducted by the CTE Committee is held by Project Management Office, and is available on request through the QFES Communications Working Group .

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6. Findings and Recommendations

The Recommendations from the CTE Committee are divided into three sections, Past, Present and Future and should be read as such.

Findings and Recommendations from the CTE Committee marked in Bold and RED are critical issues that the CTE Committee have determined be addressed as a priority.

Past

1. Prior to GWN QFES used a Motorola GP339 with a bone conduction (Guardian) interface to allow for hands free communications whilst conducting Operations in SCBA

2. The APX 6000 XE radio was selected for the digital network

3. The Guardian Bone Conduction units were not compatible with GWN and the company ceased trading

4. Two RSM's were selected as suitable as an accessory to the APX 6000 XE radio.
    i. The Black RSM (HMN4103B) for Operational Firefighters
    ii. The Green APX XE (NNTN8203) for Swiftwater Operators

5. There are no suitable accessories available for the Black RSM (HMN4103B) or the Green APX XE (NNTN8203) to use for communications whilst conducting Operations in SCBA

Present

1. During baseline testing the CTE Committee noticed a significant difference in intelligibility of radio transmissions between the Black RSM (HMN4103B) and Green APX XE (NNTN8203) when operated in the Simulated Operational Environment

2. **Pragmatic testing has confirmed Non Compliance when using the Black RSM (HMN4103B) with noise levels commonly encountered whilst firefighting**

3. The Green APX XE (NNTN8203) which is specifically designed for internal firefighting operations and has performed well in the background noise

4. **QFES Firefighting Appliances only carry the Black RSM. Firefighters need to be aware of the limitations of the Black RSM, especially in life threatening situations (DSU in Operations/Low Air Whistle Sounding)**

5. **The CTE Committee made two recommendations to manage this risk:**
    i. **Issue a Safety Bulletin to make firefighters aware of the potential risk, and to offer them suggestions on how to manage this issue in the event of a life-threatening situation**
    ii. **As an interim safety measure locate and place at least 1 Green APX XE (NNTN8203) (ideally 2) onto each frontline appliance to ensure that at least one of the firefighters in a BA Team will be able to transmit and receive messages over the noise of a DSU/Low Air Warning Whistle**

6. Workplace Health & Safety - General Duty of Care. At the time of writing QFES management have not acknowledged the Non-Compliance of the Black RSM (HMN4103B) as a safety issue and no Safety Bulletin or direction has been issued. It is a legal requirement for the Person Conducting Business or Undertaking to provide workers with information, instruction, training or supervision needed for them to work safely and without risks to their health

The Future

1. **Acquisition of a Radio Speaker Microphone to replace the Black RSM (HMN4103B) be prioritised as a Critical Firefighter Safety Issue**

2. **The recommended replacement is the Motorola ANC RSM (PMMN4012BGRN)**

   to provide the following features;

    a. Active Noise Cancelling
    b. IP67 Rating
    c. Large Tactile Push to Talk on front and side
    d. Exaggerated Controls such as high/low volume
    e. Nexus connector for the use of third party accessories
    f. 3.5mm jack for additional accessories as required
    g. Ability to adapt RSM/Accessory for use across all Fire & Rescue streams

3. **Continue acquisition and Operational Trial for SCBA Communications solution that has been determined by the CTE Committee as Titan FIRECOMM HUC 5**

4. Proceed to Stage 2 of the CTE Committee (including Tech Rescue, HAZMAT & Command and Control) Communication solutions

5. **Ensure that future procurement of Personal Protective Equipment (PPE) , Self-Contained Breathing Apparatus (SCBA), Personal Protective Clothing (PPC) and any other item for use in Operations are coordinated and integrated with communication solutions and not 'standalone' acquisitions**

Appendix A.

Subject: Noise Cancelling in Motorola Remote Speaker Microphones

Hi [redacted]

As requested, here's some additional information on how the various different Motorola Remote Speaker Microphones (RSMs) apply noise cancellation to the sound that they hear before it is transmitted over the radio channel through an APX radio. There are effectively 3 different RSM configurations that we offer:

1. APX radio only (without any RSM):
In this configuration, the user speaks directly into either side of the radio. All APX portable radios have two embedded microphones, one on each side, and when the PTT button is pressed, the signal from both microphones is sent to a Digital Signal Processor (DSP) in the radio, where a sophisticated noise cancellation algorithm is used to determine which microphone is hearing nearby human voice, and therefore which microphone is hearing mainly background noise. The DSP then uses this information to intelligently cut out background noise from the audio containing the human voice and send the "cleaned up" audio to the radio transmitter. The DSP in the radio has a number of parameters (like noise cancellation level, microphone gain, etc) which can be configured using the radio programming software to optimise the noise cancellation for the intended environments in which the radio will be used.

2. APX radio with passive RSM (such as the HMN4103 Display RSM):
A lot of Motorola RSMs utilise a passive noise cancellation design called Windporting, where the mechanical design of the RSM is optimised to reduce the impact of wind on the internal microphone in the RSM. This functions in a similar way to the fluffy cover often seen on boom microphones used by TV crews, and is an effective way to minimise wind noise. When using one of these RSMs, the audio that the microphone hears is passed directly to the radio, where the radio's DSP then removes additional background noise (as per configuration 1 above, but taking input from a single microphone only).

3. APX radio with an Active Noise Cancellation RSM (such as the ANC RSM used by FENZ, the XE RSM and the XE500 RSM):
Our most advanced RSMs contain their own DSP chip within the head of the RSM and apply similar noise suppression algorithms to the audio before it is even sent to the radio. When these RSMs are used, the radio assumes that the audio has already been 'cleaned up' when it receives it, so it bypasses the DSP in the radio (as applying the same algorithm twice will generally make the audio sound worse). Also, as these RSMs were designed specifically for firefighting applications, the DSP parameters have been optimised for these environments, and are not alterable by the radio programmer.
The level of noise cancellation available depends on the number of microphones embedded in the RSM. The ANC RSM has a single microphone, the XE RSM has two microphones, and the XE500 RSM has five microphones. Furthermore, because of the issue of applying noise cancellation algorithms more than once, the ANC RSM does NOT apply any noise cancellation to audio that it receives through its NEXUS connector, as it makes the assumption that the upstream audio accessory has applied noise cancellation before passing the audio to the RSM.

I hope this provides more clarity on how Motorola's APX radios are able to provide active noise cancellation across the range of RSM configurations, but if you would like any further information, please don't hesitate to ask.

Regards,

[redacted]

MOTOROLA SOLUTIONS