CALYTRIX PROFESSIONAL WHITE PAPER SERIES

Simulating Realistic Communications

Modern training, especially military training, occurs in a mixed Live, Virtual and Constructive (LVC) environment. In recent times the advances in 3D game engines in particular have been driven by a desire to provide high fidelity and visually realistic environments including advanced 3D graphics, improved physics models, destructible objects and large terrain areas; all of which contribute to the level of realistic immersion experienced by the end user.

However, visual immersion is only part of the total experience. Increasingly, training groups are seeking the same levels of realism across all elements of the simulated environment; specifically the ability to provide a 'lifelike' approach to simulated radio communications. This paper details the use of Calytrix's CNR-Sim family of products to provide a realistic, challenging and dynamic communications solution as an integrated part of the synthetic training environment.

SIMULATING REALISTIC COMMUNICATIONS: **Communicating with Effect**

Overview:

Simulated environments, such as 3D games, virtual environments, and part-task trainers are becoming increasingly visually realistic in order to provide an immersive training experience which stimulates realistic response and reactions from trainees. A similar increase in the underlying physics and logic models also ensures that the scenarios and situations facing trainees in the virtual world are realistic and challenging. These advances are due to a number of factors including the power of graphics hardware, more realistic and complex physics modelling and processing power, as well as increased bandwidth enabling distributed multi player environments. In providing realism and immersion in the visual environment, it is difficult to argue that a training system can ever be *too* realistic and the number of emerging technologies and companies in the visualization and gaming space, as well as their uptake, is testament to this belief.

However, unlike the visual domain, communications realism in the synthetic space has tended to be very simplistic, often providing no more than clear-comms (no distortion or delay) intercom style communications to replicate the realities of working with variable and often imperfect radio networks.

This paper explores the increasing role of realistic LVC training environments within modern military training; the imperative for realistic radio communications; and the solution provided by the CNR-Sim family.

End State:

"..but in case signals can neither be seen or perfectly understood, no captain can do very wrong if he places his ship alongside that of the enemy."

In so saying prior to the Battle of Trafalgar, Lord Nelson recognized that despite efforts to plan and train, his commanders must be prepared to act instinctively when communications are degraded or non-existent in the heat of battle. The maxim to 'train as you would fight' is increasingly realized through advances in modern military simulations, however the application of near perfect synthetic communications runs the very real risk that individuals are training for failure.

Calytrix's goal is to provide a radio communications suite capable of accurately and easily replicating the real world environment bringing increased fidelity to trainers and trainees in the manner they would expect.

The Adoption of LVC:

Outside of the first person perspective, mixed Live, Virtual and Constructive (LVC) technologies have continued to evolve ensuring that all elements of a training system can be synthesized to their greatest effect. Folding live elements into a synthetic environment plays an important role in a truly immersive environment, but increasing importance is being placed on stimulating and enriching live training through the injection of a range of simulated events and entities. This interplay between synthetically generated scenarios and augmented live exercise play offers numerous advantages and significantly enhanced training outcomes. Enrichment of live exercises through LVC integration offers significant cost savings, environmental savings and frees scarce operational assets from traditional training roles.

More importantly, the ability to augment live environments with a range of synthetic capabilities offers unparalleled access to platforms, procedures and capabilities which deploying forces would otherwise not be able to access until they were in theater. For example, successive rotations of Australian forces deploying to Afghanistan have been able to conduct Mission Rehearsal Exercises (MRE) involving a range of integrated simulated capabilities including ISR assets, C2 systems and Joint Fires effects through the use of LVC integration. This melding of the LVC environment provides enormous advantages for force preparation and training, particularly in a multi-national environment with differing tactics, procedures and systems in use.

Commensurate with advances in virtual and 3D technologies, the requirement to integrate the communications layer into LVC based exercises is critical if mission realism is to be achieved. Specifically, the ability to provide a bridge between simulated communications systems and live radio systems in a realistic manner is critical to achieving an immersive, cohesive and challenging training environment.

Regardless of the mix between live, virtual or constructive approaches to training events, there is a clear need to ensure that trainees, instructors, observers and other participants are provided with a comprehensive, realistically limited and flexible communications layer that presents the same challenges, capabilities and limitations imposed in real world operations.

Real World Training

Effective communications is an essential component of military training and at the heart of this training is the radio. Communications training is essential in preparing for a real world environment where ‘Loud and Clear’ is not always the reality, however ‘Clear Comms’ solutions are currently the norm in most virtual and constructive environments. The introduction of a fault free and clear communications environment in simulated training lacks reality, risks introducing negative learning outcomes and wastes valuable training opportunities.

Radios – Good with Interference

In a training environment there are a number of barriers which are often faced by groups setting up and training with realistic radio communications, these include:

- An inability to accurately emulate operational and environment restrictions;

- Lack of access to expensive and high-demand radio equipment;
- The administrative and security complications of issuing, accounting for and maintaining communications equipment; and
- Restrictions placed on RF emissions in training facilities and military establishments.

In order to address these limitations, trainers require access to a flexible suite of tools, both software and hardware based, which are capable of emulating real world conditions and equipment without the restrictions placed on the use of operational communications equipment. The use of radio emulators offers training establishments the opportunity to practice radio and voice procedures, and conduct mission training in an environment that closely mimics operational conditions.

A current restriction on communications management and procedural training in a virtual environment is the ability to re-create the often frustrating, but realistic, communications conditions experienced in the field. In order to address this issue at the training level, a well-designed communications training suite must be able to reflect:

- Design, management and use of the specified communications plan (COMPLAN);
- The requirement to manage and monitor a number of different radio nets;
- The effects of radio types, terrain and distance on radio signals;
- The impact of ambient and environmental noise;
- The type of equipment in use including frequency, antenna type, power, etc.; and
- Procedures to mitigate periodic equipment failure within the mission environment.

In Person

While this paper focuses primarily on radio communications there are also parallels to be drawn with the implementation of voice (face to face) communications, particularly in the 3D or First Person Shooter (FPS) domain.

Distributed training and multiplayer games pose their own challenges when it comes to simulating the types of communications required in a small team or one-on-one situation. Teams must be able to utilize realistic internal communications (intercom), particularly for mounted operations, while also maintaining the required external communications nets. Intercom through plain voice (outside of the virtual world) is not always possible when the trainees are either not physically located next to each other in the same classroom or when other players may overhear communications that they would otherwise not be privy to. A complete communications training solution must, therefore, be able to provide and capture this type of communication.

Other problems arise when trying to emulate accurate face-to-face communications within a constructive environment. The physical real-world location and the ‘virtual location’ of trainees will have an impact. As with the intercom issue, it is not always physically possible to co-locate teams to allow verbal face-to-face communication to take place in a classroom; and neither is this communication captured as part of the after action review (AAR) process. Similarly, it is

difficult to limit the talk to ensure it reaches only the intended recipients. Real world in-classroom talk between trainees also ignores the effects of their virtual location (distance) and the topography and structures within the game which will naturally impact their ability to communicate with each other. Background noise (rotor wash, gunfire, detonations, etc.) will also not be a feature of their real world chatter in the way it will in the virtual world.

What is required to emulate real world conditions is to ensure that *all* normal modes of communication (radio, intercom and plain voice) can take place within virtual environment. This ensures that:

- Any real world spatial considerations are replicated by the virtual ones;
- Communications do not bleed over in a busy training classroom(s) and reach the intended targets only;
- Environmental 'game noises' are incorporated in the communications environment; and most importantly
- That the conditions, limitations, restrictions (and frustrations) associated with communicating in an operational environment can be accurately replicated and implemented to suit the specific training objectives of the scenario in a realistic way.

CNR Background

Calytrix's Comm Net Radio (CNR) family of products has evolved from a simple voice-over-DIS application into a full communications suite capable of delivering a depth of fidelity to the virtual communications world that equals that of the visual and live environments.

CNR began as a radio-themed voice-over-DIS desktop application. The functionality overlaid some radio-like capabilities (channel management, PTT, VOX) with the ability to transmit clear-voice over a DIS network. From this foundation the CNR product line has grown through focusing on the intersection between what is needed to *model* the radio and what is needed to *support realistic communications and mission training*. Development of an SDK has allowed CNR to integrate directly with virtual systems such as VBS2/3, VENOM and others, while retaining the ability to operate as a standalone communications solution.

Recent development of CNR has been driven by several customer imperatives, specifically:

- **CNR as a Communications Platform:** Transitioning the simulation from a basic, voice-over-DIS application into a broader virtual communications platform that directly address the issues outlined previously;
- **Improved User Experience:** A refocus on CNR as a complete communications platform as opposed to a DIS VoIP solution has increased the ease-of-use and end user experience of the application;
- **Replication of Real World Effects:** The ability to simulate radio signal degradation based on terrain, radio types and environmental noise greatly increases the realism and training value of the CNR solution; and

- **Connection to the Live domain:** The provision of an interface to connect live/real radio systems into the virtual and constructive domain.

The CNR Family

Key to the philosophy behind the development of CNR is the ability to deliver flexible offerings to suit a range of customers and training environments. Calytrix CNR is not intended as a one-size-fits-all offering, rather allowing customers to select from a range of components to suit specific requirements and to add or upgrade as needs change. The main technical features of the CNR family include:

- DIS and HLA interoperability to ensure LVC interoperability,
- Use of existing computer infrastructure, either Linux or Windows, in order to reuse existing equipment without the need for proprietary networking or servers
- Unlimited user-defined channels (simulated frequencies) to allow the setup of realistic COMPLANS,
- Multiple choices for human interaction - keyboard, mouse, touchscreens, external devices,
- Application programmer's interface for remote control and embedded systems,
- Signal propagation and signal degradation effects,
- Interconnect real radios and simulated radios into a combined comms network,
- Record and playback for After Action Reviews,
- Software or hardware Push To Talk (PTT), and
- Advanced audio mixing for realistic comms.

The following table provides a summary of the CNR family of communications products:

CNR-Sim simulates communications via a multi-channel, Push To Talk (PTT) radio or Voice Operated (VOX) radio. CNR-Sim digitizes its user's voice into data packets that are sent across a standard computer network to other CNR-Sims (and compatible DIS/HLA radios) where the data packets are converted back to audio. Data packets comply with the Distributed Interactive Simulation (DIS) networking protocol standard.

CNR-Skins provides a set of pre-built, interactive, graphical radio faceplates ("skins") for more realistic operator training. Calytrix has modelled a number of radio faceplates to provide realistic, interactive controls and displays on a standard PC monitor or a touchscreen.

New skins can be added on request and current skins include:

- PRC-25
- PRC-119
- PRC-148 (MBITR)
- PRC-152
- PRC-117F/G, and
- CNR-9101a

CNR-Log records, replays and exports voice communications of DIS-based radios, making CNR-Log especially useful for After Action Reviews (AARs).

Features include:

- Recording
- Playback
- Filtering
- Unlimited Audio Sessions
- Radio IDs and Related Info
- Audio Export
- Real-time or Compressed Replay
- Configurable Network Controls

CNR-Effects adds realistic radio sound degradation effects to the CNR family. CNR-Effects calculates radio signal propagation and degradation effects based on the real physics of radio transmissions and receptions. The effects on received signal quality depend on the transmitting radio's power and antenna, the radio frequency in use, intervening terrain (including Line Of Sight), the receiving radio's antenna, and other factors. The result is a far more realistic simulated radio environment.

CNR-Effects calculates how radio signals are affected through open-air propagation, based on the:

- distance between the radio transmitter and receiver,
- Line of Sight (LOS) over terrain,
- building and vegetation,
- weather,
- radio frequency being used,
- power of the remote transmitter, and
- transmitter and receiver antennas.

Several different built-in radio signal propagation models are selectable by the CNR-Effects user, all of which are based on real-world electromagnetic physics. These models are:

- **Free Space Path Loss (FSPL)**: applicable to Short Wave (SW) and High Frequency (HF) transmissions,
- **Enhanced Free Space Path Loss (EFSPL)**: applicable to VHF and UHF bands,
- **Friis**: similar to but more advanced than FSPL, including consideration of transmitter and receiver antenna gains, and
- **Hata**: applicable in the 150 MHz to 1.5 GHz range, which covers cell phones and some military radios, and taking into account the differences in Urban, Suburban, and Open areas of operation.

CNR-Effects can be connected easily to externally-supplied (third-party) physics models for very advanced calculations and can interact directly with simulation terrain such as VBS3.

CNR-Monitor lets its user centrally administer a CNR-Sim network. Monitor is designed to allow instructors and training administrators to monitor, configure and control a large number of CNR radios in a single, or widely distributed, classroom environment.

CNR-Monitor allows administrators to:

- Remotely configure a single radio or a group of radios. Groups can be set manually or set automatically through user-defined rules.
- Remotely view the status of CNR-Sim radios, including operating frequency, transmit status and radio identifier.

- Apply smart-rules to CNR radios joining a network to ensure seamless configuration.

CNR-Live is a specialized interface device that connects real PTT radios into a computer network of simulated radios like CNR-Sim. CNR-Live's software, running inside the CNR-Live box, manages all the issues of bidirectional voice comms between the real radios and the computer network of simulated radios.

Through an easy to use GUI, CNR-Live users can map each real radio to any of the simulated radio channels. Live radio transmissions are able to be logged and re-played and CNR-Live will even allow re-transmission over different radios operating on different frequencies.

Each CNR-Live box is capable of supporting up to four live radios.

CNR-Sidetone is a small USB-powered audio mixing device that connects the user's headset and computer, providing several key features that dramatically enhance the audio realism within your simulated radio environment.

Based on user feedback, Calytrix developed CNR-Sidetone to provide significantly more realistic effects which include:

- **Sidetone Effect.** This amplifies the user's voice (microphone signal) and feeds that back into the user's headphones, and
- **Environmental Noise.** The mix of the sender's voice with virtual environment sounds is also transmitted. This enables simulated radio receivers to hear not only the user's voice but also the user's background sounds. For example, the radio transmission from a VBS2 user inside a helicopter would include the rotor wash background noise (instead of perfectly clear speech), dramatically increasing the effectiveness and realism of the sound environment.

CNR-Intercom allows users to hear each other just as they would inside a vehicle with a standard intercom system, without any delays or echoes that might be caused by software processing or network latency.

In addition, the individual users' voices and the composite "team" chatter can be separately processed by CNR-Sim and CNR-Log to realistically simulate combined vehicle Intercom and Radio systems with separated recordings and replays.

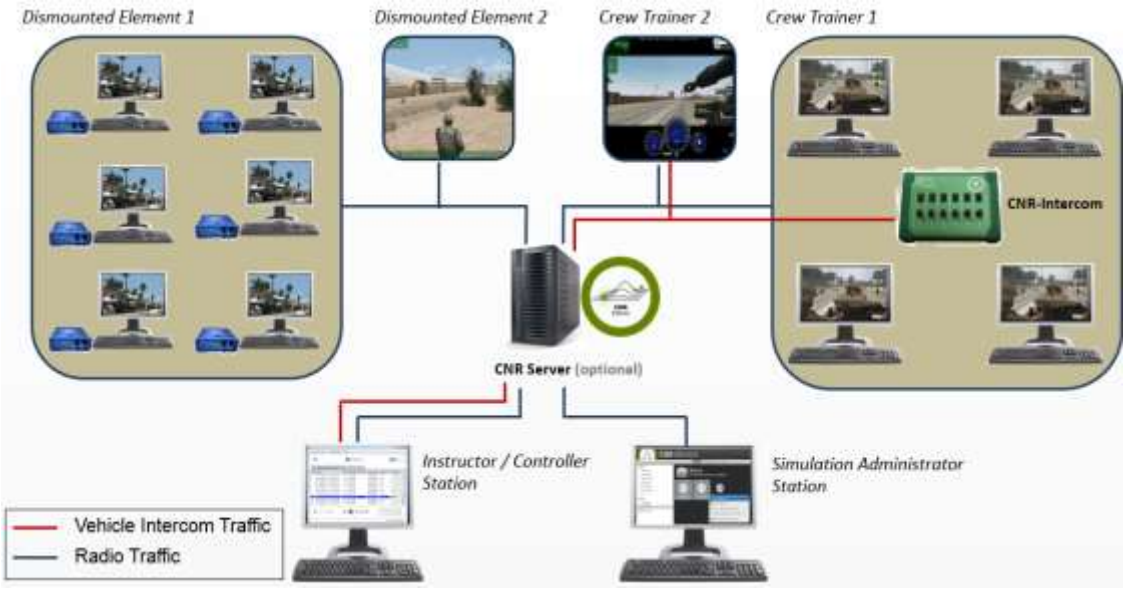
CNR-Intercom delivers a clear-speech hardware intercom solution in conjunction with an advanced simulated radio that combine to deliver a complete radio environment.

Collectively, the various CNR components can be applied to address a large range of communication training requirements. All of the communications requirements outlined above are designed to deliver a highly realistic platform for radio training.

CNR in Use

Use Case 1: Classroom Communications

This scenario demonstrates a classroom based communications architecture which blends any number of individual dismounted troops with vehicle based radio and intercom systems.



In this case, the dismounted elements have radio access through embedded CNR-Sim radio consoles (such as in VBS2/3). CNR-Effects is used to provide radio degradation across the virtual terrain also taking into account frequency, antenna type and power. In this scenario additional (optional) 'environmental noise' realism is provided by CNR-Sidetone which provides feedback to the user as well as transmitting ambient game noise such as gunfire or vehicle noise into the radio transmission.

Crew trainers are provided with the same level of radio access as well as the ability to communicate instantly and clearly together using the 'vehicle' intercom system (CNR-Intercom) with all radio and intercom traffic being logged and recorded for playback and after action review. Signal degradation is applied at the server level (using standard DTED terrain files) to ensure that factors such as distance, terrain profile, frequency, antenna type and power are taken into account.

Instructor/controllers are able to monitor the radio and intercom traffic in real time as well as utilise the logging and playback functions on CNR-Log to ensure high quality after action review. The playback functionality can be edited to provide multiple or single channel playback as well as isolating specific transmitters in time.

CNR-Monitor provides administrators and trainers the ability to rapidly configure all of the radios on the network ensuring rapid initial set up and transition between different training scenarios.

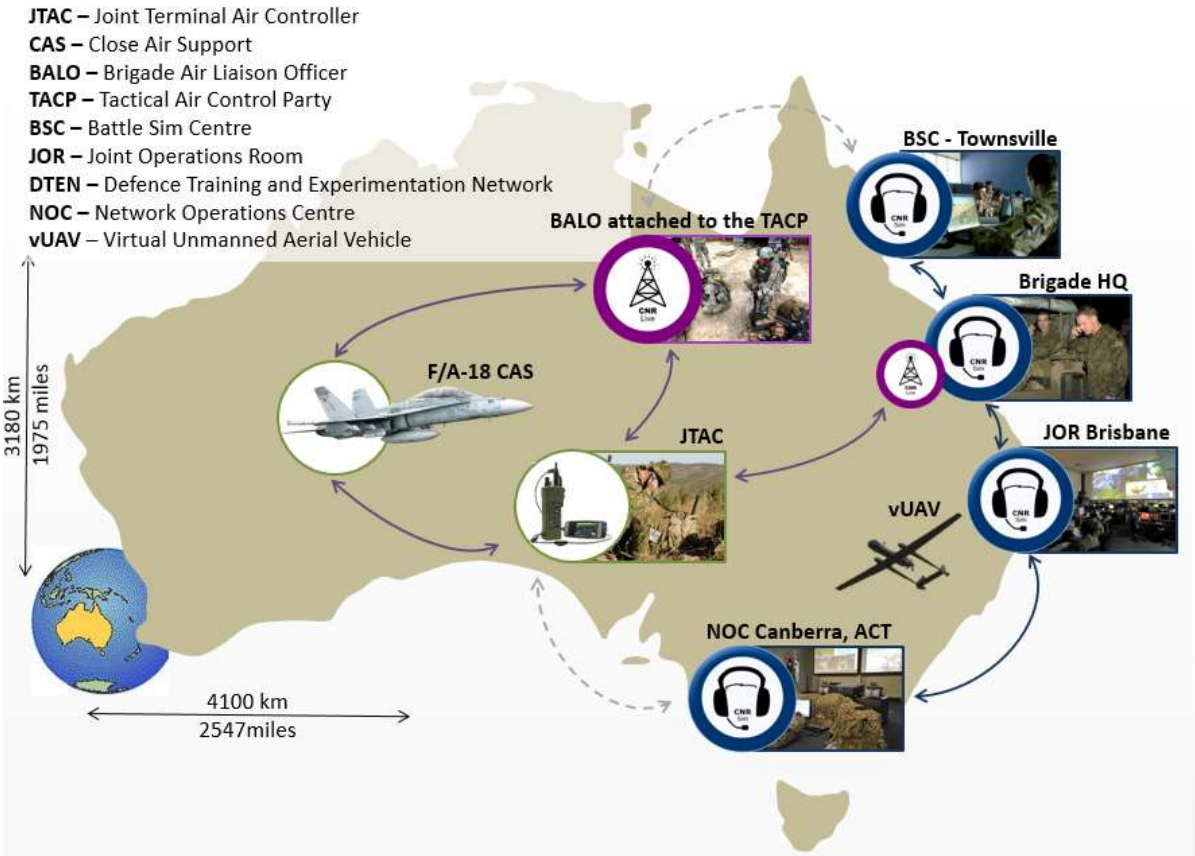
The ability to define 'smart groups' in CNR-Monitor allows administrators to apply different configuration settings across large numbers of radios by defining logical radio groups.

Use Case 2: Integrated Live Radio

The following use case demonstrates the requirement for the integration of simulated and live radios within the one training environment. Increasingly, the integration of numerous live personnel and assets supplemented by constructive and virtual capabilities demands that radio communications are also able to operate in real time between the live and virtual domains.

Both CNR-Sim and CNR-Live provided critical communications support during the Australian Defence Force's Pozieres Prospect 13 exercise. Described as the '*single largest and most complex simulation enabled, C2 Integrated event ever delivered in Australia*'.

Spanning some 1,800 kilometers (1,100 miles) the communications architecture needed to incorporate deployed live radios, ground to air communications, remote simulation interactors as well as headquarters and simulation control elements between the Shoalwater Bay Training Area (SWBTA) in far north Queensland, Townsville and Brisbane in Queensland and Canberra in the Australian Capital Territory:



Joint Terminal Air Controllers (JTACs) deployed in the SWBTA used live radios to talk to assigned aircraft and the HQ elements as well as to Virtual UAV operators located in Brisbane. The Brigade Air Liaison Officer (BALO) was deployed in the field with the Brigade HQ in Townsville and used a radio connection to a CNR-Live box to manage the BDE air space, and deliver Time Sensitive Targeting (TST) information to the Air Force simulation interactors in who were located in Brisbane.

All of the radio traffic (live and simulated) was logged and recorded from the Network Operations Centre (NOC) located well south in Canberra. For the first time in this type of exercise, the Headquarters Joint Operations Command was also able to monitor live radio traffic from an exercise which was occurring two states and 1,800 km to the north.

This exercise also highlighted the value of being able to 'virtually co-locate' various maneuver elements which would normally operate in proximity to each other. The challenge for this type of simulated event is to be able to replicate the level of communications expected when these elements would normally be geographically close.

For the Pozieres Prospect 13 Exercise, the Amphibious Task Group (ATG) used 45 laptops with CNR-Sim boxes to coordinate actions between the Joint Operations Room (JOR), the Ship-to-Objective Maneuver (STOM) cell and the simulation interactors over a Wide Area Network (WAN) between Townsville and Brisbane. At the same time an Army Brigade was using CNR-Sim for each of the Battle Groups in the simulation centre, as an alternative to using real radios; ensuring that radio communications precisely replicated the scenario being played out.

Use Case 3: Radio Training Solutions

Calytrix has worked with the Australian Army's Forces Command (FORCOMD) to develop a suite of deployable, or desk top, radio training solutions based on the CNR range of products.

As part of an integrated Battlespace Communications System for the ADF's land elements, the Army replaced current land based analogue radios with digitized combat net radios. The broad base of issue combined with the increased complexity of the radio generated a significant training liability, associated with both the initial training component and continuation training for the radios.

In order to mitigate the significant material and administrative cost of radio training a training system that is enabled by radio 'emulators' reduces the material costs of the total number of radios and peripherals held in training establishments as well as the administrative and security complications of issuing, accounting, maintaining, charging and cryptographic management.

The solution based on Calytrix's CNR-Skins and delivered both basic radio procedural training and familiarity with a number of different radios delivered under the project. Including CNR-Live, the training suites incorporated live radios to create a blended learning environment while delivering significant cost advantages and increasing access to radio training.

Conclusion

The case for fidelity and accuracy in the visualisation of virtual worlds has long been established and is increasingly being realised through enhanced game engines supported by greater bandwidth, more realistic physics models and increased processing power. Many of the same factors have also allowed for the provision of consistent, easy to manage and clear communications channels within the gaming environment.

While visual and physical clarity clearly support a more immersive and valuable training environment, the reverse is true for communications. This is especially so for radio communications which are subject to a range of limitations that can impact operational outcomes. Perfect communications does not reflect reality. Without the ability to model and manage realistic limitations in a training setting, there is an inherent risk of 'training for failure' by not imposing the same sort of conditions in a virtual environment that trainees will experience in an operational one.

The range of Calytrix CNR products supports all elements of communications training: initial RATEL training and radio familiarisation through the use of CNR Skins and Pro, realistic degradation through CNR Effects, voice communication and platform communications through CNR Intercom, background noise with CNR Sidetone and the ability to link the simulated environment with the live environment through the CNR Live. The use of these systems to support communications will enhance the realism of training while reducing the need, and subsequent cost, of using real radios.

Communications training is essential,
but 'Loud and Clear' is not always the reality.

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