U.S. Fire Administration

美國消防局

Voice Radio Communications Guide for the Fire Service

消防語音無線電通信指南

June 2016

2016 年 6 月

FEMA
美國救難總署

U.S.FireAdministration
美國消防局

MissionStatement
使命聲明

We provide National leadership to foster a solid foundation for our fire and emergency services stakeholders in prevention, preparedness, and response.

我們提供國家領導力，在預防、整備及應變方面，為我們的消防與應急服務機構樹立堅實的基礎。

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Acknowledgment
致謝辭

The U.S. Fire Administration (USFA) is committed to using all means possible for reducing the incidence of injuries and deaths to firefighters. One of these means is to partner with organizations that share this same admirable goal. One such organization is the International Association of Fire Fighters (IAFF). As a labor union, the IAFF has been deeply committed to improving the safety of its members and all firefighters as a whole. This is why the USFA was pleased to work with the IAFF through a partnership supported by the U.S. Department of Homeland Security (DHS), Science and Technology Directorate, First Responders Group, Office for Interoperability and Compatibility to develop this second edition of the "Voice Radio Communications Guide for the Fire Service." The USFA gratefully acknowledges the following leaders of the IAFF for their willingness to partner on this project:
美國消防局（USFA）致力於減少導致消防人員的死傷意外事件。採取的方法之一是與同樣以此目標為主的組織合作，而其中一個合作的組織是國際消防員協會（IAFF）。身為工會的 IAFF 致力於改善其會員與所有消防員的安全。基於此，美國消防局很樂意透過美國國土安全部（DHS）科技局第一反應小組互操作性與兼容性辦公室，與 IAFF 合作開發第二版「消防語音無線電通訊指南」。USFA 非常感謝下列 IAFF 成員願意參與此計畫。

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The IAFF also would like to thank Robert Athanas, Firefighter, Fire Department City of New York; Todd Bianchi, Captain, District of Columbia Fire Department; Jim Brinkley, IAFF Director of Occupational Health and Safety; Joseph Brooks, Radio Supervisor, Boston Fire Department; Thomas Chirhart, DHS; Billy Freeman, Lieutenant, Memphis Fire Department; Missy Hannan, Graphic Artist, International Fire Service Training Association (IFSTA)/Fire Protection Publications, Oklahoma State University; Ron Jeffers, Union City, New Jersey; Christopher Lombard, Captain, Seattle Fire Department; Andy MacFarlane, Phoenix, Arizona; Kevin Roche, FACETS Consulting; Wes Rogers, Lieutenant, Fairfax County Fire and Rescue Department; William Troup, USFA; Mike Wieder, Associate Director, IFSTA/Fire Protection Publications, Oklahoma State University; Cody Worrell, Firefighter, Phoenix Fire Department; and Mike Worrell, Battalion Chief, Phoenix Fire Department, for their efforts in developing this report.
IAFF 也感謝下列人士幫助促成此報告：Robert Athanas，紐約市消防局消防員；Todd Bianchi，哥倫比亞特區消防局局長；Jim Brinkley，IAFF 職業衛生與安全協會會長；Joseph Brooks，波士頓消防局無線電管理人；Thomas Chirhart，DHS；Billy Freeman，孟菲斯消防局中尉；Missy Hannan，俄克拉荷

馬州立大學防火出版物/國際消防服務訓練協會（IFSTA）平面設計師；Ron Jeffers，紐澤西州聯合市；Christopher Lombard，西雅圖消防局局長；Andy MacFarlane，亞利桑那州鳳凰城；Kevin Roche，FACETS 顧問公司；Wes Rogers，費爾法克斯郡消防與救援局；William Troup，USFA；Mike Wieder，俄克拉荷馬州立大學防火出版物/國際消防服務訓練協會（IFSTA）副會長；Cody Worrell，鳳凰城消防局消防員；以及 Mike Worrell，鳳凰城消防局隊長。

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Homeland Security
Science and Technology

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目錄

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Section 1 –
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Introduction
緒論

Purpose
目的

The past few decades have seen major advancements in the communications industry. Portable communications devices have gone from being used mainly in public safety and business applications to a situation where they are in every home and in the hands of almost every American man, woman and child. As users are added, there is more stress on the system, and there is only so much room on the radio spectrum. The communications industry and the government have responded by making changes to the system that mandate additional efficiency.
過去數十年來已見證了通訊業的重大進步。可攜式通訊裝置已從主要用於公共安全進展到幾乎每個美國男女與孩童家中或手邊都擁有的設備。隨著使用者的增加，系統承受更多壓力，而且無線電頻譜的空間也就如此而已。通訊業與政府的應對方式是改變授權額外效率的系統。

These advancements have improved radio frequency (RF) spectrum efficiency but have added complexity to the expansion of existing systems and the design of new systems. Some of these advances in technology are mandated by the Federal Communications Commission (FCC), while others are optional. Many users of public safety spectrum have endured the time, effort and costs associated with narrowbanding. This effort created additional capacity in the existing spectrum, but performance of some existing systems was degraded when converted from 25 kilohertz (kHz) to 12.5 kHz. Even with narrowbanding, the appetite for RF spectrum continues to grow, necessitating continued efforts for spectral efficiency. "The migration to 12.5 kHz efficiency technology will require licensees to operate more efficiently, either on narrower channel bandwidths or increased voice paths on existing channels. This will allow creation of additional channels within the same spectrum, thereby supporting more users."[1] The costs and operational effects of these changes are significant. The actual RF physics associated with moving to narrowband with no other system changes resulted in loss of range.[2] Navigating through the complex technological and legal options of public safety communications led to the development of this guide to assist the fire service in the decision-making process.
這些發展改善了射頻（RF）頻譜效率，但也提高了現有系統擴張與新系統設計的複雜度。其中一些科技的發展是由聯邦通訊委員會（FCC）所授權的，而其他的則是選擇性的。許多公共安全頻譜使用者忍受了與窄頻化相關的時間、努力和成本付出。此舉動增加了現有頻譜的容量，但有些現有系統的效能會因從 25 千赫（kHz）轉變到 12.5 kHz 而降低。即使已經窄頻化，對 RF 頻譜的需求仍持續增加，所以必須繼續努力提高頻譜效率。「改為 12.5 kHz 效率技術的轉變會需要證照，才能在現有通道較窄的通道頻寬或新增的通話路徑，進行更有效的操作。這使得可在相同的頻譜內創造額外的通道，進而支援更多使用者。」[1]這些改變的成本與運作效果相當顯著。在不進行其他系統改變的情況下，與移動到窄頻的動作相關的實際 RF 物理學，造成射頻範圍損失。[2]公共安全通訊複雜的技術與合法選擇之通過，促成此指南的制定，用以協助消防服務進行決策。

The fire service is diverse. Departments range from those that are very large in size and have multimillion dollar budgets to small departments that rely on pancake breakfasts or bake sales to augment the operating budget. All departments, professional or volunteer, require reliable communications. The size of the budget does not change the physics or RF properties. All departments and firefighters need to understand basic radio principles to remain safe on the fireground and use communications equipment effectively.
消防服務非常多樣，包含各種部門，從擁有數百萬美金經費的大型部門，到依賴鬆餅早餐或烘培特價活動來增加營運經費的小型部門。無論是專業或志願部門，所有部門都需要可靠的通訊。經費的多寡不會改變物理學或 RF 性質。所有部門與消防員都必須理解基本的無線電原理，以在火場保持安全並有效地使用通訊設備。

[1] http://transition.fcc.gov/pshs/public-safety-spectrum/narrowbanding-faq.html.
[2] http://www.cgwireless.com/images/NARROWBANDING_GUIDE_E_BOOK_JAN_2012.pdf,p.31.

Why the Fire Service is Different
消防服務不同之原因

The life safety of firefighters and citizens depends on reliable, functional communication tools that work in the harshest and most hostile of environments. All firefighters, professional and volunteer, operate in extreme environments that are markedly different from those of any other radio users. The radio is the lifeline that connects the firefighters to command and outside assistance when in the most desperate of situations. To operate safely in these dynamic environments, it is imperative that firefighters have the ability to immediately communicate information accurately. The importance was not lost by the firefighting community when they adopted the internationally recognized terminology mayday[3] to signify an emergency situation. The mayday is often the "last chance" to get outside assistance, and the fire service's ear is always listening for that call of distress.

消防員與民眾的性命安全仰賴可在最嚴酷、不友善的環境下運作的可靠、實用通訊工具。無論是專業或志願消防員，所有消防人員都在與任何其他無線電使用者明顯不同的極端環境下工作。在最危急的情況下，無線電是連結消防員與指揮部和外部援助的生命線。為了能在這些動態環境下工作，消防員必須能夠立即準確地傳達或接收資訊。當消防界採用國際公認術語 mayday[3]來代表緊急情況時，其重要性仍然存在。Mayday 求救信號通常是獲得外部援助的「最後機會」，消防服務人員的耳朵永遠都在等著聽到這個求救呼號。

Environment
環境

Firefighters operate lying on the floor, in zero visibility, high heat, high moisture, and wearing self-contained breathing apparatus (SCBA) facepieces that distort the voice. The incidents we operate on can be chaotic with an intense amount of fast-paced communications until the incident is stabilized. The fireground is filled with an extraordinary amount of noise. The only way to really understand the amount and intensity of the noisy environment is to experience it. The engines that drive pumps operating at high rpm, the sound of a circular saw blade sinking into a metal roll-up door, the roaring sound from an operating fire hose nozzle, the distorted high-volume voices straining through the mechanical voice ports of an SCBA facepiece are all part of our operating environment. Along with all of those challenges, we are enduring the prickly sensation of heat on our ears and hands. We adjust our position to "fluff up" the insulation in our turnouts, and even though our environment is hot, we have to keep a "cool head."

消防員工作時會臥躺在地上，處於零能見度、高溫、高濕度環境，並配戴會扭曲語音自給式呼吸器（SCBA）面罩。我們處理的事故可能會有大量的快步通訊，這情況會持續到事故情況穩定為止。火場充滿著異常大量的噪音。能夠真正了解環境噪音數量與強度的唯一方法就是親身體驗。幫浦驅動引擎高速運轉的聲音、圓鋸片切割金屬製捲門的聲音、消防軟管噴嘴發出的轟隆聲響、穿過 SCBA 面罩機械式語音端口的扭曲高音量聲音等，這些都是我們工作環境的一部分。連同這些艱鉅事項，我們的耳朵和雙手還得忍受刺痛感。為了使裝備的隔絕「蓬鬆化」，我們會調整姿勢，而且雖然我們處於炙熱環境，我們必須保持冷靜。

We wear bulky safety equipment to overcome the temperature extremes that we are subjected to. The thermal extremes we encounter drive us to the floor and require us to crawl on our hands and knees or operate while lying down. These positions are not the optimal position to communicate with a device using radio waves. Gloves eliminate the manual dexterity required to operate portable radio controls, hoods and flaps that protect ears affect the ability to hear clearly, vision is diminished by the smoky environment, and SCBA facepieces distort and reduce the field of view. The facepieces impede voice communications, requiring the use of a loud voice to overcome the mechanical voice port unless the facepiece is equipped with some type of voice amplifier. All of the above are barriers to using radios effectively on the fireground. This requires firefighters to be intimately familiar with the radio equipment — being able to feel what the controls are by tactile sense and operating the radio.

我們配戴笨重的安全設備以克服必須面對的極端溫度。我們面對的熱極端溫度使我們貼近地面，我們必須用雙手和雙膝爬行，或者躺著進行作業。這些姿勢並不是使用無線電波裝置溝通的最佳

[3]National Fire Protection Association (NFPA) 1561, *Standard on Emergency Services Incident Management System and Command Safety,* 2014 edition, Chapter 6, 6.3.2.1.
美國消防協會（NFPA）1561，*緊急服務事故管理系統與指揮安全之標準*，2014 年版，第 6 章，6.3.2.1。

姿勢。手套會使消除操作可攜式無線電控制器的手動靈敏度，保護耳朵的頭罩與帽邊會影響聽清楚的能力，佈滿煙的環境會降低視力，SCBA 面罩會扭曲並降低視野。面罩會妨礙語音通訊，導致必須大聲說話才能贏過機械式語音端口，除非該面罩備有某種語音放大器。前述所有事項都是會影響在火場有效使用無線電的障礙，所以消防員必須非常熟悉無線電設備─必須能夠靠觸覺感受控制器並操作無線電裝置。

Operations are conducted inside of buildings with various types of construction and size. The interiors of buildings can be as open as a warehouse or as confusing as a maze. Buildings can be as simple as a large shed to a multistory, energy efficient high-rise with many floors above and below. The construction type and materials used affect fireground communications by not allowing radio waves to penetrate the buildings. All of these factors must be considered in order to communicate in a safe and effective manner on the fireground.
消防作業執行於各種構造與大小的建築物內。建築物內部可能像倉庫一樣是開放空間，或者如迷宮般的令人困惑。建築物的複雜性不同，從一間大型儲物棚到擁有許多地上和地下樓從的高效節能大樓都有可能。建築物種類與材料會因不允許無線電波穿透建築而影響火場通訊。為了以安全、有效地方式在火場進行溝通，必須將所有的這些因素納入考量。

Radio system manufacturers have designed and developed radios and radio systems that meet the needs of the majority of users in the marketplace. The fire service is a small part of the public safety communications market and an even smaller part of the overall communications market. This has resulted in one-size-fits-all public safety radios and systems that do not always meet the needs of the fire service as a whole or those of a specific department. When you consider the extreme operating environment and the protective clothing, the fire service is unique among public safety and other municipal communications users.
無線電系統製造商已設計並研發符合市場多數使用者需求的無線電與無線電系統。消防服務是公共安通訊市場的一小部分，也是整體通訊市場更小的一部分。因此，產生了未必一定符合消防服務或特定部門需求的通用型公共安全無線電。考量到極端操作環境和防護衣，即可知道消防服務人員在公共安全與其他市政通訊使用者當中是獨特的。

Fire Service Communications Model
消防服務通訊模式

The fire service operates in a staged state with resources located in fire stations. Calls are dispatched to specific units based on their location in relation to the incident. When more than one unit responds to an incident, an on-scene Command structure is established to coordinate fire attack, provide safety and accountability, and manage resources.[4] The units assigned to these incidents work for the local Incident Commander (IC) who is the focal point of communications on the fireground. During the initial attack, fireground communications are fast-paced and chaotic to the untrained listener. The dispatch center assumes a support role and simultaneously documents specific fireground events, handles requests for additional resources, and may record fireground tactical radio traffic.
消防服務是階段式的運作，其資源位於各個消防局。依據發話位置與事故的關係，通話會被發送到特定單位。若一個以上的單位回應一件事故，會制定現場指揮結構以協調消防作業、提供安全性與問責性，並管理資源。[4]指派到事故現場的單位聽令於當地事故指揮官（IC），也就是火場的通訊重點人物。第一波滅火行動的火場通訊對未受過訓練的聽者而言，會是步調很快且混亂的。調度中心扮演支援者的角色，同時記錄特定火場事件、辦理額外資源申請，也可能會記錄火場戰術無線電通信流量。

Summary — Fire Service Environment
摘要─消防服務環境

The fire service operates in unique and challenging environments. The fire service recognizes the significance and importance of radio communications. The radio is the lifeline for firefighters in trouble. Use of the mayday term signifies the importance of the radio by using an internationally recognized term when in distress. Factors that separate fire from other disciplines:
消防服務人員在特殊、艱困的環境下作業，因此他們知道無線電通訊的意義與重要性。無線電是受困消防員的生命線。藉由利用國際認可的遇難用詞“mayday”，來表示無線電的重要性。區分火災與其他界別的要素如下：

[4]NFPA 1561, 2014 edition, Annex G.
NFPA 1561，2014 年版，附錄 G。

- Communications pace — communications on the fireground are fast-paced and may be chaotic.
  通訊速度─火場的通訊步調很快，而且可能很混亂。
- Work position — firefighters are often on the floor crawling. This is not the optimal position for radio transmissions.
  工作位置─消防員會時常在地上爬行，這並不是無線電傳輸的最佳位置。
- Visibility challenges — heavy smoke and dark situations require users to be intimately familiar with the equipment.
  能見度問題─濃煙和黑暗的情況使得使用者必須非常熟悉設備。
- SCBAs pose several challenges:
  SCBA的潛在問題：
  - Voice ports on facepieces are difficult to communicate through.
    難以透過面罩的語音端口進行溝通。
  - Visibility — restricts field of vision.
    能見度─會限制視野。
- Temperature and humidity:
  溫度與濕度：
  - High heat.
    高溫。
  - High humidity.
    高濕度。
- High noise environments — difficult to communicate from the high noise area and difficult to hear in a high noise environment.
  高噪音環境─在高噪音環境下，難以與外界溝通，也難以聽到其他聲音。
- Gloves and other personal protective equipment (PPE) restrict vision, hearing and the manual dexterity required to operate radio controls.
  手套與其他個人防護設備（PPE）會限制視力、聽力，以及操作無線電的靈活度。
- Buildings vary greatly in construction and complexity. All buildings to some degree resist penetration of radio waves. The RF resistance varies on construction type, size and layout.
  建築物的結構和複雜度差異非常大。在某種程度上，所有建築物都會阻止無線電波穿透。RF阻抗會因建築種類、尺寸與布局而不同。

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Section 2–
第 2 節–

Basic Radio Communication Technology
基礎無線電通訊技術

When talking about fire department communications systems, usually we are talking about what are traditionally called Land Mobile Radio (LMR) systems. It is important for firefighters and fire officers to have a basic knowledge of radio system technologies to help them during the design, procurement or use of the radio system. By having this basic understanding, you will be able to participate effectively in critical discussions with technical staff, consultants, and manufacturers to get the safest, most effective voice communications system for your firefighters, command staff, and community.

當我們談論消防部門溝通系統時，通常指的是過去稱為地面行動無線電（LMR）的系統。消防人員與消防官員必須具備無線電系統技術的基礎知識，以協助他們設計、購買或使用無線電系統。對技術有基本的認識，就能夠有效地與技術人員、顧問及製造商進行重要對話，進而為消防員、指揮人員和消防界取得最安全、最有效的語音通訊系統。

Most radio system users do not need or have a detailed understanding of the technology behind the systems they use. However, such knowledge is important for those involved in procurement of the systems, in developing procedures for the use of the systems, and in training field users to have a more comprehensive understanding of their limitations, capabilities and operation.

多數無線電系統使用者都不需要有或不具有對系統背後技術的詳細認識。然而，對於系統採購人員、系統使用程序制定人員，以及讓現場使用者能夠了解無線電系統限制、功能與操作的訓練人員而言，這些知識是很重要的。

All technologies have strengths and weaknesses. Understanding those characteristics is important in making decisions related to the technologies. No matter what a salesperson will tell you during the procurement process, no system is without risk, and all have had users who were not satisfied with some aspect of the system. The key is in understanding the technology enough to ask questions, understand the answers, and make a successful evaluation.

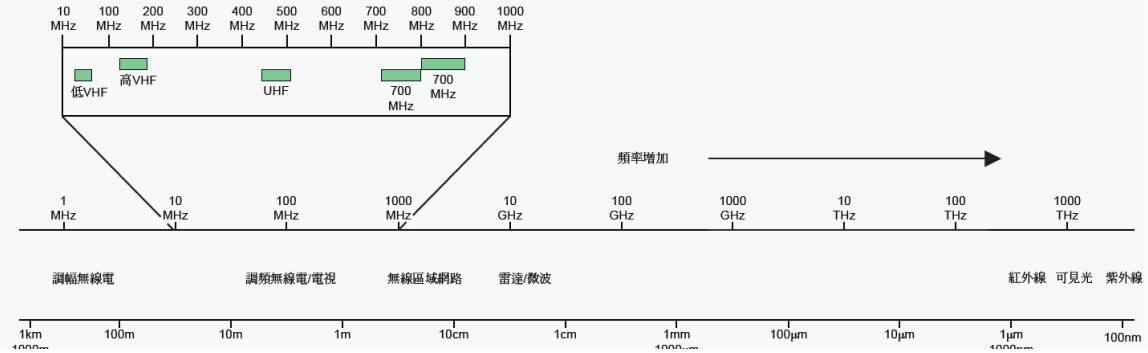
所有技術都有其優缺點。理解這些特性對於技術相關決策而言很重要。無論銷售人員在採購過程中對您說什麼，沒有任何系統是無風險的，而且所有系統都曾有過不滿意的使用者。重點在於對技術有足夠的了解，才可提出問題、理解答案，並順利進行評估。

Radio Spectrum
無線電頻譜

Radio communications are possible because of electromagnetic waves. There are many types of electromagnetic waves, such as heat, light and radio energy waves. The difference between these types of waves is their frequency and their wavelength. The frequency of the wave is its rate of oscillation. One oscillation cycle per second is called one hertz (Hz). The types of electromagnetic energy can be described by a diagram showing the types as the frequency of the waves increases (Figure 2.1).

能進行無線電通訊都是因為有電磁波。電磁波有許多種類，如熱、光、能量波等。不同種電磁波之間的差異在於頻率和波長。波頻是其振動率，每秒的一個振動週期稱為一赫茲（Hz）。可利用示圖說明電磁能量的種類，圖中波動增加的頻率即為不同能量（圖 2.1）。

圖2.1. 電磁頻譜



When describing the frequencies used by common radio systems, we use metric prefixes to quantify the magnitude of the frequency. A typical frequency used in fire department radio systems is 154,280,000 Hz. This is a frequency designated by the FCC as a mutual-aid radio channel.[5] After dividing the frequency by the metric system prefix "mega," equal to 1,000,000, this becomes 154.280 megahertz (MHz).
說明一般無線電系統使用的頻率時，我們會用字首量化頻率量。消防部門無線電系統使用的典型頻率是 154,280,000 Hz，FCC 將此頻率指定為互助無線電頻道。[5]用公制字首"mega（百萬）"除以該頻率，即變成 154.280 兆赫（MHz）。

Public safety LMR systems are allowed to operate in portions of the radio spectrum under rules prescribed by the FCC.[6] These portions of the spectrum are called bands, and LMR systems typically operate with frequencies in the 30 MHz (very high frequency (VHF) low), 150 MHz (VHF high), 450 MHz (ultra high frequency (UHF)), 700 MHz, and 800 MHz bands. Also, UHF spectrum in the T-Band, 470-512 MHz, is available to public safety within a 50 mile radius of the eleven largest metropolitan areas.[7]
使用者可依照 FCC 的規定，在部分無線電射頻下操作公共安全 LMR 系統。[6]這些射頻部分稱為頻帶，LMR 系統的運作頻率通常是在 30 MHz（低的非常高頻率（VHF））、150 MHz（高 VHF）、450 MHz（超高頻率（UHF））、700 MHz，以及 800 MHz 頻帶。此外，在 11 個最大型都會區的半徑英里範圍內，公共安全也可使用 T 頻帶的 YHF 頻譜，即 470-512 MHz。[7]

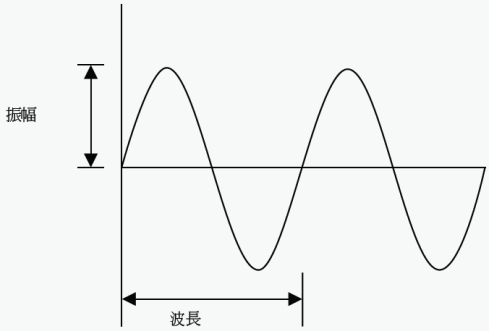
[5]U.S. DHS, Office of Emergency Communications, National Interoperability Field Operations Guide, Version 1.5, January 2014.
U.S. DHS，緊急通訊處，國家實地作業互操作性指南，1.5 版，2014 年 1 月。

[6]Code of Federal Regulations (CFR), Title 47, Part 90, Subpart B, 90.20.
聯邦管制法規（CFR），標題 47，第 90 部分，分部 B，90.20。

[7]The Middle Class Tax Relief and Job Creation Act of 2012 requires the FCC to auction the public safety T-Band spectrum by February 2021, and to clear public safety from the band within two years of conclusion of that auction. (Please see p. 79 of this document for additional information.)
2012 年中產階級減稅與就業創造法規定 FCC 必須在 2021 年 2 月前拍賣公共安全 T 頻帶頻譜，並在拍賣完成後兩年內將公共安全從該頻帶清除。（詳情請見本文件第 79 頁。）

The wavelength is the distance between two crests of the wave. The frequency and wavelength are inversely related so that as the frequency of the wave increases, the wavelength decreases **(Figure 2.2).**
波長是兩個波峰之間的距離。頻率與波長之間屬逆相關關係，所以波頻增加時，波長會縮減（**圖 2.2**）。

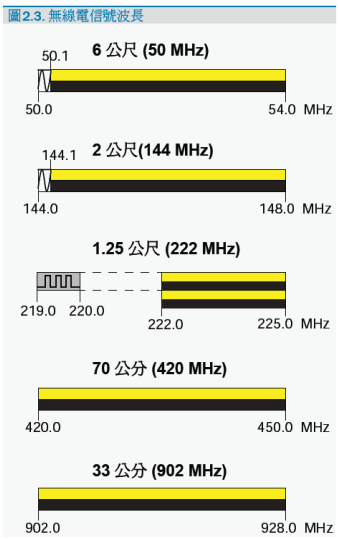
圖2.2. 電磁波



Wavelength
波長

The wavelength of the radio signal is a determining factor in the size and design of the antenna. Wave length is an actual distance that is usually measured in meters. Ham radio operators often do not refer to frequency band of the radio but use the wavelength to classify the radio. A VHF radio would be referred to as a 2 meter rig and a UHF radio would be a 70 centimeter (cm) radio **(Figure 2.3).**
無線電信號波長是天線尺寸與設計的決定因素。波長是通常以公尺計量的實際距離。業餘無線電操作人員一般不會參考無線電頻帶，而是利用波長來將無線電做分類。VHF 無線電會被稱為 2 公尺設備，而 UHF 無線電則是 70 公分（cm）無線電（**圖 2.3**）。

圖2.3. 無線電信號波長



A typical portable radio antenna is tuned to the

frequency. We commonly hear the term one-quarter wave or one-half wave antennas. What this means is that the wavelength is multiplied by 0.25 or 0.5 to determine an optimal length for a transmitting or receiving antenna.
典型可攜式無線電天線會根據頻率調整。我們一般會聽到的用詞是四分之一波或半波天線，這表示將波長乘以 0.25 或 0.5，以決定傳送或接收天線的最佳長度。

The length of a radio antenna is related to the signal wavelength with which the antenna is designed to operate. In general, the higher the frequency of the waves used by the radio, the shorter the antenna on the radio. As you can see, the length of the antenna is based on science. The practice of putting a nonapproved longer antenna on a portable radio for a perceived performance improvement can actually damage a radio and should be discouraged. Users should always consult with their radio service provider before making any component change to maintain proper performance.
無線電天線長度與信號波長有關。一般而言，無線電使用的波頻愈高，其天線就會愈短。由此可之，天線長度是有科學根據的。因為認為可改善效能，而將未經核准的長天線安裝在可攜式無線電上，可能會使無線電損壞，這是不被鼓勵的行為。為了維持適當效能，使用者在改變任何部件前，應該先詢問其無線電服務供應商。

Channel Bandwidth
通道頻寬

The radio spectrum is divided into channels. Each radio channel is designated by a frequency number that designates the center of the channel, with half of the bandwidth located on each side of the center.
無線電頻譜被分成不同通道。每一個通道都有指定通道中心的頻率碼，通道中心是頻寬的中點。

Radio channel bandwidth is the amount of radio spectrum used by the signal transmitted by a radio. The greater the bandwidth, the more information that can be carried by the signal in the channel. Minimum channel bandwidth typically is limited by the state of technology and the bandwidth required to carry a given amount of information. Standard bandwidth has decreased several times in the past to accommodate more users. However, there is a theoretical limit below which the bandwidth cannot be decreased. In addition, the actual width of a channel often is slightly greater than the minimum width, to provide some space on each side of the signal for interference protection from adjacent channels. For the purposes of radio licensing, the FCC sets the maximum and minimum bandwidth for channels in each frequency band.
無線電通道頻寬是信號傳輸所使用的無線電頻譜。頻寬愈大，通道內的信號就可承載更多資訊(12.5 kHz 只能傳語音)。最小通道頻寬通常受限於技術水平和承載特定資訊量的頻寬。過去曾數次為了容納更多使用者而縮減標準頻寬。然而，頻寬無法縮減到低於一個理論性的限制。此外，通道的實際寬度一般會稍大於最小寬度，這是為了在信號兩側保留一些空間以防止毗鄰通道的干擾。為了無線電核照，FCC 已規定各頻帶內通道的最大與最小頻寬。

The bandwidth of channels typically used in LMR is measured in thousands of Hz, or kHz. In an effort to place more communications activity within a limited radio spectrum, permitted bandwidth has been decreasing. Under older licensing rules, some of which are still in effect, typical channel bandwidths were 25 kHz. Rule changes effective Jan. 1, 2013, now require frequencies below 512 MHz to have bandwidths of 12.5 kHz. The narrowbanding of this spectrum increased the channels available for licensing **(Figure 2.4).**
一般用於 LMR 的通道頻寬的計量單位是千赫茲（kHz）。為了在限定的無線電頻譜內進行更多通訊活動，獲准的頻寬持續在擴增。根據舊的核照規定（其中有一些仍有效），典型的通道頻寬是 25 kHz。於 2013 年 1 月 1 日生效的新規定則要求低於 512 MHz 頻率的頻寬必須是 12.5 kHz。頻譜的窄頻化增加了可用於核照的通道（**圖 2.4**）。

圖2.4. 通道頻寬

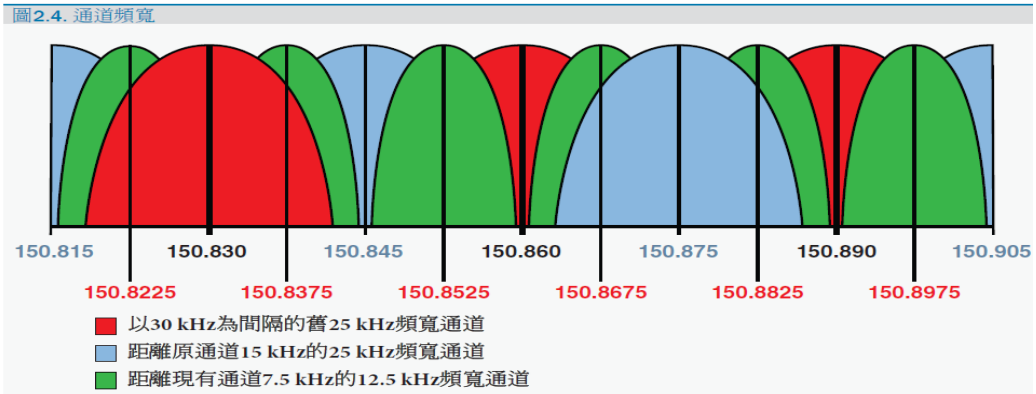
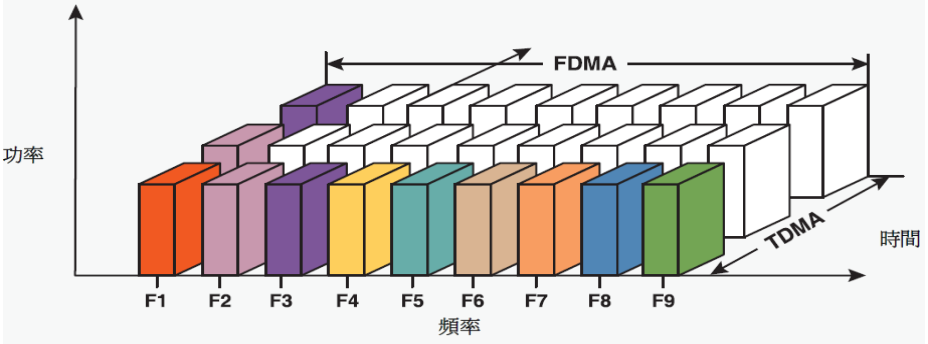


圖2.5. 兩時槽分時多重接取



Spectrum efficiency is further improved by creating time slots within the bandwidth allocated thus creating two talk paths. As you can see in **Figure 2.5,** each frequency has two time slots that allow two talk paths on a single frequency. Digital radio technology allows use of frequency division multiple access (FDMA) or time division multiple access (TDMA) technologies. FDMA is being employed on many P25 Phase 1 trunked radio systems using 12.kHz and 25 kHz channels. A newer iteration of P25 — that is, P25 Phase 2 — uses TDMA technology to provide an effective 6.25 kHz bandwidth or in industry terms, a 6.25 kHz equivalent bandwidth. Digital is optional in most bands but is required on interoperability channels in the 700 MHz band.

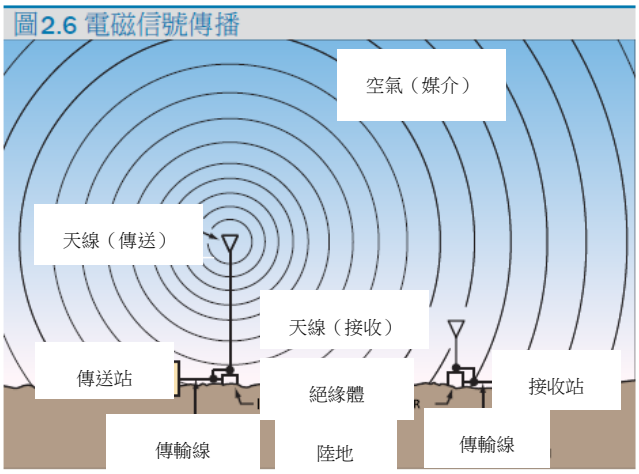
頻譜效率進一步的提升是藉由在分配的頻寬內創造時槽，進而產生兩條通話路徑。如**圖 2.5** 所示，各個頻率擁有兩個時槽，使的單一頻率可有兩條通話路徑。數位無線電技術讓使用者可使用分頻多重接取(FDMA)或分時多重接取(TDMA) 技術。使用 12 kHz 和 25 kHz 的許多 P25 第一階集群式無線電系統都採用 FDMA。較新版的 P25，即 P25 第二階，採用 TDMA 技術以提供有效的 6.25 kHz 頻寬，用工業術語來形容的話，就是 6.25 kHz 等效頻寬。多數頻帶適合使用數位系統，但必須是在 700 MHz 頻帶內的互用通道。

Radio Wave Propagation
無線電波傳播

To send a radio signal from a transmitter to a receiver, the transmitter generates electromagnetic energy and sends that energy through a transmission line to an antenna. The antenna converts that energy into electromagnetic radio waves that travel at the speed of light outward from the antenna. If another antenna is located in the path of the waves, it can convert the waves back into energy and send that energy through a transmission line to a receiver **(Figure 2.6).**

為了將無線電信號從發送器傳輸到接收器，發送器會產生電磁能，並透過傳輸線將該能量傳送到天線。天線會將能量轉換成以光速向外行進的電磁無線電波。若無線電波的行進路徑上有另一個天線，該天線會將無線電波轉換回能量，並透過傳輸線將該能量傳送到接收器（**圖 2.6**）。

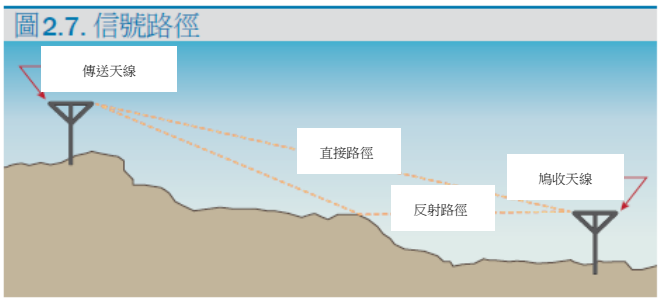
圖2.6 電磁信號傳播



Radio signals emitted from an antenna travel both a direct path to the receiving antenna and a path reflected from the ground or other obstacles. This reflection causes the wave to travel a longer distance than the direct wave, as shown in **Figure 2.7.**

天線發射的無線電信號會以直達路徑傳播到接收天線，也會以地面或其他障礙物反射的路徑傳播。反社會史無線電波的行進距離比直波還長，如**圖 2.7** 所示。

圖2.7. 信號路徑



The waves traveling over the reflected path then interfere with the direct waves, causing an effect known as multipath interference. Multipath interference causes a variation in the signal level at the receiver. The signal may be higher or lower than

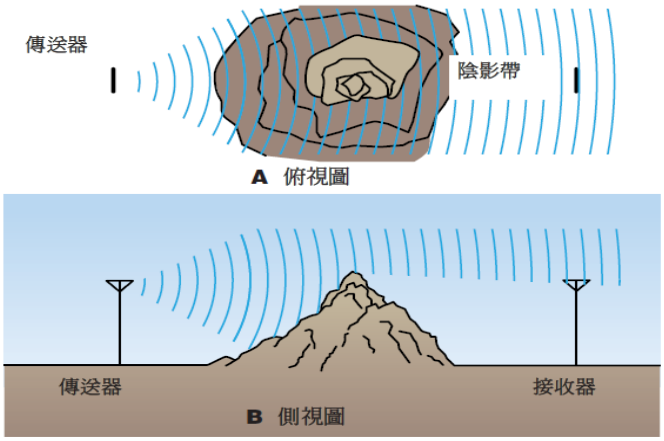
the direct signal depending on the position of the receiver's antenna. As the antenna is moved around, the signal varies, and the user hears a signal that goes from strong and clear to weak and noisy.
以反射路徑行進的無線電波會干擾直波，產生所謂的多路徑干擾現象。多路徑干擾會使接收器的信號位準不同。信號可能高於或低於直接信號，視接收器天線的位置而定。信號會因天線的移動而變化，使用者聽到的信號會從清楚的強訊變成吵雜的弱訊。

The atmosphere can have an effect on the range of radio waves. While on the surface this might be thought of as good, it is not. RFs are assigned and reassigned with enough geographic separation so they don't interfere. At times, atmospheric layers can form causing a ducting effect **(Figure 2.8).** The radio waves are usually limited to a line of sight range. When these atmospheric ducts form, the radio wave propagates out and hits the warm air layer and bounces between the warm air and ground, greatly increasing the range. The increased range often is the cause of interference on the far end due to the reuse of the frequencies. This condition is more prevalent in the lower frequency bands.
大氣可能會影響無線電波範圍。雖然這在表面上看似是好事，但事實並非如此。RF 的分配與再分配具有足夠的地理距哩，使得 RF 不會互相干擾。大氣層有時候會形成，產生波管效應（**圖 2.8**）。無線電波通常受限於視線範圍。當這些大氣波管形成時，無線電波會向外傳播，撞擊到暖空氣層，並在暖空氣層與地面之間彈跳，使得範圍大幅增加。括噌的範圍通常會因頻率的重複使用而造成遠端的干擾。此狀況在較低的頻帶內較常發生。

Radio waves can travel through some materials, such as glass or thin wood, but the strength is reduced due to absorption as they travel through. Materials such as metal and earth completely block the waves due to their composition and density. In addition, some materials will reflect radio waves, effectively blocking the signal to the other side.
無線電波可穿透玻璃、薄木等物質，但其強度會因吸收而降低。金屬、土壤等物質的組成與密度會使其完全阻隔無線電波。此外，有些物質會反射無線電波，有效地阻止信號傳到另一邊。

Because buildings are built from many types of materials, the radio waves can be passed through some, be reflected by some, and be absorbed by others. This, along with the complex interior design of a building, creates a very complex environment for radio communications inside a building **(Figure 2.9).**
由於建築物是由許多種物質所構成的，無線電波可穿透某些物質、從某些物質反射，或者被某些物質吸收。再加上建築物複雜的內部設計，建築物內對無線電通訊而言，會是非常複雜的環境（**圖 2.9**）。

圖2.9. 地形阻擋



Interference
干擾

RF interference can be either natural or man-made. Interference from internal noise occurs naturally in all electronic equipment due to the nature of the electronic circuit itself. Manufacturers take this into account during equipment design, and obtaining a low-noise design is not particularly difficult. In addition, natural noise is produced by sunspot activity, cosmic activity, and lightning storms. This noise usually is of small magnitude and not significant for most LMR communications. The exception to this is the VHF low band that is affected significantly by severe sunspot activity, sometimes to the point of completely prohibiting communications.
RF 干擾可以是自然或人為的。所有電子設備都自然會有內部噪音干擾，這是因為電路本身的特性。製造商在設計設備時會將此納入考量，而且達到低噪音設計並非難事。此外，太陽黑子活動、宇宙活動與雷暴都會產生自然噪音。這種噪音通常很小聲，不會影響多數的 LMR 通訊。但是，劇烈的太陽黑子活動會嚴重影響低 VHF 帶，甚至達到完全阻擋通信的程度。

More significant to radio communications systems is the interference produced by man-made sources. There are many sources of interference that you may encounter. Some interference sources are expected, such as vehicle ignitions, electric motors, and

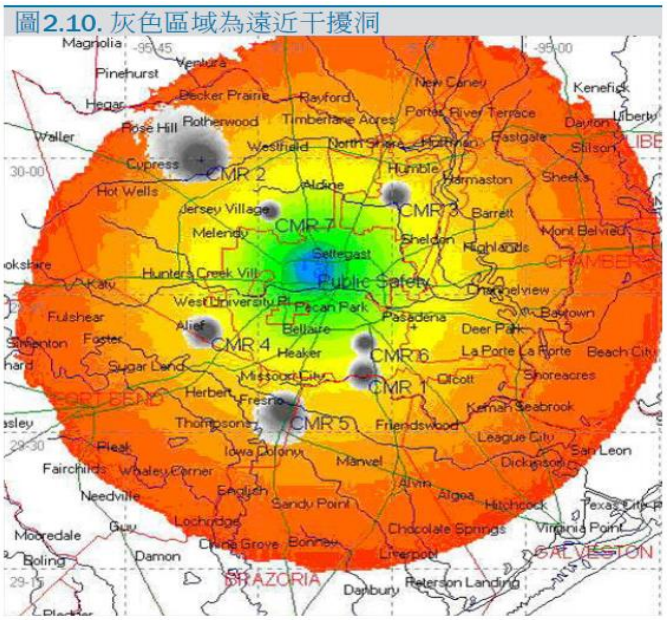
high-voltage transmission lines, but computers, light ballasts, and new energy efficient bulbs (both compact fluorescent lights (CFLs) and light-emitting diodes (LEDs)) emit radio signals that can interfere with public safety radios.
對無線電通訊系統較重要的是人為源造成的干擾。您有可能會遇到許多種干擾源。有些干擾源是預料之中的，例如車輛發動機、電動馬達和高壓傳輸線，但電腦、燈具鎮流器和新的節能燈泡（一體式螢光燈（CFL）與發光二極體（LED））會放射干擾公共安全無線電的無線電信號。

In general, man-made interference decreases with an increase in frequency. The UHF band and, initially, the 800 MHz band are much less susceptible to man-made interference than the VHF low and high bands. When systems are not subject to significant interference, they are said to be "noise limited," in contrast to "interference limited." The large number of transmitters used by cellular telephone companies has created intense interference in the 800 MHz band.
一般而言，人為干擾會隨著頻率的增加而減少。相較於低 VHF 與高 VHF 頻帶，UHF 頻帶與 800 MHz 頻帶較不容易受人為干擾的影響。若系統不受重要干擾的影響，我們稱之為「噪音限制」，反之則為「干擾限制」。手機公司使用的大量傳送器已在 800 MHz 頻帶內造成大量干擾。

Although the separation of the channels allocated to cellular companies has reduced this interference, communications problems still can occur when a user is operating close to a cellular transmission facility. This type of interference is particularly a problem when the user is located near a cellular facility and the user's radio system site is located much further away. This creates a situation called "near-far" interference. The user's system signal strength is low, and the cellular signal is high, keeping the user's radio from receiving the desired signal. The 800 MHz band always was regarded as the "cleanest" band with respect to man-made interference, and systems initially were noise limited. However, all systems in the band now must be designed for maximum interference from nearby transmitters, which requires more transmitter locations and higher power, creating more costly systems.
雖然隔離分配給手機公司的通道已使這種干擾減少，但若使用者在手機訊號傳播設施附近操作無線電，仍然會有通訊問題。若使用者位於手機設施附近，而其無線電系統位於較遠的地點，這種干擾的問題會更明顯。這種情況稱為「遠近」干擾。使用者的系統強度低，而手機訊號強度高，阻止使用者的無線電接收希望收到的信號。就人為干擾而言，800 MHz 頻帶一直都被視為是「最乾淨」的頻帶，系統原本都是噪音限制的。然而，頻帶內的所有系統現在都必須針對附近傳送器的最大干擾進行設計，這需要用到更多的傳送器位置與較高的功率，導致系統成本增加。

Interference from cellular transmitters is illustrated in **Figure 2.10.** The blue area in the center is the public safety transmitter, and in the center of the gray areas are the cellular transmitters.
手機信號傳送器的干擾示於**圖 2.10**。中間的藍色區域是公共安全傳送器，中間的灰色區域是手機傳送器。

圖2.10. 灰色區域為遠近干擾洞



Intermodulation interference is caused directly by the mixing of two or more radio signals. The mixing most commonly occurs inside the receiver or transmitter of a radio. This mixing can create a third signal that is radiated from the antenna out to other radios. The mixing also can occur outside a radio in the transmission line or through rusty tower bolts or guy wires. Intermodulation can be difficult to identify, due to the large number of frequencies that may be present at large communications sites.
互調干擾是直接由兩個或以上無線電信號的混合所造成的。這種混合最常發生於無線電接收器或傳送器的內部，會產生從天線向外發射到其他無線電的第三信號。混合也可能發生於無線電外部，包括傳輸線、生鏽的塔台螺栓或風繩。互調可能難以辨識，因為大型通訊場所可能會有大量的頻率。

Receiver desensitization interference, also called

receiver overload, is caused by nearby high-level transmitter signals that overload the initial parts of the radio's receiver. This overload prevents the receiver from detecting the weaker desired signals, making the receiver nonfunctional. Receiver desensitization occurs near high-power radio sites, such as television and radio stations, and also can occur in poorly designed repeater systems where the transmit and receive frequencies are too close in frequency.
接收器鈍化干擾，又稱為接受器過載，是由附近使無線電接收器原始部件過載的高位準傳送器信號所造成的。過載會防止接收器偵測希望收到的弱訊號，令接收器無法運作。接收器鈍化發生於高功率無線電場所附近，如電視台和廣播電台，也可能發生於傳收器與接收器頻率太接近的設計不良的中繼器系統。

Several things can be done to reduce or eliminate interference. The first is the use of high-quality radio equipment. High-quality equipment has better transmitter and receiver performance that minimizes interference and reduces its effects. The use of receiver multicouplers, transmitter combiners, and repeater duplexers reduce the possibility of intermodulation and receiver overload by filtering the transmitter and receiver signals to ensure only those signals actually used by the system are passed through.
有數種方法可減少或消除干擾。第一種方法是使用高品質的無線電設備。高品質設備有較好的傳送器與接收器性能，可使干擾最小化並減少其影響。藉由過濾傳送器與接收器信號，確保只有實際由系統使用的信號可通過，多路耦合器、傳送器合路器及中繼器雙工器可降低互調和接收器過載的機率。

Radio system designers can reduce the possibility of their systems causing interference by selecting appropriate designs. By selecting the appropriate antenna and adjusting transmitter power levels, the system can minimize interference with other users of the same frequency. This allows more efficient use of the available radio spectrum and keeps more resources available for all users.
藉由選擇適當的設計，無線電系統設計師可降低系統產生干擾的機率。透過適當天線的選擇及傳送器功率的調整，系統可令相同頻率使用者的干擾最小化，讓可用的無線電頻譜更有效率，並保持更多資源以供所有使用者使用。

What Affects System Coverage?
有什麼會影響系統覆蓋範圍？

The coverage of a radio communications system generally is described as the useful area where the system can be used reliably. Many factors affect coverage, including the radio power output, antenna height and type, and transmission line losses. However, the factor that most influences system coverage is the height of the antenna above the surrounding ground and structures. As systems age, the coverage of the system can change due to man-made structures that are built.
一般將無線電通訊系統的覆蓋範圍描述為系統能可靠運作的有用區域。有許多要素影響著覆蓋範圍，包括無線電功率輸出、天線高度與種類，以及傳輸線損耗。然而，影響系統覆蓋範圍最大的要素是周圍地面與結構上的天線高度。隨著系統老化，系統覆蓋範圍可能會因人造構造體而改變。

System designers place antennas on towers or mountain tops to provide a more direct path from the transmitter to the receiver. In the case of one portable radio user transmitting directly to another portable radio user, having the radio antenna as high as feasible (hand-held at shoulder height) significantly improves system coverage.
系統設計師將天線放置在塔台或山頂上，以提供傳送器與接收器之間更直接的路徑。若一位可攜式無線電使用者直接傳送信號給另一位可攜式無線電使用者，將無線電天線架設在盡可能高的位置（手持的話是肩膀高度）可大幅改善系統覆蓋範圍。

Antennas have three major properties: operating frequency, polarization, and radiation pattern. In general, these properties apply whether the antenna is used for transmitting or receiving. The operating frequency of an antenna is the frequency at which the antenna acts as specified by its manufacturer. The antenna may operate outside its design frequency, but the performance of the antenna will be reduced.
天線具有三大特性：運作頻率、極化，以及輻射圖。一般而言，無論天線是用於傳送或接收信號，這些特性都會存在。天線運作頻率是天線依其製造商規定運作的頻率。天線可在其設計頻率外運作，但其效能會降低。

In LMR systems like those used by public safety, most antennas are vertically polarized. You can see

evidence of this with the wire antennas mounted on the roofs of vehicles. Like car antennas designed for FM broadcast radio, they stick up vertically from the surface of the vehicle.
就公共安全所使用的 LMR 系統而言，多數天線是垂值偏極化的，從架設在車頂上的線狀天線即可看出這點，就像專為 FM 廣播無線電設計的汽車天線，天線會從車輛表面垂直突出。

The radiation pattern of the antenna is the shape of the relative strength of the electromagnetic signal emitted by the antenna. This depends on the shape of the antenna. The radiation pattern can be adjusted through antenna selection to provide coverage where desired and to minimize coverage (and interference) in undesired directions.
天線輻射圖是天線放射電磁信號的相對強度的形狀，這取決於天線形狀。可透過選擇天線來調整輻射圖，以在希望的地方提供覆蓋範圍，並在不希望的方向使覆蓋範圍（與干擾）最小化。

Fixed-Site Antennas
定點天線

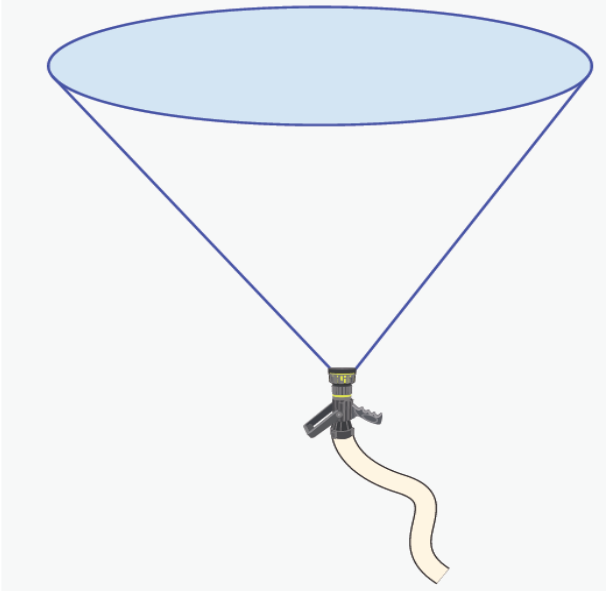
Fixed-site antennas are mounted on towers or buildings to provide the dispatch or repeater coverage throughout the service area **(Figure 2.11).** The antennas used must be designed to operate in the system's frequency band and, for best power coupling, should have a center frequency as close as possible to the actual operating frequency.
定點天線架設在塔台或建築物上，以提供整個服務區的調度或中繼器覆蓋範圍（**圖 2.11**）。天線的設計必須使其能夠在系統頻帶內運作，而且為了達到最佳功率耦合，天線的中心頻率應該盡可能接近實際運作頻率。

The radiation pattern for the antenna should be selected to provide a signal in the desired sections of the coverage area and have minimal coverage outside the desired coverage area. This will help ensure that the system is not interfering with other systems unnecessarily. The most basic practical antennas are omnidirectional and have approximately equal coverage for 360 degrees around the antenna. In fire service terms, a nozzle set to a wide angle fog would be equivalent to an omnidirectional antenna **(Figures 2.12 and 2.13).**
天線輻射圖的選擇應該使其能夠在希望的覆蓋範圍區域內提供信號，並在希望的覆蓋範圍區域外擁有最小覆蓋範圍，這會有助於確保系統不會干擾到其他系統。最基本的實用天線是全向天線，周圍 360 度都有大概相同的覆蓋範圍。以消防服務術語來說，設定在廣角噴霧的噴嘴等同於全像天線（**圖 2.12 與圖 2.13**）。

圖2.11. 天線塔與天線

（照片來源：**Mike Warrell**）

圖2.12. 設定在廣角的噴霧嘴會朝所有方像噴灑—150 gpm



However, as shown in **Figure 2.13**, the antenna pattern is more like a slightly flattened donut. This causes an area immediately under the antenna to have lower signal strength, and less coverage, than farther away from the antenna.
然而，如**圖 2.13** 所示，天線輻射圖較像是稍微被壓扁的甜甜圈。這使得天線正下方的區域擁有比

離天線較遠的區域更低的信號強度和更小的覆蓋範圍。

Directional antennas are used to direct the signal toward the users and away from unwanted areas. The antenna is said to have gain over an omnidirectional antenna in the direction of highest signal. If we think of this in fire terms, when we place a fog nozzle to straight stream, we are directing the same gpm in a focused direction as depicted in **Figure 2.14.** There is no increase in energy, but it is now focused in a specific direction. Directional antennas essentially do the same with RF energy. **Figure 2.15** shows a directional antenna called a Yagi, along with its radiation pattern looking down on the antenna. The pattern shows a stronger signal from the front of the antenna and a weaker signal from the back. The signal strength protrusions behind the main signal are called lobes, and, in most cases, antenna designers strive to minimize this unintended signal.

定向天線用以將信號導向使用者，遠離不希望的區域。這時會聲稱天線在最高信號的方向勝過全向天線。從消防術語的角度思考的話，當我們將噴霧嘴設定為直流時，我們正在將相同的 gpm 導向焦點方向，如**圖 2.14** 所示。能量並沒有增加，但卻已專注在特定方向。定向天線基本上會對 RF 能量做出同樣的動作。**圖 2.15** 顯示一種稱為八木天線的定向天線，以及其俯視輻射圖。根據輻射圖，天線前方的信號較強，後方的則較弱。主要信號後面的信號強度突出稱為波瓣，在多數案例中，天線設計師會努力降低這非計畫中的信號。

圖2.13. 全向天線輻射圖

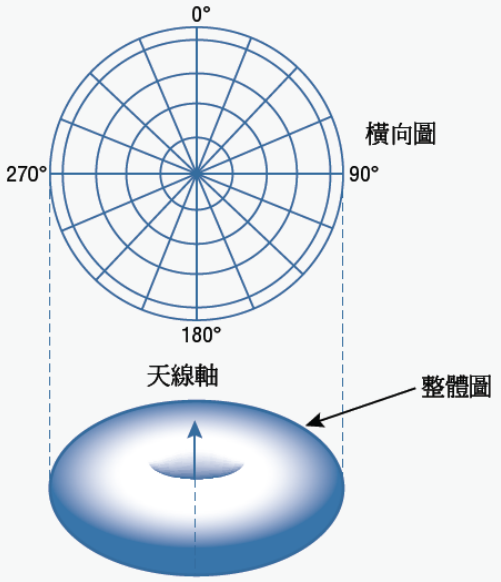


圖2.14. 設定為直流的噴霧嘴會將能量集中在一個方向–150 gpm

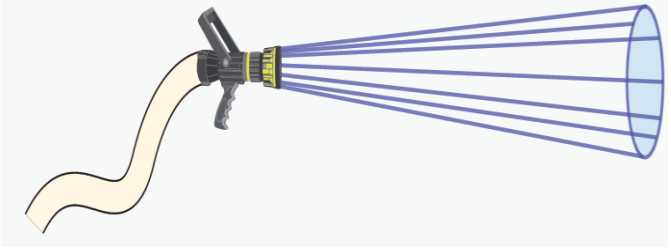
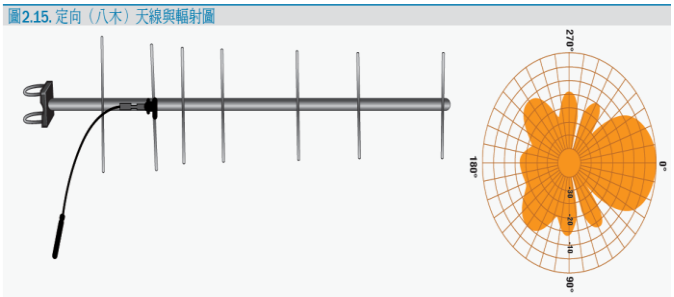


圖2.15. 定向（八木）天線與輻射圖



Downtilt
下傾

When an antenna is located on top of a mountain or tall building, the coverage loss created by the “hole” in the radiation donut may have a significant impact on coverage in the area immediately around the antenna. To compensate for this, directional antennas can be tilted slightly to direct more of the signal downward **(Figure 2.16).** This tilting is known as mechanical downtilt and increases the energy immediately below the antenna while reducing the maximum distance the signal will travel. Unfortunately, when using an omnidirectional antenna, tilting the antenna down in one direction will result in tilting the pattern up on the opposite side of the antenna. For this reason, special antennas with electrical downtilt are used when omnidirectional coverage is required, such as on a tall building in the center of the coverage area.

當天線位於山頂或高樓上時，輻射甜甜圈內「孔洞」所造成的覆蓋範圍損失有可能會嚴重影響天線周圍的區域。為彌補這缺點，可使定向天線稍微傾斜以將更多信號導向下方（**圖 2.16**）。這稱為機械下傾的動作可增加天線正下方的能量，同時縮短信號傳輸的最大距離。可惜的是，使用全向天線時，讓天線朝一個方向下傾會導致天線的對側上傾。基於此，會在需要全向覆蓋範圍的時候使用備有機械式下傾的特殊天線，例如在覆蓋範圍中心的高樓上。

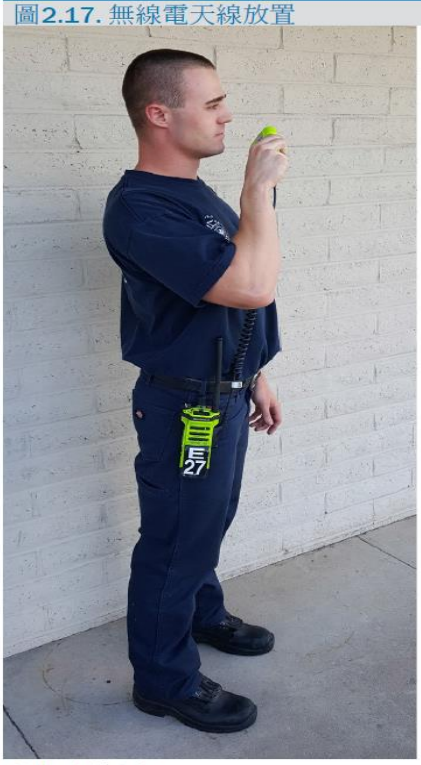
PortableRadioPosition
可攜式無線電位置

The principles discussed earlier affect the

performance of the portable radio. When a user transmits from a portable radio using a speaker microphone and it is against the body, RF energy is blocked altering the omnidirectional radiation pattern. If you place your fog nozzle on wide and place it next to an object, that pattern is altered, and the stream is not directed in the desired direction. The same happens with the RF energy when the radio is against your body. Some energy is absorbed, and the remaining signal is shadowed by your body.
稍早探討過的原理會影響可攜式無線電的效能。當使用者利用喇叭麥克風從可攜式無線電進行傳送，而且無線電緊貼著使用者身體時，RF 能量會受阻，使得全向輻射圖改變。若將噴霧嘴設定在廣角並將其放在某物體旁邊，輻射圖會改變，而且水流方向不會是希望的方向。無線電緊貼著身體時，RF 能量會發生相同的事情。有些能量會被吸收，而剩餘的信號會被身體遮蔽。

Antennas must be oriented in the correct position for optimal performance. When an antenna is tilted out of vertical, the signal received is not as strong as it would be if vertical. There is no ideal location to wear the radio as a firefighter. As firefighters, we need to be aware of the radio position particularly when having difficulty communicating. As our position is changed, the effectiveness of the radio changes with the new position. We must be educated users and know that we might need to alter our position or move the radio to better communicate. Simply reorienting the radio will often correct a communications problem **(Figure 2.17).**
天線的方位必須正確，才能達到最佳效能。若天線傾斜偏離垂直方向，收到的信號強度會不如垂直姿態。對於消防人員而言，並沒有所謂理想的無線電配戴位置。身為消防員，我們在遇到通訊困難時，必須特別注意無線電位置。我們的姿勢改變時，無線電效力會隨著新姿勢而改變。我們必須是有知識的使用者，必須知道我們可能必須改變我們的位置或移動無線電以達到更好的通訊結果。通常只要將無線電重新定位，即可解決通訊問題（**圖 2.17**）。

圖2.17. 無線電天線放置



身體改變信號。


垂直舉起無線電以達到最佳效能。


無線電對SCBA語音端口的位置良好。無線電保護在口袋裡。

（照片來源：Cody Warrell）

Mobile and Portable Antennas
移動式與可攜式天線

In general, all mobile and portable radio antennas are omnidirectional to provide coverage 360 degrees around the radio user.
一般而言，所有移動式與可攜式無線電天線都是全向的，這是為了在使用者周圍提供 360 度的覆蓋範圍。

Vehicle antennas should be mounted so that they are not obstructed by equipment mounted on the top of the vehicle. Light bars, air-condition units, and master-stream appliances are some typical

obstructions found on fire service vehicles. Some obstructions, such as aerial ladders on truck companies, cannot be avoided, and the designer must select the best compromise location.
車輛天線的架設應該使其能夠不受到安裝在車輛上方設備的阻擋。可常在消防服務車輛上看到的典型障礙物包括燈條、空氣調節器、主流裝置等。有些障礙物是不可避免的，例如雲梯車上的雲梯，設計者必須選擇折衷的最佳位置。

Vehicle antennas mounted on the roof of fire apparatus can be damaged by overhead doors, trees and other obstructions. Ruggedized low-profile antennas often are a better choice, even if they have a lower gain than a normal whip antenna. A properly mounted intact antenna with a lower gain is much better than a damaged antenna of any type.
裝設在消防器具屋頂上的車輛天線可能會因上頭的門、樹等障礙物而受損。耐用的低側高天線通常是較好的選擇，即使其增益低於正常的鞭狀天線。增益較低但正確裝設的完好天線遠好過任何種類的受損天線。

Portable antennas usually are provided by the portable radio manufacturer and are matched to the radio. In some cases, alternative antennas can be selected for the radio to overcome specific user conditions.
可攜式天線一般是由可攜式無線電製造商所供應，而且會配合無線電。在某些情況下，為了克服特定使用者狀況，可選擇使用替代天線。

When a portable radio is worn at waist level, such as with a belt clip or holster, the user's body absorbs some of the signal transmitted or received by the radio. In addition, the antenna is at a much lower level than if the user were holding the radio to his or her face for transmitting.
利用皮帶扣或皮套將可攜式無線電繫在腰間時，使用者的身體會吸收無線電傳送或接收的一些信號。此外，天線的高度會低於使用者於傳送信號時將無線電舉到他或她的臉旁的高度。

Since the radio system is designed for use with the antenna oriented vertically, the performance of the radio is reduced when the antenna is horizontal. This is particularly important for firefighters, since the radio they use may become oriented horizontally when they are crawling low inside a structure fire.
由於無線電系統設計的使用方式是用垂直天線，天線處於橫向位置時會使無線電效能降低。這點對消防員特別重要，因為當他們在建築火場內趴低爬行時，他們的無線電可能會變成橫向姿勢。

Summary — Basic Radio Communication Technology
摘要─基礎無線電通訊技術

Radio communication takes place using electromagnetic waves that travel from the transmitter to the receiver. These waves are defined by the number of oscillations per second or Hz. Wavelength is an actual length in distance that is determined by the operating frequency. The wavelength is a key factor in the determination of the antenna length. Antennas are tuned to the operating frequency of the radio. The practice of putting a longer antenna on to increase performance should be discouraged and can result in damage to the radio.
無線電通訊是利用傳送器與接收器之間的電磁波。這些電磁波的定義是藉由每秒的振動數，即 Hz。波長是由運作頻率決定的實際距離長度。波長是確定天線長度的關鍵要素。天線會被調整到無線電的運作頻率。不應該鼓勵安裝較長的天線以提升效能，因為這種舉動可能會導致無線電損壞。

Radio channel bandwidth is the amount of radio spectrum used by the signal transmitted by a radio. The greater the bandwidth, the more information that can be carried by the signal in the channel. Minimum channel bandwidth is limited by the state of technology and the bandwidth required to carry a given amount of information. Standard bandwidth has decreased several times in the past to accommodate more users. Rule changes effective Jan. 1, 2013, now require frequencies below 512 MHz to have bandwidths of 12.5 kHz. Digital radio technology allows use of TDMA, and it is being employed on many P25 trunked radio systems to increase capacity, even though it is not mandated. Use of TDMA provides an effective 6.25 kHz bandwidth or in industry terms a 6.25 kHz equivalent bandwidth.
無線電通道頻寬是無線電傳送信號使用的頻譜量。頻寬愈大，通道內的信號就可承載更多資訊。最小通道頻寬通受限於技術水平，以及承載特定資訊量所需的頻寬。過去曾數次為了容納更多使用者而縮減標準頻寬。於 2013 年 1 月 1 日生效的新規定要求低於 512 MHz 頻率的頻寬必須是 12.5 kHz。數位無線電技術讓使用者可使用 TDMA，雖然並非強制性，但許多 P25 集群式無線電系統都採用此技術來增加容量。TDMA 技術可提供有效的 6.25 kHz 頻寬，用工業術語來形容的話，就是 6.25 kHz 等效頻寬。

Transmitted radio waves can be reflected or absorbed by materials, such as buildings, the earth or trees, reducing the strength of the wave when it reaches the receiving antenna. Elevating the transmitting or receiving antenna will reduce the likelihood of the wave being affected by buildings or trees because the path to the receiver will be more direct.
傳出的無線電波可被建築物、土壤、樹等物質反射或吸收，使得無線電波在到達接收天線時的強度降低。將傳送或接收天線升高會降低無線電波受到建築物或樹影響的機率，因為傳送到接收器的路徑會較直接。

Interference from undesired radio waves is always a possibility in a radio system. The potential for natural interference decreases as the frequency band increases, but man-made interference is very high in the 800 MHz band due to the proximity of cellular and other nonpublic safety communications systems. This interference can make it difficult to communicate effectively in the presence of the interference.
不希望發生的無線電波干擾總是有可能出現於無線電系統。自然干擾的機率會隨著頻帶的擴增而降低，但人為干擾在 800 MHz 頻帶發生的機率非常高，這是因為手機與其他非公共安全通訊系統的鄰近性。這種干擾可能會令使用者難以進行有效通訊。

When designing radio communications systems, the designers must take into account the presence of reflecting or absorbing materials and interference. This may require constructing taller towers to support the antennas or increasing the power of the transmitters to overcome the loss of signal strength and interference. The system's design must account for local terrain, trees, buildings and the density of interference-generating sources.
設計無線電通訊系統時，設計者必須考量反射性或吸收性物質與干擾的存在。這可能會需要建造更高的天線支援塔台，或者提升傳送器功率，才能克服信號強度損失與干擾的問題。系統設計必須考量到當地地形、樹木、建築物，以及干擾源密度。

Antennas are designed with radiation patterns to direct RF in the desired direction. This is very similar to the use of a fog nozzle on the fireground. The nozzle can be adjusted in a wide pattern to spread a set gpm or can be set to straight stream to focus the same gpm in a specific direction.
天線具有輻射圖，用以將 RF 導向希望的方向。這很像是在火場利用噴霧嘴。噴嘴可被調整到廣角以噴灑設定的 gpm，或者可被設定在直流以將相同的 gpm 集中在特定方向。

When using a portable radio, users must remember that their body absorbs some of the RF energy and the antenna must be oriented properly for the best radio performance. There is no ideal location to wear the radio as a firefighter. As firefighters, we need to be aware of the radio position particularly when having difficulty communicating. As our position is changed, the effectiveness of the radio changes with the position. We must be educated users and know that we might need to alter our position or move the radio to better communicate. Simply reorienting the radio will often correct a communications problem.
使用可攜式無線電時，使用者必須記住，他們的身體會吸收一些 RF 能量，而且天線的方位必須正確才能發揮無線電的最佳效能。對於消防人員而言，並沒有所謂理想的無線電配戴位置。身為消防員，我們在遇到通訊困難時，必須特別注意無線電位置。我們的姿勢改變時，無線電效力會隨著姿勢而改變。我們必須是有知識的使用者，必須知道我們可能必須改變我們的位置或移動無線電以達到更好的通訊結果。通常只要將無線電重新定位，即可解決通訊問題。

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Section 3–
第 3 節–

Digital and Analog Radio
數位與類比無線電

Several different types of radios are used in the fire service. These radios can be classified as mobile, portable or fixed. They operate in either analog or digital mode on direct, repeated or trunked systems. This section discusses the operation of these types of radios and the features, benefits and problems associated with their use in the fire service. All technologies have strengths and weaknesses. It is important for the fire service to understand the strengths and weaknesses of all communications technologies to be able to make informed decisions to keep members safe.
消防服務界使用數種無線電，可分成移動式、可攜式或固定式無線電。這些無線電在直接、中繼或集群系統的運作是採用類比或數位模式。此章節探討這些無線電的運作，以及其與消防服務用途有關的特性、優點和問題。所有技術都有其優缺點，消防服務界必須了解所有通訊技術的優缺點，才能夠做出知情決策，保持消防界人員的安全。

Mobile radios are designed to be mounted in vehicles and get their power from the vehicle's electrical system. They can be of either a one- or two-piece design, with the radio itself separated from the controls. An external antenna is connected to the radio and permanently mounted to the vehicle. Mobile radios usually have better performance than portable radios, including better receivers and more powerful transmitters. One exception to this is that mobile radios used in trunked radio systems may or may not have more powerful transmitters because the systems are designed for portable use, reducing the need for high-powered transmitters.
移動式無線電的設計是為了將其安裝在車輛內，並從車輛的電力系統取得電源。這種無線電可以是單件式或兩件式設計，即無線電本身與控制器分開。外部天線連接到無線電，並永久架設在車輛上。移動式無線電的效能通常比可攜式無線電好，包括較好的接收器和較強的傳送器。但是，集群無線電系統使用的移動式無線電可能有也可能沒有較強的傳送器，因為這些系統是專為攜帶用途所設計的，因此會降低對高功率傳送器的需求。

Portable radios are hand-held radios powered by rechargeable, replaceable battery packs or power sources. They usually have an external rubber antenna attached to the top of the radio.
可攜式無線電是由可充電、可替換電池組或電力源所驅動的手持無線電。這種無線電通常備有連接在頂端的橡膠天線。

Mobile and portable radios have similar controls to perform their essential functions. These include things such as changing channels, adjusting the speaker volume, and transmitting. The common names for these controls are the channel (or talkgroup) selector, volume adjustment, and push-to-talk (PTT) switch. Some radios, particularly those intended for fire and police use, will have an orange or red **emergency** button. This button may be programmed to indicate to the radio system and to other users that a user has an emergency. Older radios may have a squelch adjustment knob, but most modern radios have internal control settings or adaptive squelch so that a squelch adjustment knob is no longer necessary.
移動式與可攜式無線電具有相似的控制器可執行其基本功能，包括切換頻道、調整喇叭音量，以及傳送。這些控制器的通用名稱為頻道（或通話群組）選擇鍵、音量調整鍵，及一鍵通（PTT）按鍵。有些無線電會有橘色或紅色的**緊急**鍵，尤其是消防用與警用無線電。可設定此按鍵，使其向無線電系統與其他使用者表明有使用者正面臨緊急事件。舊型無線電可能會有靜噪調整鈕，但多數新型無線電具有內部控制設置或自適性靜噪，所以不再需要有靜噪調整鈕。

Base station radios are located at fixed locations and usually are powered by AC utility power. Base stations are generally higher in performance than mobile and portable radios, with higher powered and more stable transmitters and more sensitive and interference-resistant receivers. Some fire departments equip fire stations with base station radios to provide enhanced coverage throughout their service area and to provide backup communications in the event of a primary communications system failure.
基地台無線電位於固定地點，通常是由 AC 公用

電力驅動。基地台的效能一般會高於移動式與可攜式無線電，會有功率較高且更穩定的傳送器，以及更敏銳的抗干擾接收器。有些消防部門會讓消防局具備基地台無線電，藉以擴增服務的覆蓋範圍，並在主要通訊系統故障時提供支援通訊。

Repeaters are similar to base stations, but they can transmit and receive at the same time, retransmitting the signal received by the receiver. Repeaters are used to extend the coverage of portable or mobile radios.
中繼器類似於基地台，但可同時進行傳送與接收，重發接收器所收到的信號。中繼器的利用是為了擴展可攜式或移動式無線電的覆蓋範圍。

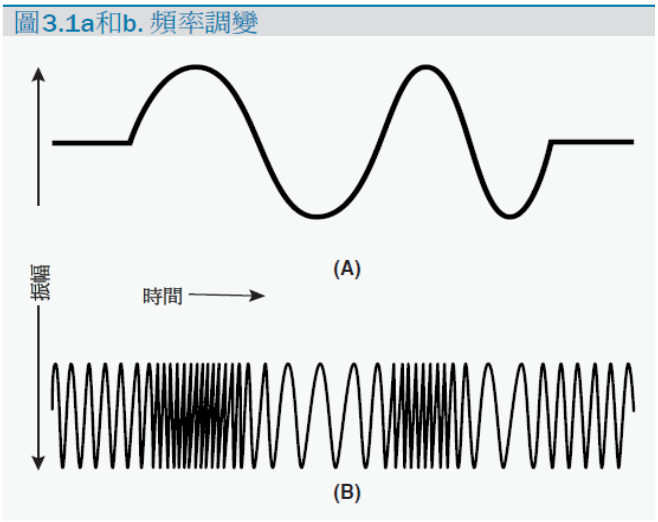
Radio console equipment is used by dispatchers to control base station radios and repeaters and allow the dispatcher to receive and transmit on one or more radios simultaneously. The consoles typically have individual volume and transmit controls for each radio as well as a master volume and transmit control. Headsets can be connected to the consoles along with footswitches, allowing dispatchers to operate the console hands-free so they can operate computer equipment simultaneously.
調度人員利用無線電控制臺設備控制基站無線電與中繼器，並同時接收和傳送一個或以上無線電。控制臺一般具有各無線電的音量與傳送個別控制器，以及音量與傳送的主控制器。控制臺可連接耳機和腳踏開關，讓調度人員可用雙手操作控制臺，同時操作電腦設備。

Analog Radios
類比無線電

The human voice is an analog signal. It is continuously varying in frequency and level. Analog radios have been in use since the invention of voice radio in the early 1900s. The type of analog radio used today was invented in the 1930s to improve on the older radio's poor immunity to noise. These radio systems use FM to modulate the transmitted signal with the user's voice. The main advantage of FM over older radio system types is that FM radios tend to reject (interfering) signals that are weaker than the desired signal.
人聲是類比信號，其頻率與位準會持續變化。類比無線電的使用始於二十世紀初期語音無線電的發明。今日使用的類比無線電發明於 30 年代，是為了改善舊型無線電的不良抗噪音性而產生的。這些無線電系統利用 FM 來調整載有使用者聲音的傳送信號。相較於舊型無線電系統，FM 無線電的主要優點是能夠拒絕比希望的信號還要弱的（干擾）信號。

Analog FM radios operate by causing the transmitting frequency of the radio to change directly with the microphone audio. Initially, the signal is filtered to remove any frequencies above human voice, but no other changes are made to the signal. **Figure 3.1a** shows an example signal from the microphone, and **Figure 3.1b** shows the resulting change in frequency of the transmitted signal.
類比 FM 無線電的運作是藉由令無線電傳送頻率直接與麥克風音頻一起改變。起初會過濾信號以清除任何高於人聲的頻率，除此之外，並未對信號做出任何改變。**圖 3.1a** 顯示麥克風信號的範例，**圖 3.1b** 顯示傳送信號頻率的改變結果。

圖3.1a和b. 頻率調變



FM radios constantly have a signal at the output of the receiver, and a squelch circuit is used to mute the output of the radio receiver when no desirable signal is present. Squelch circuits mute the output automatically until the signal is strong enough to unmute. Older radios had adjustable squelch level controls, allowing the user to make the radio less sensitive if there was interference. However, most new radios have squelch levels that are adjustable only by radio technicians using radio programming software.
FM 無線電的接收器輸出經常會有一個信號，當希望的信號不存在時，會使用靜噪電路令無線電接收器的輸出靜音。靜噪電路會自動將輸出消音，直到信號強度足以取消靜音。舊型無線電有可調式靜噪等級控制器，讓使用者可在信號受干擾時降低無線電敏感度。然而，大多數新型無線電的

靜噪等級，只能由無線電技術人員利用程式設計軟體來進行調整。

To further reduce received noise and interference, well-designed analog radio systems use Continuous Tone-Coded Squelch System (CTCSS) or Digital-Coded Squelch (DCS). CTCSS is also known by proprietary names such as Private Line™ (PL) or Channel Guard™ (CG).
為了進一步減少接收到的噪音與干擾，設計良好的類比無線電系統會使用連續音頻靜噪碼系統（CTCSS）或數位靜噪碼（DCS）。CTCSS 又以專利商標名為稱，如 Private Line™ (PL)或 Channel Guard™ (CG)。

CTCSS mixes a subaudible tone with the audio from the microphone and transmits the resulting signal. When a radio receives a signal with tone-coded squelch, the CTCSS decoder attempts to match the tone present in the received signal with the desired tone. If the correct tone is present, the receiver is unsquelched, and audio is routed to the speaker.
CTCSS 會混合次聲頻與麥克風的音頻，並將結果信號送出。無線電收到帶有語音靜噪碼的信號時，CTCSS 解碼器會試圖比對收到的信號與希望的信號。若正確的音頻存在，接受器的靜音會被取消，音頻會被發送到擴音器。

Digital Radios
數位無線電

To improve audio quality and spectrum efficiency, radio manufacturers introduced digital radios. Digital radio also provides a pathway for the FCC to improve efficiency and to meet the increasing requests for the radio spectrum. This is evidenced by a mandate to narrowband 700 MHz channels to a 6.25 kHz equivalent bandwidth by Dec. 31, 2016. However, this mandate was eliminated by an FCC ruling made October 2014. The FCC stated the following "We conclude that the December 31, 2016 narrowbanding implementation deadline is no longer viable. The record indicates that requiring narrowbanding by December 2016 would force many licensees to modify or replace existing systems well before the end of their useful life. In addition, we share the concerns expressed by many commenting parties about the maturity of 6.25 kilohertz-capable equipment, including the lack of developed open standards governing major system components."[8] The FCC recognized that many of the systems affected by the mandate would have been newer systems and that the mandate would require modification of systems that were not near end of life.
為了改善音頻品質與頻譜效率，無線電製造商研發了數位無線電。數位無線電也提供了一種途徑，讓 FCC 能提升效率並滿足對無線電頻譜的要求。FCC 下達命令，規定必須在 2016 年 12 月 31 日前將 700 MHz 通道窄頻成 6.25 kHz 等效頻寬。然而，此命令因 FCC 於 2014 年 10 月做出的裁決而撤銷。FCC 表示道：「我們推斷 2016 年 12 月 31 日的窄頻化限期不再可行。記錄顯示，要求於 2016 年 12 月以前完成窄頻化，會迫使許多證照持有人於系統使用期限到期前，修改或更換現有系統。此外，我們同意許多關於 6.25 千赫茲可用設備的完善度，包括缺乏管理主要系統部件的開放標準。」[8]FCC 承認許多受到該命令影響的系統有可能會是新型系統，也承認該命令會要求在使用期限尚未到達前對系統進行修改。

Digital radio continues to be plagued with difficulties in processing voice with high background noise. Advancements have been made in the signal processing, but there continues to be instances where digital radios struggle. The prime examples continue to be Personal Alert Safety System (PASS) devices and SCBAs with vibrating regulators that signify low air.
數位無線電在處理帶有高背景噪音的聲音方面持續遇到各種困難。信號處理已有許多進展，但仍然會有數位無線電難以運作的案例。主要的例子依舊是個人安全警報系統（PASS）裝置和具有顯示低氣量的振動調節器的 SCBA。

In the digital world, when a user speaks into the microphone the radio samples the speech and assigns the sample a digital value. A vocoder (voice coder) or codec (coder/decoder) in the radio performs the function of converting analog voice to a digital data packet. The digital data packet can vary in the number of bits. The use of digital audio was expected to reduce static and increase the range of radios in weak signal conditions. P25 vocoder manufacturer Digital Voice System Inc. (DVSI) has improved the Enhanced Vocoder's ability to recognize and suppress high frequency noise. The result is improved voice quality and intelligibility in high frequency noise such as PASS alarms. These improvements improve the

[8]FCC Report and Order, October 2014, FCC-14-172.
FCC 報告與指令，2014 年 10 月，FCC-14-172。

performance of digital radios on the fireground. Radio manufacturers also continue to improve the technology by employing noise canceling features and embedding noise filtering options in the radios.
在數位世界裡，使用者對著麥克風說話時，無線電會擷取語音樣本，並給予該樣本一個數位值。無線電的聲碼器（語音編碼器）或編解碼器（編碼器/解碼器）會將類比聲音轉換成一個數位資料包。數位資料包會有不同的位元數。過去預計使用數位無線電可減少靜電噪音，並在信號微弱的情況下擴增無線電覆蓋範圍。P25 聲碼器製造商，即 Digital Voice System Inc.（DVSI），已改善了強化聲碼器辨識與抑制高頻率噪音的能力，因而提升了 PASS 警報器等高頻率噪音中的聲音品質與可辨識度。這些改善提高了數位無線電在火場的效能。無線電製造商利用降造特性，並內建選購式噪音過濾器，藉以繼續改善無線電技術。

Digital Audio Processing
數位音頻處理

In digital radios, analog voice is converted to a digital interpretation from an audio sample received from the microphone **(Figure 3.2).** P25 digital radios have very limited data rates and bandwidth available to transport the digitized voice. P25 digital vocoders are designed to encode and decode the frequency range and elements of human voice. For example, digital radios do not accurately reproduce pure tones. The inability to transmit tones affects departments that use tones to alert firefighters of specific events on the fireground. Human speech is a constant variation in frequency and amplitude. If you attempt to transmit a pure tone, the received audio will not be a true reproduction of the source, and it is noticeably different.
數位無線電會將麥克風收到的音頻樣本的類比聲音轉換成數位判釋（**圖 3.2**）。P25 數位無線電擁有非常有限的資料傳輸率與頻寬可供數位化聲音使用。P25 數位聲碼器的設計是為了對人聲的頻率範圍與元素進行編碼和解碼。例如，數位無線電並不會精確地複製純音。無法傳送音頻會影響利用音頻警告消防員關於火場特定事件的部門。人在說話時，其言詞的頻率與振幅會不斷地變化。若您試圖傳送純音，接收到的音頻不會是音源的真實複製品，而且會有明顯的差異。

This is a basic explanation of how analog voice is processed by the radio.
以下是無線電如何處理類比聲音的基本說明。

Transmitting radio:
傳送無線電：

1. The user speaks into the microphone.
   使用者對著麥克風說話。
2. The audio is sampled and converted to a digital interpretation by an analog to digital converter (A/D converter).
   類比數位轉換器（A/D 轉換器）擷取音頻樣本，並將其轉換成數位判釋。
3. The vocoder converts the digitized speech into digital data.
   聲碼器將數位化語音轉換成數位資料。
4. The modulator modulates the RF with the digital data.
   調節器利用數位資料調整RF。
   The modulated RF signal is boosted in power by transmitter amplifier.
   傳送器增強器使得經調整的RF信號的強度增加。
5. The signal is transmitted from the radio antenna.
   信號從無線電天線傳出。

Receiving radio:
接收無線電：

1. The modulated RF is received by antenna.
   天線接收經調整的RF。
2. The received RF signal is boosted to a usable level by the receive amplifier.
   接收增強器將接收到的RF信號加強到可使用的程度。
3. The signal is demodulated by a demodulator. This removes the RF component of the signal leaving the digital data component.
   解調器解除信號調變。這會清除信號的RF部分，只留下數位資料部分。
4. Digital data is decoded by the vocoder into digitized speech.
   聲碼器將數位資料解碼成數位化語音。
5. Speech data is converted to an analog signal by a digital to analog converter (D/A converter).
   數位類比轉換器（D/A轉換器）將語音資料轉換成類比信號。
6. Analog is sent to the speaker.
   類比信號發送到擴音器。

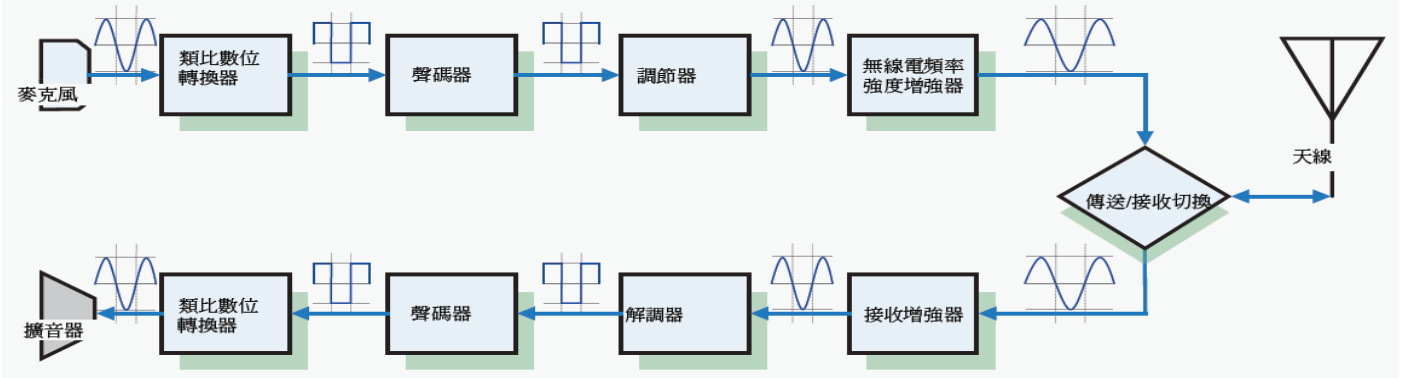
Analog and Digital Comparisons
類比與數位之比較

Distance
距離

As the radio user travels further from the transmitting radio, the signal strength decreases. The signal strength directly affects the ability of the radio to reproduce intelligible audio.
無線電使用者移動遠離傳送無線電時，信號強度會隨之變弱。信號強度會直接影響無線電複製可辨識語音的能力。

In an analog system, the clarity and intelligibility of the transmission, as received by the user, decreases directly as the signal level decreases. The noise (static) in the signal progressively increases in strength, while the desired signal decreases until the transmitting user cannot be heard over the noise. When the signal level is high, the voice quality is high. As the signal level decreases, the voice quality decreases in a predictable manner giving the user hints that the signal is getting weaker. This characteristic adds to the situational awareness allowing the user to make decisions about the environment.
在類比系統中，隨著信號強度的降低，使用者接收到傳輸的清晰度與可辨識度會直接下降。信號噪音（靜音噪聲）的強度會逐漸加強，而希望的信號強度會降低，直到發送信號的使用者無法聽到噪音以外的聲音。信號強度高，聲音品質就高。隨著信號強度的增加，聲音品質會以可預測的方式降低，讓使用者知道信號正在逐漸減弱。此特徵有助於狀態意識，能讓使用者做出與環境有關的決策。

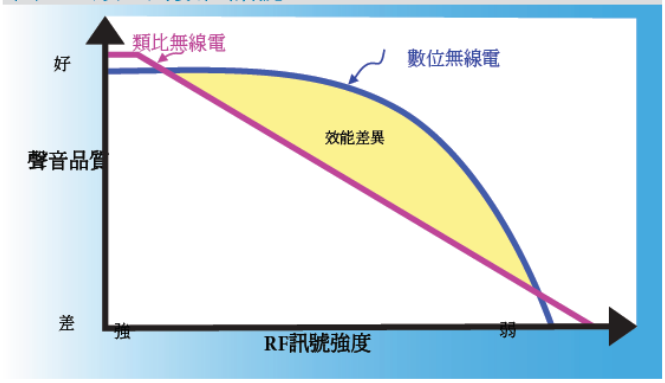
圖3.2. 數位無線電



When a digital user transmits to a receiver, the transmitted signal decreases just as the analog signal decreases. However, the digital transmission contains extra data providing error correction and allowing audio to be recovered despite declining signal. As the receiver travels further from the transmitter, the signal level decreases to the point where the error correction cannot correct all errors in the signal. When this point is reached, the receiving users will hear some distortion in the signal and may hear some strange nonspeech noises. These noises are often referred to as **digital artifact**. Once this point is reached, a small reduction in signal level will cause the number of errors to exceed the ability of the system to compensate, and all audio will be lost.
數位使用者傳送訊號到接收器時，訊號強度會像類比訊號一樣降低。然而，數位傳輸具有額外的資訊，可提供錯誤更正，且即使訊號減弱，也可讓語音得以被修復。接收器與傳送器之間的距離愈遠，訊號強度會降低到錯誤更正無法修正訊號所有錯誤的程度。達到這種程度時，接收的使用者會在訊號裡聽到一些失真的聲音，也有可能會聽到一些奇怪的非語言噪音。這些噪音通常稱為**數為人為失真**。依但達到這種程度，訊號強度稍微降低會導致一些錯誤超出系統的補償能力範圍，所有聲音都會不見。

Although digital radios provide a larger range of usable signal levels, the lack of advanced indication of signal level decrease allows users to get closer to complete loss of communication with less warning than an analog radio. As you note in **Figure 3.3,** the analog signal voice quality decreases in a near linear rate as signal level decreases. In comparison, digital voice quality has a steeper degradation when it reaches lower signal levels.
雖然數位無線電提供較大的可用訊號強度範圍，但因為缺乏先進的訊號強度減弱指示，使用者在完全失去通訊前所得到的警示比類比無線電還少。如**圖3.3**所示，類比訊號聲音品質會隨著訊號強度減弱，以接近線性的速率降低。相較之下，數位聲音品質在達到較低的訊號強度時，會有較陡的衰減斜度。

圖3.3. 類比對數位訊號



Voice Intelligibility
聲音可辨識度

The ability to understand the digital radio transmissions has been a focus of many fire departments. After implementation of P25 digital systems, it was discovered that digital audio was not the same as analog, and the performance differences were most prevalent during fire operations. One of the most significant differences was attempting communications with a vibrating low air alarm or a PASS device alarming.

理解數位無線電傳輸的能力一直都是許多消防局重視的事項。實施 P25 數位系統之後，發現數位無線電與類比無線電不一樣，兩者的效能差異在救火行動中最為明顯。最明顯的差異之一是試圖利用振動式低氣量警報器或 PASS 警報裝置進行通訊。

In 2007, the International Association of Fire Chiefs (IAFC) formed a working group to address potential problems with P25 digital radio. The working group consisted of fire service personnel, other public safety representatives, wireless radio manufacturers, manufacturers of fire apparatus and equipment, and consultants to address potential problems found in digital radios in the presence of loud background noise.[9] Funding for this effort was provided jointly by the DHS Office of Interoperability and Compatibility, the National Institute of Standards and Technology (NIST) Office of Law Enforcement Standards, and the Federal Partnership for Interoperable Communications (FPIC). As a result of the findings of the IAFC workgroup, the National Telecommunications and Information Administration (NTIA) allocated resources to perform testing of the P25 vocoders in the firefighting environment. NTIA TR-08-453[10] was released in 2008. The report identified performance differences between digital and analog radios. As we move forward in time, technology continues to advance. Emerging technologies and new vocoders, such as the ones used in cellphone technology (4G Long Term Evolution (LTE)), required testing. In response to emerging digital voice technologies, additional testing was performed by the NTIA. NTIA report 13-495[11] documents the performance of the different technologies in the firefighting environment. This next section will focus on the performance contrast between digital radio and analog radio.

國際消防隊長協會（IAFC）針對 P25 數位無線電的潛在問題，於 2007 年成立了一個工作小組。工作小組的成員包括消防服務人員、其他公共安全代表、無線電製造商、消防裝置與設備製造商，以及顧問，其目的在於解決在有巨大背景噪音時，所發現的數位無線電的潛在問題。[9]工作小組的資金是由 DHS 互操作性與兼容性辦公處、國家標準暨技術研究院（NIST）執法標準辦公處，以及聯邦可互用通訊夥伴關係（FPIC）所共同提供。根據 IAFC 工作小組的調查結果，美國國家通信暨資訊管理局（NTIA）分配資源，對消防環境的 P25 聲碼器進行測試。NTIA TR-08-453[10]於 2008 年發布。報告確認了數位與類比無線電之間的效能差異。當我們隨著時間前進，科技持續進步。新興技術和新的聲碼器需要進行測試，例如用於手機技術（4G 長期演進技術（LTE））的聲碼器。為因應新興數位語音技術，NTIA 執行了額外的測試。NTIA 13-495[11]報告記錄不同技術在消防環境的效能。下一章節將著重於數位無線電與類比無線電之間的效能對比。

Program 25 History
計畫 25 緣由

The Association of Public Safety Communications Officers (APCO), representing the public safety technical community and the Telecommunications Industry Association (TIA), recognized that there would be a requirement to move to digital technology. This provided an opportunity to develop an open standard that would allow different manufacturers to build equipment that could operate together. The goal

[9] http://www.iafc.org/digitalProject.

[10] NTIA Technical Report TR-08-453 Intelligibility of Selected Radio Systems in the Presence of Fireground Noise: Test Plan and Results, http://www.its.bldrdoc.gov/publications/2490.aspx.
NTIA 技術報告 TR-08-453 火場噪音下選定無線電系統之可辨識度：測試計劃與結果，http://www.its.bldrdoc.gov/publications/2490.aspx。

[11] http://www.its.bldrdoc.gov/publications/2720.aspx.

was to introduce competition into the market, help control costs, and provide a technology platform for improved interoperability.
代表公共安全技術群體與電信工業協會（TIA）的公共安全通訊官協會（APCO）承認將會有轉移到數位技術的需要。這提供了一個制定開放標準的機會，讓不同製造商能夠製造可以一起運作的設備。目的是為市場帶來競爭、幫助控制成本，以及提供一個改善互操作性的技術平台。

Up until the development of this standard, each manufacturer had proprietary digital radios that could interoperate only with like radios. Working with the TIA, APCO coordinated the work of manufacturers to develop the APCO P25 standard for digital radios. Modern public safety digital radios use this standard. P25 is the national standard for public safety digital radios but also is backward compatible for analog use. This standard was developed to allow radios from multiple manufacturers to communicate directly using a common digital language, to define standards for trunked radio systems to allow multiple manufacturers to operate on a common platform, and to provide a roadmap for future features and capabilities.
在此標準制定之前，各製造商擁有只可與相似無線電互相操作的專利數位無線電。在與 TIA 的合作之下，APCO 協調製造商的成品，以制定數位無線電的 APCO P25 標準。現代數位公共安全無線電採用此標準。P25 是數位公共安全無線電的國家標準，但也可反向相容於類比無線電。此標準的制定是為了讓不同製造商的無線電可利用通用數位語言直接進行通訊，定義集群式無線電系統以讓不同製造商可在共同平台上進行操作，以及提供一個路線圖給未來特色與功能。

The TIA Engineering Committee (TR-8) formulates and maintains standards for private radio communications systems and equipment for both voice and data applications. TR-8 addresses all technical matters for systems and services, including definitions, interoperability, compatibility and compliance requirements. The types of systems addressed by these standards include business and industrial dispatch applications as well as public safety (such as police, ambulance and firefighting) applications.
TIA 工程委員會（TR-8）制定並維持用於語音與資訊的私人無線電通訊系統與設備的標準。TR-8 處理系統與服務的所有技術性事項，包括定義、互操作性、相容性及符合性要求。這些標準所針對的系統種類包括商業與工業派遣應用，以及公共安全（如警察、救護車、消防等）應用。

Much of the work of the committee relates to the formulation of the TIA-102 series standards for APCO Project 25. These are standards sponsored by the Association of Public Safety Officials International, the National Association of State Telecommunications Directors (NASTD), and agencies of the federal government. P25 standards are developed to provide digital voice and data communications suited for public safety and first responder applications.[12]
委員會大部分的工作都相關於 APCO 計畫 25 的 TIA-102 系列標準之制定。這些標準的提議者為國際公共安全官協會、國家電信主管協會（NASTD），以及聯邦政府機構。P25 標準的制定是為了提供適合公共安全與應變人員應用的數位語音與數據通訊。[12]

Program 25 Interoperability
計畫 25 互操作性

P25 does not address any operational or interoperability needs. P25 also does not provide a fire department with interoperability unless it is planned for. A lone agency on P25 is no more interoperable than being on a UHF system trying to interoperate with a department on VHF. P25 only provides manufacturers with a common digital language for the radios and system infrastructures. The use of the P25 standard has provided a common platform that allows technical interoperability between systems. This, in turn, provides the technical path to provide interoperability for public safety operators.
P25 並不針對任何操作性或互操作性需求。除非早有計畫，否則 P25 也不會提供消防局互操作性。使用 P25 的單獨機構之互操作性並不會好於利用 UHF 系統試圖與使用 VHF 的部門進行互操作。P25 只提供製造商一個用於無線電與系統基礎設施的共同數位語言。25 標準的使用提供一個共同平台，讓系統之間有技術互操作性，而這又提供了用以讓公共安全操作者有互操作性的技術路徑。

P25 system standards also were meant to allow radios

[12]http://www.tiaonline.org/all-standards/committees/tr-8.

from different manufacturers to operate on any other P25-trunked radio system. While the intent was to provide complete interoperability between different trunked systems and portable manufacturers, the P25 standard allows manufacturers to implement nonstandard features. So a P25 radio may not have full functionality on a trunked system of a different manufacturer. The trunked systems available today offer many features and have complicated roaming schemes. If you are purchasing devices from a different manufacturer than your trunked system, care must be taken to thoroughly test to ensure all of the features you expect to use are functional.
P25 系統標準的制定也是為了讓不同製造商的無線電能夠在任何其他 P25 集群式無線電系統運作。P25 的用意在於提供不同集群式系統與可攜式製造商之間的完整互操作性，同時也讓製造商能實現非標準性能。今日的集群式系統具有許多性能和複雜的漫遊機制。如果您是向與您的集群系統不同的製造商購買裝置，務必謹慎地進行徹底的測試，以確保您希望使用的性能能夠確實運作。

Program 25 Characteristics in High-Noise Environments
P25：高噪音環境下之特徵

When P25 is used in settings where the background noise level is within limits set in the P25 standard, it provides usable audio. However, the P25 vocoder was not designed to operate in the high-background-noise environments encountered on the fireground. When the P25 vocoder was being developed, the designers tested intelligibility of the digital audio with high ambient noise levels at the receiving radio. The P25 vocoder is unable to differentiate the spoken voice from the high background noise and assigns a digital value that does not accurately represent the voice. The result is unintelligible audio or broken audio with digitized noise artifact. Users of P25 radios have been affected by many common fireground noises. The SCBA alerting systems for low air or inactivity and PASS devices have made the audio transmitted from digital radios unusable. P25 radios transmitting from high-noise environments do not perform to the same levels as analog radios.
於背景噪音強度在 P25 標準的限制範圍內使用 P25 時，P25 會提供可用的音頻。然而，P25 聲碼器的設計並不是為了用於火場的高背景噪音環境。研發 P25 時，設計師在接收器處於高環境噪音強度的情況下，測試了數位音頻的可辨識度。P25 聲碼器無法辨識說話的聲音和高背景噪音，而且會分配一個無法精準地代表聲音的數位值。產生的結果是帶有數位化噪音失真的不可辨識或中斷的語音。P25 無線電使用者受到許多常見火場噪音的影響。SCBA 低氣量或無運作警報系統與 PASS 裝置令數位無線電傳輸的語音變得無法使用。從高噪音環境傳輸的 P25 無線電無法以與類比無線電相同的程度運作。

Self-Contained Breathing Apparatus Mask Effect on Communications
自給式呼吸氣面罩對通訊之影響

The effect of SCBA masks on the human voice was published by the Institute of Electrical and Electronics Engineers (IEEE) Communications Magazine.
國際電機電子工程師學會（IEEE）通訊雜誌曾發表文章關於 SCBA 面罩對人聲的影響。

The testing in the IEEE article documents the effects of the SCBA system on voice intelligibility. Based on the testing, the conclusion was that “SCBA systems are frequently used by firefighters and other public service personnel who rely on speech radio communications to perform their work. The SCBA mask acoustically distorts speech and the breathing system produces noises that can detrimentally affect speech communications, especially when a digital speech codec is used in the communications link. Both speech intelligibility and speech quality are detrimentally affected by SCBA equipmentuse.”[13]
IEEE 文章中的測試說明了 SCBA 系統對聲音可辨識度的影響。根據測試結果，結論是「工作時依賴語音無線電通訊的消防員與其他公共服務人員經常使用 SCBA 系統。SCBA 面罩會使語音失真，呼吸系統會產生可能對語音通訊有不利影響的噪音，尤其是在通訊連結中有使用數位語音編解碼器的時候。使用 SCBA 設備會對語音客辨識度與語音品質有不利的影響。」[13]

[13] IEEE Communications Magazine, January 2006, “The acoustic properties of SCBA equipment and its effects on speech communication,” William M. Kushner, Member IEEE, S. Michelle Harton, Member IEEE, Robert J. Novorita, Member IEEE, and Michael J .McLaughlin ,Fellow IEEE.
IEEE 通訊雜誌，2006 年 1 月，「SCBA 設備的聲音性質與其對語音通訊的影響」，William M. Kushner,，IEEE 成員，S. Michelle Harton，IEEE 成員，Robert J. Novorita，IEEE 成員，以及 Michael J .McLaughlin，IEEE 會士。

Feedback
回饋

The presence of feedback can be affected by the type of system the radio is on. In simplex/direct systems, the presence of feedback is all radios are on the same frequency. If transmitting near many other radios set on high-volume settings, the receiving radios squeal due to a feedback loop that is created. In digital radios, the same conditions exist, but the radios emit what sounds like "crickets." In both analog simplex and digital simplex, it is important for users to be aware of this characteristic and shield the microphones from the other radios that are nearby.
回饋的存在可能會受無線電所使用的系統種類的影響。在單工/直接系統中，回饋的存在是所有無線電都在在同一個頻率。若在許多其他設定為高音量背景的無線電附近進行傳輸，產生的回饋環路會令接收的無線電發出尖銳的聲音。數位無線電也會相同的情況，但無線電發出的聲音聽起來會像是「蟋蟀」。就類比單工與數位單工無線電而言，使用者必須知道這項特徵，並保護麥克風遠離附近的其他無線電。

Simultaneous Transmissions
同時傳輸

When on the fireground, communications are often very fast, and many users are often trying to communicate at the same time. This can result in simultaneous transmissions. Simultaneous transmissions can be a hindrance to fireground communications, and there is a difference between analog and digital. In analog simultaneous transmissions, the result is a warble-like tone behind the voice. The technical term for this is heterodyning or mixing of frequencies. In analog, the receivers can hear that two units are transmitting and can ask for a repeat of the transmission. In digital, if the two signals are equal in strength, the receiver may quiet due to a corruption of the data stream. This can occur in any digital simplex/director digital repeated system where access is not controlled. Trunked systems only allow one user to transmit at a time, so this situation is highly unlikely.
火場上的通訊通常非常快速，許多使用者經常試圖同時進行溝通，這可能會造成同時傳輸。同時傳輸可能會阻礙火場通訊，而且類比與數位無線電之間有差異。類比無線電同時傳輸的結果是聲音背景會有一種像顫音的音調，技術術語是外差頻率或混頻。類比無線電的接收者器可聽出有兩個單位在進行傳輸，且可要求重複傳輸。若兩個訊號的強度一樣，數位無線電的接收器可能會因數據流中斷而安靜。這種情況有可能發生於任何未受管控的數位單工/直接系統或數位中繼系統。集群系統一次只能讓一名使用者進行傳輸，所以這種情況不太可能會發生。

Program 25 Digital for Firefighting
P25：用於消防之數位無線電

Fire departments and other emergency service agencies have successfully implemented digital radio systems. However, fire departments around the country have reported difficulties with digital radios.[14] A simple Internet search of "Fire Department Digital Radio Problems" will yield a long list of problems encountered by firefighters using digital technology.[15] To say that all digital is bad would be an incorrect statement. Each instance must be analyzed individually for the cause. What is important is to understand the cause of the communications problem and either design it out of the system or avoid use of the technology when it is does not meet operational requirements. This analysis should be done for any technology employed on the fireground. Studies performed by NIST, IAFC and portable radio manufacturers have supported the findings from the field users. Fire departments need to consider the performance differences between digital and analog technologies when researching new communications systems. This is supported by NFPA 1221, *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems*, (2013 edition). It requires a tactical analog channel for on-scene communications.

消防局與其他緊急服務機構已成功實施數位無線電系統。然而，全國各地都有消防局提出關於數位無線電的使用問題。[14]在網路上搜尋「消防局數位無線電問題」，會出現許多消防員在使用數位技術時遇到的問題。[15]說所有數位無線電都不好是錯誤

[14] http://www.iafc.org/files/digProj_DPWGinterimReport.pdf.
[15] This website is a collection of information on radio system that can be of value:
http://blog.tcomeng.com/index.php/digital-trunked-radio-system-problems/.
此網站提供的無線電系統資料可能屬重要資料：
http://blog.tcomeng.com/index.php/digital-trunked-radio-system-problems/.

的陳述。必須對各情況進行個別分析以釐清原因。重要的是，必須了解通訊問題的起因，並在不符合操作要求時，從設計中排除或避免使用該技術。應該對在火場採用的任何技術進行分析。NIST、IAFC 與可攜式無線電製造商的研究已證實現場使用者的發現結果。尋找新的通訊系統時，消防局必須考量數位與類比技術之間的差異。NFPA 1221，*緊急服務通訊系統之安裝、維修與使用標準*（2013 年版），規定必須有現場通訊專用的戰術類比通道。

9.3.1.3 A communications radio channel, separate from the radio dispatch channel, shall be provided for on-scene communications.
9.3.1.3 應該提供一個與無線電調度通道不同的現場專用通訊無線電通道。

9.3.1.4 At a minimum, the tactical communications channel identified in 9.3.1.3 shall be capable of analog simplex mode.
9.3.1.4 第 9.3.1.3 節所定義的戰術通訊通道至少應該能夠以類比單工模式運作。

When fireground noise of high amplitude is introduced, the voice translation ability of the P25 radio decreases and generates audio that is poor or not intelligible. These problems are worsened when the firefighter is speaking into the portable radio through an SCBA facepiece. Bone microphones, throat microphones and microphones in the facepiece minimize the interference caused by background noise by isolating the transmitted voice from background noise. Speaker microphones are subject to the same problems that are found with the microphone on the portable radio.
火場高振幅噪音傳入無線電時，P25 無線電的聲音轉發能力會下降，所產生的聲音會是品質不良或不可辨識的聲音。當消防人員透過 SCBA 面罩對著可攜式無線電說話時，這些問題會更嚴重。骨導傳麥克風、喉式麥克風和面罩內建麥克風會將傳輸聲音與背景噪音隔離，藉以令背景噪音造成的干擾最小化。喇叭麥克風容易會有與可攜式無線電麥克風相同的問題。

The configuration of the P25 vocoder is limited in its capability to translate the human voice in the presence of common fireground noise or through a facepiece. The studies performed by NIST and IEEE illustrate that digital radio intelligibility when talking through an SCBA facepiece is degraded. This can pose a safety hazard for fireground operations. To maintain safety, fire departments should consider using portable radios that incorporate analog modulation for operations where the firefighter is using an SCBA.
P25 聲碼器的配置受限於其於一般火場噪音存在下或透過面罩轉發人聲的能力。NIST 與 IEEE 的研究顯示數位無線電可辨識度在透過 SCBA 面罩說話時會降低。這可能會對火場行動造成安全上的危險。為了保持安全，消防局應考慮在消防局使用 SCBA 的行動中，採用結合類比調變的可攜式無線電。

Radios using the P25 digital technology have performed well for other fire service functions, such as on emergency medical incidents and support functions on the fireground where an SCBA is not required, as well as law enforcement operations. The difficulties presented by the inability of P25 radios to produce intelligible voice messages in the presence of fireground noise is a significant safety concern and should be considered seriously by public safety radio system designers and users.
使用 P25 數位技術的無線電在其他消防服務功能的表現良好，例如緊急醫療事件和不需要使用 SCBA 的火場支援行動，以及執法行動。因 P25 無線電無法在火場噪音下產生可辨識聲音訊息而引起的問題是重要的安全顧慮，公共安全無線電系統設計師與使用者應慎重考量這點。

P25 radio manufacturers recognized the need to filter or cancel background noise in the firefighting environment. Manufacturers took advantage of digital audio processing to remove the noise or use noise canceling using one microphone to detect the spoken audio and a second to detect the background noise. While these methods can work, it is important to note that this has increased the complexity of programming the radio. A missed checkbox when programming the radio can have detrimental effects. All new radio configurations must be thoroughly tested to ensure proper operation. The days of just buying an off-the-shelf speaker microphone and it working are gone.
P25 無線電製造商知道必須過濾或消除消防環境的背景噪音。製造商利用數位語音處理來消除噪音，或者利用兩支麥克風分別用以偵測言詞語音和背景噪音，藉以進行噪音消除。雖然這些方法可能有用，但必須知道這提升了無線電成式設計的複雜度。設計無線電程式時，一個未選取的核取方塊可能會造成不良影響。所有新無線電配置都必須經過徹底的測試以確保正常運作。單單購

買現成的喇叭麥克風即可使用的日子已不復存在。

Summary — Digital and Analog Radio
摘要─數位與類比無線電

There are multiple radio types in use by the fire service. Mobile radios are usually mounted in vehicles. Mobile radios usually have better performance than portable radios. Mobile radios usually have better receivers and more powerful transmitters. Mobile radios used in trunked radio systems may or may not have more powerful transmitters. Portable radios are hand-held radios powered by rechargeable or replaceable battery packs. They usually have an external rubber antenna attached to the top of the radio. Portable radios have power limitations and suffer performance degradation based on where the user operates from and where the radio is worn. Base station radios are located at fixed locations, and usually are powered by AC utility power. Base station radios generally are higher in performance than mobile and portable radios. Repeaters are similar to base stations, but they can transmit and receive at the same time, retransmitting the signal received by the receiver. Repeaters are used to extend the coverage of portable or mobile radios.
消防服務採用多種無線電。移動式無線電通常安裝在車上。移動式無線電的效能通常比可攜式無線電好。移動式無線電通常備有較好的接收器與更強的傳送器。可攜式無線電是由可充電或可替換電池組所驅動的手持無線電。可攜式無線電通常有一支連結在上方的外部橡膠天線。可攜式無線電有功率限制，且其效能會因使用者操作的地方和無線電的配戴位置而降低。基站無線電位於固定的地點，通常是由 AC 公用電力所驅動。基站無線電的效能比移動式與可攜式無線電好。中繼器類似於基站。但可同時進行傳送和接收，即轉發接收器收到的訊號。中繼器用於擴展可攜式或移動式無線電的覆蓋範圍。

Analog radios have been in use since the invention of voice radio in the early 1900s. The type of analog radio used today was invented in the 1930s to improve on the older radio's poor immunity to noise. These radio systems use FM to modulate the transmitted signal with the user's voice.
類比無線電的使用始於二十世紀初期語音無線電的發明。今日使用的類比無線電發明於 30 年代，是為了改善舊型無線電的不良抗噪音性而產生的。這些無線電系統利用 FM 來調整載有使用者聲音的傳送信號。

To improve audio quality and spectrum efficiency, radio manufacturers introduced digital radios. Digital radio also provides a pathway for the FCC to improve efficiency and to meet the increasing requests for the spectrum.
為了改善音頻品質與頻譜效率，無線電製造商研發了數位無線電。數位無線電也提供了一種途徑，讓 FCC 能提升效率並滿足對無線電頻譜的要求。

P25 digital radios have different performance characteristics from analog radios. Digital radio in some environments provides clear voice with no background noise. The fire service environment is a challenging environment to operate in, and digital radios have performance degradation in several areas. The specific areas to be concerned with are:
P25 數位無線電的效能與類比無線電不同。數位無線電在某些環境中可提供無背景噪音的清楚聲音。消防服務環境是具有挑戰性的環境，數位無線電的效能在某些區域會降低。應顧慮的特定區域如下：

- Radio use with an SCBA.
  透過 SCBA 使用無線電。
- Intelligibility in a high-noise environment.[16,17]
  高噪音環境下的可辨識度。[16] [17]
- PASS device.[18]
  PASS 裝置。[18]
- Vibrating low-air alarms.

[16] Position Paper — Background Noise and Radio Performance, http://content.motorolasolutions.com/promo/sayitloud/FRI_Paper_RO-99-2169_3.pdf.
立場書—背景噪音與無線電效能，http://content.motorolasolutions.com/promo/sayitloud/FRI_Paper_RO-99-2169_3.pdf.

[17] NTIA Technical Report TR-08-453 Intelligibility of Selected Radio Systems in the Presence of Fireground Noise: Test Plan and Results, http://www.its.bldrdoc.gov/publications/2490.aspx.
NTIA 技術報告 TR-08-453 火場噪音環境下選定無線電系統之可辨識度：測試計劃與結果，http://www.its.bldrdoc.gov/publications/2490.aspx.

[18] National Public Safety Telecommunications Council (NPSTC) Brief — August 2008: International Association of Fire Chiefs Investigate Fireground Noise and Digital Radio Transmissions.
國家公共安全通訊委員會(NPSTC)簡報—2008 年 8 月：國際消防隊長協會調查火場噪音與數位無線電傳輸。

振動式低氣量警報器。
- Feedback。
  回饋。

Fire departments need to consider the performance differences between digital and analog technologies when researching new trunked communications systems.
尋找新的集群通訊系統時，消防局必須考量數位與類比技術之間的效能差異。

An analog simplex channel is a requirement in NFPA 1221 (2013 edition). The availability of analog simplex channel(s) for firefighting applications when the firefighter is using an SCBA is vital. Local fire departments need to test all elements of the communication system to ensure reliability (SCBA, radios, and any accessories such as speaker microphones, in-mask communications systems, etc.).
NFPA 1221（2013 年版）規定必須有類比單工通道。類比單工通道的可用性於消防人員使用 SCBA 進行消防作業時，是非常重要的。地方消防局必須測試通訊系統的所有要素，以確保可靠性（SCBA、無線電，以及任何配件，如喇叭麥克風、面罩內件通訊系統等）。

NFPA 1221 (2013 edition) requires a tactical analog channel for on-scene communications.
NFPA 1221（2013 年版）規定必須提供現場通訊專用的戰術類比通道。

> 9.3.1.3 A communications radio channel, separate from the radio dispatch channel, shall be provided for on-scene communications.
> 9.3.1.3 應該提供一個與無線電調度通道不同的現場專用通訊無線電通道。
>
> 9.3.1.4 At a minimum, the tactical communications channel identified in 9.3.1.3 shall be capable of analog simplex mode.
> 9.3.1.4 第 9.3.1.3 節所定義的戰術通訊通道至少應該能夠以類比單工模式運作。

The P25 standard continues to be the most common radio platform and will be into the foreseeable future. P25 systems offer a common radio language that provides a path to interoperability, but as with any system, interoperability has to be part of the plan.
P25 標準持續是最常用的無線電平台，可預見未來也會是如此。P25 系統提供一種共用無線電與研做為互操作性的途徑，但如同任何其他系統，該互操作性必須是計畫的一部分。

Section 4–
第 4 節–

Conventional Radio Systems
傳統無線電系統

There are a wide variety of radio systems in use today. There are simple systems that use a conventional analog repeater to complex trunked systems that employ the latest technologies. Conventional systems are generally categorized as nontrunked. Conventional systems are not computer controlled systems that require data infrastructure and controllers to manage radio traffic. Trunked systems, on the other hand, do require data infrastructure, and the portable units on a trunked system are infrastructure dependent. It is important that users of the system understand how the system works. This does not mean that they need to know the technical details of the system, but how to make it or adjust it to achieve reliable communications. In today's world, most of us carry a mobile communications device, either a cellphone or smartphone. We may not understand what code division multiple access (CDMA), FDMA, 1XRTT, 3G or 4G are, but we do use these systems and are able to make these systems work for us. An example would be walking inside of a building, and your 4G indication is absent, and the signal level indicator has one bar. You know that these indications mean that you need to move to an area with better cellular coverage. It has become second nature to us, and we need to have the same comfort level with the radio systems when we do the dangerous work of firefighting. The following sections describe some typical system configurations. Each and every system can vary based on how the system is programmed or how the portable radios are programmed. It is incumbent on us to train firefighters on the operational capabilities and limitations of these systems and their ability to provide reliable communications.

今日使用的無線電系統種類繁多。有利用傳統類比中繼器令採用最新科技的集群式系統複雜化的簡單系統。傳統系統一般歸類為非集群式。傳統系統不是需要資料基礎建設與控制器才能管理無線電流量的電腦控制系統，而集群系統則需要資料基礎建設，且使用集群系統的可攜式單元仰賴基礎建設。重要的是，系統使用者必須了解系統的運作原理。這並不表示他們必須知道系統的技術細節，而是如何讓系統或調整系統使其達到可靠的通訊。在今日的世界中，大部分人們會攜帶移動式通訊裝置，即一般手機或智慧型手機。我們可能不懂甚麼是分碼多重接取(CDMA)、FDMA、IXRTT、3G 或 4G，但我們確實會使用這些系統，也能夠讓這些系統為我們服務。舉例來說，當您走進一棟建築，您的 4G 指示不存在，且訊號強度指示器只有一格時，您知道這些指示表示您必須移動到手機覆蓋範圍較好的區域。這已經成為我們的習慣，所以執行危險的消防作業時，我們必須能輕鬆地使用無線電系統。以下章捷說明一些典型的系統配置。根據系統或可攜式無線電的程式設計或，每一個系統都有可能不同。教育消防人員關於操作功能，以及這些系統的限制與其提供可靠通訊的能力，是我們的責任。

Direct and Repeated Radio Systems
直接與重複無線電系統

Radios communicate when the transmitter sends out a signal that is received by one or more receiving radios. When the signal is received from the radio initially transmitting the signal, the communication is direct. (That is, there is no intervening radio or system.) When one radio transmits and the other radios receive, this type of communication is known as simplex communication. In a repeated system, the portable radio transmit frequency is received by the repeater and retransmitted on the portable receive frequency at a higher power to extend range or increase penetration.

當傳送器送出由一個或以上接收無線電所接收的訊號時，無線電即進行通訊。若訊號來自於原始發送信號的無線電，通訊是直接的。(也就是說，沒有任何干預無線電或系統。)若傳送與接收的是不同的無線電，這種通訊稱為單工通訊。在重複系統中，可攜式無電線傳輸頻率由中繼器接收，並用較高功率的可攜式無線電接收頻率進行轉發，以擴展範圍或增加穿透度。

Direct/Simplex Communications on the Fireground
火場之直接/單工通訊

Using simplex communications maintains positive communications between the IC, exterior on-scene units, and interior units without the reliance on

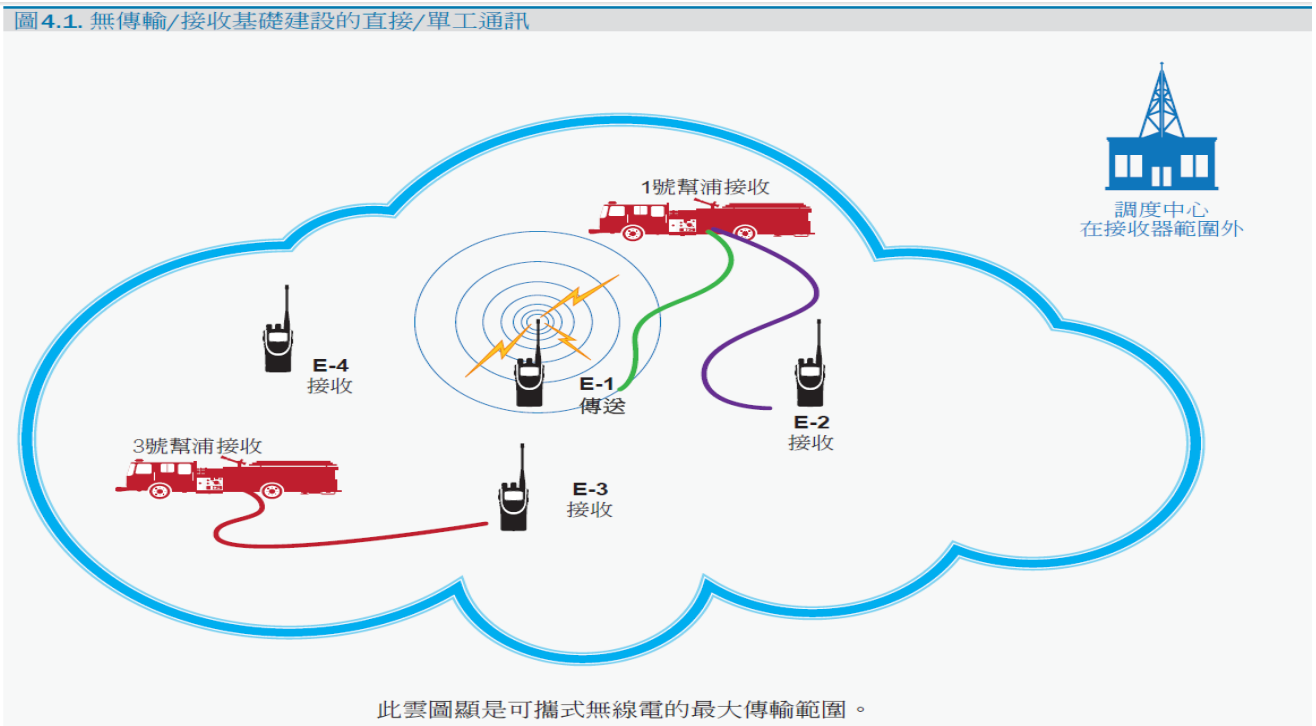
exterior communications systems. Maintaining positive communications is especially important in "mayday" situations. When users on simplex radios are deployed to the interior of a structure, they create a radio receiver network. As more and more radios move into the structure, the strength of the network increases. If Engine 1 calls mayday, the probability of another radio on the interior receiving the transmission is high. If the mayday is not heard by the IC, another radio operator on the interior can act as a human repeater to repeat the message to the IC. In addition, the number of radios in a structure creates redundancy, whereas reliance on a single repeater or trunked system creates a single point of failure. Simplex communications allow direct communications with the initiator of the mayday and other crews on the fireground.

使用單工通訊可維持 IC、外部現場單位與內部單位之間的確實通訊，無須仰賴外部通訊系統。確實通訊的維持在"mayday"情況下特別重要。單工無線電使用者被部署到建築內部時，會創造一個無線電接收器網路。隨著建築內的無線電數量增加，網路強度也會提升。若 1 號消防車呼叫 mayday，內部另一台無線電接到傳輸信息的機率很高。若 IC 未聽到 mayday 呼叫，內部的另一名無線電操作員可擔任人類中繼器，將訊息重複給 IC。此外，建築內無線電數量會造成冗餘，而對單一中繼器或集群系統的依賴會造成單點故障。單工通訊讓 mayday 發送者能夠與火場其他工作人員直接通訊。

This is an example of direct/simplex communications with no infrastructure **(Figure 4.1).** This means that there is no infrastructure to support receiving and transporting the fireground communications to the dispatch center, and without remote transmitters, the dispatch center is not able to transmit to the fireground. When the radios involved in direct communication are portable radios, the communication distance typically is limited to a few miles; for mobile radios the distance can be 50 to 100 miles. Often this is referred to as "line-of-sight communication," and this makes direct/ simplex radio communication most suitable for tactical use by units on an incident scene. Command systems that use these types of channels often have a command channel. In this type of system, the dispatch center monitors the command channel and the IC relays the relevant information received on the direct/simplex channel onto the command channel.

這是無基礎建設的直接/單工通訊的例子(**圖4.1**)。這表示沒有可支援火場通訊與調度中心接收和傳輸的基礎建設，而少了遠端發送機，調度中心會無法傳輸訊號到火場。若直接通訊使用的是可攜式無線電，通訊距離一般受限於數英里內；移動式無線電的距離可達 50-100 英里。這通常稱為「視距通訊」，這使得直接/單工無線電通訊成為最適合事故現場單位作為戰術用途的無線電。使用這種通道的指揮系統一般會有一個指揮通道。在這種系統中，調度中心監控指揮通道，而 IC 將直接/單工通道收到的相關資料轉傳到指揮通道。

圖4.1. 無傳輸/接收基礎建設的直接/單工通訊



此雲圖顯是可攜式無線電的最大傳輸範圍。

The direct communication method is the simplest form of radio communication and is easily affected by terrain blocking, including man-made structures such as buildings. If an obstruction is between the transmitting and receiving radios, communication may not be possible. Users must be aware that some buildings due to size or construction cause communications difficulty. Many jurisdictions place warnings in computer-aided dispatch (CAD) systems to alert users of structures with known communications difficulties. Users can be advised to use human repeaters to communicate to the IC. Additionally, awareness on the fireground is important; if a communication attempt to the IC from the interior is heard and the IC does not answer, that might be a cue to relay the information. The short-range nature of direct communication also allows one radio channel used by one communicating group to be reused by another group further away. If the second group is far enough away that it does not hear the first group's communications, then the channel can be reused. This minimizes the number of channels needed by an agency.

直接通訊方式是最簡單的無線電通訊形式，但容易受地形阻擋的影響，包括建築物等人造結構。若傳輸與接收無線電之間有障礙物，可能會無法進行通訊。使用者必須知道，某些建築物會因其尺寸或構造而造成通訊問題。許多管轄單位會在電腦輔助調度（CAD）系統放置警示，以警告使用者有通訊問題的存在。可建議使用者利用人類中繼器與 IC 進行通訊。此外，覺悟性在火場上是相當重要的；若聽到內部試圖傳到 IC 的訊號，而 IC 未回應，這可能意味著必須轉發該信息。直接通訊的短程性質也讓一個通訊群組使用的無線電通道可被另一個距離較遠的群組重複使用。若第二個群組的距離夠遠，無法聽到第一組的通訊，即可重複使用通道。這可令一個機構所需的通道數量最小化。

When a radio system must cover a larger area, or when terrain or other obstructions limit the distance a system can cover, additional equipment is needed to overcome these limitations.

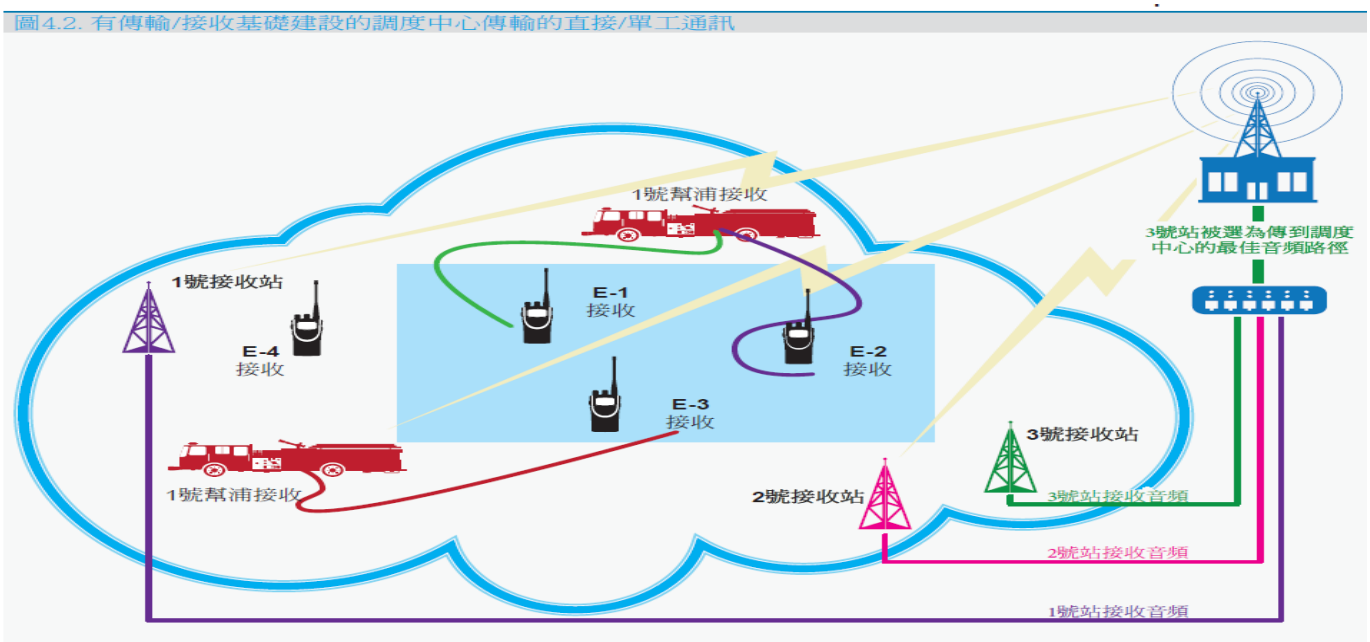
當無線電系統必須涵蓋較大的區域時，或者當地形或其他障礙物限制了系統可涵蓋的範圍時，需要有額外的設備來克服這些限制。

Receiver Voters — Improve Field Unit to Dispatcher Communications
接收器選擇器─改善現場單位與調度人員之通訊

Dispatch centers connected to high-powered transmitters provide the dispatch center with talk-out capability. Transmitters are elevated to achieve better line-of-sight communications with the service area. High-powered transmitters ensure that the dispatch center transmissions are heard throughout the service area and provide some level of in-building coverage **(Figure 4.2).**

連接到高功率傳送器讓調度中心能夠對外說話。改善傳送器以達到與服務區域較好的視距通訊。高功率傳送器確保整個服務區域都可聽到調度中心發出的信息，並提供某種程度上的建築內覆蓋範圍（**圖 4.2**）。

圖4.2. 有傳輸/接收基礎建設的調度中心傳輸的直接/單工通訊

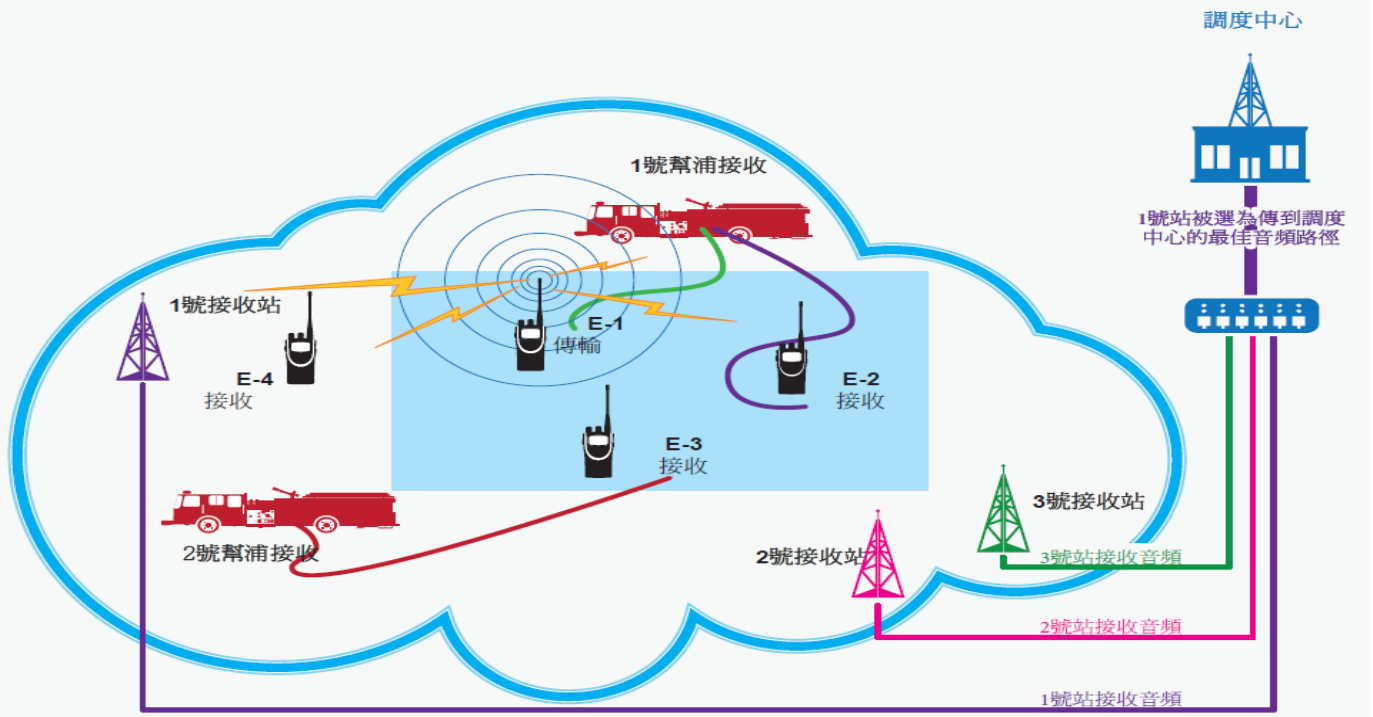


調度中心的高功率傳送器讓火場所有無線電都能進行接收。

Portable radios have limited power and cannot always transmit a signal strong enough to reach the transmitter sites. To provide a more balanced system, receivers are networked together throughout the service area in a receiver voter system (RVS) **(Figure 4.3).** Comparison of the received audio signal takes place in a receiver voter. The receiver voter and its network of receivers are referred to as the RVS. The RVS usually is located at the dispatch center. The receiver voter compares the audio from all receivers and routes the audio from the receiver with the best audio quality to the dispatcher. This type of system provides very reliable fireground communications and supports fireground simplex channels.

可攜式無線電的功率有限，無法一直傳輸強度足以抵達傳送器站的訊號。為了提供一個更平衡的系統，整個服務區域內的接收器以接收器選擇器系統（RVS）連結在一起形成一個網路（**圖 4.3**）。接收器選擇器會比較收到的語音訊號。接收器選擇器與其接收器網路共同稱為 RVS。RVS 一般位於調度中心。接收器選擇氣會比較所有接收器傳來的音頻，並將從最佳語音品質接收器收到的音頻轉發給調度人員。這種系統提供非常可靠的火場通訊，並且支援火場單工通道。

圖4.3. 有傳輸/接收基礎建設的可攜式無線電傳輸的直接/單工通訊



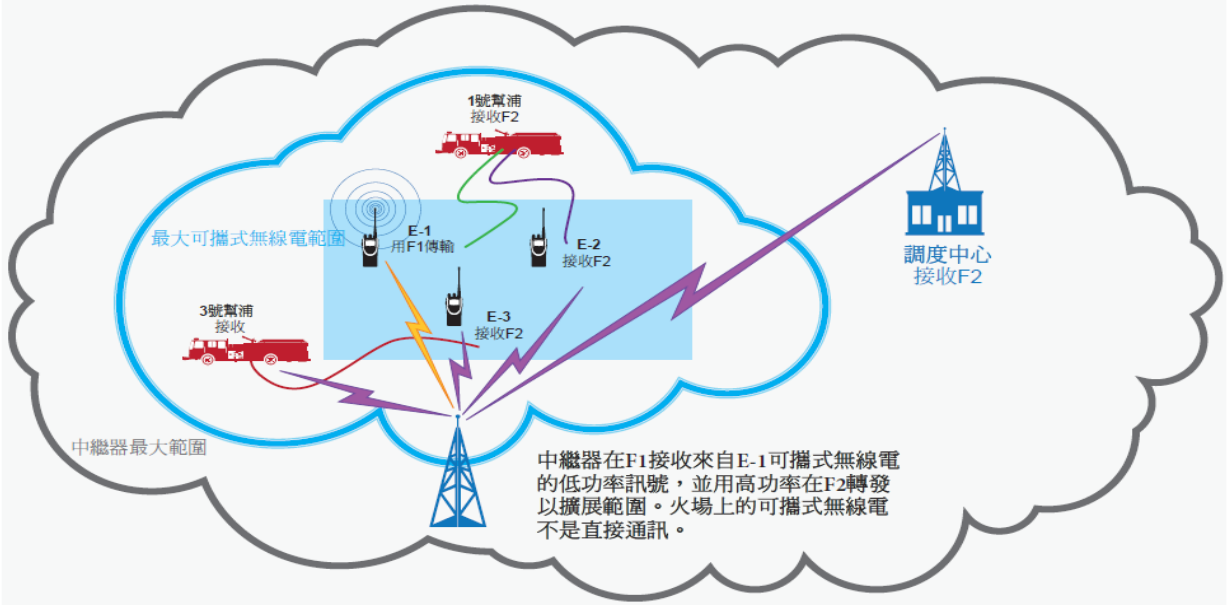
此雲圖顯示可攜式無線電的最大傳輸範圍。

Repeaters — Improve Field Unit to Dispatch and Off-Scene Units
中繼器─改善現場單位與調度和離場單位之通訊

Receiver voters are one solution to get communications from a radio user to the dispatch center, but another solution is needed to get the communication to other radio users. One type of system that can solve this problem is a repeated radio system **(Figure 4.4).** Repeated radio communication, also known as half duplex communication, uses two RFs for communication. The transmitting radio transmits on Frequency 1 (F1), and that signal is received by the repeater. The repeater then repeats the transmission on Frequency 2 (F2), and this signal is received by the receiving radio. By locating the repeater on a high building or mountain, the range of transmissions from the transmitting radio can be more than doubled and can reach over obstacles effectively.

接收器選擇器是將無線電使用者的訊息傳到調度中心的一種方法，但需要另一種方法來將訊息傳給其他無線電使用者。可解決此問題的系統之一是重複無線電系統（**圖 4.4**）。使用兩個 RF 進行通訊的重複無線電通訊又稱為半雙工通訊。傳送無線電利用 1 號頻率（F1）進行傳輸，該訊號由中繼器接收。中繼器會在 2 號頻率（F2）重複該傳輸，此訊號由接收無線電進行接收。藉由將中繼器安裝在高樓或山上，可令傳送無電線的傳輸範圍加倍，並有效地越過障礙物。

圖4.4. 中繼器系統—可攜式無線電傳輸—火場通訊



Another solution to improving communication between field units inside buildings or tunnels and dispatch and off-scene units is the bidirectional amplifier (BDA). BDAs can be used with half duplex radio systems to extend coverage from inside the structure to outside the structure and vice versa, but BDAs do not operate with simplex radio systems. BDAs are discussed in more detail in Section 5 — Trunked Radio Systems.

建築或隧道內現場單位與調度和離場單位之間通訊的另一種改善方法是雙向放大器（BDA）。BDA 可與半雙工無線電系統一起使用，以擴展建築內部到外部的覆蓋範圍，反之亦然，但 BDA 無法與單工無線電系統一起使用。第 5 節—集群式無線電系統將更詳細地探討 BDA。

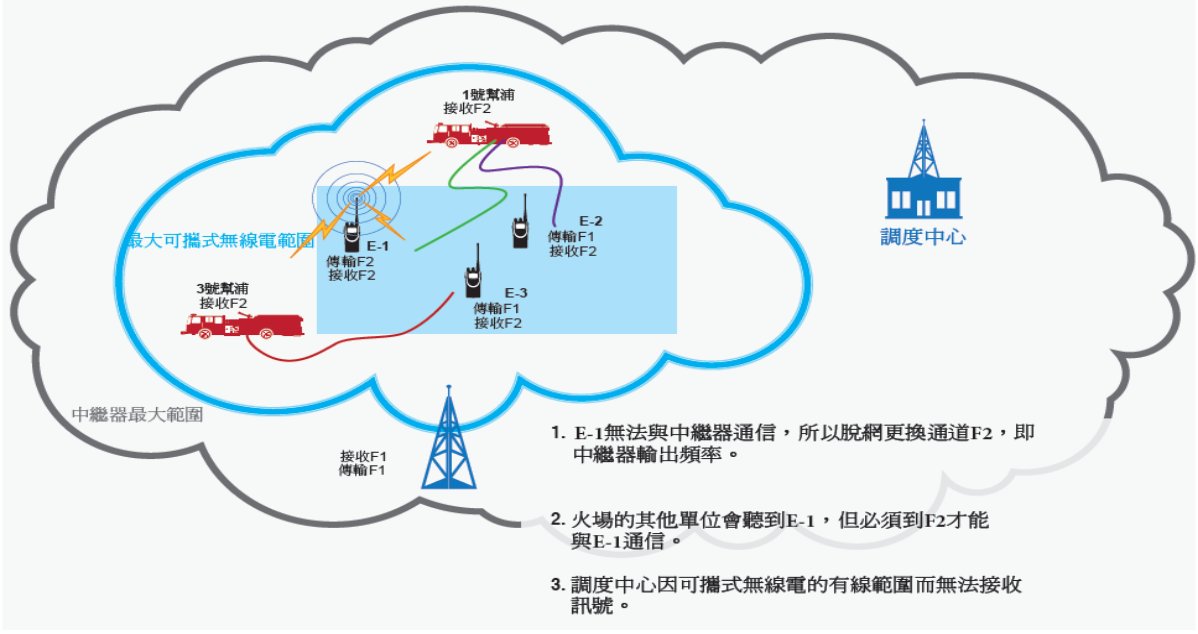
The significant operational difference between direct and repeated communications is that with direct communication, the transmitting radio's signal only needs to reach other radios directly on the incident scene. With a repeated system, the signal must reach the closest repeater location, which may be much further from the incident than the receiving radios.

直接與重複通訊之間明顯的運作差異是，利用直接通訊時，傳送無線電的訊號只需要直接傳達到事故現場的其他無線電，而利用重複系統時，訊號必須傳達到最近的中繼器位置，但該位置與事故現場的距離可能遠大於接收無線電。

Figure 4.5 shows a method to overcome this limitation. If unit E-1 is unable to communicate with other units on the fireground using the repeater system, E-1 can switch to talk-around mode on the radio. This mode allows the unit to transmit in direct mode to other radios on the fireground and receive from the units in either direct or repeated mode. Since the radio is not able to reach the repeater, the dispatch center cannot hear the radio, although other radios on the fireground can hear the unit. A unit that switches to talk-around should announce this immediately so other units know that they also may need to switch to communicate with the isolated unit.

圖 4.5 顯示可用以克服這限制的方法。若 E-1 單位無法與火場上使用中繼器系統的其他單位通信，E-1 可將無線電切換到脫網模式。此模式讓該單位能夠直接傳輸訊號到火場的其他無線電，並接收使用直接或重複模式的各單位的訊息。因為無線電無法傳達到中繼器，調度中心無法聽到無線電，即使火場上的其他無線電可聽到該單位的聲音。切換到脫網的單位應該立即告知此情況，讓其他單位知道他們可能也必須進行切換以與脫網單位通信。

圖4.5. 中繼器系統—可攜式無線電傳輸脫網—火場通訊



Simulcast Transmitter Systems
同頻共波傳送器系統

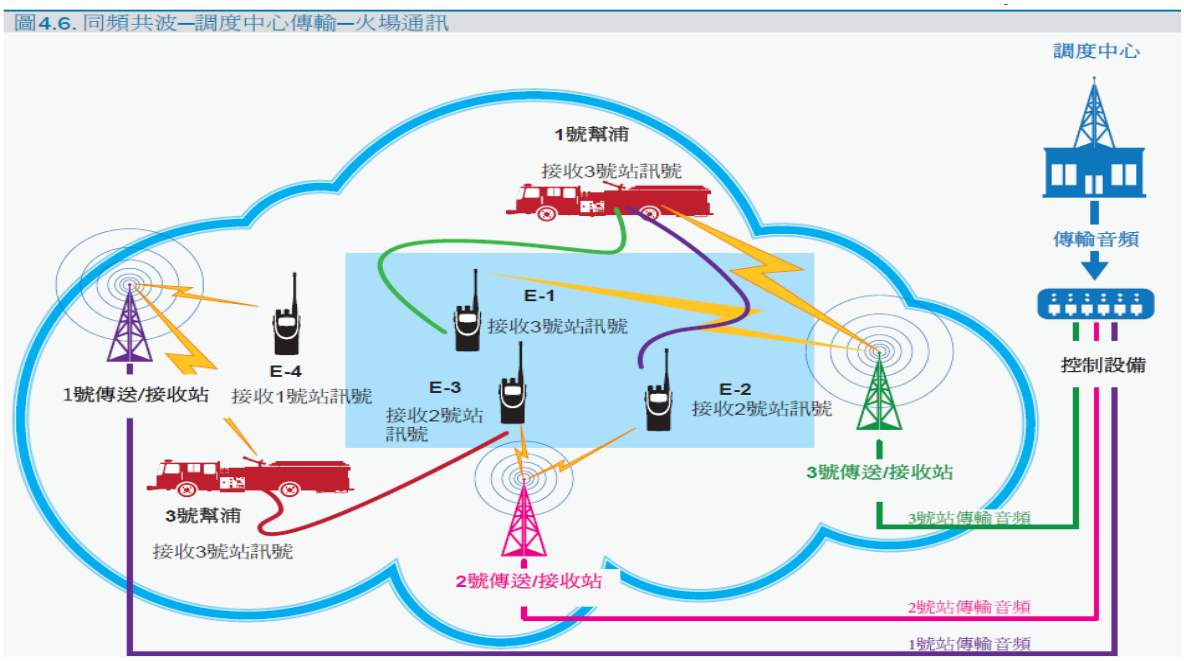
When a radio system must cover a large area but the number of available frequencies is limited, a simulcast transmitter system may be the solution **(Figure 4.6).** With this system, multiple transmitters simultaneously transmit on the same frequency. The transmitters must be precisely synchronized so that the signals they transmit do not interfere with each other.

若無線電系統必須涵蓋大區域，但可用的頻率數量有限，同頻共波傳送器系統可能會是解決方案（**圖4.6**）。透過此系統，多個傳送器可同時用相同的頻率進行傳輸。傳送器的同步必須非常精準，如此才不會干擾到彼此的訊號。

In addition, the audio source sent to the transmitters must be synchronized so that the radio user hears the same signal from each transmitter. The system consists of a simulcast controller and two or more simulcast transmitters. The advantages of a simulcast system are the coverage of a large area, with high signal levels throughout the area, while using only a single frequency.

此外，發送到傳送器的音頻源必須同步化，才能讓無線電使用者聽到來自於各傳送器的相同訊號。此系統的組成包括一個同頻共波控制器，以及兩個或以上同頻共波傳送器。同頻共波系統的優點在於大區域覆蓋範圍，只需使用單一頻率，即可在大型區域內進行高強度訊號傳輸。

圖4.6. 同頻共波—調度中心傳輸—火場通訊



Alerting
警報

Many users of conventional analog systems use paging as a method of alerting personnel or fire stations of an incident or other important information. In an analog system, the use of two-tone paging accomplishes this. This feature has proven to be a low cost method of alerting for professional and volunteer firefighters. Unfortunately, digital radio systems cannot pass the tones required for two-tone alerting. The use of commercial paging services may be required to provide paging services in digital or trunked systems. Recently, companies are providing applications for smartphones that provide the ability to notify smartphone users using commercial data services, if the users' dispatch system feeds the application with the required data. You must be aware that these notifications may not happen in real time and may be delayed by a few seconds to minutes depending on delays in the commercial data service. If the commercial data system is congested during a disaster, the delays may be significant. Data and phone congestion were identified as a weakness in the Boston Bombing[19] and the Virginia earthquake.[20]
許多傳統類比系統使用者採用傳呼做為警告人員或消防局關於事故或其他重要資訊。在類比系統中，利用雙音傳呼即可達到此目的。已證實此性能是警示專業與志願消防員的低成本方法。可惜的是，數位無線電系統無法傳播雙音警報所需的音調。為了在數位與集群系統提供傳呼服務，可能必須利用商業傳呼服務。許多公司最近都提供智慧型手機的應用程式，若使用商業數據服務的智慧型手機使用者的調度系統傳送必要資料到應用程式，該應用程式會通知使用者。您必須知道，這些通知可能不是即時的，可能會延遲數秒到數分鐘，視商業數據服務的延遲而定。若商業數據服務於災害期間壅塞，延遲可能會非常明顯。數據與電話流量壅塞被認定為波士頓爆炸事件[19]和維吉尼亞地震[20]的弱點。

[19] April 2013, http://www.huffingtonpost.com/2013/04/15/boston-cell-service_n_3087341.html.
2013 年 4 月，http://www.huffingtonpost.com/2013/04/15/boston-cell-service_n_3087341.html.

[20] August 2011, http://www.pcmag.com/article2/0,2817,2391635,00.asptrunked-radio-system-problems/.
2011 年 8 月，http://www.pcmag.com/article2/0,2817,2391635,00.asptrunked-radio-system-problems/.

Summary — Conventional Radio Systems
摘要—傳統無線電系統

There are a wide variety of radio systems in use today. There are simple systems that use a conventional analog repeater to trunked systems that employ the latest technologies.
今日使用的無線電系統種類繁多。有利用傳統類比中繼器令採用最新科技的集群式系統複雜化的簡單系統。

Direct Communications
直接通訊

Radios using direct communications are not dependent on infrastructure to communicate to other units on the fireground. Direct communications are limited in range, so they are commonly used as fireground tactical channels. Using simplex communications maintains positive communications between the IC, exterior on-scene units, and interior units without the reliance on exterior communications systems. There are limitations in range due to the portable radios having limited power. Awareness on the fireground is important; if a communication attempt to the IC from the interior is heard and the IC does not answer, that might be a cue to relay the information. Dispatch centers can employ receiver voters and high-powered transmitters to allow reliable communications with fireground units.
使用直接通訊的無線電不會依賴基礎建設來與火場其他單位通信。直接通訊受範圍限制，所以通常做為火場站數通道使用。使用單工通訊可維持 IC、外部現場單位與內部單位之間的確實通訊，無須仰賴外部通訊系統。可攜式無線電因為功率有限，所以其傳輸範圍有限。覺悟性在火場上是相當重要的；若聽到內部試圖傳到 IC 的訊號，而 IC 未回應，這可能意味著必須轉發該信息。調度中心可採用接收器選擇器和高功率傳送器，與火場單位進行可靠的通訊。

Repeaters
中繼器

Provide wide area coverage for portable radios. The portable signal is received and retransmitted at a higher power to extend the range. Communications with repeaters are dependent on the repeater as part of the communications infrastructure. Coverage to the

repeater can be degraded when operating on the interior of a building. Use of talk-around allows users to use the output frequency to bypass the repeater. This is referred to as a talk-around frequency.
為可攜式無限電提供大區域覆蓋範圍。可攜視訊號的接收與轉傳使用較高功率，這是為了擴展範圍。利用中繼器進行的通信依賴中繼器做為通訊基礎建設的一部分。在建築物內部操作時，中繼器覆蓋範圍可能會縮小。脫網讓使用者可利用輸出頻率繞過中繼器，這稱為脫網頻率。

Simulcast
同頻共波

Simulcast systems are employed when trying to cover a large service area. Simulcasting allows the dispatch centers to transmit simultaneously from multiple transmitters that cover a larger geographic area. The advantages of a simulcast system are the coverage of a large area, with high signal levels throughout the area, while using only a single frequency.
試圖涵蓋大型服務區域時，會採用同頻共波系統。同頻共波讓調度中心可同時從大型地理區域內的多個傳送器進行傳輸。同頻共波系統的優點在於大區域覆蓋範圍，只需使用單一頻率，即可在大型區域內進行高強度訊號傳輸。

Alerting
警報

Many users of conventional analog systems use paging as a method of alerting personnel or fire stations of an incident or other important information. In an analog system, the use of two-tone paging accomplishes this. Unfortunately, digital radio systems cannot pass the tones required for two-tone alerting. The use of commercial paging services may be required to provide paging services in digital or trunked systems.
許多傳統類比系統使用者採用傳呼做為警告人員或消防局關於事故或其他重要資訊。在類比系統中，利用雙音傳呼即可達到此目的。可惜的是，數位無線電系統無法傳播雙音警報所需的音調。為了在數位或集群系統提供傳呼服務，可能必須利用商業傳呼服務。

Section 5–
第 5 節–
Trunked Radio Systems
集群式無線電系統

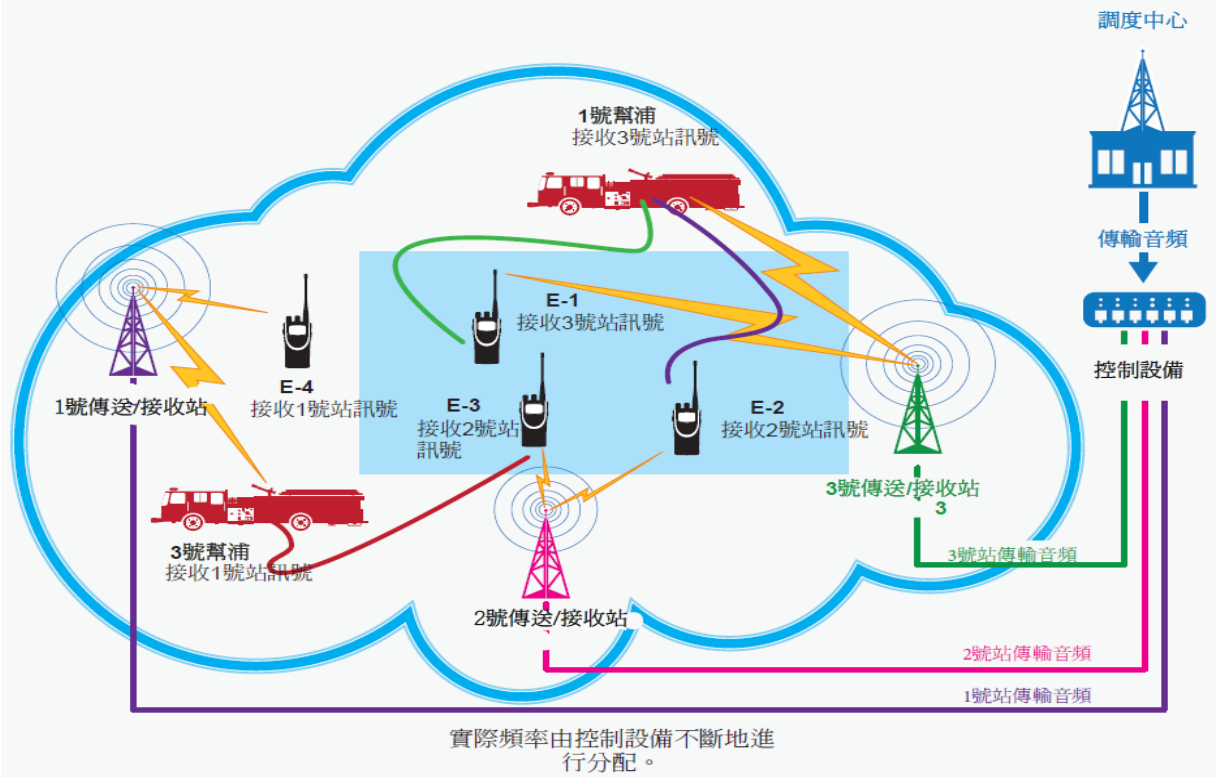
Trunked radio systems are complex radio systems that were developed to improve the efficiency of the use of available radio spectrum. In conventional (nontrunked) radio systems, an RF is dedicated to a single function or workgroup. When the RF is not in use, it cannot be used by another function or workgroup. Trunking borrows technologic concepts from telephone systems to assign RFs to active calls, improving the efficiency of frequency use.

集群式無線電系統是複雜的系統，其研發是為了改善可用無線電頻譜的使用效率。在傳統（非集群）無線電系統中，RF 專用於單一功能或工作小組，RF 未被使用時，另一個功能或工作小組會無法利用 RF。集群借取電話系統的技術概念，將 RF 分配給行進中的通話，藉以改善頻率使用效率。

Like a conventional repeated radio system, trunked radios communicate with each other through two or more repeaters **(Figure 5.1).** In a trunked system, the radios often are known as **subscriber units**, and a voice communications exchange is known as a **call**. A basic trunked radio system has a system controller that controls the assignment of the repeaters, called voice traffic repeaters, to individual calls. The radios communicate with the system controller, for example to request the use of a voice traffic repeater, by sending data messages to the system controller on a special dedicated channel called the control channel. The system controller acknowledges these communications and sends information to the radios using the control channel as well. The radios also can communicate some information using the voice traffic channels after a call has been terminated.

如同傳統重複式無線電系統，集群式無線電透過兩個或以上中繼器與彼此通信（**圖 5.1**）。在集群式系統中，無線電一般稱為**用戶單位**，而聲音通訊交流則稱為**呼叫**。基本集群式無線電系統具有一個系統控制器，可控制中繼器（稱為聲音流量中繼器）對個別呼叫的分配。藉由在專屬通道（稱為控制通道）發送數據信息到系統控制器，無線電利用系統控制器通信，例如要求使用聲音流量中繼器。系統控制器接收這些通信，並利用控制通道將資訊發送到無線電。無線電也可在呼叫終止後，利用聲音流量通道進行資料通信。

圖5.1. 集群式無線電系統—調度中心傳輸



實際頻率由控制設備不斷地進行分配。

The voice traffic repeaters are shared among all users of the system. They also are known as resources. In complex systems that use encryption and dispatch consoles, other equipment is necessary for the

operation of these features, and they are considered shared resources.
所有系統使用者一起分享聲音流量中繼器。此設備又稱為資源。在使用加密與調度控制臺的複雜系統中，這些性能的操作必須利用被視為共享資源的其他設備。

The radio industry uses the term **"talkgroup"** to distinguish among physical frequencies or channels used in conventional radio systems. This terminology often is confusing, since from the actual radio user's point of view, a talkgroup and a conventional channel are the same; they are both communications paths. The distinction is made by the technologists to differentiate a physical channel or frequency from the logical channel or talkgroup.
無線電業利用「**通話群組**」一詞來區分傳統無線電系統使用的物理頻率或通道。此術語常令人感到困惑，因為從實際無線電使用者的觀點，通話群組與傳統通道是相同的；兩者都是通訊路徑。技術人員做出差別，以區分物理通道或頻率與邏輯通道或通話群組。

The system controller and other parts of the trunked radio system maintain a log of all activity that occurs in the system, as well as statistical information on the operation of the system. These system logs can be used in the event of a suspected anomaly in the operation of the system to help determine the cause.
系統控制器與集群式無線電系統的其他部件會記錄所有發生於系統的活動，以及關於系統運作的統計資料。懷疑系統運作異常時，可利用這些系統記錄，幫助確認原因。

Basic Trunked Radio Operations
基本集群式無線電運作

Radio On/Off — Registration/Deregistration/Talkgroup Affiliation
無線電開/關—註冊/註銷/通話群組聯合

When a trunked radio is powered on initially, it begins operation by telling the system controller that it is active, along with the talkgroup currently selected on the radio, using the control channel. If the registration is successful, the radio is registered on the system and now can receive and transmit; if the registration is not successful, the radio will not operate on the system.
開啟集群式無線電時，無線電會利用控制通道，告知系統控制器其與當前選定的通話群組已啟動，藉以開始運作。若註冊成功，無線電會登記道系統，即可進行傳輸與接收；若註冊失敗，無線電不會於該系統運作。

Any time that the radio is powered on and the user changes talkgroups, the radio will tell the system the new talkgroup selection, and the system will confirm the selection. In this way, the system tracks the currently selected talkgroup for all radios registered on the system.
無線電啟動和使用者更改通話群組時，無線電會告知系統表示已選定新的通話群組，而系統會確認該選擇。如此一來，系統可針對登記於系統的所有無線電，追蹤當前選定的通話群組。

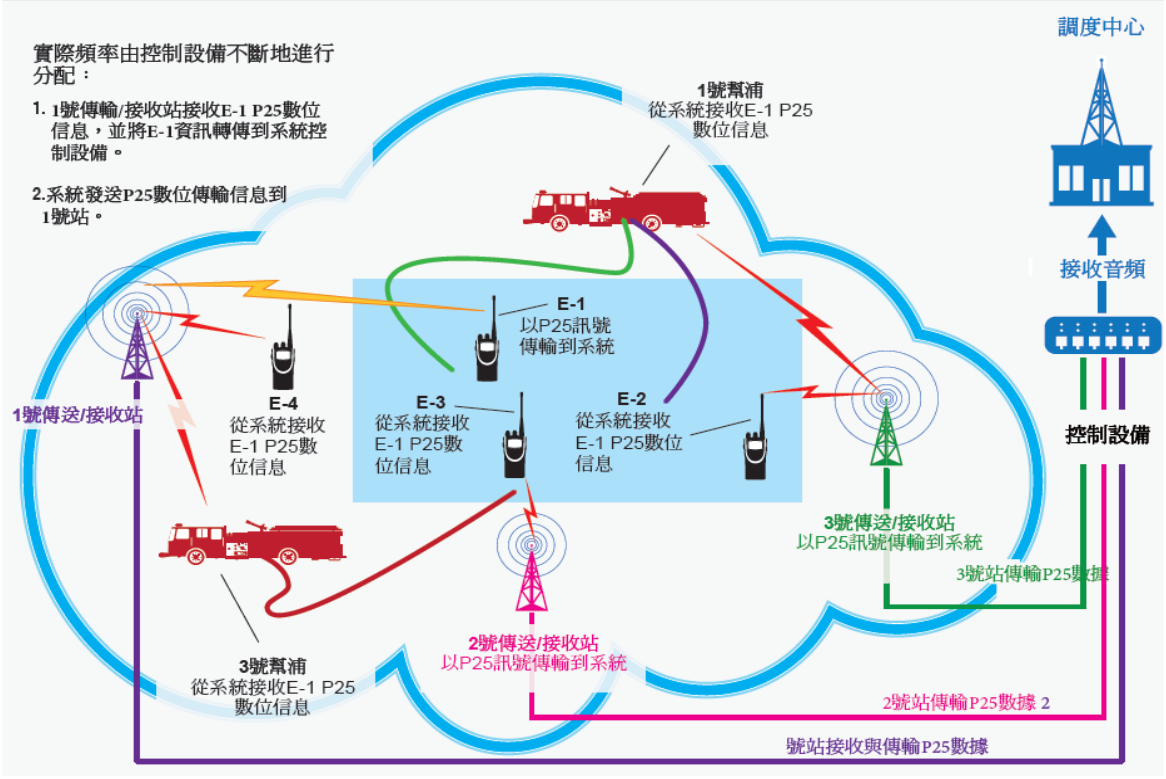
When the radio is switched off by the user, the radio transmits a message to the system controller telling the system to deregister the radio. The radio then will wait for an acknowledgment from the system before actually powering off.
使用者關閉無線電時，無線電會發送訊息給系統控制器，要求系統註銷該無線電。無線電接著會在關閉前，等候系統進行確認。

Talkgroup Call
通話群組呼叫

When a radio user wishes to transmit on a talkgroup, he or she presses the PTT switch, just as with a conventional radio. The radio then sends the trunking system a request to transmit, using the control channel. The trunking system checks to see if the requested talkgroup is free and if there are available voice traffic repeaters. If these are true, then the system assigns a voice traffic repeater to the call and instructs all radios with the talkgroup selected to change frequencies to the voice traffic repeater frequency. The system also sends a message to the requesting radio telling it that it may proceed with its transmission. This causes the user's radio to play a tone sequence (typically three short beeps) to tell the radio user that he or she may proceed with the transmission. The radio's transmission is received by the voice traffic repeater and retransmitted to the other radios on the frequency **(Figure 5.2).**
若無線電使用者希望在通話群組進行傳輸，他或她會按下 PTT 按鈕，與使用傳統無線電時一樣。無線電接著會利用控制通道，發送信息要求集群系統進行傳輸。集群系統會檢查要求的通話群組

是否可用，以及是否有可用的聲音流量中繼器。若答案皆是，系統會為呼叫分配一個聲音流量中繼器，並指示所有有選定通話群組的無線電，將頻率更換到聲音流量中繼器頻率。系統也會發送信息到提出要求的無線電，告知可進行傳輸。這會令使用者的無線電播放一個音調序列（通常是三個短嗶聲），藉以通知無線電使用者表示他或她可進行傳輸。無線電傳輸訊號會由聲音流量中繼器接收，並在該頻率轉傳到其他無線電（**圖 5.2**）。

圖5.2. 集群式無線電系統—可攜式無線電傳輸—火場通訊



If there are no voice traffic repeaters available for the call, the system will place the request in a busy queue in order of priority, send a busy message to the requesting radio, and wait a short time for resources to become available. If the resources become available, the transmission proceeds. If the resources do not become available before the wait time expires, the system transmits a message to the requesting radio telling it that the request failed. The radio will play a tone (commonly called a "bonk") to the user, indicating the failure.

若呼叫沒有可用的聲音流量中繼器，系統會依照優先性將要求列入繁忙列隊中，發送繁忙信息給提出要求的無線電，並等候可用資源。資源可用時，傳輸會繼續。若資源在等候時間結束時仍然不可用，系統會發送信息給提出要求的無線電，告知要求失敗。無線電會播放一個音調（一般稱為「輕敲聲」）向使用者表示失敗。

Call Disconnection
呼叫中斷

When the transmitting user is finished with the transmission, he or she will release the PTT switch. This causes the radio to send a message on the control channel telling the system that it can release the resources assigned to the transmission. Depending on the configuration of the talkgroup, the system either waits a few seconds for additional transmission requests before releasing the resources or it releases the resources immediately. Once the timeout is reached, the system tells all radios on the talkgroup to change channels to the control channel and releases the voice traffic repeater for use for other requests. If another request is received before the resources are released, then the system immediately grants the requesting radio's transmission request and does not need to tell the other radios to switch frequencies.

傳輸使用者結束傳輸時，他或她會放開 PTT 鈕。這會令無線電在控制通道發送信息，告知系統可釋放分配給訊號傳輸的資源。根據通話群組的配置，系統會在釋放資源前針對額外傳輸等待數秒，或者會立即釋放資源。一旦到達時限，系統會要求通話群組的所有無線電，將通道更換到控制通道，並釋放聲音流量中繼器以供其他要求使用。若在釋放資源之前收到另一個要求，系統會立即同意該無線電的傳輸要求，且不需要通知其他無線電切換頻道。

Designing a Trunked Radio System

設計集群式無線電系統

Trunked radio systems are complex combinations of radio equipment with computer control systems and require skilled engineering to design an effective system properly. Trunked radio systems have been in use for over 20 years, and the manufacturers of these systems are fully capable of delivering a system that is technically reliable. These systems are designed and manufactured to be as reliable as conventional radio systems. Trunked systems can be deployed in either analog or digital technologies, depending on the frequency band they are deployed on.
集群式無線電系統是備有電腦控制系統的無線電設備的複雜組合，需要專業工程才能正確地設計出有效的系統。集群式無線電系統的使用已超過 20 年，這些系統的製造商完全能夠提供技術可靠的系統。這些系統的設計與製造，使得其具有與傳統無線電系統相同的可靠性。類比或數位技術都可採用集群式系統，視其部署的頻帶而定。

The design of the overall system, including the system's coverage and capacity, involves considerable effort to produce a communications system that is effective for the community and agencies that will use it. The system must have the capacity to accommodate the needs of all of the users of the system and must provide usable coverage in all of the agency's service areas. It is critical to have the end users involved in the specification of these parameters.
整體系統的設計，包括其覆蓋範圍與容量，涉及製造對使用社群與機構有效的通訊系統。系統的容量必須能夠容納系統所有使用者的需求，也必須能夠提供所有機構服務區域的可用覆蓋範圍。這些參數的詳細計畫必須考量終端使用者。

Capacity Design
容量設計

The capacity of a trunked radio system is the amount of communications traffic that the system can support in a given amount of time. The frequencies in the trunked radio system are shared among users and assigned to conversations, as necessary. If there are more talkgroups (i.e., channels) than there are frequencies, which is often the case, then the potential exists for calls to be blocked.
集群式無線電系統的容量視系統在特定時間內可支援的通訊流量。集群式無線電系統的頻率由使用者共享，並依照需求分配給不同的對話。通話群組數量時常多於頻率數量，在此情況下，呼叫有可能會被阻擋。

It is most desirable for public safety users to never have a call blocked, although this never can be guaranteed in a system with shared frequencies. Manufacturers use statistical models to estimate the traffic presented to the trunked radio system. These models are based on historical traffic information collected from other customers, along with predictions of usage based on experience with similar agencies. This historical information may not represent operations in your agency. In addition, the traffic information may not represent peak loading but only average loading. If the system is designed and constructed for average loading, and performs as designed with average loads, then it may not be able to provide adequate service when confronted with abnormally high loads. These high loads can occur during natural disasters or large-scale incidents such as train derailments, plane crashes, or multialarm fires.
公共安全使用者最希望的事永遠不會遇到呼叫受阻的情況，即使使用共享頻率的系統永遠都無法保證這點。製造商利用統計模式估算集群式無線電系統的流量。這些模式的依據是收集自其他顧客的流量資料，以及根據相似機構的經驗所得到的使用預測。歷史資料可能不代表於您機構的運作結果。此外，流量資料可能不會顯示尖峰負載，只會顯示平均負載。若系統的設計與建設是針對平均負載，並以設計的平均負載量運作，系統面臨異常高負載時，可能會無法提供適當的服務。這些高負載可能發生於自然災害期間或者大型事故時，如貨車出軌、飛機失事、多重火警等。

An important concept is that all users of a trunked radio system affect the system's performance and can affect other users. The channels used by the system are shared among all users of the system, and like any other shared resource, all users must be aware of their impact on other users and must act accordingly. For example, some users may talk excessively and use the trunking system to discuss issues best discussed face to face or on the telephone. Proper user education and the establishment of a formal communications order model can help prevent unnecessary system load.
一個重要的概念是，集群式無線電系統的所有使用者都會影響系統效能，且可能會影響其他使用

者。系統使用的通道是由所有系統使用者共享的，如同任何其他共享資源，所有使用者必須知道他們對其他使用者的影響，並以其為根據動作。例如，有些使用者可能會過度說話，並利用集群系統探討最好是面對面或用手機討論的議題。正確的使用者教育與正式通訊次序模式的制定可幫助預防不必要的系統負載。

Site capacity is determined by the number of radio channels on a site. For instance, a low capacity site might have five radio channels. The five-channel site allows four simultaneous voice calls, and the fifth channel is the control channel (FDMA system). A high capacity site in the system could have 20 channels that would allow 19 simultaneous voice calls and one control channel. If four users being serviced by the low capacity site monitor high volume traffic on four separate talkgroups in the high capacity site, the low capacity site can get busied out due to the users "dragging traffic" onto the low capacity site. System administrators must work with operational personnel to determine the number of wide-area talkgroups that are allowed on the system. Wide-area talkgroups must be used appropriately to minimize busies caused by dragging unwanted traffic into low capacity sites. Other talkgroups may be restricted to specific sites in the system to minimize dragging traffic into unwanted areas. Site restrictions can be done by the user or the talkgroup. This gives the administrators flexibility in being able to meet the needs of responders and maintaining system performance.
站台容量取決於站台的無線電通道數量。例如，低容量站台可能會有五個無線電通道。五通道站台可同時允許四通聲音呼叫，第五個通道是控制通道（FDMA 系統）。系統的高容量站台可有 20 個通道，同時允許 19 通呼叫和一個控制通道。若服務四名使用者的低容量站台監測到高容量站台有四個不同的通話群組處於高流量狀態，低容量站台可能會因使用者「拖拉流量」到低容量站台而處於忙線。系統管理員不需與操作員合作，確認系統所允許的廣域通話群組數量。必須適當地使用廣域通話群組，以令被拖拉到低容量站台的流量所造成的忙線狀態最少化。可將其他群組限制在系統的特定站台，藉以使被拖拉到不希望的區域之流量最少化。站台限制可由使用者或通話群組達成。這讓管理員有空間能夠滿足應變人員的需求，並維持系統效能。

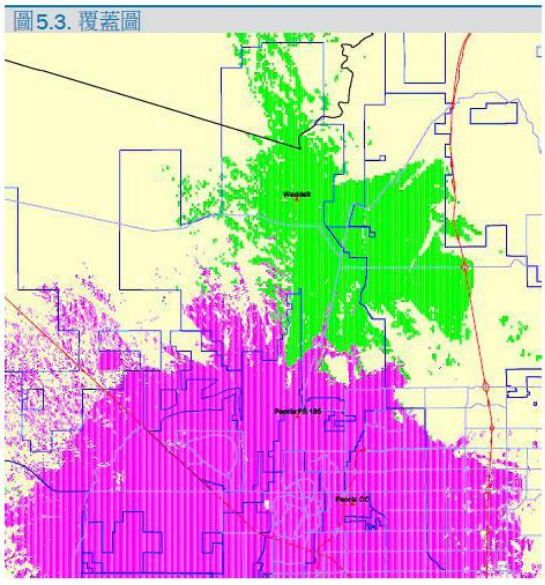
Coverage Design

覆蓋範圍設計

Trunked radio systems that are for firefighting operations must be designed to provide radio coverage inside buildings. System manufacturers estimate what the system will require in terms of radio tower sites and other system components to provide coverage on the street. This becomes the base signal reference level and is referred to as zero decibel (dB). In-building coverage levels are dictated by the construction of the buildings from which the users need to communicate. The heavier the construction, the higher the signal level needed to provide RF penetration into the structure.
用於消防作業的集群式無線電系統的設計，必須可提供建築物內部的無線電覆蓋範圍。為了提供街道的覆蓋範圍，系統製造商會判斷系統需要的無線電塔台點與其他構成要素。這是站台信號參考水平，稱為零分貝（dB）。建築內覆蓋率取決於建築物構造。構造愈重大，就會需要愈強的訊號來讓 RF 穿透到建築內部。

During system design, the service area is analyzed, and geographic areas are categorized based on the structures within them **(Figure 5.3).** For example, the central area of a city may have high-rise structures that require the highest penetration signal levels. The area surrounding the high-rise district may consist of midrise and warehouse
設計系統時會分析服務區域，會根據區域內的建築對地理區域進行分類（**圖 5.3**）。舉例來說，一個城市的中央區域可能會有需要最高穿透信號強度的高樓建築。高樓區周圍的區域可能包含訊號強度需求較低的

圖 5.3. 覆蓋圖



structures requiring less signal level to penetrate the

structure. In suburban areas, even less signal generally is required to communicate on the interior of a structure. Areas with the greatest RF penetration demand will have a higher number of radio sites than areas with lesser penetration. When a building such as a hospital or school is built in a predominately suburban area, the radio system will not provide in-building communications because the area was designed for residential structures. Interior radio system coverage is dependent on the ability of the system designer to estimate the signal loss accurately for each building type. During testing performed by NIST, building losses as high as 50 dB were found in a 14-story apartment building.[21] For reference, a 50 dB loss equals 1/100,000th of the transmitted signal. The actual RF losses encountered are often much higher than the standard recommendations that system manufacturers use. This can result in marginal in-building communications in many structures.
中層建築和倉庫建築。在郊區的建築內部進行通信所需的訊號強度更低。RF 穿透率需求最高的地區，其無線電站台數量會高於低穿透率地區。若醫院、學校等建築物位於郊區，無線電系統不會提供建築內通訊，因為該區域是為了住宅結構所設計的。內部無線電系統覆蓋範圍取決於系統設計者針對各種建築種類準確估算信號損失的能力。NIST 進行測試時，發現 14 層樓公寓建築的建築損失可高達 50 dB。[21]50 dB 損失等於傳輸訊號的 1/100,000。實際遇到的 RF 損失通常遠高於系統製造商使用的標準建議值，這可能會造成許多結構的邊際建築內通訊。

System manufacturers and designers will never guarantee, and it is impractical to expect, 100 percent coverage. It is impossible to guarantee 100 percent coverage in any city. There is always some corner of a building that a radio system does not cover. The problem with no coverage from a trunked system is very different from a simplex area. In a trunked system, no coverage means no communications.

系統製造商與設計師永遠不會保證 100%覆蓋率，做預計也是不切實際的動作。保證任何城市會有 100%覆蓋率是不可能的事。總會有某個建築物角落是無線電系統無法涵蓋的。未在集群式系統覆蓋範圍內的問題與單工區域非常不同。就集群式系統而言，無覆蓋範圍代表無通訊。

Since trunked radio systems can have several levels of RF penetration, the users of the system need to be aware that a particular building type in one area of the system may have communications, while the same building in another area may not have communications.
由於集群式無線電系統可擁有數種 RF 穿透率，使用者必須知道系統一個區域內的特定建築種類或許會有通訊，但另一個區域內的相同建築物或許不會有通訊。

Coverage Enhancement Devices
覆蓋範圍延伸裝置

The following devices are coverage enhancers for trunked and conventional systems. The same theory applies in both trunked and conventional applications. They receive a weak signal and retransmit at a level that allows the system to capture the signal. The coverage enhancement devices have been placed in this section due to being discussed in most trunked system deployments. Trunked systems commonly use these devices to achieve coverage requirements.
以下裝置是用於集群式與傳統系統的覆蓋延伸器。集群式與傳統系統採用相同的理論。延伸器接收微弱訊號，並以系統可捕捉到訊號的強度轉傳。於此章節探討覆蓋延伸裝置是因為延伸器的話題最常出現於集群式系統部署。集群式系統通常利用這些裝置來達到覆蓋要求。

Bidirectional Amplifiers
雙向放大器

To overcome system in-building coverage difficulties, BDAs often are used to rebroadcast the trunked system in buildings **(Figure 5.4).** BDAs also can be used with conventional duplex radio systems. There are many types of BDAs; all require electrical power and some type of antenna system. The antenna systems are often installed in the plenum spaces of commercial structures. Most BDA systems include battery backup power to keep them operational if a loss of commercial power occurs.
通常會利用 BDA 轉播建築物內的集群式系統，以

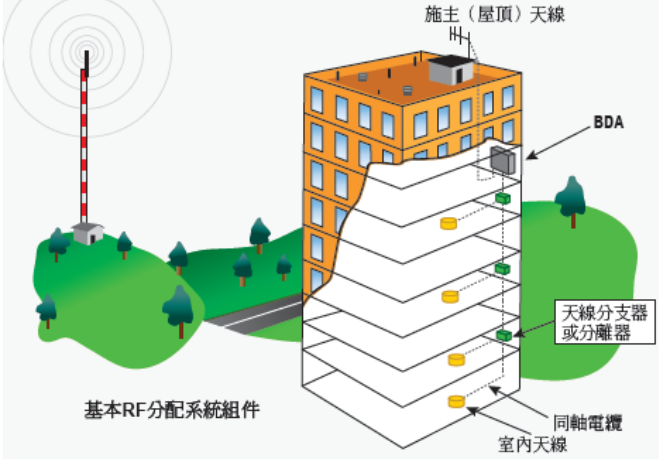
[21] Radio Propagation Measurements during a Building Collapse: Applications for First Responders, Conclusions and Discussion p.3, Christopher Holloway, Galen Koepke, Dennis Camell, Kate A. Remley and Dylan Williams.
建築物倒塌之無線電傳播量測：應變人員應用，結論與探討，第 3 頁，Christopher Holloway、Galen Koepke、Dennis Camell、Kate A. Remley，以及 Dylan Williams。

克服系統建築內覆蓋問題（**圖 5.4**）。BDA 也可與傳統雙工無線電系統一起使用。BDA 種類繁多，但都需要電力和某種天線系統。天線系統通常安裝在商業結構的通風空間。多數 BDA 系統包含電池備援供電，使其可在商業供電中斷時持續運作。

BDAs work well for incidents such as Emergency Medical Services (EMS) calls and law enforcement incidents where there is no fire involvement in the building or building systems. In a structure with active fire, the building and building systems are affected directly. The building environment changes with the introduction of fire. Temperatures rise, and particulate matter is suspended in the atmosphere. Firefighter actions to eliminate the fire can also have a detrimental effect on BDA systems. As water is applied to the fire, steam is generated that may have an effect on electronic equipment. Acids are formed when moisture mixes with suspended materials. These acids can cause intermittent failure of exposed electrical contacts over time. As with all electronics, BDAs are subject to failure when exposed to high heat and moisture. Other actions taken during firefighting operations also could destroy the BDA system. Firefighters checking for extension using pike poles may inadvertently tear the BDA antenna system down, rendering the BDA useless and causing loss of communications inside the building.

BDA 在事故現場的表現良好，例如建築或建築系統內未涉及火災的事故現場之緊急醫療服務（EMS）呼叫與執法行動。在有火災的結構內，建築與建築系統會直接受到影響。建築環境會隨著火的導入而改變。溫度會上升，顆粒物會懸浮在空氣中。消防人員的滅火行動也可能會對 BDA 系統造成不利影響。用水滅火會產生蒸氣，這可能會影響電子設備。水汽與懸浮顆粒混合時會產生酸，這些酸可能會隨著時間導致暴露的電氣接點發生間歇故障。如同所有電子產品，BDA 暴露於高溫和高濕度時容易故障。消防行動的其他行為也可能會破壞 BDA 系統。利用火鉤檢查蔓延處的消防人員可能會意外地將 BDA 天線系統扯下，導致 BDA 失效並造成建築內部喪失通訊。

圖5.4. 建築內通訊系統



Identifying the buildings that need BDAs and installation of the equipment is a monumental task, especially in fast-growing metropolitan areas. BDAs, like any other transmitters, require periodic maintenance to keep the equipment operating at peak performance. To maintain BDAs in a system requires staffing and technical expertise to keep the equipment operating properly. As building density increases in a given area, a building that did not need a BDA when constructed may need one as it is surrounded by new construction. This requires periodic RF surveys to determine if new BDAs are needed. In 2013, the FCC made changes to the Part 90 rules that require installation by FCC licensees and qualified installers. The revision to Part 90 also requires registration of signal boosters. These actions were taken to control harmful interference.[22]

辨識需要 BDA 與設備安裝的建築物是一項艱鉅的工作，尤其是在發展迅速的都會區。如同任何其他傳送器，BDA 需要定期維修，讓設備能夠以高峰性能持續運作。必須要有員工與技術專業知識，才能維持系統的 BDA，使其持續正常運作。隨著特定區域內建築物密度的增加，建造時不需要 BDA 的建築物，可能會因為被新建結構環繞而需要安裝 BDA。必須進行定期 RF 調查，以確認是否需要新的 BDA。FCC 於 2013 年針對規定必須由 FCC 持照者與合核安裝人員進行安裝的第 90 部分規定做出修改。第 90 部的修訂也要求必須登記訊號增強器。採取這些動作是為了控制有害干擾。[22]

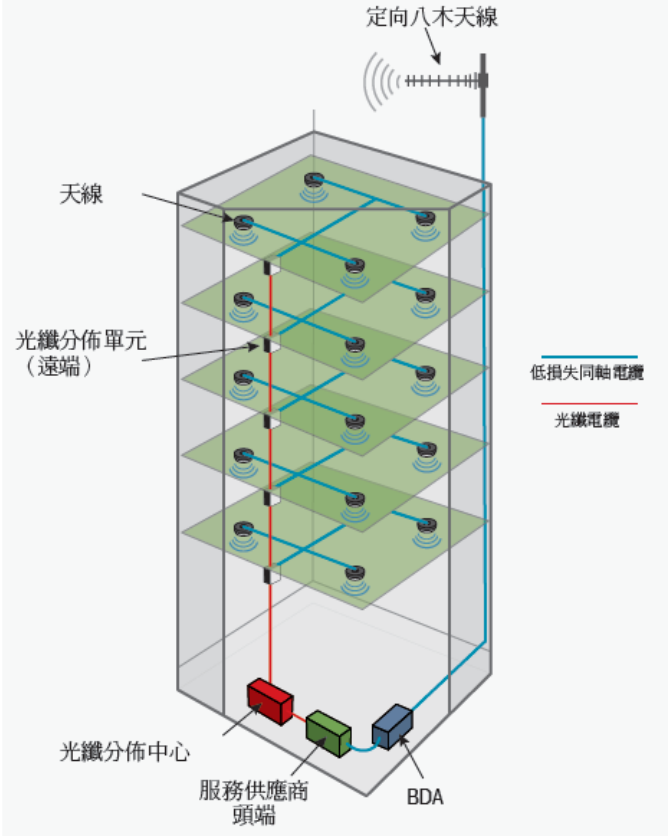
Many municipalities have developed fire codes that require installation of this equipment. The codes often require BDAs when a building exceeds some square

22 http://wireless.fcc.gov/signal-boosters/part-90-boosters/index.html.

footage value, during additions increasing square footage by some percentage of the original, or in all-new construction. The 2012 International Fire Code (IFC) requires that "All new buildings shall have approved radio coverage for emergency responders within the building based upon the existing coverage levels of the public safety communication systems of the jurisdiction at the exterior of the building."[23] In addition to requiring radio coverage, IFC, Section 510 specifies technical, installation and maintenance requirements for in-building public safety radio coverage systems.

許多市政當局制定了要求安裝此設備的消防法規。法規會要求安裝 BDA，一般是在建築物超過某平方英尺時，增建部分使得平方英尺增加某百分比時，或者建造全新結構時。2012 年國際消防法規（IFC）規定，「所有新建築物應根據其外部管轄區公共安全通訊系統的現有覆蓋率，於其內部提供經核准的無線電覆蓋範圍以供緊急應變人員使用」。[23]除了要求無線電覆蓋範圍，IFC 第 510 節具體說明對建築內公共安全無線電覆蓋系統的技術、安裝與維修規定。

圖5.5. 建築內分佈天線系統



圖畫出處： http://www.l-com.com/what-is-a-distributed-antenna-system-das

An array of antennas is installed on each floor in some installations of BDAs **(Figure 5.5).** These systems often provide better coverage due to having more antennas on each floor to bring the signal in for retransmission or redistribution inside. The Distributed Antenna System (DAS) approach is commonly deployed in complex structures, such as high-rise buildings or airport terminals. In **Figure 5.5,** each floor has a DAS that is connected by low loss coaxial cable. The coaxial cable is terminated on each floor at a fiber distribution unit. Fiber optic cables run between each floor to connect the fiber distribution units. All of the fiber distribution units are connected to a fiber distribution hub. The hub is connected to the RF head-end and to the BDA and then by coaxial cable to the exterior antenna. These systems can be very complex, and their survivability in a fire is dependent on the standards or codes that they are built to.

有些BDA裝置會在各樓層安裝天線陣列(**圖5.5**)。這些系統一般提供較好的覆蓋，因為各樓層有更多天線，可將訊號導入並在內部轉發或重新分配。分佈天線系統（DAS）法一般用於複雜結構，如高樓建築或機場航廈。**圖 5.5** 中，各樓層都有利用低損失同軸電纜連結的 DAS。各樓層的同軸電纜終端是光纖分佈單元。光纖電纜穿梭於樓層之間，連結光纖分佈單元。所有光纖分佈單元都連結到光纖分佈中心。此中心連結到 RF 頭端和 BDA，再透過同軸電纜連結到外部天線。這些系統有可能非常複雜，系統於火災的存活率決定於其遵循的標準或法規。

Vehicular Repeaters
車載中繼器

Some municipalities have recognized the weaknesses in BDA systems and have installed vehicular repeaters (VRs) on fire apparatus to provide in-building coverage that is suitable for firefighting operations. Each apparatus is equipped with a VR that is activated manually prior to entering the involved structure. These repeaters are operated in the repeater mode, meaning that the users transmit from the portable radio, it is received by the repeater, and then retransmitted to the other portable radios on the fireground **(Figure 5.6).** The VR retransmits all radio traffic from the repeater (transmit and receive) onto the trunked system talkgroup. Radios that are not in range of the VR are capable of bidirectional communication through the wide-area coverage

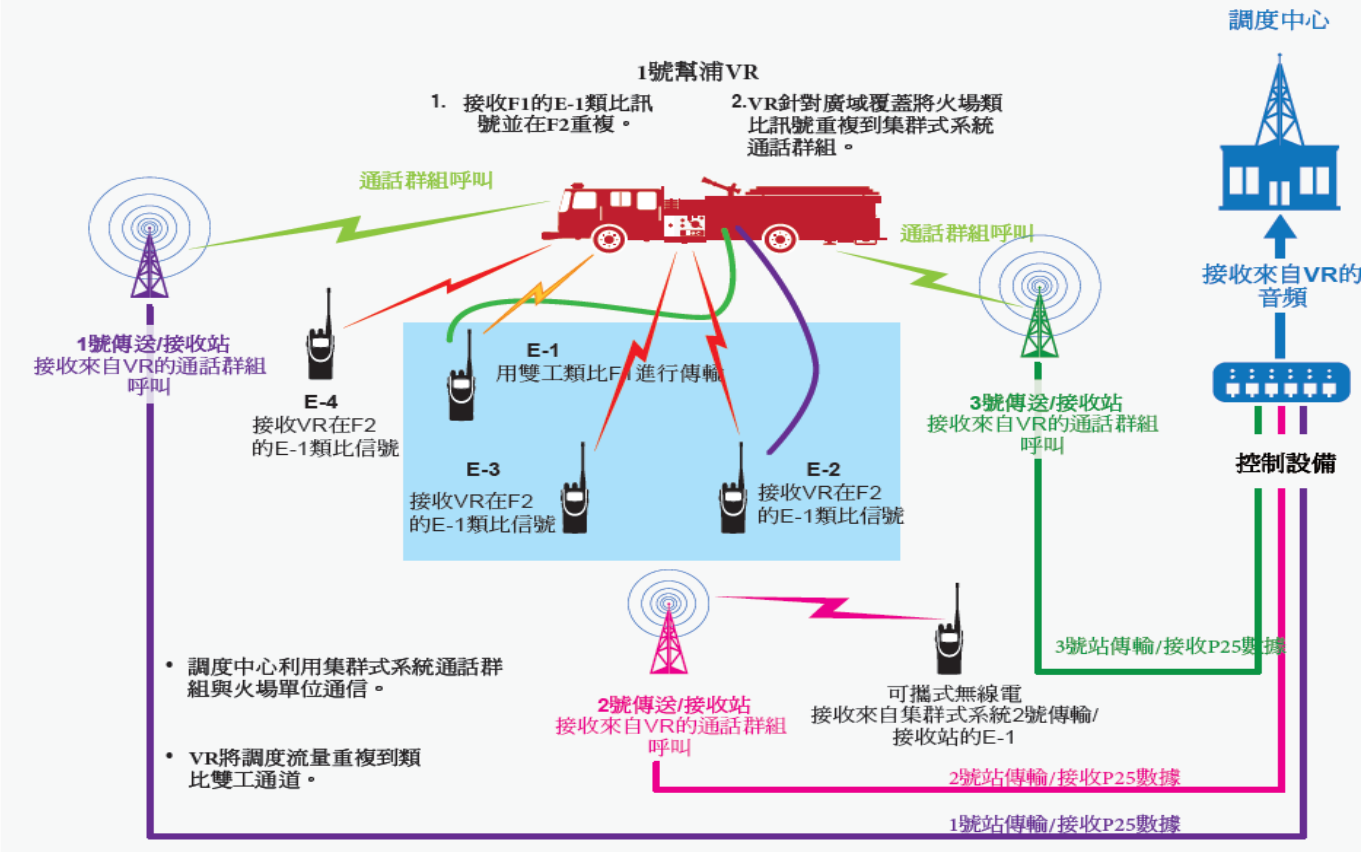
[23] IFC 2012 First Printing, Section510.
2012 年 IDC 第一版，第 510 節。

provided by the trunked system.
有些市政當局知道 BDA 系統的弱點，所以在消防器具上安裝車載中繼器（VR）以提供適合消防作業的建築內覆蓋。這些中繼器以中繼模式運作，表示使用者從可攜式無線電進行傳輸，訊號由中繼器接收，再轉傳到火場其他可攜式無線電（**圖 5.6**）。VR 將中繼器（傳輸與接收）的所有無線電流量轉傳到集群式系統通話群組。在 VR 範圍外的無線電能夠透過集群式系統提供的廣域覆蓋範圍，進行雙向通訊。

In the repeater mode of operation, fireground radios are not communicating directly with one another. The radios are dependent on the repeater for communications. If an interior crew encounters an area where it does not have repeater coverage, it can switch to a talk-around channel to communicate directly with other interior crews.
以中繼模式運作之下，火場無線電並非直接與彼此通信。無線電通訊依靠中繼器。若內部工作人員遇到沒有中繼器覆蓋的地區，可切換到脫網通道以與其他內部工作人員直接通信。

If the unit on talk-around can hear the repeater but the repeater does not receive the transmitted traffic, the unit on talk-around can transmit — and on the repeater output with units in direct range on the repeater channel. Units on the repeater channel will be receiving the transmissions directly from the talk-around unit. When the units on the repeater channel respond, they will transmit through the repeater, and the talk-around unit will receive the traffic on the repeater output channel.
若使用拖網通道的單位可聽到中繼器，但中繼器無法接收傳輸流量，該單位可在拖網通道傳輸訊號，也可在中繼器輸出與中繼器通道直接覆蓋的單位通信。中繼器通道的單位會直接收到來自脫網單位的訊息。中繼器通道單位做出回應時，他們會透過中繼器傳輸，而脫網單位會在中繼器輸出通道接收流量。

圖5.6. 集群式無線電系統—可攜式無線電傳輸—車載中繼器



If the unit on talk-around cannot transmit or receive traffic from the repeater, the unit on talk-around will only be able to transmit to units within range of the portable. The units on the repeater channel will receive the talk-around traffic, but since the talk-around unit cannot hear transmissions from the repeater, the units on the repeater channel will be required to change to the talk-around to have bidirectional communications.
若拖網通道的單位無法與中繼器互相傳輸或接收流量，該單位會無法傳輸訊號給可攜式無線電範圍內的其他單位。中繼器通道的單位會收到脫網流量，但因為拖網單位無法聽到中繼器的傳輸內容，中繼器通道的單位會比需更換到脫網通道以

進行雙向通信。

The other interior crews need to change to the talk-around channel to communicate with the out-of-range crew. When talk-around is used, the unit on talk-around can hear radio traffic through the repeater but cannot transmit to other units unless those units also change to talk-around. The talk-around function can cause some confusion unless the unit that switched to talk-around clearly communicates the channel change to other units on the fireground.
其他內部工作人員必須切換到脫網通道，才能與覆蓋範圍外的工作人員通信。使用拖網時，使用單位可透過中繼器聽到無線電流量，但無法傳輸訊號到其他單位，除非那些單位也切換到脫網通道。拖網功能可能會引起困惑，除非切換到脫網的單位清楚地告知火場其他單位，表示其已更換通道。

Other Trunking System Features
其他集群系統性能

Trunked systems are feature-rich and can provide much more than just voice traffic. Some of the features greatly decrease the labor required to maintain and update fleets of radios. To maintain the ability to have voice traffic, these features must be accounted for in system design to build the capacity to maintain the reliability needed to carry the voice traffic.
集群式系統性能繁多，其能提供的不只是聲音流量。有些性能可大幅降低維護和更新無線電機群所需的人力。為了維持擁有聲音流量的能力，設計系統時必須將這些性能納入考量，在系統內建置可維持能有效承載聲音流量的容量。

Emergency Alarm
緊急警報

There are two different emergency features in trunked radio systems: emergency alarm and emergency call. When a radio user presses the emergency button on the radio, the radio switches to the control channel and transmits an emergency alarm message. This message is processed by the system, and an indication of the activation of the alarm is presented to any dispatchers using radio consoles. The benefit of the emergency alarm feature is that it is possible to send the alarm message even when all repeaters in the system are busy. Thus, even when the talkgroup is in use, an emergency alarm can be sent by a firefighter in trouble.
集群式無線電系統有兩個不同的緊急性能：緊急警報與緊急呼叫。無線電使用者按下無線電上的緊急鍵時，無線電會切換到控制通道並發出緊急警報信息。此信息會由系統處理，而使用控制臺的任何調度人員都會收到警報啟動指示。緊急警報性能的優點在於，即使系統的所有中繼器都在忙，也能夠發送警報信息。因此，即使通話群組處於忙線狀態，遇到困難的消防人員也可發出緊急警報。

Emergency Call
緊急呼叫

An emergency call is similar to a normal talkgroup call or a multigroup call, but the radio initiating the call is in emergency mode after having its emergency button pressed.
緊急呼叫類似於正常通話群組呼叫或多群組呼叫，但發出呼叫的無線電在緊急鍵被按下時即處於緊急模式。

Emergency calls are initially processed in the same way as talkgroup calls or multigroup calls. The difference in processing occurs when resources are not immediately available for assignment to the emergency call. If resources are not available, the emergency call can be processed in two ways: top-of-queue or ruthless preemption, depending on the configuration of the trunked radio system.
緊急呼叫的處理起初與通話群組呼叫或多群組呼叫的方式一樣。當資源無法立即被分配給緊急呼叫時，就會發生處理上的差異。若沒有可用資源，有兩種方法可用以處理緊急呼叫：佇列頂端或強制預佔，視集群無線電系統的配置而定。

If the system is configured for top-of-queue, the request for resources is placed on the busy queue in front of all other requests. When the resources become available, the emergency call is assigned the newly available resources immediately.
若系統設定為佇列頂端，資源申請會被放置在忙碌佇列所有其他申請的前面。有可用資源時，緊急呼叫會立即被分配到該資源。

If the system is programmed for ruthless preemption, the request for resources is not queued, and instead, the voice repeater for the lowest priority existing talkgroup is reassigned to the emergency call. To

accomplish this, the receiving radios on the existing lower priority call are instructed to terminate that call, and the radios on the emergency call are instructed to tune to the frequency of that voice repeater. Unfortunately, the transmitting radio on the lower-priority call cannot be instructed to terminate the call. This can cause the emergency radio to compete with the lower-priority radio, resulting in distorted audio or no audio.
若系統設定為強制預佔，資源申請不會被列入佇列，而優先性最低的現有通話群組的聲音中繼器會被重新分配到該緊急呼叫。現有低優先性呼叫的接收無線電會收到指示，必須終止呼叫，而緊急呼叫的無線電則被指示，必須調整到該聲音中繼器的頻率。可惜的是，無法指示低優先性呼叫的傳輸無線電終止呼叫。這可能會導致緊急無線電與低優先性無線電的競爭，造成音頻失真或者無音頻。

Radio Alerting
無線電通知

Individual radios can be alerted to notify the user of incoming traffic. Some agencies use this when dispatching units. A radio or radios assigned to a specific unit will be alerted much like a pager when traffic for them is inbound.
可通知個別無線電告知新進流量的使用者。有些機構會在調派單位時採用此功能。有新進流量時，一個或數個被分配到特定單位的無線電會收到通知，類似於呼叫器。

Location Services
定位服務

Many trunked systems integrate the ability to receive location information from radios in the field if they are equipped with GPS. This feature allows tracking of units when they are receiving GPS signals from the satellites. This location service has severe limitations in the fire service due to loss of signal when entering buildings.
許多集群式系統能夠收到在現場備有 GPS 的無線電的位置資料。此性能讓系統可在收到衛星的 GPS 訊號時，追蹤單位。進入建築物時會有訊號損失，所以定位服務在消防服務受到嚴格限制。

Multigroup Call
多群組呼叫

A multigroup call is a call that transmits to two or more talkgroups simultaneously. The system can be configured to wait for all talkgroups in the multigroup to become available before initiating the call or configured to begin the call immediately, with busy talkgroups joining when their calls are complete. During the call, all associated talkgroups act as a single talkgroup. Because of this, after the initial multigroup transmission completes, a user in one of the associated talkgroups can call all users in the associated talkgroups. In a busy system, this can keep the multigroup call in progress for a significant amount of time, severely disrupting operational communications.
多群組呼叫是同時傳輸到兩各或以上通話群組的呼叫。可設定系統使其等候到多群組的所有通話群組都有空，再發出呼叫，或者設定為立即開始呼叫，讓忙碌的通話群組在完成他們的呼叫時可加入多群組。呼叫期間，所有相關通話群組都是單一通話群組。基於此，起始多群組傳輸完成後，相關通話群組之一的使用者可呼叫相關通話群組內的所有使用者。這在忙碌的系統中可讓多群組呼叫在一段相當長的時間內持續進行，嚴重中斷作業通訊。

Dynamic Regrouping
動態重組

The dynamic regrouping feature allows an authorized system administrator to assign a radio to a specific talkgroup remotely. The purpose of this feature is to allow multiple radios to be grouped together on a talkgroup for operational purposes. This feature is limited in function due to the potential delays while the radio is assigned to the new talkgroup. Because of this, few agencies use this for critical operations.
動態重組性能讓獲得授權的系統管理人員能從遠端將無線電分配到特定通話群組。此性能的目的在於讓多個無線電可為了作業而在通話群組聚集在一起。無線電被分配到新的通話群組時，可能會有延遲，造成此性能的功能受限。基於此，少數機構會在進行關鍵行動時採用此性能。

Over the Air Rekeying
空中換鑰

Encryption allows the voice traffic to be unintelligible unless both the transmit radio and receive radio have a common key. While mentioned in the trunked section, encryption is an available option on conventional

systems as well. Encrypted operations require the use of a "key" to decode scrambled signals. Trunked system operators that use encryption periodically change the keys to maintain security on the system. The changing of the keys requires that all radios that use the encryption key be changed or rekeyed. Changing keys or rekeying was labor intensive, requiring each radio to be individually rekeyed. Most contemporary trunked systems have over the air rekeying (OTAR) available for encrypted operations. The use of OTAR has greatly decreased the labor required to maintain and rekey the portable radios on a system. The rekeying process in older systems required that each and every radio on a system be manually rekeyed one by one.
加密會令聲音流量不可辨識，除非傳送無線電與接收無線電擁有共用密鑰。雖然在此集群無線電章節提及加密，但傳統系統也可選擇使用加密。加密的運作需要使用「密鑰」來對擾亂的訊號進行解碼。使用加密的集群式系統操作人員會定期更新密鑰，以維護系統安全。密鑰的更新會要求對所有使用加密金鑰的無線電進行更新或換鑰。密鑰更新或換鑰是需要大量人力的作業，必須將無線電個別換鑰。多數當代集群式系統有加密作業可用的空中換鑰（OTAR）。OTAR 的採用大幅降低了系統可攜式無線電維護與換鑰所需的人力。舊型系統的換鑰過程會要求以手工方式為系統的每一台無線電進行換鑰。

Over the Air Programming
空中編程

The newest systems will soon be offered with over the air reprogramming. Again as with OTAR, over the air programming (OTAP) will allow updates to entire fleets of radios without the need to bring them to a radio technician. Some radios use Wi-Fi to provide the needed bandwidth to provide OTAP. In Wi-Fi-enabled radios, the radio uses the Wi-Fi connection for OTAP. This method of OTAP does not impact trunked radio system performance.
最新型系統不久後將收到空中編程的提議。如同 OTAR，空中編程（OTAP）可在無須將無線電送至技術人員的情況下，對整個無線電機群進行更新。有些無線電利用 Wi-Fi 提供 OTAP 所需的頻寬。Wi-Fi 支援無線電的 OTAP 是利用 Wi-Fi 連結。這種 OTAP 法不會影響集群式無線電系統的效能。

Short Message Service
簡訊服務

Since the radios are digital, many trunked systems support sending short messages across the network. This has the possibility to send dispatch information over the network if the radios are equipped with a liquid-crystal display (LCD) screen.
由於無線電是數位式的，許多集群式系統支援在網路內傳送簡訊。若無線電備有液晶顯示（LCD）螢幕，此性能使得可在網路內傳送調度資料。

Selective Disabling
選擇性關閉

This feature allows radios to be disabled if lost or stolen. Radios can be remotely disabled to maintain security of encrypted channels.
此性能可在無線電遺失或遭竊時，關閉無線電。可遠端關閉無線電，以維護加密通道的安全。

Private Call
私人呼叫

The private call feature allows one radio to call another radio and to carry on a conversation without any other radios hearing the conversation. The radio user initiating the call must select the called radio from a list or know the numerical ID of the called radio. Some more advanced radios allow the user to change numbers in a cellphone-like phone book, making this feature more usable.
私人呼叫功能讓一台無線電可呼叫另一台無線電並進行對話，任何其他無線電都無法聽到對話內容。發出呼叫的無線電使用者必須從一份清單上選擇要呼叫的無線電，或者知道其數字 ID。一些更先進的無線電讓使用者能夠更改類似手機的電話簿裡的號碼，令此性能更有用。

A problem with the private call feature is that it is very difficult to predict the capacity or loading impact of this feature during system design. When the system is in operation, high private call usage can cause other system users to experience more talkgroup busy signals than the design would predict. Some system operators prohibit the use of private call to eliminate the possibility of these calls affecting more critical operations.
私人呼叫的問題之一是，難以於系統設計期間預測其容量或者負載影響。系統運作時，私人呼叫的高度使用會導致其他系統使用者遇到比設計預

測結果更多的通話群組忙線訊號。有些系統操作人員會禁止私人呼叫的使用，以排除這些呼叫影響更多關鍵作業的機率。

Telephone Interconnect
電話互連

The telephone interconnect feature allows system users to answer or make calls to telephone users from the user's radio, similar to a cellular phone. The difference between telephone interconnects and a cellphone is that the trunked user cannot transmit and receive simultaneously. Telephone interconnect was a much more valuable feature before the cellphone became commonplace. In addition, similarly to private call, it is difficult to predict telephone interconnect usage during system design. Telephone interconnect can have adverse effects on system capacity.
電話互連性能讓系統使用者利用無線電接聽電話用戶的電話或打電話給他們，類似於手機。電話互連與手機之間的差異在於，集群使用者無法同時進行傳輸和接收。在手機普及化之前，電話互連曾是更有用的性能。此外，與私人呼叫相同，於系統設計期間預估電話互連用量是件很困難的事。電話互連可能會對系統容量有不利影響。

Summary — Trunked Radio Systems
摘要─集群式無線電系統

Trunked radio systems are the most complex of public safety radio systems. As with all radio systems, the coverage of the trunked radio system is the key to its safe operations for the firefighters. Users can live with systems that lack telephone interconnects, private calling, and paging, but they cannot operate safely inside a hazardous atmosphere with a radio system that does not provide reliable communications.
集群式無線電系統是最複雜的公共安全無線電系統。如同所有無線電系統，集群式無線電系統的覆蓋範圍是其讓消防人員安全作業的關鍵。使用者接受缺乏電話互連、私人呼叫與呼叫器的系統，但若無線電系統沒有提供可靠的通訊，使用者即無法在危險環境中安全地作業。

Basic Trunked Radio Operations
基本集群式無線電運作

In trunked radio operations, the radios request functions of the system, such as requesting a voice call. These system requests require constant handshaking between all of the units in the system to operate.
集群式無線電運作中，無線電會要求系統功能，例如申請語音呼叫。這些系統要求，需要系統內所有單位之間更多的握手協議，才能作業。

The design of a trunked system is a very deliberate process that requires analysis of current communications requirements and forecasting what will be required in the future. When systems are being designed, these are some of the key elements to consider:
集群式系統的設計是個非常謹慎的過程，必須分析當前通訊需求，且未來將會需要進行預報。設計系統時，必須將一些重要要素納入考量：

- Capacity.
  容量
  - Number of users.
    使用者數量
  - Number of talkgroups.
    通話群組數量
  - Peak traffic load.
    尖峰流量負載
- Coverage.
  覆蓋範圍
  - Geographic area.
    地理區域
  - Levels of coverage.
    覆蓋率
    - In-building penetration
      建築內穿透率

Coverage Enhancement Devices
覆蓋延伸裝置

While discussed in the trunked section, coverage enhancement devices can be used in other system types. BDAs are commonly used in trunked system deployments to achieve in-building coverage goals. The systems installed vary in complexity based on the building. An example of a complex installation might be a large airport. Simple installations might be installed to achieve coverage in a specific area of a building, such as a jail. VRs can repeat local signals from the fireground to a wide-area system, such as a trunked system.
雖然是在集群式系統的章節裡進行探討，但覆蓋範圍延伸裝置可用於其他種類的系統。BDA 一般

用於集群式系統部署，以達到建築內覆蓋的目的。系統裝置的複雜度會因建築物而有所不同。複雜裝置的例子之一是大型機場。可安裝簡易裝置已達到建築內特定區域的覆蓋，如監獄。VR 可將火場的局部訊號重複到廣域系統，如集群式系統。

Features
性能

Trunked radio systems offer many functions and features not available in conventional systems. During system design, it is important to identify the features that will be used and plan for their implantation when the system is deployed. OTAR and OTAP are features that are extremely helpful in management of radios in the system. Some features can impact the performance of the system, or the feature may not work in the fire service environment.

集群式無線電系統提供許多傳統系統沒有的功能與性能。系統設計期間，必須找出會用到的性能，並計畫將其納入設計。OTAR 與 OTAP 是對系統無線電管理極為有幫助的性能。有些性能可能會影響系統效能，或者無法在消防服務環境運作。

Section 6–
第 6 節–

Portable Radio Selection and Use
可攜式無線電之選擇與使用

General
一般事項

The success of a fire service radio system project hinges on the performance of the portable radio. If the portable radio has poor performance, the end user relates it to the performance of the radio system as a whole. All the firefighter knows is that when the PTT was pressed, the communications worked or did not work.
消防服務無線電系統的成功突顯了可攜式無線電效能的障礙。若可攜式無線電的表現不佳，終端使用者會將其與整體無線電系統做聯想。消防人員只知道，按下 PTT 時，系統會運作或無法運作。

Manufacturers offer radios at different price points to meet market need. As with any other product, the options and performance levels increase with the cost. Usually there are three tiers of radios available. At the lowest level are nonruggedized radios meant for users who do not handle radios in a rough manner and do not operate in environmental extremes. The second level of radio is for the user who needs more reliability and performance features. The highest tier radios are focused on the public safety user. They offer the highest levels of performance and reliability and have the most options available. Radios with the most options are typically more complex and require appropriate training and reinforcement to maintain proficiency. At this level, the radios often are submersible and have intrinsically safe options. Submersible radios are a very worthwhile option for the fire service, considering the possibility of radios getting wet or exposed to steam.
製造商用不同價格點供應無線電以滿足市場需求。如同任何其他產品，選項與效能水平會隨著成本上升。市場供應的無線電一般有三種等級。最低級的是非耐用型無線電，其目標使用者是不會粗魯對待無線電，也不會在極端環境中操作無線電的用戶。第二級無線電是提供給需要更多可靠性和效能性能的使用者。最高等級的無線電著重於公共安全使用者。有最多選項的無線電通常較複雜，需要經過適當訓練與強化才能維持熟練度。這種程度的無線電通常是可在水中使用的，且本身具有安全選項。考量到無線電會弄濕或暴露於蒸汽的可能性，防水無線電視消防服務非常值得購買的選擇。

Ergonomics
人體工學

Today's radios are an integral part of firefighting and a key component of fireground safety. The form and fit of the radios for firefighting have not improved much over the past decade. Buttons and knobs have increased in size as compared to the radios of the 1980s and 1990s, but firefighters have the same difficulties operating radios while in PPE. Radio knobs are still difficult to manipulate with a gloved hand, even though it is required as a component of NFPA 1221 (2013 edition) **(Figure 6.1).**
今日的無線電是消防的主要部分，也是火場安全的重要要素。過去十年來，消防無線電的形狀與合適性未有太多改善。相較於 80 年代和 90 年代的無線電，按鍵與旋鈕都變大了，但消防人員穿戴 PPE 時，仍然遇到相同的無線電操作問題。帶著手套仍然會令消防人員難以操作無線電旋鈕，即使旋鈕是 NFPA 1221（2013 年版）規定的部件（**圖 6.1**）。

The radios of today can be programmed with hundreds of channels or talkgroups. The large number of channels/talkgroups has made "hard switches" that correspond with a channel/ talkgroup impossible. To select channels on radios with added channel capabilities requires LCDs and "soft keys" to provide access. In firefighting, the LCDs are not readable in smoky environments, and the soft keys cannot be pressed with a gloved hand. When programming the radio, take care to make firefighting radio channels easily accessible.
現在的程式編碼可讓無線電具有上百個通道或通話群組。大量通道/通話群組導致無法使用對應一個通道/通話群組的「硬開關」。要在有額外通道功能的無線電上選擇通道，必須有提供使用權的 LCD 和「軟鍵」。進行消防行動時，LCD 在佈滿濃煙的環境下是不可讀的，也無法用戴者手套的手按軟鍵。撰寫無線電程式時，務必小心讓消防無線電通道更容易使用。

Environmental Technical Standards
環境技術標準

Radios are designed to operate in environmental ranges. The harsh environment of firefighting is hard on equipment and personnel. To provide reliable communications, it is common to purchase ruggedized communications equipment. The technical specifications and testing protocols used to determine if a device is rugged can be confusing. Manufacturers use several testing protocols to determine if the device is "Public Safety Grade." Some of the more common standards encountered are Military Standards (MIL-STD) and International Electrotechnical Commission (IEC) standards.

無線電的設計是為了在環境範圍內運作。消防的惡劣環境對設備與人員非常嚴酷。為了提供可靠通訊，通常會購買耐用的通訊設備。用以確認裝置是否耐用的技術規格與測試準則可能會令人困惑。製造商採用數個測試準則，以判斷裝置是否符合「公共安全等級」。一些較常見的標準包括軍用標準（MIL-STD）和國際電工委員會（IEC）標準。

圖6.1. NFPA 1221第9.3.6.6節：可攜式無線電的設計應該讓帶著手套的緊急響應人員能夠切換通道

（照片來源：Cody Worrell）

International Electrotechnical Commission Ingress Protection Codes
國際電工委員會異物防護代碼

Ingress Protection (IP) codes are international standards that test for IP into an electrical enclosure. Manufacturers use this code to rate intrusion against solid objects from hands to dust and water in electrical enclosures. The rating consists of the letters "IP" followed by two digits. The standard is intended to provide an objective testing protocol to reduce subjective statements such as "waterproof." The first digit represents the size of the object that is protected against, and the second digit represents the water protection. More detailed information on this standard can be found at www.iec.ch, International Electrotechnical Committee, IEC 60529.

異物防護（IP）代碼是測試異物進入電氣外殼的國際標準。製造商利用此代碼評估電氣外殼防止手、灰塵、水等固態物入侵的防護等級。等級名稱包含「IP」和兩個數字。此標準的用意在於提供客觀測試準則，以減少「防水」等主觀陳述。第一個數字代表抵抗的物件尺寸，第二個則代表防水性。更多關於此標準的資料，請到 www.irc.ch，國際電工委員會，IEC 60528。

Military Standards
軍用標準

In the 1970s and 1980s, radios were manufactured to various industry standards for ruggedness and technical stability. In the 1990s, radio manufacturers adopted MIL-STD 810 as a standard for reliability and ruggedness. MIL-STD 810 was developed by the military to provide an environmental test protocol that would prove qualified equipment would survive in the field. MIL-STD 810 is a test protocol written for the military environment, not the firefighting environment. The specification sheets often reference a letter designation behind the MIL-STD. The letter designation represents the revision level of the MIL-STD being tested to. The latest revision is MIL-STD 810 F. Earlier revisions of MIL-STD 810 were generic up to revision C. Subsequent revisions became more tailored to the actual environment the equipment would operate in. Manufacturers sometimes only perform specific test components of the MIL-STD. For instance, an equipment

specification may read "MIL-STD 810 F for water, dust and shock resistance." When we see MIL-STD 810, we assume that the equipment is ruggedized and will survive the firefighting environment. We need only look to the temperature specification to see that this is questionable. MIL-STD 810F actually has two temperature specifications depending on where the equipment is to be used **(Table 6.1).**
在 70 年代與 80 年代，無線電的製造是依據各種針對耐用性與技術穩定度的工業標準。在 90 年代，無線電製造商針對可靠性與耐用性，採用了 MIL-STD 為標準。軍方制定 MIL-STD 810 以提供可證明合格設備會在現場存活的環境測試準則。MIL-STD 810 是專為軍事環境編寫的測試準則，而非消防環境。規格表通常會參考 MIL-STD 背後的字母代碼。字母代碼代表測是採用的 MIL-STD 之修訂級別。最新版是 MIL-STD 810 F。在修訂版 C 之前，MIL-STD 810 都是通用版本。後續的版本比較針對使用者會操作設備的實際環境。製造商有時候只會執行 MIL-STD 的特定測試要件。舉例來說，設備說明可能顯示「通過 MIL-STD 810 防水、防塵、防震測試」。當我們看到 MIL-STD 810，我們會認為該設備耐用性已加強，且可承受消防環境。我們只要看溫度規格，即可知道這是值得質疑的。MIL-STD 實際上有兩種溫度規格，取決於使用設備的地方（**表 6.1**）。

The table shown is the high temperature table from MIL-STD 810F. A similar table is included in MIL-STD 810F for low temperatures. Most manufacturers test to the "Basic Hot" and "Basic Low" temperature levels. This temperature range is from approximately minus 30 C to 60 C (minus 22 F to 140 F). These temperature extremes do not replicate the environments that firefighters encounter. Radios that are available today are still manufactured to this specification.
這是 MIL-STD 810F 的高溫表。MIL-STD 810F 也有類似的低溫表。多數製造商會根據「基本高溫」和「基本低溫」等級進行測試。此溫度範圍大約介於-30℃到 60℃（-22℉到 140℉）。這些極端溫度無法複製消防人員遇到的環境。今日市場上供應的無線電仍然是依照此規格製造的。

How Many?
多少？

After defining the technical and operational requirements of the radio, the number of radios needed has to be determined. Departments have to identify who needs radios. A portable radio for each firefighter provides the highest level of safety. In addition to firefighters, radios for support and other fire department functions should be considered.
定義無線電的技術與運作要求後，必須確認所需的無線電數量。各部門必須確認需要使用無線電的人員。所有消防員都備有可攜式無線電可達到最高安全等級。除了消防人員以外，應考量支援用無線電與其他消防局功能。

Figure 6.1. Military Standard 810F High Temperature Table
圖 6.1. 軍用標準 810F 高溫表

Design Type 設計種類	Location 地點	Ambient Air ℃ (℉) 周圍空氣 ℃ (℉)	Induced ℃ (℉) 導入空氣 ℃ (℉)
Basic Hot 基本高溫	Many parts of the world, extending outward from hot category of the United States, Mexico, Africa, Asia, and Australia, southern Africa, South America, southern Spain, and southwest Asia. 世界許多地方，從分類為熱點的區域向外延伸，熱點包括美國、墨西哥、非洲、亞洲、澳洲、非洲南部、南美、西班牙南部，以及西南亞。	30-43 (86-110)	30-63 (86-145)
Hot 高溫	Northern Africa, Middle East, Pakistan and India, southwestern United States and northern Mexico. 非洲北部、中東、巴基斯坦與印度、美國西南部，以及墨西哥北部。	32-49 (90-120)	33-71 (91-160)

Additional guidance can be found in the following NFPA standards:

更多引導請見下列 NFPA 標準：

NFPA 1561

6.3Emergency Traffic.
6.3 緊急流量。

6.3.1* To enable responders to be notified of an emergency condition or situation when they are assigned to an area designated as immediately dangerous to life and health (IDLH), at least one responder on each crew or company shall be equipped with a portable radio and each responder on the crew or company shall be equipped with either a portable radio or another means of electronic communication.
6.3.1* 應變人員被分配到指定為會直接危害生命與健康（IDLH）的地區時，為了能夠告知他們關於緊急狀態或情況，各作業小組或消防隊中至少有一名應變人員應備有一台可攜式無線電，各作業小組或消防隊的每一位應變人員都應備有可攜式無線電或其他電子通訊工具。

NFPA 1221

9.3.6 Two-Way Portable Equipment.
9.3.6 可攜式雙向設備

9.3.6.1 All Emergency Response Units (ERUs) shall be equipped with a portable radio that is capable of two-way communication with the communications center.
9.3.6.1 所有緊急應變單位（ERU）都應備有能夠與通訊中心進行雙向通信的可攜式無線電。

9.3.6.2 Portable radios shall be manufactured for the environment in which they are to be used and shall be of a size and construction that allow their operation with the use of a gloved hand.
可攜式無線電的製造應依據其使用環境，且其尺寸與結構應允許使用者帶著手套進行操作。

9.3.6.10 Spare batteries shall be maintained in quantities that allow continuous operation as determined by the authority having jurisdiction (AHJ).
9.3.6.10 應依照管轄機構規定，持有備用電池，且數量應能夠維持運作。

9.3.6.11Aminimumofonespareradioshallbeprovidedfor each10units,orfractionthereof,inservice.
9.3.6.11 每 10 個服務單位或其中一部分應有一台備用無線電。

What Type?
類型？

Since radios are tiered based on performance and ruggedness, there can be significant cost savings by buying high-tier radios for responders and the appropriate lower tiered radios for support staff **(Figure 6.2).**
由於無線電的分級是根據效能和耐用度，購買高級無線電給應變人員，以及購買較低等級的無線電給支援人員，可大幅節省成本（**圖 6.2**）。

High-tier: High-tier radios should be provided to each firefighter. This level of radio gives the highest level of performance and reliability that radio manufacturers can provide. Within each tier, there may be options that provide additional capabilities or functions. If using radios for EMS and fire functions, encryption may be required for operations with law enforcement agencies or to comply with the Health Insurance Portability and Accountability Act of 1996 (HIPAA) requirements.
高級：應提供高級無線電給每一位消防員。這種等級的無線電具有製造商可提供的最高效能與可靠度水平。每一種等級都有提供額外性能或功能的選擇。若使用無線電是為了 EMS 與消防，可能會需要加密，以與執法機構合作作業，或符合 1996 年健康保險可攜與責任法案（HIPAA）規定。

圖6.2. 各種等級無線電例子

高級　中級　低級
（照片來源：Motorola Solutions與Harris）

Mid-tier: Mid-tier radios may be appropriate for users who do not enter into the firefighting environment. This type of radio would be a good choice for EMS functions. Again, encryption may be required to meet HIPAA requirements.
中級：中級無線電可能適合不會進入消防環境的使用者。這種無線電會是 EMS 的良好選擇。可能會需要加密以符合 HIPAA 規定。

Low-tier: Low-tier radios are an option for some support staff. These radios provide communications for users who are not in harsh environments and may not need all the functionality of the higher tier radios.
低級：有些支援人員可選擇使用低級無線電。這些無線電提供通訊給不處於嚴峻環境和不需要高級無線電所有功能的使用者。

Multiband
多頻帶

Multiband radios are now offered and can provide added levels of interoperability or provide flexibility to improve operability. The selection of which multiband radio may require assistance from the spectrum coordinators in your department or area of operation. Depending on the manufacturer of the radio, the radios are commonly triband (VHF, UHF, 700/800 MHz) or dual band. In dual band radios, a decision on which two bands provide the best use in your jurisdiction will have to be decided. The access to multiple bands has the capability of providing interoperability with other jurisdictions or disciplines you interact with. Having access to multiple bands and channels does not create interoperability. Interoperability must be planned, coordinated, agreed upon, trained for and practiced to be effective when you need it.
現在市面上有多頻帶無線電，這種無線電可提供更多互操作性層級，或提供靈活度以改善操作性。對於多頻帶無線電的選擇，或許會需要您所屬部門或作業地區的協調人員之協助。無線電一般是三頻（VHF、UHF、700/800 MHz）或雙頻，視無線電製造商而定。就雙頻無線電而言，使用者必須決定哪兩個頻帶在其所屬管轄區內最有效。擁有多個頻帶與通道的使用權不會創造協同合作。協同合作必須經過計劃、協調、同意、訓練和練習，才能在您需要時展現效力。

Having access to multiple bands also can enhance operability. In the metropolitan area of Phoenix, Arizona, use of multiband allows the firefighters in the region to use a 700/ 800 MHz trunked radio system for dispatch and EMS-related calls. Fire calls are run on VHF analog direct channels. This model allows the participating fire departments to use the trunked system for interoperability with law enforcement, meet wide-area communications needs, and use VHF direct for operations with local command, such as at fire incidents. Having two systems has the added benefit of providing redundant systems for increased reliability. Just a few years ago, they had to operate on two different radios.
具有多個頻帶的使用權也可提升操作性。在亞利桑那州鳳凰成的都會區，多頻帶的使用讓消防員能利用 700/800 MHz 集群是無線電系統進行調度與 EMS 相關呼叫。消防呼叫是利用 VHF 類比直接通道。此模型讓參與的消防局利用集群式系統與執法機構進行協同合作、滿足廣域通訊需求，以及利用 VHF 直接通道與當地指揮部合進行行動，如火災事故。擁有兩個系統的額外好處是，能提供多餘系統以增加可靠度。他們在數年前必須用兩個不同的無線電作業。

NationalInstituteofStandardsandTechnologyTesting
國家標準暨技術研究院

NIST has performed testing on portable radios that closely replicates the firefighting environment.
MIST 複製了接近消防環境的狀況，並對可攜式無線電進行測試。

TechnicalNote1477
技術摘記 1477

Technical Note 147724 test results exposed the vulnerability of the portable radios to elevated temperature conditions and emphasized the need to protect the radios when used in firefighting situations. Radios tested inside the turnout gear pocket showed that the turnout gear pocket was able to protect the radios and allow them to operate at the Thermal Class III temperature of 260 C (500 F). This contrasts with tests where the radios were exposed directly to the airflow, in which the radios did not survive at Thermal Class II conditions and beyond. In all but one test, the exposed radios were able to operate properly at the Thermal Class I temperature of 100 C (212 F), above the listed maximum operating temperature of 60 C (140 F). Failure of the electronics due to heating was

not permanent for the radios. In all cases where the radio casing was not damaged, the radios regained normal operating function once they had cooled sufficiently. Permanent damage to the casing, such as difficulty turning knobs or pressing buttons, did occur for some radios whose casings experienced melting. Permanent damage also occurred to the external speaker/microphones, especially due to the melting of the connecting cables.

技術摘要 1477[24]測試結果揭露可攜式無線電的弱點以提高溫度條件，並強調必須在消防情況中保護無線電。在消防衣口袋內測試無線電的結果顯示，消防衣口袋能夠保護無線電，並讓無線電可在耐熱等級第 III 級 206℃（500℉）下運作。在無線電直接暴露於氣流的測試中，無線電無法承受耐熱等級第 II 級的條件和更高的溫度。所有的測試中，只有一個測試的無線電能夠在耐熱等級第 I 級 100℃（212℉）和高於登記的最高作業溫度 60℃（140℉）的環境下正常運作。加熱造成的電子裝置故障就無線電而言並非永久故障。在無線電外殼未受損的所有案例中，無線電在經過足夠的冷卻後，都恢復正常作業功能。有些外殼遭熔化的無線電確實受到永久損壞，如難以轉動旋鈕或按下按鍵。外部喇叭/麥克風也會受到永久損壞，尤其是在原因為連接電纜熔化時。

TechnicalNote1850
技術摘要 1850

Technical Note 185025 was released in September 2014. The purpose of this study was to determine the firefighting environment that the radios operate in. While NFPA 1221 states: “Portable radios shall be manufactured for the environment in which they are to be used and shall be of a size and construction that allow their operation with the use of one hand,”26 no standard had been developed to quantify the firefighting environment. Seven radios were tested to measure radio performance at elevated temperatures. At 100 C (212 F), all radios maintained frequency. When the radios were subjected to 160 C (320 F) for 15 minutes, all of the radios experienced frequency drift, and some radios completely stopped transmitting. This is quite alarming and clearly indicates the need to protect the radios as noted in Technical Note 1477.

技術摘要 1850[25]發表於 2014 年 9 月。研究的目的是確認無線電運作的消防環境。雖然 NFPA 1221 規定：「可攜式無線電的製造應依據其使用環境，且其尺寸與結構應允許使用者可單手進行操作」[26]，但尚未有任何標準可用於消防環境量化。對七台無線電進行測試以測量無線電於溫度上升時的效能。在 100℃（212℉）下，所有無線電都維持其頻率。無線電承受 160（320）長達 15 分鐘後，所有無線電都發生頻率飄移，而且有些無線電完全停止傳輸。這測試結果相當驚人，顯然表示無線電必須受到保護，如技術摘要 1477 所述。

[24] Available at http://www.fire.nist.gov/bfrlpubs/NIST_TN_1477.pdf.
請到 http://www.fire.nist.gov/bfrlpubs/NIST_TN_1477.pdf.

[25] Available at http://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1850.pdf.
請到 http://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1850.pdf.

[26] NFPA 1221-13, 9.3.6.2.
NFPA 1221-13，9.3.6.2。

圖6.3. 各種消防設備與美國消防協會溫度等級

（圖片來源：Mike Worrell）

NFPA1802,*StandardonPersonalPortable(Hand-Held)Two-WayRadioCommunicationsDevicesforUsebyEmergencyServicesPersonnelintheHazardZone*

NFPA 1802，*緊急服務人員於危險區域內使用的個人可攜式（手持）雙向無線電通訊裝置之標準*

In response to a line of duty death in San Francisco, the San Francisco Fire Department asked the NFPA Standards Council to approve a new project to develop a standard for portable communications devices used in firefighting. The Council approved the project and assigned its development to the Technical Committee on Electronic Safety Equipment. Committee work on NFPA 180227 began in March 2013 to establish minimum requirements for the proper function of the communications equipment that operates in hostile thermal, IDLH, and nonhostile emergency scene environments. The goal is to increase the reliability of the communications equipment used by firefighters. The document, when issued, will not address interoperability, and its scope will be limited to the performance of the portable radio in the firefighting environment.

針對舊金山的因公殉職個案，舊金山消防局要求 NFPA 標準委員會批准一項新企劃，以為消防使用的可攜式通訊裝置制定標準。委員會核准該企劃，並指定由電子安全設備技術委員會執行。針對在惡劣的炙熱環境、IDLH 環境及安全的緊急現場環境運作的通訊設備，NFPA 1802[27]於 2013 年 3 月開始建立其正常功能的最低需求。目的是提高消防員使用的通訊設備之可靠度。發表的文件不會針對互操作性，且其範疇會受限於消防環境中可攜式無線電的效能。

Figure 6.3 is a comparison of equipment used in firefighting. It is easy to recognize that the NFPA temperature rating of the radio does not equal the same capabilities of other equipment in use by firefighters. The working group in cooperation with representatives from many fire departments, NIST, and the equipment manufacturers are working to define the operating environment and develop

tests to create a standard for communications equipment. In addition to defining the environment and developing testing, the group is working to establish ergonomics standards so that the communications equipment is easier to use in the firefighting environment. In addition to defining the environmental requirements and test procedures, the working group is also identifying mandatory safety features of the radio. Most manufacturers have the features available, but the jurisdiction programming the radio must identify and program each feature and select the correct value for the firefighting environment. Often, the function or characteristic of each button varies depending on who is programming the radio. The NFPA 1802 Technical Committee is developing the standard set of safety features.

圖 6.3 比較用於消防的設備。可輕易看出無線電的 NFPA 溫度等級不等於消防人員使用的其他設備之相同性能。與許多消防局、NIST 及設備製造商代表合作的工作小組正努力定義作業環境和進行測試，以制定通訊設備的標準。除了定義環境和進行測試外，工作小組也正在努力建立人體工學標準，讓現場人員可更輕易地在消防環境中使用通訊設備。除了定義環境需求與測試程序外，工作小組也正在辨識無線電的強制安全性能。多數製造商提供這些性能，但進行無線電編程的管轄當局必須確認並設計各項性能，以及選擇消防環境的正確數值。每一個按鍵的功能或特性通常會有差異，視無線電編程者而定。NFPA 1802 技術委員會正在制定一組安全性能標準。

27 http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=1802.

FireRadioFeatures
消防無線電性能

Many features are available in modern radios. Like automobiles, stripped-down versions of radios are available. When options are added, the cost rises. To identify the desired features, focus and user groups can assist in developing the radio feature sets that meet users' needs. Today's radios are extremely flexible in programming features and the functions of buttons on the radio. Cooperation between the radio vendor and technical provider for your radio system will be instrumental in filtering through all of the programming parameters. Some of the newer features that increase firefighter safety are:
現代無線電提供許多性能。如同汽車，市面上也有精簡版的無線電。選擇增加時，成本也會上升。為了確認希望的性能，焦點小組與使用者團體可協助研發滿足使用者需求的無線電性能組。現在的無線電在性能與按鍵功能方面的編程彈性極高。無線電系統的無線電供應商與技術提供者之間的合作，有助於所有編程參數的過濾。以下是一些會提高消防人員安全性的新性能：

-
- Voice channel announcement: This feature uses voice prompts to notify the firefighter what channel the radio is on as the channel select knob is moved.
  語音通道宣告：此性能利用語音提示，於通道選擇鈕被轉動時，通知消防人員無線電使用的通道。

- Emergency indications: Radios on the fireground receive an indication of emergency activations on the assigned channel.
  緊急指示：火場上的無線電會在指定通道上收到緊急行動的指示。

- Personnel accountability: There are more radio ID numbers available in new systems. This makes it possible for each radio to have an individual ID code enabling identification of the unit and specific position of the unit on an emergency activation. ID of the individual firefighter is possible if it is tied to roster information in a CAD system.
  人員責任：新系統有更多可用的無線電ID碼。者讓每一台無線電都可擁有個別ID碼，用於辨識緊急行動單位及其所在位置。若個別消防人員的ID有在CAD系統的名冊資料進行綁定，即可辨識他們的ID。

- Tones: Many radios use tones as an indication of trunked system access, out of range, repeater access, encrypted channel, and other reasons. Use of tones may provide added awareness to the firefighter and increase safety.
  音調：許多無線電利用音調，針對集群式系統進入、超出範圍、中繼器進入、加密通道等原因提供指示。音調的使用可提高消防員意識及安全性。

For guidance on the minimum feature set a radio should have, refer to NFPA 1221, Section 9.3.6.28
關於無線電應有的最低性能組，請參考 NFPA 1221 第 9.3.6 節。[28]

9.3.6 Two-Way Portable Equipment
9.3.6 可攜式雙向設備

9.3.6.2 Portable radios shall be manufactured for the environment in which they are to be used and shall be of a size and construction that allow their operation with the use of one hand.
9.3.6.2 可攜式無線電的製造應依據其使用環境，且其尺寸與結構應允許使用者可單手進行操作。

9.3.6.3 Portable radios equipped with key pads that control radio functions shall have a means for the user to disable the key pad to prevent inadvertent use.
9.3.6.3 備有無線電功能鍵盤的可攜式無線電應該能夠讓使用者關閉鍵盤以避免意外操作。

9.3.6.4 All portable radios shall be equipped with a carrier control timer that disables the transmitter after a predetermined time that is determined by the authority having jurisdiction.
9.3.6.4 所有可攜式無線電都應備有載子控制計時器，以在管轄當局規定的預定時間經過後關閉傳送器。

9.3.6.5 Portable radios shall be capable of multiple-channel operation to enable on-scene simplex radio communications that are independent of dispatch channels.
9.3.6.5 可攜式無線電應該能夠進行多通道作業，以允許調度通道以外的現場單工無線電通信。

[28] NFPA1221-13.

9.3.6.6 Portable radios shall be designed to allow channels to be changed while emergency response personnel are wearing gloves.
9.3.6.6 可攜式無線電的設計應該讓戴著手套的緊急應變人員可更換通道。

9.3.6.7 Single-unit battery chargers for portable radios shall be capable of fully charging the radio battery while the radio is in the receiving mode.
9.3.6.7 可攜式無線電的單件式電池充電器應該能夠於無線電處於接收模式時充滿無線電電池的電力。

9.3.6.8 Battery chargers for portable radios shall automatically revert to maintenance charge when the battery is fully charged.
9.3.6.8 可攜式無線電電池充電器於電池充滿電時，應該自動回復到充電模式。

9.3.6.9 Battery chargers shall be capable of charging batteries in a manner that is independent of and external to the portable radio.
9.3.6.9 電池充電器的充電方式應該使其獨立於可攜式無線電，並從外部進行。

9.3.6.10Sparebatteriesshallbemaintainedinquantitiesthatallowcontinuousoperationasdeterminedbytheauthorityhavingjurisdiction.
9.3.6.10 應依照管轄機構規定，持有備用電池，且數量應能夠維持運作。

9.3.6.11 A minimum of one spare portable radio shall be provided for each ten (10) units, or fraction thereof, in service.
9.3.6.11 每十（10）個服務單位或其中一部分應有一台備用無線電。

9.3.6.12 Portable radios used by first responders who might encounter hazardous conditions likely to cause fire or explosion because of the release of flammable liquids or gases shall be rated as Intrinsically Safe by a recognized testing authority if determined necessary by the authority having jurisdiction.
9.3.6.12 若管轄當局認為必要，針對因為可燃性液體或氣體釋放而可能引起火災或爆炸的危險情況，應變人員使用的可攜式無線電應由受到認同的測試機構評等為本質安全的設備。

PortableRadioUserTrainingGuide
可攜式無線電訓練指南

Firefighters often lack the basic knowledge and training of their portable radios, systems, and the capabilities of each. Training is required to form a basic operating knowledge and awareness of their radios. The awareness should include regular training and familiarization with the radio. The IAFF Fire Ground Survival (FGS) program states that “no probationary firefighter should enter the field without having practiced requesting resources and calling a Mayday. Furthermore, fire departments must have an ongoing training program specifically focused on using the radio” (IAFF FGS). Radios are often the only way to communicate on the fireground, especially in the case of an injured or downed firefighter. The next paragraphs will provide a simple and basic understanding of radio operations. It is not a prescriptive answer for every situation nor will it go over every single type of radio. The goal is for users to understand how to care for their radio, how to wear their radio, radio discipline, and training.
消防人員往往缺乏對可攜式無線電、系統及個別性能的基本知識和訓練。必須接受訓練才能養成對無線電的基礎操作知識與知覺。知覺應包括一般訓練和無線電熟悉度。IFAA 火場生存（FGS）計畫表示：「未練習操作資源和呼叫 Mayday 的見習消防員不得進入現場。此外，消防局必須有特別著重於無線電使用的現行訓練計畫」（IAFF FGS）。無線電通常是火場上唯一的溝通方式，尤其是在有消防員受傷或倒下的情況。下文將提供對無線電操作的簡單、基本知識。這不是每一種情況的標準答案，也不適用於每一種無線電。目的是讓使用者了解如何照顧無線電，如何配帶無線電、無線電紀律，以及訓練。

When a firefighter arrives to the fire station or is checking his or her equipment prior to engaging in work, it usually involves placing his or her gear and equipment in a ready state. Depending on where you work or who you work for, the radio may not be a big part of this routine. If it is not a major part of the routine, then it should be. The radio provides the means to summon help for you or your fellow firefighter. A basic radio check-off would include proper inspection of the radio’s physical properties, such as knobs, switches and the antenna as well as the radio’s functionality. Users should also have some knowledge and understanding of battery/power supply

life, rotation and maintenance. They should also be aware of the effect of temperature on the battery/power supply. Further questions about radios can be answered in this report, your department's technical personnel, or the manufacturer.
消防人員抵達消防局時，或者在投入工作前檢查他或她的設備時，這通常包括令他或她的工具與設備處於隨時可用的狀態。根據您工作的地方或您所屬的單位，無線電可能不是此慣例的一個重要部分。若這不是慣例的重要部分，應該使其成為重要部分。無線電提供可為您或您的消防同事請求協助的方法。基本無線電檢查包括正式檢視無線電的物理特性，如旋鈕、開關、天線、功能等。使用者應該對電池/供電期限、循環及維修有某種程度的知識與了解。他們也應該知道溫度對電池/供電的影響。此報告、您所屬部門的技術人員或製造商可回答更多關於無線電的問題。

Users and their behaviors have an impact on the effectiveness of fireground communications. Human factors, such as the way we speak and organization of reports, affect communications. Technical factors obviously have an impact on fireground communications. Like any other technology, users need to know the limitations of the technology and how to use the tool appropriately.使用者與其行為會影響火場通訊的有效性。人性因素會影響通訊，例如我們說話的方式和報告的結構。技術因素顯然會影響火場通訊。如同任何其他技術，使用者必須知道技術的限制，以及如何正確地使用工具。

Human Factors
人性因素

When we talk on the radio, each of us subconsciously performs a process before we speak. Managing this process will provide more effective communications. Key aspects of managing this process include the following:用無線電說話時，我們每一個人都會在說話前下意識地執行一個程序。管理此程序會提供更有效的通訊。管理此程序的重要觀點包括以下事項：

- Organization: Before speaking, formulate what information is being communicated, and put the information in a standardized reporting template. For instance, a standard situational report might contain Unit ID, location, conditions, actions and needs. This method forces users to fill in the blanks, answer all the necessary questions, and filter out unnecessary information.
  組織：說話前，先構想要溝通的資料，把資料放入標準化的報告範本中。例如，標準狀況報告可能會包含單位 ID、地點、情況、行動和需求。此方法讓使用者著重於填空、回答所有必要問題，以及排除不必要的資訊。

- Discipline: ICs are often overwhelmed by excess information on the radio. Radio discipline on the fireground will help to determine if information needs to be transmitted on the radio. If face-to-face communications are possible between members of a crew and the information is not needed by the IC, don't get on the radio.
  紀律：IC往往會收到無線電過多的資訊。貨場上的無線電紀律有助於判斷資料是否必須透過無線電傳輸。若行動小組成員之間可面對面溝通，且IC不需要該資訊，請勿使用無線電。

- Microphone location: Placing a microphone too close to the mouth or exposing the microphone to other fireground noise may result in unintelligible communications. When transmitting in a high-noise environment, shield the microphone from the noise source. Hold the microphone a couple of inches from the mouth or, when speaking through an SCBA mask, place the microphone near the voice port on the facepiece.
  麥克風位置：麥克風太接近嘴部或暴露於其他火場噪音時，可能會導致無法辨識的通訊。在高噪音環境中進行傳輸時，應擋住麥克風以免受噪音源影響。將麥克風舉在離嘴部數英吋的地方，若是透過SCBA面罩說話，將麥克風放在接近面罩語音端口的地方。

- Voice level: Use a loud, clear and controlled voice when speaking into a microphone. When users are excited, their speech often is louder and faster. These transmissions often are unintelligible and require the IC to ask for a rebroadcast of the information, resulting in more radio traffic on the channel.
  音量：對著麥克風說話時，利用大聲、清楚、受控的聲音。使用者感到激動時，他們所說的話往往會較大聲、較快。這種情況下的傳輸信息通常不可辨識，所以IC必須要求重播資訊，導致通道中更多的無線電流量。

Managing these human factors will have a positive impact on fireground communications. Reporting

should be complete, necessary, and in a controlled, clear voice. These actions will reduce the amount of repeat transmissions on the fireground and reduce air time.管理這些人性因素會對火場通訊有正向衝擊。報告應該是完整、必要的，且應使用受控、清楚的聲音。這些動作會減少火場上重複傳輸的數量，並縮減通話時間。

Technical Factors
技術因素

In some cases, communications problems are caused by a technical issue. Users need to recognize technical problems and take corrective action to improve communications. Training users to understand the system they use, as well as features of the system such as VR and BDA, may help users to more readily recognize communications issues and take corrective action to rectify them. Radio users often blame the radio or system for coverage problems. In many cases, users' actions can improve communications.
在某些情況下，通訊問題的起因是技術問題。使用者必須找出技術問題，並採取更正行動以改善通訊。訓練使用者了解他們使用的系統，以及 VR、BDA 等系統性能，可幫助使用者更容易找出通訊問題，並採取更正行動以解決問題。發生覆蓋問題時，無線電使用者經常責怪無線電或系統。在許多情況下，使用者的行動可改善通訊。

圖 6.4. 無線電放置

（照片來源：Cody Worrell）

Where to Wear Your Radio
無線電配戴處

Now that the radio is ready to be placed into service, the decision of where to wear the radio will have to be made **(Figure 6.4).** Most firefighters haven't given much thought to where the radio should be worn. Not much thought has been given because the limitations are not fully understood. Many firefighters assume that the equipment they are given is bulletproof and tested to all of the same standards. The radios that the fire service uses are far from bulletproof, and where the radio is worn will have an effect on radio performance. In order to decide on where to wear the radio, radio accessories will also need to be looked at since they are a part of the ensemble.
無線電已準備好投入服務後，接著必須決定配戴位置（**圖 6.4**）。許多消防人員不曾思考無線電的佩帶位置。不曾多花心思是因為他們不完全了解無線電限制。許多消防員認為他們收到的設備是防彈的，而且是根據相同標準經過測試的。消防服務使用的無線電與防彈根本沾不上邊，無線電配戴位置會影響無線電效能。為了決定無線電配戴位置，使用者也必須考量無線電配件，音位者些配件是整體的一部分。

Many users do not use a radio pocket or case. In the middle photo of **Figure 6.4,** the Company Officer's (CO's) radio (left) is clipped to the exterior of the coat, while the firefighter's radio is protected. The trade-off is that the radio is exposed to heat and steam but is in a better transmitting position. When unprotected, the radio may fail to operate when needed. NIST tested seven different radios at a temperature of 320 F for 15 minutes; all radios experienced an issue. After testing concluded, three radios failed to recover, while the other four worked properly after cooling down. When a radio is in a pocket, the temperature reduction is 135 to 167 degrees Fahrenheit cooler, which may keep the radio at the proper operating temperature, which was also tested by a NIST study.
許多使用者不使用無線電袋或無線電盒。**圖 6.4** 中間的照片中，消防隊隊長（CO）的無線電夾在外套外部，而消防員的無線電則受到保護。無線電暴露於高溫和蒸汽，但處於較好的傳輸位置。在未受保護的情況下，無線電可能會在需要時無法運作。

NIST 讓七種不同無線電處於 320°F長達 15 分鐘；所有經測試的無線電都出現問題。測試結束後，三台無線電無法恢復運作，而其他四台於冷卻後可證常運作。無線電放在口袋內時，溫度可降低 135-167 °F，讓無線電處於正常運作溫度，NIST 研究也測試了此情況。

There have been many studies, blogs and articles written on the best practices for carrying your portable radio, the most prevalent being the coat pocket versus the radio strap underneath the coat with the speaker microphone protruding from the top of the firefighter's coat. A number of factors play into the decision on where to carry, with pros and cons to both locations. The takeaway is to understand the limitations of what is issued to you and maximize the performance by your actions. No single location is optimal in **all** situations. A user that understands this limitation can react to a no transmit or no receive situation by changing something (i.e., body position or radio orientation).
曾有許多關於最佳可攜式無線電攜帶方法的研究、網路日誌及文章，其中最普遍的方法式外套口袋和外套內的無線電帶，喇叭無線電會消防員外套的上端突出。配戴位置的決定涉及許多因素，兩個位置都有其優缺點。重點在於了解設備的限制，以及藉由您的行動來使效能最大化。沒有一個位置是**所有**情況的最佳選擇。了解此限制的使用者可透過改變某樣事物（即身體位置或無線電方向）來應對沒有傳輸或接收訊號的情況。

Radios in the fire service vary greatly. Many were designed for public safety; however, manufacturers are now offering radios with "fire features." The fire features include larger knobs but still can pose a challenge to manipulate with gloved hands. Take one look at the knobs and buttons on some fire service radios, and it will be obvious that they are not made for firefighters because they are difficult to use with gloved hands. The other agencies that use our same radios don't find themselves transmitting with gloves on in environments that are hot and wet. All radios are susceptible to heat and moisture — to what degree, it may vary. Regardless, all firefighters should follow some basic
rules on where to wear their radio. If firefighters are leaving the radio exposed, they are exposing themselves to danger and run the risk of making the radio inoperable. Protect the radio at all costs. Most turnout coats have radio pockets to protect the radio, but some may not. Many departments use radio harnesses as well to aid in protecting and carrying the radio **(Figure 6.5).**
消防服務使用的無線電之間差異頗大。許多無線電是專為公共安全而設計的；然而，製造商現在推出具有「消防性能」的無線電。消防性能包括較大的旋鈕，但用帶著手套的手進行操作仍有其困難點。看一眼某些消防服務無線電上的旋鈕和按鍵，即可知道這些不是專為消防員製造的，因為會難以用帶著手套的手進行操作。使用與我們相同無線電的其他機構不會在高溫、高濕度的環境下帶著手套操作無線電。所有無線電都容易受到熱和濕度的影響─但受影響的程度可能不同。僅管如此，所有消防人員都應遵守一些關於無線電配戴位置的基本規則。若消防員讓無線電處於暴露狀態，他們是在讓自己暴露於危險，並在承受著令無線電失效的風險。無論如何都務必保護無線電。許多消防衣有保護無線電的無線電口帶，但有些消防衣可能沒有。許多部門也會利用無線電束帶來幫助保護和攜帶無線電（**圖 6.5**）。

圖6.5. 左邊的消防員正確地將無線電放在口袋裡。注意無線電喇叭麥克風線漏出的部分很少。右邊的消防員示範肩帶和皮套的使用。

（照片來源：**Cody Worrell**）

An important factor in where the radio is worn depends on the antenna. Portable radio antennas are designed to work in an upright position, so the radio waves can transmit out. All firefighters reading this should have questions popping up in their minds. Firefighters often find themselves crawling on the floor on top of their radio. Being in this position limits the capabilities of the antenna; however, the user

should be able to adjust and to help this. Depending on where the radio is will determine what may need to be done. If the radio is in the pocket, the firefighter may need to turn over to transmit. If the radio is worn around the waist, the firefighter may not need to do anything if the radio is exposed. The important thing to note is that the radio needs to be exposed so that it can transmit effectively. The other aspect to carrying a radio will be the accessories used in conjunction with it (Figure 6.6).

無線電配戴位置的一項重要因素取決於天線。可攜式無線電天線的設計是為了讓無線電以直立姿勢運作，如此才能發出無線電波。所有閱讀到這點的消防人員腦中應該會出現一些疑問。消防員經常會趴在無線電上，並在地上爬行。這姿勢會限制天線功能；然而，使用者應該能夠進行調整以改善此情況。根據無線電的位置，可決定必須採取的動作。若無線電在口袋裡，消防人員可能必須轉身才能進行傳輸。若無線電配戴在腰際，且是露出的，消防員可能不需做任何動作。必須注意的重點是，無線電必須是露出的，如此才能有效地進行傳輸。無線電攜帶的另一個重點是配合使用的配件（圖 6.6）。

圖6.6. 消防員以不利於傳輸-接收的姿勢爬行。第二張照片中，消防員已調整姿勢讓傳輸更順利。注意看到他的身體已不再擋住天線。

（照片來源：Cody Worrell）

Section 2, Recommendation 5 in the IAFC “Portable Radio Best Practices” states: “When practical consider the use of accessories, such as speaker microphones, throat microphones, and in-ear microphones, to reduce the impact of background noise” (IAFC Best Practices, p.18). Another factor is the use of remote speaker microphones (RSMs) and other accessories that allow the radio to be protected in a harness or pocket from heat. Radio pocket protection has been proven by NIST Technical Note 1477 where temperatures in the pocket were 135 to 167 degrees Fahrenheit cooler than outside the pocket29 (converted to F). Other common radio accessories found in the fire service are remote speaker mics, amplifiers and talk-around systems. RSMs connect to the radio with a pin connection and have a cord that attaches to the speaker and microphone (Figure 6.7). The RSM is also commonly referred to as a lapel mic. RSMs have been in use for a long time and are recommended as a best practice by the IAFC30 because they can dramatically reduce the impact of background noise on audio intelligibility. RSM problems were documented in the Houston Fire Department31 and San Francisco Fire Department32 line-of-duty deaths (LODDs) reports.

IAFF「可攜式無線電最佳實務」第 2 節第 5 項建議寫到：「實際操作時，考量喇叭麥克風、喉式麥克風、耳道式麥克風等配件的使用，以減少背景噪音的影響」（IAFC 最佳實務，第 18 頁）。另一項因素是遠端喇叭麥克風（RSM）與其他讓無線電可在束帶或口袋內免受熱影響的配件之使用。NIST 技術摘要 1477 已證實無線電口袋內的溫度比外部低 135-167°F（轉換成°F）。29其他常見於消防服務的無線電配件包括遠端喇叭麥克風、放大器及脫網系統。RSM 利用樞接連接到無線電，並有一條連接喇叭和麥克風的電線（圖 6.7）。RSM 又稱為領夾式麥克風。RSM 的使用已經過一段很長的時間，IAFC30推薦其為最佳實務，因為 RSM 可大幅減少背景噪音對語音可辨識度的影響。RSM 問題記錄於休士頓消防局31與舊金山消防局32的因公殉職（LODD）報告。

In San Francisco, an LODD report concluded that “victim 1’s remote speaker/microphone failed due to high heat/fire, causing constant transmit condition. This disabled the radio from transmitting or receiving after 60 seconds.” The biggest problem has been the cord that connects the speaker/ microphone to the radio body. The cord can melt

[29] NIST1477, p.6.
NIST 1477，第 6 頁。

[30] http://www.iafc.org/files/digProb_PortableRadioBestPractice.pdf, Section2, p.18.
http://www.iafc.org/files/digProb_PortableRadioBestPractice.pdf，第 2 節，第 18 頁。

[31] Houston Fire Dept. Southwest Inn Recovery Committee Final Report and Recommendations Sept. 1, 2014.
休士頓消防局西南飯店復原委員會最終報告與建議，2014 年 9 月 1 日。

[32] San Francisco Fire Dept. Safety Investigation Report Line of Duty Deaths 133 Berkeley Way June 2, 2011 Box 8155 Incident #11050532.
舊金山消防局因公殉職安全調查報告，133 Berkeley Way，2011 年 6 月 2 日，信箱 8155，事件#11050532。

causing a short. When the short occurs, the radios are sometimes keyed up, unbeknownst to the user, or inoperable. The user needs to protect the cord to help prevent this from happening. The cord can be tucked into the radio pocket or underneath the jacket where temperatures are significantly cooler. It is worth noting that some manufacturers offer cords that can withstand 500 F temperatures, as well as having more firefighter friendly features. These are just two solutions; there is no prescriptive answer. Furthermore, the IAFC recommends that special attention be paid when selecting radio accessories to ensure that they are compatible with the environment that they are to be used in.33 What the last sentence is saying is that not all cords are created equal, so the user must know the temperature ratings of his or her equipment because they may be different.

舊金山的一份 LODD 報告斷定「1 號遇難者的遠端喇叭/麥克風因高溫/火而故障，造成斷續傳輸的情況。這在 60 秒後令無線電無法進行傳輸或接收」。最大的問題是連接喇叭/麥克風與無線電主體的電線。電線可能會熔化，導致短路。發生短路時，無線電有時候會鎖住、令使用者不知情或者無法運作。使用者必須保護電線以防止這種情況發生。可將電線塞進溫度明顯較低的無線電口袋裡或夾克下。值得一提的是，有些製造商提供可承受 500°F和具有更多消防友善性能的電線。這只是其中兩種解決方法；沒有所謂規定的答案。此外，IAFC 建議，選擇無線電配件時，應特別注意以確保配件與其使用環境相容。33這是在說並非所有電線都相同，所以使用者必須知道他或她的設備的溫度等級，因為可能會有所不同。

圖6.7. 遠端喇叭麥克風例子

（照片來源：Harris與Motorola Solutions）

Amplifiers are attached to the SCBA facepiece (Figure 6.8). The amplifiers do not connect to the radio; they only amplify the voice of the user out of the SCBA mask. A benefit of the amplifier is that users do not need to significantly raise their voice to be heard. Transmissions sound better and more controlled because the users are not required to yell. The amplifiers operate off batteries that need to be tested and maintained. The amplifiers areonly effective if the user places the radio or RSM in the correct area when speaking. The user will position his or her radio 1 to 2 inches from the audio source when in use as recommended by the IAFC "Portable Radio Best Practices" report. Once again, it is important to note that the temperature rating of the equipment needs to be known.

放大器連接到 SCBA 面罩（圖 6.8）。放大器未連接到無線電；只會放大使用者傳出 SCBA 面罩的聲音。放大器的優點之一是，使用者不需要大量提高他們的聲音。傳輸訊息聲音會較好且較受控，因為使用者不需要大聲叫喊。放大器使用的電池必須經過測試與維護。只有在使用者將無線電或 RSM 放在正確的區域時，放大器才會有效。依照 IAFC「可攜式無線電最佳實務」的建議，使用者會將他或她的無線電放在距離音源 1-2 英吋的地方。再次聲明，必須知道設備的溫度等級。

圖6.8. 自己式呼吸器聲音放大器

（照片來源：Scott Safety）

The third accessory is a talk-around system. Some SCBA manufacturers produce a talk-around system that attaches to the facepiece. The models may offer multiple talk-around channels that allow users to talk with each other on the fireground. A benefit of this system is that users can talk to each other without tying up airtime on the tactical channel.

33 IAFC "Portable Radio Best Practices."
IAFC「可攜式無線電最佳實務」。

Airtime is available for important information and maydays. This type of system would aid in mayday situations because interior crews communicate without being on the tactical channel. The systems also can attach to the radio. There is a switch to allow you to talk through the radio. The talk-around system may have a PTT button on the facepiece itself. The RSM cord is the same that is used for this system as well. The dangers listed above in the RSM section apply to this piece of equipment as well.
第三個配件是脫網系統。有些 SCBA 製造商生產連接到面罩的脫網系統。模型可提供多個脫網通道，讓使用者能在火場上彼此對話。此系統的優點之一是，使用者不需要佔用戰術通道的傳輸時間，即可與彼此對話。傳輸時間可用於發送重要資訊和 mayday 呼叫。這種系統有助於緊急 mayday 情況，因為內部人員不需要使用戰術通道即可溝通。系統也可連接到無線電。有一個開關讓使用者可透過無線電說話。脫網系統可能在面罩上會有一個 PTT 按鍵。RSM 電線也與此系統使用的相同。前文關於 RSM 的危險事項也適用於此設備。

The question of where to wear the radio depends on all of the factors discussed above. Proper placement should be where the radio transmits and receives reliably. There is no prescriptive answer for where the radio should be. The radioshould be protected and in a place where the user is comfortable operating it with his or her given equipment. Proper placement of the radio has been a researched topic by multiple agencies and departments. The research has shown that the radio needs to be protected, or it may malfunction.34,35 Placing the radio in a turnout coat pocket resulted in a temperature difference of 135 F to 167 F.無線電配戴處的問題取決於以上討論的所有因素。適當的配戴位置應該能讓無線電可進行可靠傳輸與接收。無線電配戴位置並沒有所謂的規定答案。無線電應受到保護，並放在使用者感到舒適的地方。許多機構與部門都曾研究過無線電的適當配帶位置。研究證實無線電必須受到保護，否則有可能會故障。[34,35]將無線電放在消防衣口袋內可令其承受溫度差別高達 135-167˚F。

Coverage
覆蓋範圍

When communicating on the fireground, some areas of a building may be difficult to communicate rom. When encountering these areas, move to a location where communications are possible. Areas that may improve communications are near windows and doors.
在火場上溝通時，可能會難以從建築物的某些區域通信。遇到這些區域時，應移動到可進行通訊的地點。接近門窗的區域或許可改善通信。

Accessories
配件

Many accessories are available for radios. Use of accessories that protect the radio from heat and steam allows the radio to operate in high-heat environments. Each user group may have specific working conditions that require some accessories to make radio communications easier. Common accessories include carrying cases, speaker microphones, ear pieces, chargers, battery types, and optional antennas. A few considerations when evaluating radio accessories are:
件可供無線電使用。使用保護無線電免受熱和蒸汽影響的佩件讓無線電得以在高溫環境中運作。每一個使用者團體都可能會有需要配件來令無線電通訊更簡易的特定工作環境。常見配件包括攜帶盒、喇叭麥克風、耳機、充電器、電池種類，以及可選天線。以下是評估無線電配件時應考量的事項：

- Is the accessory approved for firefighter use in the IDLH environment?
  配件是否經核准可讓消防人員在 IDLH 環境中使用？
- Does the accessory hinder the firefighter in donning PPE?
  配件是否會阻礙穿著 PPE 的消防人員？
- Can buttons/controls be manipulated with PPE?
  穿著 PPE 時，能否操作按鍵/控制？
- Is there a method to disengage accessory in case of snare or malfunction?
  發生捕捉或故障時，是否有辦法可關閉配件？

User and focus groups will help identify the accessories needed to support your department's needs.
使用者與焦點團體有助於確認可支援您所屬部門需求的配件。

[34] NIST TN 1850.
[35] NIST TN 1477.

Summary—PortableRadioSelectionandUse
摘要─可攜式無線電之選擇與使用

Portable radio equipment is what the firefighter sees and has the most impact on fireground communications. Firefighters expect the radio is going to work when the PTT is pressed. Multiple tiers of radios are available at different price points. Select the appropriate radio for entering the hazard zone. Today's radios have better ergonomics than in the past, and firefighters should be able to operate them with a gloved hand.
可攜式無線電設備式消防人員看見的事物，對火場通訊的影響最大。按下 PTT 鍵時，消防員預計無線電正常運作。市面上有以不同價格點出售的多種等級的無線電。選擇適合進入危險區域的無線電。現在的無線電有比過去更好的人體工學，消防人員應該能夠帶著手套用單手操作無線電。

Radios are currently manufactured to meet MILSTD 810. Environmental specifications for this standard range from minus 22 F to 140 F. This has proven to be a weakness.
無線電的製造目前是依據 MIL-STD 810 標準。此標準的環境規定範圍為-22°F到 140°F。已證實這是一項弱點。

NFPA 1561 and 1221 are guiding documents on the type and capabilities of the radio and should be referenced during radio purchases or system design.
NFPA 1561 與 1221 是關於無線電種類及性能的指導文件，購買無線電或設計系統時，應多加參考。

NIST Technical Notes
NIST 技術摘要

1477: This study tested radios in the firefighting environment and proved that radios protected from the direct heat increased the survivability of the radios.
1477：此研究測試消防環境中的無線電，並證實保護無線電使其免於直接受熱可增加無線電存活率。

1850: This study tested seven radios and subjected the radios to 320 F for 15 minutes. All radios experienced frequency drift, and some completely stopped transmitting.
1850：此研究測試七台無線電，並將無線電放置在 320°F下 15 分鐘。所有無線電都發生頻率飄移，有些甚至完全停止傳輸。

NFPA1802
NFPA 1802

Draft development of this document began in March 2013 with the establishment of minimum requirements for the proper function of the communications equipment that operates in hostile thermal, IDLH, and nonhostile emergency scene environments. Turnouts, thermal imaging cameras (TICs) and PASS units are all rated for 500 F for five minutes. The radio is the only piece of equipment that does not meet the 500 F rating. The standard, when issued, will also mandate basic safety functions on the radio.
此文件的起草始於 2013 年 3 月，連同於惡劣高溫、IDLH 及安全緊急現場環境運作的通訊設備正常運作之最低要求一起制定。消防衣、熱像儀（TIC）與 PASS 單元被評估為可承受 500°F大約五分鐘。無線電是唯一未達到500°F等級的設備。此標準於**發布後**也會規定無線電的基本安全功能。

User Guide
使用者指南

As with any equipment used in the fire service, training is a key factor in successful use of theequipment. This is especially true when in high stress situations. Users need to be aware of actions that they can take to successfully communicate:
如同任何用於消防服務的設備，訓練是順利使用設備的關鍵要素。在高壓情況下，事實更是如此。使用者必須知道，他們能採取哪些行動以成功進行通信：

- Organized thought process.
  過程中保持井然有序。
- Discipline — when to speak, what to speak,
- controlled voice (speed and amplitude).
  紀律─什麼時後說話、說什麼、受控聲音（言語和音量）。
- Equipment.
  設備。
  - Component location — microphones, voice ports, antennas.
    部件位置─麥克風、語音端口、天線。
  - Position where the radio is worn — protected.

無線電配戴位置─受保護的位置。

- No single location is optimal in all situations. A user that understands this limitation can react to a no transmit or no receive situation by changing something (i.e. body position or radio orientation).
  沒有一個地點是所有情況的最佳位置。
- RSM use.
  RSM 的使用。

- Recognition of coverage (poor transmit or receive):
  確認覆蓋範圍（傳輸或接收不良）：
  - Change radio or body position — get the antenna vertical.
    改變無線電或身體姿勢─讓天線直立。
  - Move toward windows or exterior of the building and retransmit.
    向窗戶或建築外部移動並重新傳輸。

Section 7–
第 7 節–

System Design and Implementation
系統設計與實施

Project Organization
專案組織

Designing and implementing a communications system is an extremely complicated process. It is important to create a structured organization to provide input, carry out decision-making, and conduct implementation work on the project. Get the organization established before beginning the project.
通訊系統設計與實施是一個極為複雜的過程。必須創造一個有架構的組織，以提供資源、做決策，及執行專案實施作業。專案開始前，先建立組織。

Everyone affected by the fire communications system should have a hand in its selection. This doesn't mean everyone participates at every step, but it does mean stakeholders must be consulted and their needs given serious consideration. If any constituency gets left out of the planning process, those needs may get overlooked, and the result could be a system that fails to meet the requirements and expectations of the entire community.
每一位受通訊系統影響的人都應該有權參與其選擇。這並不代表每個人都會參與每一個步驟，而是必須與利害關係人商議，並慎重考慮他們的需求。若計畫過程遺漏了任何選擇人，他們的需求可能會被忽略，結果是系統無法滿足整個社群的需求與期望。

When creating the project organization, be careful to clearly define the roles various workgroups have in the organization. The term "user" often has different meanings to different people, so using a more descriptive term is best to avoid confusion. Some example roles include:創造專案組織時，務必小心明確地定義各種工作小組在組織裡的角色。「使用者」一詞對不同的人往往會有不同的意義，所以最好採用較具描述性的言語以避免困惑。一些角色的範例包括：

- Front-line firefighters and the teams that support them in the field.
  前線消防人員與在現場支援他們的團隊。
- Dispatchers and others who provide support away from the scene.
  調度人員與從現場外部提供支援的人。
- Operational supervisors.
  作業監管人員。
- Department and other organizational business management.
  部門與其他組織業務管理。
- Union representatives.
  工會代表。
- Elected officials.
  民選官員。
- Personnel from other agencies that collaborate with the fire service.
  與消防服務合作的其他機構之工作人員。

Interoperability is a major concern in today's world. The ability of public safety agencies to communicate with each other is critical when events require them to coordinate a joint response. Many localities are answering this need by designing large networks that will be shared by multiple departments and sometimes by multiple cities and counties.
互操作性是現代世界非常注重的事項。當事故需要公共安全機構協調執行聯合行動時，機構之間彼此溝通的能力非常重要。許多地區對此需求的回應是，設計大型網路，讓多個部門可用共享，偶爾也可讓多個城市與國家共享。

If your community is working on a communication system that will be shared by other entities in addition to the fire service, you need to be collaborating with representatives of those organizations. You'll face the challenge of giving each agency's needs appropriate weight. The law enforcement component of the system may often drive the overall direction of the project, but it's essential for the fire service to make system designers aware of the needs of the fire service and to make sure that the system is designed to accommodate those needs.
若您的社群正在打造一個將由消防服務以外的其他個體共享的通訊系統，您必須與這些組織的代表合作。您會面臨給予每一個機構需求適當重要性的挑戰。系統的執法部分可能會主導整體專案方向，但消防服務必須使系統設計師了解其需求，

並確保系統的設地符合這些需求。

Each community has a different approach toorganizing the planning effort. Typical efforts include:
每一個社群都有不同的計畫工作整理方式。典型的工作包括：

- A steering committee with top leadership setting the overall policy agenda. Every attempt should be made to have fire department management and labor leadership as participants on the steering committee at the project's earliest stages.
  由頂尖領導組成的指導委員會，負責制定整體政策議程。應盡力讓消防局管理人員與勞工領導人員於專案初期加入指導委員會。

- Working groups that are assigned to complete specific tasks and report back to the steering committee. If you are appointed to one of these groups, it sometimes can be difficult to determine exactly what your role is supposed to be — both as a group and as individuals. It is important that fire department management and labor are involved in establishing the goals and expectations for each work group.
  被指定完成特定任務並向指導委員會回報的工作小組。若您被分配到其中一個小組，有時候可能會難以確定您的角色到底是什麼─無論是個人或小組的角色。消防局管理人員與勞工必須參與各個工作小組目標及期望的制定。

Requirements Definition
需求定義

You may be collaborating with other departments to build a shared multiagency network, or you may go it alone on a system for the fire service only. Either way, the more you learn about your department's needs, the more effectively you can represent the perspective of the fire service in your community.
您可能會與其他部門合作建立一個共享的多機構網路，或者您可能單獨使用消防服務專用系統。無論如何，您對所屬部門的需求了解愈多，您愈能更有效地表示所屬社群的消防服務觀點。

The design and procurement of radio systems for fire departments is technical and very expensive. Many departments rely on expertise outside of the fire service to advise them on communications technologies. Often these technical experts do not have a complete understanding of the fire service or special requirements related to fireground communications. As a result, many communications systems are built to design parameters based on incomplete or inaccurate information.
消防局無線電系統的設計與購買是具技術性且非常昂貴的。許多部門依賴消防服務外部的專業人士來提供關於通訊技術的意見。這些技術專家通常不完全了解消防服務或與火場通訊有關的特殊需求。因此，許多系統的建立都是依據資料不完整或不準確的設計參數。

The development of a Requirements Definition provides an opportunity to analyze communications needs based on operational practices and inherent risks associated with fire operations. The Requirements Definition also provides a measurable parameter set to evaluate the current radio system.
需求定義的制定提供一個機會，可根據操作實務及消防服務相關固有風險，分析通訊需求。

Identify Operational Needs
確認運作需求

The planning horizon for a new communications system can range from a few months to several years. Once installed, the system could have a life of 10 years or more. The following are some things that must be considered.
新通訊系統的規劃展望期可從數個月到數年。安裝之後，系統的使用壽命可達 10 年或以上。以下是一些必須考量的事項。

Operational needs should be grouped into three different categories based on the frequency of use:
操作需求應根據使用頻率分成三種：

1. Everyday incidents that all departments engage in, including structure fires, vehicle crashes, location of fire facilities, etc.
   所有部門都投入的常見事故，包括建築火災、車禍、消防設施定位等。

2. Mutual and automatic aid responses that occur less frequently but are still common.

發生頻率較少但仍常見的互助與自動援助應變。

3. Major incidents like disaster responses requiring long-duration coordination between local, state and federal agencies with heavy logistical support.
擁有大量後勤支援，且需要地方、國家與聯邦機構長期協調合作的重大事故，如災害應變。

When considering the operational needs in these categories, it is important that the everyday incident operations are not compromised for the rare complex incident.
考量這些種類的運作需求時，重要的是，不讓常件事故行動因為罕見的複雜事故而受影響。

Major disaster response communications can be accommodated by using regional or national resources to supplement the everyday system, just as regional or national resources supplement the response and recovery response. This does not mean that communications planning for large-scale incidents is not necessary, only that you may not need a system that accomplishes all possibilities, no matter how unlikely. A large and complex radio system will be more complex for users, be more costly upfront, and require more operation and maintenance cost than a system designed for routine incidents. Consider the needs of the community and the risks involved before putting together a plan for the ultimate system.
利用地區或國家資源輔助日常系統可容納重大災害應變通訊，如同地區或國家資源輔助應變與復原應變一般。這並不表是大型事故不需要通訊計畫，只是說您或許不需要一個可滿足所有可能性的系統，無論達成機率有多低。大型、複雜的無線電系統對使用者而言會比較複雜，比較昂貴，且需要的運作與維修成本高於專為一般事故設計的系統。為最終的系統制定計劃時，應考量社群的需求與其中的風險

Plan for Change
變更計畫

Communications needs can change over time due to community changes, such as population growth, density changes, geographic expansion, alliances with other communities, and evolving issues in homeland security and all-hazards management. Any investment you make today should have the potential to grow tomorrow.
通訊需求可能會因社群改變而隨著時間改變，例如人口增加、密度變化、地理擴張、與其他社群結盟，以及國土安全與全風險管理的新興議題。您今日所做的投資都應該有明天會成長的潛力。

Organizational changes like budget constraints, staffing changes, departmental realignments, the creation of new work teams and task forces, greater collaboration with state and federal agencies can also affect communications needs. Will you be hiring more firefighters, opening or closing stations, or fielding specialized teams such as hazardous materials, weapons of mass destruction (WMD), wildland firefighting, technical rescue, or others? There are a number of other things to consider
組織變化也會影響通訊需求，例如預算限制、人員變動、部門重調、新工作團隊與專案小組的成立、更多與國家及聯邦機構的合作等。您會雇用更多消防人員，開啟或關閉消防局，或者網羅危險物質、大規模毀滅性武器（EMD）、野地消防、技術救援等專業團隊？有許多事項必須考量。

- Be prepared with statistics that reinforce your department's importance to the community. This includes how many incidents you handle each year, how many citizens receive service each year, and how many lives are saved. These can be hard to quantify, but some research should produce numbers you can use.
備好統計數據，加強您所屬部門對社群的重要性。這包括每年處理的事故量、每年接受服務的人數，以及拯救的性命數。這些資料可能難以量化，但有些研究應該會有您可使用的數據。

- Be familiar with your department's planning initiatives, and be prepared to talk about anticipated growth, addition of fire stations, potential incidents, and disaster scenarios to demonstrate the importance of fire service preparedness.
熟悉所屬部門的規劃倡議，並做好準備探討預期的成長、消防局的增加、潛在事故及災害情節，以展示消防服務整備的重要性。

- or special requirements related to fireground communications. As a result, many communications systems are built to design parameters based on incomplete or inaccurate

information.
專注於結果。這不是塔台持有數的問題，而是消防人員在建築物內工作時，能否進行通信以協調任務和戰略或者聽到緊急流量或 mayday 呼叫。強調每一個決定對工作人員與民眾安全的影響。

With the current focus on interoperability, don't lose sight of the basic mission. It is still more important to be able to respond effectively and safely to the everyday incidents than it is to provide for every possible (and unlikely) disaster scenario. This is not to say that interoperability is not important, but don't sacrifice a system that you can use for a rarely used feature.
不要因為現在的焦點都在互操作性上，而忽略了基礎任務。能夠對常見事故進行有效、安全的應變，比支援每一種可能（或不可能）發生的災害情境來得重要。這並不是在說互操作性不重要，只是說別犧牲可用於罕見性能的系統。

Evaluationo f Current System
當前系統之評估

What is the current state of your fire communications? This is not an easy question to answer. It's not uncommon for a department to use more than one communications system, and even with the same equipment, procedures can vary markedly. Collecting this information and pulling it all together in one place is a necessary step that requires the commitment of time and resources.
您消防通訊目前的狀態為何？這不是個可簡單回答的問題。一個部門使用一個以上通訊系統是常見的事，即使是相同的設備，程序也可能大有差異。收集資料並將其整合於一個地方是必要的步驟，需要時間與資源的投入。

An assessment of your current communications will help in identifying gaps in your communications infrastructure and plans, and identifying what it does well will assist in determining the need for a new system, or if updating the old system would be cost effective.
對您當前的通訊系統進行評估有助於找出通訊基礎建設與計畫的差異，而知道通訊系統的長處則有助於確認對新系統的需求，或者舊系統更新是否可節省成本。

Few departments keep statistics about radio usage and performance, so you'll have to generate much of this information from scratch. Many departments use technical staff, vendors or bring in a consultant at this phase, especially to help with the more technical aspects of the job, such as charting call traffic and measuring grade of service. A consultant also can be helpful in collecting "softer" data. Soft data might include user perception of the current system or where users feel where improvements need to be made. Sometimes it's easier for an outsider to interview users and get their honest feedback on how the system works or doesn't work for them.
很少有部門會記錄無線電使用率與效能，所以您必須從零開始建立資料。許多部門會在此階段採用技術人員、供應商或聘請顧問，尤其是為了在工作較技術性的方面提供協助，例如呼叫流量製表和服務等級量測。顧問也有助於收集「較軟的」數據。軟數據可包括使用者對當前系統的看法，或使用者認為必須改善的地方。有時候外部人士比較容易訪問使用者，並得到關於系統對他們而言有沒有用的誠實回饋。

It may be beneficial to create scenario descriptions that describe all communications flows for various types of incidents from receipt of the call by the call taker, through dispatching units, unit response, and incident management and logistics support. Consider all aspects of the communications including the use of pagers and station alerting, mobile data, and wide-area and fireground voice communications. The most expensive communications system will be of little use if a major function performed today is left out of the future system.
製造情境描述可能會有幫助，其中說明各種事故的所有通訊流程，從接聽人員收到呼叫，到調度單位、單位應變，以及事故管理與後勤支援。考量所有方面的通訊，包括呼叫器和消防局警示的使用、行動數據，以及廣域與火場語音通訊。若未來的系統不包含今日發揮作用的重要功能，即使是最昂貴的通訊系統也會是沒有用的。

Finally, consider the state of physical infrastructure, such as communications building condition and susceptibility to weather effects, tower condition, commercial and backup power sources, and communications backhaul (telephone lines, data circuits, and microwave systems).
最後，考量物理基礎建設的狀態，例如通訊建築狀況與受天氣影響的程度、塔台狀況、商用與備用電力資源，以及通訊回傳網路（電話線、數據

電路、微波系統）。

Funding
資金

After the needs are identified, the budget can be developed. If the budget is developed too early, the system design may be unduly constrained. When this happens, it is inevitable that functionality and performance will be lost. Once the budget is set, it will be very difficult to get additional funding later to "get it right," especially if other agencies are pushing forward.
確認需求後，即可編列預算。若太早編列預算，系統設計可能會不適當地受限。發生這種事時，會無可避免地損失功能與效能。一旦預算已制訂，以後要得到額外資金來「做好事情」會非常困難，尤其是如果其他機構正在努力前進。

One method for getting a rough budget in place is to survey similar agencies with similar needs on the cost of their system or hiring a consultant to make a system design recommendation and cost estimate based on your system needs. Another method is to issue a request for information (RFI) to manufacturers and system integrators describing your operational communications needs and requesting a rough not-to-exceed cost for a system. Regardless of the method used for the estimate, this type of information will be very rough since the system design will be based on incomplete information and limited detail. It is difficult to get a solid cost without going through a complete system design with a specific manufacturer's equipment.
一個讓初步預算到位的方法是，調查有類似需求的相似機構之系統成本，或者聘請顧問根據您的系統需求提供系統設計建議與成本概算。另一個方法是向製造商與系統整合商發出資訊需求書（RFI）說明您的作業通訊需求，並要求提供系統的大概成本。無論採用的概算法為何，這種資訊會非常粗略，因為系統設計會以不完整資訊和有限細節為基礎。未經過特定製造商社備的完整系統設計，難以達到確實的成本。

Alternative Funding Sources
替代資金來源

Funding is a huge issue, but it should not be your first consideration when assessing your communications requirements. With the renewed focus on public safety and first-response capabilities, more funding is becoming available through federal, state and regional government grants. Examples include:
資金是依個很大的問題，但不應該是評估通訊需求時的首要考量。因為現在焦點都放在公共安全與應變能力，有更多資金可透過聯邦、國家與地方政府補助金取得。例如：

- State Homeland Security Grant Program (HSGP) and Urban Areas Security Initiative (UASI), administered by DHS through the Office for Domestic Preparedness (ODP) (https://www.fema.gov/fy-2015-homelandsecurity-grant-program).
  透過國內備災辦公處（ODP），由 DHS 掌管的國家國土安全補助金計畫（HSGP）與市區安全計畫（UASI）（https://www.fema.gov/fy-2015-homeland-security-grant-program）。

- Assistance to Firefighters Grant Program, administered by FEMA (https://www.fema.gov/welcome-assistance-firefighters-grant-program)
  由 FEMA 掌管的消防員援助補助金計畫（https://www.fema.gov/welcome-assistance-firefighters-grant-program）。

- USFA document "Funding Alternatives for Emergency Medical and Fire Services" (http://www.usfa.fema.gov/downloads/pdf/publications/fa_331.pdf).USFA 文件「緊急醫療與消防服務資金方案（http://www.usfa.fema.gov/downloads/pdf/publications/fa_331.pdf）。

In some cases, it may be feasible to participate in joint investments with other agencies or nearby communities. This will allow for networking facilities, such as core systems, repeater systems, fire-alerting systems, and towers. Costs can be shared among several different organizations. This also improves day-to-day interoperability among these organizations.
在某些情況下，與其他機構或附近的社群合資或許可行。這會將核心系統、中繼器系統、火災警報系統、塔台等網路設施納入考量。數個不同組織可一起分擔成本。這也可改善組織間的日常互操作性。

Explore leasing agreements and other financing alternatives as opposed to immediately committing upfront capital investment. Phased implementation plans and adaptable networks that start small and add more capabilities over time as the funding becomes available are also an option. Do not allow cost to become a barrier that prevents your community from building the fire communications system its citizens and your colleagues deserve.
研究租賃協議與其他融資方案，而不是立即投入預付資本投資。一開始很小的階段式實施計畫與適宜網路，可在資金變多時隨著時間增加更多性能，這也是一個選擇。別讓成本成為障礙，防止您的社群建立其民眾與您的同僚值得獲得的消防通訊系統。

Grant Writing
補助金計畫書寫作

If you decide to try to obtain grant funding, it is important that you get started on the grant proposal early and spend the necessary time to get the proposal right. A successful grant proposal is well-prepared, thoughtfully planned, and concisely packaged.
若您決定試圖取得補助金資金，您必須早點開始進行補助金計畫書寫作，並花費必要的時間寫對計畫書內容。成功的補助金計畫書是做好充分準備、精心策劃且簡潔包裝的。

Become intimately familiar with the grant criteria and the eligibility requirements. You must be able and willing to meet these requirements. You might find that eligibility would require providing services otherwise unintended, such as working with particular client groups or involving specific institutions. You may need to modify your concept to fit. Talk to the grant information contact person to determine whether funding is still available, what the applicable deadlines are, and what process the agency will use for accepting applications.
您必須非常熟悉補助金標準與合格要求。您必須能夠並願意達到這些要求。您或許會發現，合格必須提供非計畫中的服務，例如與特定客戶群合作或者社及特定機構。您可能會必須調整您的觀念。與補助金資訊連絡人談話，以確認資金是否可用、申請截止日為何，及機構接受申請的程序。

Determine whether any similar proposals have already been considered in your locality or state. Check with legislators and area government agencies and related public and private agencies that currently may have grant awards or contracts to do similar work. If a similar program already exists, you may need to reconsider submitting the proposed project, particularly if duplication of effort may be perceived.
確認您的地區或州內是否有任何類似的提案已經被考量過。聯繫目前可能有類似作業的補助獎金或合約之立法委員、地方政府機構，及相關公共與私人機構。若已存在有類似的計畫，您或許必須重新考慮是否提交擬定的專案，尤其是如果可能會被認為是重複的工作。

Enlist the support of community leaders. Once you have developed your proposal summary, look for individuals or groups representing academic, political, professional, and lay organizations that may be willing to support the proposal in writing. The type and caliber of community support is critical to your proposal's ability to survive the nitial and subsequent review phases.
取得社群領導的支持。完成計畫書摘要後，尋找會願意以書面支持計畫書的個人或團體，他們必須能夠代表學術、政治、專業和一般組織。社群支持的類型與程度對於計畫書度過初步和後續審查階段的能力非常重要。

You probably can develop the proposal without hiring a grant writer. Most fire grant programs are designed so that an astute member of any fire department can write a successful application. FEMA has a help desk staffed with competent professionals who help applicants through the process. In addition to the help desk, FEMA offers free grant-writing seminars and supports a website with helpful grant information (https://www.fema.gov/welcome-assistance-firefighters-grant-program).您或許不需要聘請補助金計畫書寫作加即可完成計畫書。多數消防補助金計畫的設計，讓任何部門的精明成員都可成功寫出申請書。FAMA 有一個服務台，其職員都是能幫助申請者走完程序的專家。除了服務台以外，FEMA 也提供免費的補助金計畫書寫作課程，並支援一個提供有用補助金資訊的網站（https://www.fema.gov/welcome-assistance-fifirefighte-grant-program）。

Evaluation of Proposed Technologies
擬定技術之評估

After collecting the description of the current

communications system, armed with a Requirements Definition and rough budget, a comprehensive evaluation of your current system and proposed technologies can be made. The Requirements Definition becomes the scorecard where the current and proposed technologies can be graded on compliance, partial compliance, or noncompliance. All components of the Requirements Definition may not be compliant in all technologies. Each department will have to evaluate each component of the Requirements Definition and derive an importance factor to determine if noncompliance or partial compliance is acceptable for its department.
收集當前通訊系統的說明書，並持有需求定義和預算概算後，即可對您當前的系統與擬定的技術進行全面性評估。可針對合規、部分合規或不合規為當前與擬定技術打分數時，需求定義會成為計分卡。需求定義的所有部分可能不符合所有技術。每一個部門都必須評估需求定義的每一個部分，並導出一個重要性要素，以決定是否期部門可接受不合規或部分合規。

Technical Options and Conceptual Design
技術選擇與概念設計

What technology is available to close the gaps between operational needs, federal, state and local mandates, and the current system? Select the best combination of technologies that close the gaps without compromising the mission. Keep in mind the safety of firefighters, mission effectiveness, and long-term sustainability when making decisions.
有哪些技術可用於縮小作業需求、聯邦、國家與地方指令，及當前系統之間的差距？在不危及任務的情況下，選擇能縮小差距的最佳技術組合。做決定時，隨時想著消防人員的安全、任務有效性，以及長期持續性。

New technologies: While you can't predict every future capability, you can read news reports and technology journals for emerging systems, pilot programs, and development projects. Look for military spinoffs that will be adapted to the fire service. This is how we got TICs for locating fire victims and missing personnel, GPS location systems, and radios that can operate using different frequency bands and protocols as needed. Radio networks will be able to support a range of new features in the coming years. Even if you don't have the funding to activate these features today, you may choose to invest in a system that will be capable of supporting them later. These may include:
新技術：雖然您無法預測每一種未來能力，您可閱讀關於新興系統、先導計畫及開發計畫的新聞報導和科技期刊。尋找可適應消防服務的軍用轉民用技術。這是我們取得 TIC 的方式，用以尋找火災遇難者與失蹤人員位置、GPS 定位系統與可依需求用不同頻帶和協定運作的無線電。無線電網路在未來數年內將能夠支援一系列新的性能。即使您現在沒有啟動這些性能的資金，您可選擇投資未來能夠支援這些性能的系統，包括：

- Voice-activated intercom systems that would allow multiple interior attack firefighters to communicate while keeping their hands free.
  語音聲控對講機系統可讓多名內部滅火消防人員進行通信，同時保持雙手空閒。
- Large, accessible buttons on turnout gear to enable immediate distress signaling.
  消防衣上容易操作的大型按鍵可允許即時求信號。
- Radio-linked PASS devices that alert a Safety Officer if a firefighter remains motionless for too long.
- 連接無線電的PASS裝置可在消防人員長時間處於靜止狀態時通知安全官。
- Encryption to maintain operational security when needed.
  加密以在需要時維持操作安全。

As an advocate for the fire service, you can use these tips to help ensure that your concerns will not be lost in the shuffle. While many of these technological improvements will prove to be beneficial to firefighters in the future, this guide is directed primarily at voice communications.
身為消防服務的提倡者，您可利用這些訣竅，幫助確保您的擔憂得到應有的重視。雖然這些技術改良於未來會被證實對消防人員有益，此指南的主要重點是語音通訊。

Should You Hire a Consultant or System Integrator?
您是否應僱用顧問或系統整合商？

Consultants can provide technical knowledge about systems — and should have up-to-date knowledge of what various manufacturers can provide to meet differing communications needs — and can provide design and procurement assistance, as well as

implementation project management. Manufacturer-neutral system integrators can provide equipment and labor to design and implement a complete system and will typically be responsible for providing the final working system.
顧問可提供關於系統的技術知識─應該了解不同製造商可針對不同通訊需求提供的服務─也可提供設計與採購協助，以及實施計畫管理。中立製造商系統整合商可提供設備與勞力以設計和實施完整的系統，一般也會負責提供最終運作系統。

Time, staffing and know-how are factors in deciding whether to hire a consultant or integrator. Do you have people with the necessary technical capabilities and an understanding of complex modern communications systems? Does your organization have time to do the job alone? Can you obtain the necessary staff internally? Do your people know how to perform the assigned tasks? If the answer is "no" to any of these questions, consider getting the assistance of a consultant or integrator.
時間、人員配備與技能是決定是否僱用顧問或整合商的要素。您的職員是否具備必要技術能力，並了解複雜的現代通訊系統？您的組織是否有時間單獨完成這項工作？您的員工是否知道如何執行指派的任務？如果任何一個問題的答案是「否」，您應考慮聘請顧問或整合商。

Even if you have some degree of technical capability in-house, use of an outside contractor brings the benefit of experience. The contractor has (or should have) more experience than you in dealing with communications challenges and providing communications project oversight. Contractors also provide an outsider's viewpoint, which can be valuable when there are conflicting requirements. Contractors can be hired to perform a single, clearly defined task or to take on a more comprehensive role in the project implementation. Often, it's wise to hire a consultant for a small-scale project and see how he or she performs before turning over largescale responsibility for a major project.
即使部門內部有某種程度的技術能力，僱用外部承包商可帶來經驗的優勢。在應付通訊問題和提供通訊專案監督的方面，承包商擁有（或者應該擁有）比你多的經驗。承包商也提供外部人士的觀點，這在有矛盾需求時會是可貴的意見。可僱用承包商執行清楚定義的單一任務，或者在專案實施中扮演更全面性的角色。針對小型專案聘請顧問，並在交付重要專案的大規模責任前觀察他或她的表現結果，往往是明智的決定。

If you decide to use a contractor, ask these questions before you hire:若您決定雇用承包商，應在聘請前問這些問題：

- Have you worked with other public safety agencies before?
  您過去是否曾與其他公共安全機構合作？

- Have you worked with fire departments before? Discuss some typical issues in fire department operational communications to see how familiar the contractor is with the issues and risks to the fire service.
  您過去是否曾與消防局合作？討論一些消防局作業通訊的典型議題，觀察承包商對這些議題和消防服務風險的了解程度。

- Have you worked with fire departments of our size?
  您過去是否曾與我們這種規格的消防局合作？

- Are you able to provide assistance to overcome budget issues, such as grant writing, understanding the bond process, and creative financing solutions?
  您是否能夠提供協助以克服預算問題，例如補助金計畫書寫作、了解保稅流程、創意融資解決方案等？

- What types of systems have resulted from your work?
  您的工作曾造就哪些種類的系統？

- What are some of your successes, what were some of your failures, and how did you overcome them?
  您的成功個案、失敗個案，以及您克服的方式？

- Who are your references, and how can we contact them?
  您的推薦人有誰，以及我們如何聯絡他們？

- Investigate relationships between the contractors and vendors.
  調查承包商與供應商之間的關係。

Where to Get Advice

可尋求建議之處

Whether or not you use a contractor, investigate these alternative sources of assistance and information:
無論您是否採用承包商，請調查以下協助預資訊的替代來源：

- Other communities: Chances are that another agency similar to you has been through this process already. Look at other departments of comparable size, contact their committee members, and arrange a meeting or conference call where you can "pick their brains."
其他社群：與您所屬部門類似的另一個機構很有可能已經跑過這此程序。查看規模可相比的其他部門，連絡他們的委員會成員，並安排讓您可向他們「討教」的會議或電話會議。

- Conferences: Attend fire and public safety conferences with an eye for communications sources. Programs, panels, vendor displays, demo projects … they're all good places to get information and hook up with others who have experience they're willing to share.
會議：參加注重通訊來源的消防與公共安全會議。課程、專題討論小組、供應商展覽、示範計畫…這些都是取得資訊和認識願意分享經驗的人的好地方。

- Vendors: Manufacturers and system integrators often can provide brochures, white papers, and similar information resources. This is another place to find information about technical issues. An established vendor understands that wellinformed customers are the best customers and that providing accurate information is one way to build a strong, lasting relationship and ensure the customer's long-term satisfaction. Be cautious of vendors who are in business solely to make money, not necessarily to meet your needs. Currently, there is a lack of real competition due to the extremely small number of companies who build these systems. You must have a strong labor/management commitment not to use a system until it is proven to be safe and cost effective and to get the best system performance from the contractor.
- 供應商：製造商與系統整合商通常可提供手冊、白皮書及類似的資訊資源。這也是另一個可找到技術議題相關資訊的地方。信譽卓著的供應商知道知情的顧客是最好的顧客，也知道提供準確資訊可建立堅固、長久的關係，並確保顧客的長期滿意度。小心那些只為了賺錢，且未不會滿足您的需求的供應商。目前缺乏真正的競爭，因為建立這些系統的公司數量太少。您必須有堅強的勞工/管理人員承諾不會使用某個系統，直到證實該系統是安全且可節省成本的，也可從承包商處得到最佳系統效能。

- Government and professional organizations: Several national organizations act as clearinghouses for information about public safety communications. Again, a word of caution: While the organizations listed below do good work in the areas of interoperability and system standardization, no other organization outside of the IAFF is focused on the special needs of firefighters involved in interior operations.
政府與專業組織：有些國家組織是情報交換所，交換關於公共安全通訊的資訊。再次提醒您：雖然以下列出的組織在互操作性與系統標準化方面的表現良好，但除了 IAFF，沒有任何組織著重於投入內部作業的消防人員之特殊需求。

  - DHS SAFECOM program: The SAFECOM program's mission is to help local, tribal, tate and federal public safety agencies improve response through more effective and efficient interoperable communications (http://www.dhs.gov/safecom).
  DHS SAFECOM 計劃：SAFECOM 計劃的使命是幫助地方、部落、國家與聯邦公共安全機構，透過更有效率、更有效力的可互操作性通訊，改善應變（http://www.dhs.gov/safecom）。

  - DHS Science and Technology Directorate, Office for Interoperability and Compatibility Office of Emergency Communications: This is an operating unit within DHS Science and Technology's First Responders Group (FRG) which provides the science and technology that enables emergency communications and facilitates the seamless exchange of information to protect property and save lives (http://www.dhs.gov/st-oic).
  DHS 科學技術局，互操作性與兼容性辦公處，緊急通訊辦公處：這是 DHA 科學技術局第一應變小組（FRG）內部的作業單位，

可提供允許緊急通訊並促進資訊無縫交換的科學與技術以保護資產和拯救性命（http://www.dhs.gov/st-oic）。

- SAFECOM provides guidance, tools, and templates on communications-related issues and supports research and testing of communications products for public safety (http://www.dhs.gov/safecom).
  SAFECOM 提供通訊相關議題的指導、工具和範本，並為公共安全支持通訊產品的研究與測試（http://www.dhs.gov/safecom）。

- APCO is a professional organization whose mission "… provides leadership; influences public safety communications decisions of government and industry; promotes professional development; and, fosters the development of technology for the benefit of the public." APCO sponsors the P25 digital radio standards process. APCO's focus is primarily on technical and operational standards relating to communications systems and communications centers (https://www.apcointl.org).
  APCO 是一個專業組織，其使命是「…提供領導；影響政府與工業的公共安全通訊決策；促進專業發展；以及為民眾利益培養技術發展」。APCO 倡議 P25 數位無線電標準程序。APCO 的重點主要在於與通訊系統及通訊中心有關的作業標準（https://www.apcointl.org）。

- The National Public Safety Telecommunications Council (NPSTC) is a federation of federal, state, and local associations and agencies. It serves as a liaison among the FCC, Congress and appointed officials involved in public safety communications. NPSTC was originally formed to implement the recommendations of the Public Safety Wireless Advisory Committee (PSWAC). NPSTC has taken on a wide range of activities related to spectrum policy coordination and the development of new technologies (www.npstc.org).
  國家公共安全電信委員會（NPSTC）是聯邦、國家與地方協會及機構的聯盟。此聯盟是 FCC、國會及參與公共安全通訊的指定官員之間的聯絡人。NPSTC 的組成起初是為了實施公共安全無線諮詢委員會（PSWAC）的建議。NPSTC 已接受進行各種與頻譜政策協調有關的活動，以及新技術的發展（www.npstc.org）。

- NFPA: The mission of the international nonprofit NFPA, established in 1896, is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. The world's leading advocate of fire prevention and an authoritative source on public safety, NFPA develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks (http://www.nfpa.org/).
  NFPA：成立於 1896 年，國際非營利組織 NFPA 的使命是，藉由提供和提倡共識法規與標準、研究、訓練及教育，減少全球火災與其他災害對生活品質的重擔。身為世界領先的消防提倡者和公共安全的權威來源，NFPA 制定、發表並宣傳超過 300 項用以減少火災與其他風險發生率和影響的共識法規與標準（http://www.nfpa.org/）。

- IAFF is the driving force behind nearly every advance in the fire and emergency services in the 21st century. With headquarters in the District of Columbia and Ottawa, Ontario, the IAFF represents more than 300,000 full-time professional firefighters and paramedics in more than 3,100 affiliates. IAFF members protect more than 85 percent of the population in communities throughout the U.S. and Canada (http://www.iaff.org/).
  IAFF 是 21 世紀幾乎所有消防與緊急服務進展背後的推動力。總部位於哥倫比亞特區和安大略省渥太華市的 IAFF，代表 3,100 個以上附屬機構的高作 300,000 全職專業消防人員與急救護理人員。IAFF 成員保護美國與加拿大超過 85%的社群人口（http://www.iaff.org/）。

- IAFC represents the leadership of firefighters and emergency responders worldwide. Their members are the world's leading experts in firefighting, EMS, terrorism response, hazardous materials spills, natural disasters, search and rescue, and public safety policy. Since 1873, the IAFC has provided a forum for fire and emergency service leaders to exchange ideas, develop professionally, and uncover

the latest products and services available to first responders (http://www.iafc.org/).

- IAFC 代表全球消防人員與緊急應變人員的領導。IAFC 成員是世界頂尖的消防、EMS、恐怖行動應變、有害物質溢出、天然災害、搜索與救援，以及公共安全政策的專家。自 1873 年起，IAFC 提供了一個論壇，讓消防與緊急服務領導可交換想法、在專業方面成長，並找出第一應變人員可使用的最新產品與服務（http://www.iafc.org/）。

- TIA is the leading trade association representing the global information and communications technology (ICT) industry through standards development, policy initiatives, business opportunities, market intelligence and networking events. With support from hundreds of members, TIA enhances the business environment for companies involved in telecom, broadband, mobile wireless, information technology, networks, cable, satellite, unified communications, emergency communications and the greening of technology. TIA is accredited by American National Standards Institute (ANSI) (http:// www.tiaonline.org/).
  TIA 是頂尖同業公會，透過標準制定、政策倡議、商機、市場情報及社交活動，代表全球資訊與通訊技術（ICT）工業。擁有著上百名成員的支持，TIA 為參與電信、寬頻、行動無線、資訊技術、網路、電纜、衛星、統一通信、緊急通訊及技術綠化的公司提升商業環境。TIA 受到美國國家標準協會（ANSI）認可（http://www.tiaonline.org/）。

- National Interagency Fire Center (NIFC): The U.S. Department of Agriculture (USDA)and the Department of the Interior provide information on the use of radios in fighting wildland fires. Much of this information also applies to communications on structural fires. The information includes portable and mobile radio testing results, including digital radios, and training on various topics (https://www.nifc.gov/ NIICD/index.html).
  國家林火協調中心（NIFC）：美國農業部（USDA）與內政部提供資訊關於無線電於野地滅火行動的使用。大部分的資訊也適用於建築火災的通訊。資訊包含可攜式與移動式無線電測試結果，包括數位無線電，以及各種主題的訓練（https://www.nifc.gov/NIICD/index.html）。

Procurement

採購

Based on the identified funding and the conceptual design, the next step is to solicit companies to construct the system. The procurement process typically will involve the development of a request for proposals (RFPs). The purchasing itself can often be assisted by using existing procurement agreements, such as state contracts or cooperative purchasing contracts. Be cautious, however, as these purchasing agreements are typically targeted at commodity purchasing and often do not take into account the complexities in purchasing widearea communications systems. This can make a seemingly simple purchase much more costly as items are purchased “a la carte.” System integration costs may dramatically increase the overall system cost. Also, a complex system procurement can include services such as system engineering services, communications building and tower construction, microwave system design and installation, and project management services that cannot be purchased as simple line items from a price sheet.
根據已確認的資金和概念設計，下一個步驟是徵求公司打造系統。採購過程通常會涉及需求建議書（RFP）的制定。往往可利用現有採購協議幫助進行購買，如國家契約或合作採購契約。然而，必須要小心，因為這些採購協議通常以商品購買為目標，而且往往不會將購買廣域通訊系統的複雜性納入考量。這會讓看似簡單的購買動作付出更多代價，因為物品是「照單」購買的。系統整合費用可能會大幅增加整體系統成本。此外，複雜系統採購可能包括無法像單系列商品一樣用價格表購買的服務，例如系統工程服務、工訊建立與塔台建造、為波系統設計與安裝、專案管理服務等。

Developing the Request for Proposals
需求建議書之制定

The more information about your community, your department, and your needs that you write into an RFP, the better. Vendors need to know about your operational needs and your current systems, so they can propose appropriate solutions. If it’s not in the RFP, you can’t expect to have it addressed properly in the proposals. Use the labor/management process to document userrequirements for operations as the foundation for all of the designs and studies that will follow. This is not about technologists and engineers telling you what technology you need. This is about you

telling local government leaders and vendors what you need to support operations in the field.
在 RFP 裡寫下愈多關於您的社群、部門與需求的資料愈好。供應商必須知道關於您的作業需求和當前的系統，他們才能夠提出適當的解決方案。若問題不在 RFP 裡，您無法期望提案中會有適當的解答。利用勞資流程記錄使用者對作業的需求，做為所有設計與後續研究的基礎。這不是關於技術人員和工程師告訴您您需要什麼技術，而是關於您告訴地方政府領導與供應商您需要什麼來支援現場作業。

It is very important to involve the agency's purchasing personnel early in the purchasing process. This helps ensure that all state and local purchasing requirements are followed and that important contract language is included in the RFP. The RFP should include a summary of all of the steps taken to get to the RFP stage, including the results of the requirements gathering and current system analysis. The more background information you can provide to potential bidders, the closer their proposals will match your needs. In addition, by removing uncertainty from the purchasing process, you reduce the bidder's risk, hopefully reducing the overall price.
於購買初期讓機構的採購人員加入是非常重要的。這有助於確保遵守所有國家與地方採購要求，以及 RFP 包含重要的契約語言。RFP 應包含一份摘要說明為達到 RFP 階段所採取的所有步驟，包括需求收集與當前系統分析的結果。您提供給潛在出價者的背景資料愈多，他們的提案就會愈接近您的需求。此外，藉由排除購買過程中不確定的事物，您可降低出價者風險，進而降低整體價錢。

The RFP development stage is a good time to have a consultant involved in reviewing the requirements and possibly assisting in the preparation of the RFP itself. Much of the RFP can be tedious to develop, and selecting a consultant who has done this work before will reduce the burden on the agency members.
RFP 制定階段是讓顧問參與需求審查和協助準備 RFP 的好時機。大部分 RFP 內容的制定是乏味的，選擇曾經做過此工作的顧問會減少機構成員的重擔。

Evaluating Request for Proposals Responses
需求建議書回覆之評估

Modern radio networks employ many different technologies. The best choice for your community usually boils down to striking the right balance between initial cost and long-term capabilities. You need a system that fits your needs and available resources today, with the potential to grow and add more capabilities tomorrow.
近代無線電網路採用許多不同技術。您社群的最佳選擇通常會歸結為達到初始成本與長期功能之間的平衡。您需要一個現在可符合您需求與可用資源，且有潛力於未來成長和增加功能的系統。

Vendors' responses to your RFP not only should detail the type of system they're proposing but also explain why they're recommending it over the alternatives. Vendors should be ready to answer any questions you have about the reasoning behind the recommended system design. Be sure vendors are recommending this design because it best meets your specific requirements.
供應商對您的 RFP 的回覆，應該不只詳細說明他們提議的系統種類，也要解釋推薦原因。供應商應該做好準備回答您任何關於系統設計背後理由的疑問。務必確認供應商會推薦此設計是因為該設計最符合您的特定需求。

Some questions to ask about the proposed system and equipment:
一些關於所提出的系統與設備之問題：

- Does the system cover your routine and automatic/mutual-aid service area?
  系統是否涵蓋您的日常與自動援助/互助服務區？

- What is the vendor's solution for fireground communications where the network doesn't provide 100 percent coverage? What will users do if they are outside the range of your network system or indoors where signals don't penetrate?
  針對網路不提供 100%覆蓋的地區，供應商的火場通訊解決方案為何？若使用者不在網路系統範圍內，或者在訊號無法穿透的室內，使用者應該怎麼做？

- Does the system have enough capacity to handle routine and abnormal incidents? What happens if the system becomes overloaded?
  系統容量是否足以處理日常與異常事故？系統過載時會如何？

- How do other public safety and nonpublic

safety users affect the fire department's use of the system?
其他公共安全與非公共安全使用者如何影兩消防局對系統的使用？

- How will the system facilitate interoperability with communications systems used by the departments with whom you have mutual-aid agreements?
系統如何促進與您簽訂互助協議的部門所使用的通訊系統之互操作性？

- How will it alert units of dispatches in fire stations and when out of the station? Can the system accommodate any paging needs?
系統如何通報位於消防局內部和外部的調度單位？系統能否適應任何呼叫需求？

- Fire-capable end-user equipment (submersible, etc.) is more costly than the radios commonly recommended for police departments; be sure the quote includes equipment for the usage environment.
防火終端使用者設備（防水等）成本高於一般為警察局推薦的無線電；務必確認報價包括使用環境的設備。

- Are the accessories you need included with each radio (battery charger, speaker microphones, etc.)?
每一台無線電是否都包含您需要的配件(電池充電器、喇叭麥克風等）？

Also, look for an understanding that deploying a new network is not just a technical challenge but also a major organizational change that requires a full support structure.
此外，供應商應了解展開新網路不只是艱鉅的技術工作，也是需要完整支援結構的重大組織改變。

The vendor's response should include:
供應商的責任應包括下列事項：

- Clear identification of how the technology will support your operations and not affect them negatively. Radio systems should be designed and implemented to support your work, not vice versa. Your existing internal procedures should not be affected negatively by the new system.
明確確認技術會如何支援您的作業，且不會對作業有負面影響。無線電系統的設計與實施應該支援您的工作，不是相反的情況。新系統應該不會對現有內部程序有負面影響。

- A phased rollout plan for gradual transition from your current system to the new one.
階段式展開計畫，讓當前系統逐漸轉換成新系統。

- An upgrade/migration plan for making further changes in the future.
升級/遷移計畫，以供未來更多改變。

- User training information before, during and after implementation. This is far more important than most people realize.
實施之前、期間和之後的使用者訓練資訊。此資訊比許多人所認為的還要重要。

- System testing and acceptance procedures.
系統測試與驗收程序。

- Scenario-based training.
情節為基的訓練。

- Life cycle maintenance, network performance monitoring, and repair procedures.
生命週期維護、網路效能監管即修理程序。

- Software upgrades for radios and the system infrastructure. To evaluate the solution proposed by each vendor, you'll need to understand the relative advantages of the technological choices each are recommending. The next chapter will help.
無線電與系統基礎建設的軟體升級。為了評估各廠商提出的解決方案，您必須了解技術選擇的相關優點。下一章的內容會有幫助。

Implementation
實施

Involve the right people throughout the implementation process. Thoroughly test the system as it is built to ensure that it is meeting needs and expectations.
在整個實施過程當中讓對的人加入。徹底測試原始系統以確認符合需求與期望。

Successful implementation/integration requires

careful attention from the beginning to design compatible links and then test, test and test again. The vendor's engineers must have a detailed plan that identifies all of the systems to be integrated and defines which capabilities will be made to work together and when. The plan also should include schedules and priorities and whether the new network will be made operational before all of the integration is completed.
成功的實施/整合需要從一開始就投入關注，以設計相容環節，接著就是不斷地重複進行測試。供應商的工程師必須有詳細計畫可確認所有欲整合的系統，以及定義要讓哪些功能合作和時間點。該計畫也應該包含時間表與優先事項，以及新系統是否能在完成所有整合之前進行運作。

Encourage everyone to ask questions and make comments. You will want to handle concerns and objections early, before they have the chance to evolve into rumors and long-standing gripes.
鼓勵所有人提出問題和意見。在擔憂和反對事項演變成謠言與長時期的不滿之前，您會想要盡早處理這些問題。

Before the contract is signed, ask the vendor or consultant to explain the following and begin to share that information with the rest of your department:
簽訂契約前，要求供應商或顧問姐是下列事項，並開始與您的部門分享該資訊：

- What operational differences will our users notice between our current system and the new one? How will their procedures change? What new features will be available? Which, if any, of the old features will change or become unavailable?
  我們的使用者會注意到哪些當前系統與新系統之間的差異？他們的程序會如何改變？有什麼新功能？若有的話，哪些舊功能會改變或無法使用？

- What's different for the dispatchers? For field supervisors? For personnel back at the station? For personnel using the in-vehicle radios? For administrators and network managers?
  對調度人員而言，會有甚麼差別？現場監督人員？消防局的工作人員？使用車載無線電的工作人員？管理人員與網路管理員？

- Will users still be able to use their old equipment, or will they be required to learn new equipment?
  使用者是否能夠繼續他們的舊設備，還是他們必須學習新設備？

- What successes and pitfalls have been experienced by other fire departments implementing this type of system? What have you learned from previous deployments?
  實施這種系統的其他消防局曾經經歷什麼成就和困難？您從過去的展開學習到什麼？

Training and Transition
訓練與轉變

Ensure that all firefighters and command staff members train with the system often prior to fina l switch over. Inadequate training is an especially critical problem and could endanger the lives of firefighters and the citizens they protect.
確保消防人員與指揮人員於最終轉換前經接受系統相關訓練。訓練不足是特別嚴重的問題，可能會危及消防人員與他們保護的民眾之性命。

Training is far more than simply knowing how to turn on the radio and which buttons to press. Training must not become a one-time experience. Firefighters need initial exposure, formal training, and opportunities to incorporate radio usage into other training and simulation exercises. The integration plan also may cover interoperability with systems in other departments or jurisdictions. Interoperable communications must be tested with the joint cooperation of these other agencies and, perhaps, their system vendors as well. Training can be broken down into phases, as described below, that lead from general information on the system to specific operational aspects of the system, and finally to periodic refresher training.
訓練不只是知道如何啟動無線電和要按哪些按鍵。訓練不得成為一次性經驗。消防人員需要初次體驗、正式訓練，以及結合無線電使用與其他訓練和模擬練習的機會。整合計畫也可包含與其他部門或管轄區內的系統之互操作性。在這些機構與其供應商的合作之下，必須測試可互操作通訊。訓練可分成不同階段，如下文所述，從系統的一般資訊，到系統的特定作業部分，最後到定期回訓。

- Awareness: This phase provides general

information. A series of videos, using a live representative, explains what's different about the new system and expectations for the new equipment. The goal is to create interest, not to provide detailed information, and hopefully begin to create champions within your system.
意識：此階段提供一般資訊。一系列影片利用現場代表說明新系統的差別和對新設備的期望。目的是引起興趣，而不是提供詳細資料，以及開始在您的系統內製造優勝者。

- Education: Additional videos are distributed to provide more detailed information on topics such as how to use your radio and what the direct operational implications are of the new system or subscriber equipment. The videos may be broadcast over the department's video network or local cable public safety access channel and also can be available in the station for firefighters to view at will. Lesson plans
should be available on the department's website.
教育：散佈其他影片以提供更多詳細資料關於如何使用無線電、新系統或用戶設備的直接作業影響為何等主題。可透過部門的視頻網路或地方有線電視公共安全存取通道廣播影片，也可在消防局提供影片讓消防人員可隨意觀賞。部門網站應提供課程計畫。

- Training: Six months to one year before the system's operational deployment, use of the new radios is integrated into fireground training scenarios and in-building tactical preplan surveys. Training is structured in a three-month cycle. The first month, trainees focus on how to use the radio. In the second month, there's a walk-through. In the third month, the radios are part of a live drill, complete with smoke, while trainees wear full turnouts. After this three-month cycle is completed, a new lesson plan is used in the next quarter, and the cycle continues until the entire set of training classes has been completed.
訓練：於系統作業部署前，訓練 6-12 個月，新系統的使用融入火場訓練情境與建築內戰術重新規劃調查。訓練結構是三個月週期。第一個月，受訓者專注於如何使用無線電。第二個月，提供逐步教學。第三個月，無線電是實際演練的一部分，受訓者穿著整套消防衣並處於佈滿煙霧的環境。完成三個月週期後，下一季會採用新的課程計畫，循環會持續直到完成整套訓練課程。

- Transition: By the time the network is operational and transition begins, users will have had six months to one year of hands-on training. Two-thirds of the total training time is handson. Mobile radio training takes place at the time of installation of the equipment in the truck.
轉變：網路運作且轉變開始的時候，使用者以接受了 6-12 個月的實習訓練。總訓練時間的三分之二都是實習訓練。移動式無線電訓練會在設備安裝於消防車時進行。

- Refreshers: Quarterly refresher training (with an emphasis on lessons learned) and just-intime updates should continue to be given, as well as an annual refresher on fireground communications.
回訓：應持續提供季度回訓（強調已學會的課程）與即時更新，以及火場通訊的年度回訓。

Beyond this training program, which was designed to support the rollout of the new radios, there are implications for other training organizations and curricula.
除了這個專為支援新無線電首次展示而設計的訓練計畫以外，其他訓練組織與課程有其含意。

Communications training must be integrated into all phases of recruit training and company training programs:
通訊訓練必須融入新進人員訓練與消防隊訓練計畫的所有階段：

- Recruit training should incorporate radios from the beginning. In the past, radios were not used during recruit training, and a rookie's first day on the job was the first day he or she was given a radio.
新進人員訓練應從一開始就納入無線電。新人訓練過去未使用無線電，新人到職的第一天就是他或她拿到無線電的第一天。

- The engineer's academy, captain's academy, and command officer's academy, as well as special team training, should integrate radio communication throughout the curriculum.
工程師學會、隊長學會、指揮官學會及特殊小組訓練應將無線電通訊融入整個課程。

Implementation Lessons Learned and Feedback
實施心得與回饋

During the first few months after the initial cutover to a new system, collect and analyze information regularly on the operation of the system. Share this information among all members of the implementation team and, if issues are found that affect operations, share that with the field users.
在初期轉換到新系統後的數個月內，定期收集並分析關於系統運作的資料。與實施團隊的所有成員分享這些資料，若發現影響作業的問題，與現場使用者分享資料。

All members must be involved in providing feedback on system issues and must be kept involved with the solutions. Get buy-in from the system operator and technical staff to take field user input seriously. Encourage all members to report perceived deficiencies in the system, and follow up with the users with updates on their reports. If it appears to the users that their feedback is not acted on, they will stop providing that feedback. It is important to ensure that management is honest with users about the operation and safety of the system. If something isn't working properly, disclose it, and find a workaround until the solution is found and in place.
所有成員必須參與系統問題回饋的提供，且必須持續投入解決方案。令系統操作人員與技術人員同意認真看待現場使用者的意見。鼓勵所有成員通報他們察覺到的系統缺點，並與使用者追蹤其報告的最新消息。若使用者認為部門未針對他們的回饋採取行動，他們會停止提供回饋。必須確保管理階層誠實告知使用者關於系統的運作與安全事宜。若有運作不正常的部分，坦白揭露，並找出能避開問題的方法，直到找到並實行解決方案。

Long-Term Operationand Maintenance
長期運作與維修

Ensure that adequate funding is allocated to the operation and maintenance of the system. Just like fire apparatus, the system must be maintained, and equipment must be replaced as it becomes unable to serve the agency's needs. Continuously solicit feedback to keep on top of any problems that come up with the system over time. Throughout the life of the new network, fire service representatives will need a way to handle such ongoing responsibilities as: 確保系統運作與維修分配到足夠的資金。如同消防設備，必須進行系統維護，並在設備變得無法滿足機構需求時進行更換。持續徵求回饋以控制隨著時間出現的任何系統問題。於新網路的整個壽命期限內，消防服務代表會需要能處理下列持續性責任的方法：

- Answering users' questions and helping them solve problems.
  回答使用者的疑問，並幫助他們解決問題。

- Operating and maintaining modern radio systems is expensive. Long-term planning is required to maintain software and hardware that is required to keep systems operating at peak levels. This is especially true of trunked radio systems that require frequent software updates/upgrades, and these eventually lead to required hardware changes. If a decision is made to fall behind and not maintain current software or hardware, the system is at risk of becoming nonsupported.
  當代無線電系統的營運與維護相當昂貴。需要長期計畫以維持讓系統持續以尖峰水準運作的軟體與硬體。需要頻繁軟體更新/升級的集群式無線電系統更是如此，而這最後會形成必須更換硬體的情形。若決定要落後，並不維護當前的軟體或硬體，系統即暴露於無支援的風險。

- Incorporating radio usage into new training programs and exercises, and presenting refresher courses.
  將無線電使用納入新的訓練計畫與練習，以及提出回訓課程。

- Monitoring the performance of the system and collecting reports of problems, such as buildings that lack coverage or situations in which there were not enough channels or talkgroups available.
  監控系統效能以及收集問題報告，例如缺乏覆蓋的建築或者可用通道或通話群組不足的情況。

- Implementing network interoperability links to support new mutual-aid agreements with

other communities.
實施網路互操作性環節以支持與其他社群的互助協議。

Summary — System Design and Implementation
摘要—系統設計與實施

Developing and implementing a new communications system can be a complex and expensive project. In the case of a large system, it may be the most expensive and most complex project a department has ever undertaken. These facts make it critical that the project is managed adequately.
新通訊系統的開發與實施可能會是複雜且昂貴的專案。就大型系統而言，這可能會是一個部門有史以來最昂貴、最複雜的專案。這些事實使得專案的適當管理極為重要。

- Establish a project team that includes fire department management and labor representation early in the project lifetime.
  於專案早期，成立包含消防局管理階層勞工代表的專案小組。

- Involve all stakeholders and ensure that they continue to participate in the implementation process.
  讓所有利害關係人加入，並確保他們持續參與實施過程。

- Gather information on the communications needs of field personnel and compare this to the radio systems they use. This comparison will result in a gap analysis that shows the deficiencies in the current system. The current system description along with the gap analysis can be used to produce a specification for the new radio system.
  收集關於現場人員通訊需求的資料，並比較這些資料與他們所使用的無線電系統。此比較會產生差距分析，顯示當前系統的缺點。可利用當前系統描述與差距分析，制定新無線電系統的規格。

After the specification is established, a budget can be developed using the requirements and cost estimates developed from similar systems or through talks with potential vendors. Be cautious in reducing the system functionality if the cost is determined to be too large. Removing coverage or features from the system to reduce cost could affect the usability or safety of the entire system.
制定規格之後，可利用從類似系統或透過與潛在供應商談話所得到的成本概算產生預算。若認為成本太高，務必小心減少系統功能。為了降低成本而移除系統的覆蓋或性能，可能會影響整個系統的可用性或安全。

Once the implementation of the system has begun, familiarization and training should start as well.Early, simple training will provide end users with information on the system in a more controlled manner. If users don't get the information they are seeking, they will find it through another path or will develop their own.
一旦系統實施開始，應該同時開始熟悉化與訓練。早期的簡易訓練會以較受控的方式提供系統相關資訊給終端使用者。若使用者沒有得到他們尋求的資訊，他們會透過其他途徑取得或者自行建立資訊。

After the new system has been placed into operation, it is critical to follow up with end users on the operation of the system. Over time, users will find design, implementation and performance issues with the system that were not discovered prior to cutover, or that occurred after cutover. Timely resolution of these issues will ensure that your successful project remains successful in the eyes of its users.
新系統開始實行後，必須追蹤終端使用者關於系統的運作。隨著時間的流逝，使用者會發現轉換前未發現或者轉換後發生的系統設計、實施及效能問題。這些問題的及時解決方案會確保您成功的專案在使用者眼中持續成功。

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Section 8–
第 8 節–

Interoperability
互操作性

This definition of interoperability is taken from the DHS SAFECOM project:
以下互操作性的定義擷取自 DHS SAFECOM 專案：

> "The ability of Public Safety responders to share information via voice and data communications systems on demand, in real time, when needed, and as authorized."「公共安全應變人員透過語音與數據通訊系統於收到請求時、即時、必要時及獲得授權時，分享資訊的能力。」

In general, interoperability refers to the ability of emergency responders to work seamlessly with other disciplines, jurisdictions, systems or products without any special effort. Wireless communications interoperability specifically refers to the ability of emergency response officials "to share information via voice and data signals on demand, in real time, when needed, and as authorized" (DHS SAFECOM).一般而言，互操作性指的是緊急應變人員不需要額外努力即可與其他紀律、管轄區、系統或產品進行無縫合作的能力。無線通訊互操作性特別指的是緊急應變官員「透過語音與數據訊號於收到請求時、即時、必要時及獲得授權時，分享資訊」的能力（DHS SAFECOM）。

Frequency Coordination
頻率協調

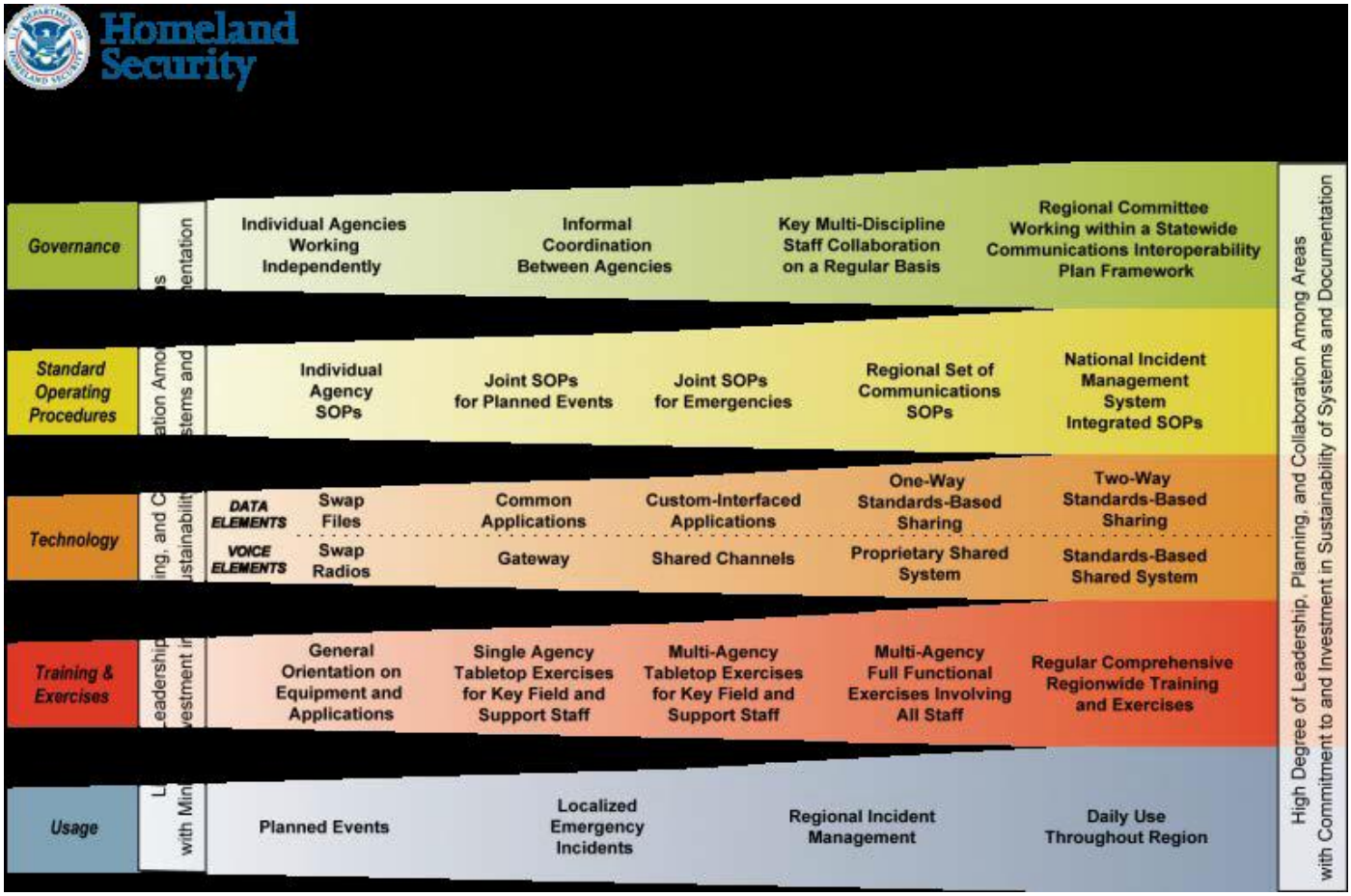
Identifying interoperability frequencies often required research by frequency coordinating bodies or individual frequency coordinators from a jurisdiction. This task was often too difficult for a single fire department to tackle. The DHS published the National Interoperability Field Operations Guide36 (NIFOG) in 2007. This guide is a comprehensive listing of interoperability frequencies in all frequency bands and identifies both federal and nonfederal frequency listings. It is a common practice and advisable to include these frequencies in standard radio programming templates. This allows interoperability between disciplines, jurisdictions, and multiple levels of government — federal, state, county and local.互操作性頻率的確認通常需要經過管轄區內頻率協調單位或個別頻率協調人員的研究。這往往是單一消防局無法勝任的艱難任務。DHS 於 2007 年發表了國家互操作性現場作業指南[36]（NIFOG）。此指南列出所有頻帶的互操作性頻率，並確認聯邦與非聯邦的登記頻率。這是常見的實務，建議將這些頻率納入標準無線電編程範本。這會允許領域、管轄機構與多種政府層級單位─聯邦、州、縣郡及地方─之間的互操性。

Interoperability Continuum
互操作性連續理論

DHS, in collaboration with public safety agencies, developed the Interoperability Continuum to provide a roadmap to achieve interoperability (Figure 8.1). The continuum is a visual depiction of the multidimensional elements of interoperability.
DHS 與公共安全機構合作開發互操作性連續理論，以提供達到互操作性的準則（**圖 8.1**）。此連續理論是互操作性多元要素的視覺描繪。

36 http://www.dhs.gov/national-interoperability-field-operations-guide.

Figure 8.1. Interoperability Continuum
圖 8.1. 互操作性連續理論



Each lane in the continuum represents one element needed to attain some level of interoperability. Ideally, the right side of the chart is the highest level of interoperability. When looking at the chart, an organization may have some elements of the continuum on the right with others in the middle or to the left. While ideally the goal is to have all elements on the right side, the reality is the capability in each lane may vary, but the goal is to deliver interoperability as defined by the Office of Emergency Communications (OEC)/SAFECOM.
連續理論的每一列都代表一個達到某程度互操作性所需的要素。觀念上，圖表的右側是最高等級的互操作性。看著圖表時，一個組織可能有一些右側的連續理論要素，而其他要素則位於中間或左邊。雖然理想的目標是具有所有右側的要素，實際上是各列的能力可能會不同，但目標是提供緊急通訊辦公處（OEC）/SAFECOM 所定義的互操作性。

An example of this would be use of "shared channels" for a planned event, elements of each lane provides a component of the interoperability.
一個範例是已規劃活動「**共享通道**」的使用，各列要素提供一個互操作性的部分。

- Governance — regional committee working within a statewide communications interoperability framework. The state has a plan for use of shared channels. This could be use of nationally recognized interoperability channels in the NIFOG.
  管理─區域委員會於州際通訊互操作性架構中工作。州有共享通道的使用計畫，這可能視 NIFOG 國家公認互操作性通道的使用。
- Standard operating procedures (SOPs) — agencies have joint SOPs for planned events to use the interoperability frequencies.
  標準作業程序（SOP）─機構有已規劃活動使用互操作性頻率的聯合 SOP。
- Technology — shared channels from the NIFOG.
  技術─源自 NIFOG 的共享通道。
- Training and exercises — multiagency tabletop prior to a planned event.
  訓練與練習─進行已規劃活動前的多機構桌上演習。
- Planned event.

已規劃活動。

Day to Day
日常

Most interoperability efforts are driven by the need to meet day-to-day operational requirements (Figure 8.2). In many large urban areas, the responsible fire department may not require dayto- day interoperability, while some departments interoperate on a daily basis. Since Sept. 11, 2001, there has been significant attention toward efforts to expand interoperability past the dayto-day needs of a public safety agency to address extraordinary events and incidents. Interoperability is required and necessary in today's world. Where and how it happens is based on a logical analysis of operational practices and requirements.

大部分互操作性的努力是由日常作業要求的需求所驅動（**圖 8.2**）。在許多大市區，消防局的責任可能不需要日常互操作性，而一些部門則每天進行互操作。自 2001 年 9 月 11 日起，為了解決異常事件與事故，對日常需求以外的互操作性擴展之努力獲得大量關注。在今日的世界，互操作性是被需要且必要的，其發生地點和方式是基於作業實務與要求的邏輯分析。

圖8.2. 機動車輛事故應變

（圖片來源：**Mike Wiederm3Ron Jeffers**，紐澤西州聯合市）

Many fire departments have interoperability with other fire departments. Interoperability between agencies in the same discipline is intradiscipline interoperability. Interdiscipline interoperability is between different disciplines. Intradiscipline interoperability is the easiest to achieve, since there is a common language, terminology and tactical objectives. Interdiscipline interoperability may not share common terminology or have the same tactical objectives. These factors should be considered in determining where interoperability occurs in the command structure. A prime example is when law enforcement responds to a house fire for traffic control. Each discipline has very different tactical objectives. As the fire responders fight the fire using the "common language" of the fire service, this terminology may not be understood by the law enforcement component. In addition, understanding when to talk and when not to talk becomes a safety issue. In these situations, interoperability may be face-to-face coordination with the command element or coordination at the dispatch center level. In the example below, both disciplines respond to a motor vehicle crash — fire/EMS for medical care and law enforcement for traffic investigation and traffic control.

許多消防局與其他消防局有互操作性。相同業界機構之間的互操作性是領域內互操作性。跨領域

互操作性是不同業界之間的互操作性。領域內互操作性是最容易達成的，因為有共同語言、術語及戰術目標的存在。跨領域互操作性能沒有分享共同語言或者擁有相同戰術目標。決定互操作性發生於指揮結構的位置時，應將這些要素納入考量。一個主要例子是執法人員於房屋失火時進行交通控制的應變動作。各業界都有非常不同的戰術目標。例如，於滅火行動使用消防服務「共同語言」的消防應變人員，執法單位或許不會明白這術語。此外，知道在何時說話和不說話會成為一個安全問題。在這些情況下，互操作性可能視與指揮要素的面對面協調，或者是調度中心層級的協調。在以下的例子中，兩個領域都對機動車輛事故採取應變─消防/EMS 人員進行醫療，執法人員進行交通調查和控制。

The respective dispatch centers send the appropriate response for each discipline on separate radio channels and maybe even on different systems. Each responds, and when on-scene, they coordinate at the task level face to face. If a shared dispatch center and radio system were used, both units could be assigned on a common channel. SAFECOM would consider this a high level of interoperability.
各調度中心利用不同無線電通道，甚至不同系統，向各領域發出適當應變行動。針對各應變行動和在現場時，他們會面對面以任務層級進行協調。若使用共享調度中心與無線電系統，兩個單位有可能會被分配到共同通道。SAFECOM 會認為這是高度互操作性。

Large Incidents
大型事故

As incidents grow, interoperability should be planned for in the Command structure. When developing interoperable Command structures, many interoperability tools may be employed. Technical staff plays a pivotal role in providing these technology tools to meet the operational requirements. The technical staff must be familiar with the operational objectives and Command structure to supply the appropriate technological tools. NFPA 1221 recommends the use of a Communications Officer at all major incidents and a Communications Unit Leader (COML) is part of the National Incident Management System Incident Command System (NIMS-ICS) Command structure. The technical staff should receive the appropriate training to fulfill these roles successfully. COMLs in the NIMS-ICS Command structure provide a central point of contact to develop a communications plan to meet the interoperability needs on a large incident and manage the Communications Unit to meet the communications needs on an incident.
由於事故會增長，應為指揮結構規劃互操作性。有許多互操作性工具可用於建立互操作性指揮結構。技術人員扮演著關鍵角色，他們提供這些技術工具以滿足作業需求。技術人員必須熟悉作業目標與指揮結構以提供適當的技術工具。NFPA 1221 建議於所有重大事故利用通訊官，通訊單位領導（COML）是國家事故管理系統事故現場指揮體系（NIMS-ICS）指揮結構的一部分。技術人員應接受適當訓練以順利扮演這些角色。NIMS-ICS 指揮結構的 COML 提供一個中心聯絡點，以制訂滿足大型事故互操作性需求的通訊計畫，並為事故的通訊需求管理通訊單位。

Communications Unit
通訊單位

The use of a Communications Unit has proven to improve interoperability on incidents. The individuals that fill these roles understand the technology and have a good understanding of operational requirements. The Communications Unit is tasked with supporting all communications needs on the incident. These requirements may be to provide operability in difficult situations where there are limited communications resources or in some instances no communications infrastructure. The Communications Unit consists of:
已證實使用通訊單位可改善事故現場互操作性。扮演這些角色的人都了解該技術，並知道作業需求。通訊單位的任務是支援事故現場的所有通訊需求。這些需求可能包括，在通訊資源有限或無通訊基礎建設等困難情況下，提供互操作性。通訊單位的組成包括：

- COML: This position is tasked with the management of communications on the incident. Responsibilities include:
  COML：此職位的任務是管理事故現場的通訊。責任包括：
  - Operational communications.
    作業通訊。
  - Interoperability.
    互操作性。
  - Allocation of communication resources.
    通訊資源分配。

- Developing prioritization of the communications unit.
  通訊單位優先性的制定。
- Management of the communications unit.
  通訊單位管理。
- Knowledge of local interoperability plans, area and systems is helpful.
  對地方互操作性計畫、區域及系統的了解是有益的。

- Communications Technician (COMT): This position is the technical person assigned to implement technologies as directed by the COML. Knowledge of the following is necessary:
  通訊技術員（COMT）：此職位是被指派依照 COML 指示實施技術的技術人員。必須具備以下相關知識：
  - Radio systems.
    無線電系統。
  - Gateways.
    閘道器。
  - Portable radios.
    可攜式無線電。
  - Telephone.
    電話。
  - Data systems.
    資料系統。
  - Knowledge of local area, systems is helpful.
    對地方區域與系統的了解是有益的。

- Incident Communications Manager (INCM): This position manages Radio Operators (RADOs) and communications center functions on incident if required.
  事故現場通訊主管（INCM）：此職位負責管理無線電操作員（RADO），並於需要時管理事故現場通訊中心工作。
  - Management of the communications center.
    通訊中心管理。
    - Staffing of RADOs to cover operation periods.
      作業期間 RADO 人員配備。
    - Monitoring of radio channels as required by the IC or Operations Chief.
      依 IC 或作業主管要求，監管無線電通道。
    - Recording and routing of messages.
      信息記錄與路由。

- RADO: This position is responsible for communicating on assigned radio channels.
  RADO：此職位負責在指定無線電通道進行通信。
  - Documenting notable events or radio traffic.
    記錄值得注意的事件或無線電流量。

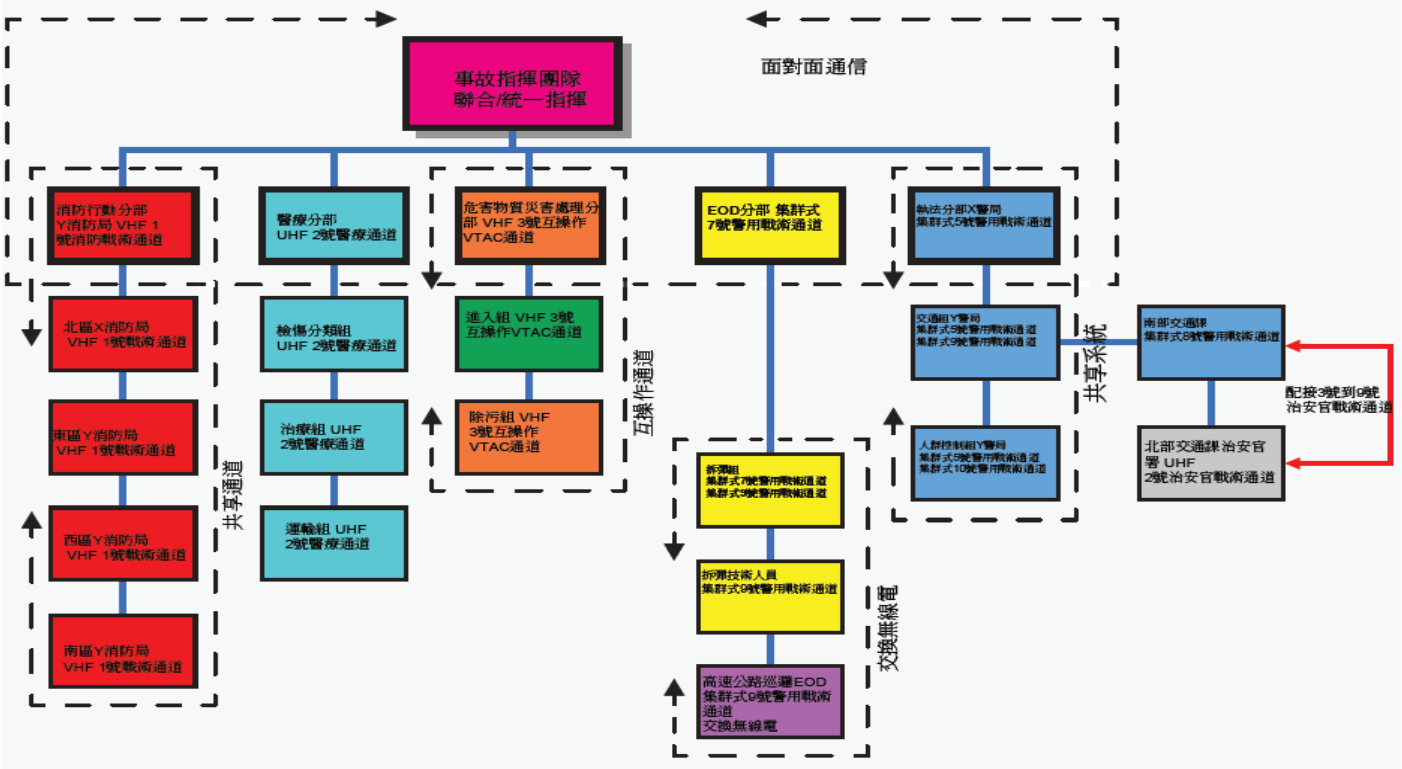
Jurisdictions need to understand the capabilities and resources the Communications Unit provides and develop a deployment plan for incidents or events where a COML would provide benefit. It is important to note that day to day our dispatch centers provide this function. The centers allocate and coordinate frequencies/talkgroups and provide communications resources as needed by operations. The Communications Unit's role is to allow the dispatch centers to maintain normal operations. A Communications Unit may be implemented on large incidents that last many operational periods or special events that require complicated interoperability plans. A good example of this might be the Super Bowl, the presidential Inauguration Day, or other large special events. It is not always necessary to deploy a Communications Unit. Some events may only require a COML to develop the radio plan. The important takeaway is knowing where this capability is in your area. The state and federal governments have spent a substantial amount of money to train personnel as COML or COMT. Most states have a Statewide Interoperability Coordinator (SWIC). The SWIC in your state can assist you in identifying the COML or COMT personnel in your state.
管轄機關必須了解通訊單位提供的功能與資源並針對 COML 會提供利益的事故或事件，制定部署計畫。必須注意的是，我們的調度中心每天都提供此功能。中心分配和協調頻率/通話群組，並依作業需求提供通訊資源。通訊單位的角色是讓調度中心得以維持正常作業。於橫跨許多作業期的大型事故或需要複雜互操作性計畫的特殊事件，都可實施通訊單位，例如超級盃、總統就職日或者其他大型特殊活動。並非所有事件都必須部署通訊單位。有些事件可能只需要 COML 即可制定無線電計畫。重點在於知道此功能於您所在地區的位置。州與聯邦政府花費大量金錢訓練訓練人員成為 COML 或 COMT。許多州擁有州際互操作性協調員（SWIC）。您所屬州的 SWIC 可協助您找到州內的 COML 或 COMT 人員。

The example below is a large Command structure where multiple technologies are employed to

achieve the appropriate level of interoperability for the incident (Figure 8.3). When interoperating, determining the number of channels needed to support the incident must be a consideration. It is always important to account for the amount of radio traffic on a channel and to reserve some airtime for unforeseen needs such as a mayday. Complex operations that are communications intensive should have their own channel to ensure that there is adequate on-air time and reserve capacity for unforeseen events. Shared or patched channels can be used when there are common tactical objectives. Before patching channels or using gateways that essentially tie channels together, the amount on each of the channels must be considered. If both of the channels are near saturation, the patch or gateway will make communications nearly impossible. Below is an example of a large-scale multidiscipline Command structure where multiple technologies are used to achieve interoperability.

下方是大型指揮結構的例子，其中部署了多項技術以達到事故現場適當的互操作性等級（**8.3**）。進行互操作時，必須考慮支援事故所需通道數量的確認。必須知道通道的無線電流量數，並保留一些通話時間以供 mayday 呼叫等意外需求。通訊密集的複雜作業應有專屬的通道，以確保有足夠的傳輸時間，並且應為意外事件保留容量。有共同戰術目標時，可利用共享或配接的通道。在配接通道或使用將通道綁在一起的閘道器之前，必須考量通道的各別數量。若兩個通道都接近飽和，配接或閘道器會令通訊幾乎無法實現。下方的例子是採用多項技術以達到互操作性的大型多領域指揮結構。

圖8.3. 事故通訊



Many technologies are available to achieve interoperability, and often the simplest solutions are overlooked in favor of complex technological solutions. The simple solutions usually are the quickest to implement and easiest to understand. In some instances, face-to-face communications may provide the desired level of interoperability, while in other cases other methods may be necessary. In Figure 8.3, a joint Command structure in a common location allowed the use of face-toface communications for coordination. When a common Command location is not employed, a strategic-level Command channel is an option.

有許多技術可用於達到互操作性，最簡單的答案經常被忽略，而複雜的技術性解決方案則被選中。簡單的解決方案通常是可最快實施並最容易了解的。在某些情況中，面對面溝通可提供希望的互操作性水平，而其他情況則需要其他方法。**圖 8.3** 中，在共同地點的聯合指揮結構允許可透過面對面溝通進行協調。若沒有一個共同指揮地點，可選擇策略級指揮通道。

Many technologies are used to achieve interoperability, and many other factors have an impact on interoperability. SAFECOM is a program within the U.S. DHS that is tasked with achieving communications interoperability for local, tribal,

state and federal emergency response agencies. SAFECOM has many documents available that will guide and assist in achieving interoperability. SAFECOM documentation is available at http://www.dhs.gov/safecom.
互操作性的達成利用許多技術，而許多其他因素會影響互操作性。SAFECOM 是美國 DHS 的計畫，其任務是達到地方、部落、國家與聯邦緊急應變機構的通訊互操作性。SAFECOM 有許多文件可指導並協助互操作性的達成。欲取得 SAFECOM 文件，請到 http://www.dhs.gov/safecom.。

Summary—Interoperability
摘要─互操作性

> DHS SAFECOM definition: "The ability of Public Safety responders to share information via voice and data communications systems on demand, in real time, when needed, and as authorized."
> DHS SAFECOM 定義:「公共安全應變人員透過語音與數據通訊系統於收到請求時、即時、必要時及獲得授權時，分享資訊的能力」。

Interoperability refers to the ability of emergency responders to work seamlessly with other disciplines, jurisdictions, systems or products without any special effort.
互操作性指的是緊急應變人員不需要額外努力即可與其他領域、管轄機構、系統或產品進行無縫合作的能力。

The NIFOG37 is a comprehensive listing of interoperability frequencies. The guide lists frequencies for federal and nonfederal interoperability in all bands. It is a common practice and advisable to include these frequencies in standard radio programming templates. This allows interoperability between disciplines, jurisdictions and multiple levels of government — federal, state, county and local.
NIFOG[37]是互操作性頻率的綜合清單。此指南列出所有頻帶的聯邦與非聯邦互操作性頻率。這是常見的實務，建議將這些頻率納入標準無線電編程範本。這會允許領域、管轄機構與多種政府層級單位─聯邦、州、縣郡及地方─之間的互操作性。

The Interoperability Continuum is a tool developed to respond to an event and address all elements needed to achieve optimal interoperability. Interoperability can be intradiscipline or interdiscipline:
互操作性連續理論是為了對事件採取應變行動和針對最佳互操作性達成所需的所有要素所開發的工具。互操作性可分為領域內或跨領域：

Intradiscipline:
領域內：

- Like disciplines such as fire department to fire department or law enforcement to law enforcement.
  相似領域，如消防局對消防局或者執法單位對執法單位。
- Common tactical objectives.
  共同戰術目標。
- Common language and terminology.
  共同語言與術語。
- Easiest to achieve.
  最容易達成。

Interdiscipline:
跨領域：

- Different disciplines such as fire department to law enforcement.
  不同領域，如消防局對執法單位。
- Different tactical objectives and priorities.
  不同戰術目標與優先事項。
- Differen tterminology.
  不同術語。

Communications Unit
通訊單位

The use of a Communications Unit has proved to improve interoperability on incidents. The Communications Unit consists of:
已證實通訊單位可改善事故現場的互操作性。通訊單位包括：

- COML: This position is tasked with the management of communications on the incident.
  COML：此職位的任務是管理事故現場的通訊。
- COMT: This position is the technical person assigned to implement technologies.

37 http://www.dhs.gov/national-interoperability-field-operations-guide.

COMT：此職位是被指派實施技術的技術人員。

- INCM: This position manages the communications center functions.
  INCM：此職位管理通訊中心工作。
- RADO: Communicates on assigned radio channels.
  RADO：利用指定的無線電通道進行通信。

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Section 9–
第 9 節–
Radio Spectrum Licensing and the Federal Communications Commission
無線電頻譜核照與聯邦通訊委員會

The FCC is an independent agency of the U.S. government established by the Communications Act of 1934. It is made up of seven bureaus, organized by function, that are responsible for various communications areas. The bureau that is most involved in public safety issues is the Public Safety and Homeland Security Bureau (PSHSB), which: FCC 是由 1934 年通信法案成立的獨立美國政府機構。FCC 的組成包含依功能組織的七個局，負責各種通訊領域。最投入公共安全議題的是公共與國土安全局（PSHSB）：

> … is responsible for developing, recommending, and administering the agency's policies pertaining to public safety communications issues. These policies include 911 and E911; operability and interoperability of public safety communications; communications infrastructure protection and disaster response; and network security and reliability. The Bureau also serves as a clearinghouse for public safety communications information and takes the lead on emergency response issues.
> …負責制定、建議與管理機構關於公共安全通訊議題的政策。這些政策可包括 911 與 E911；公共安全通訊操作性與互操作性；通訊基礎建設防護與災害應變；以及網路安全與可靠性。公共與國土安全局也做為公共安全通訊情報的交換所，引領緊急應變議題。

As this description implies, the PSHSB is responsible for rulemaking, licensing, education and outreach to public safety agencies. Portions of the activities of the PSHSB were previously carried out by the Wireless Telecommunications Bureau, particularly the rulemaking and licensing functions. The outreach and coordination functions were added to create a single bureau to handle all public safety issues.
如此描述所言，PSHSB 負責規則制定、核照、教育，及對公共安全機構推廣。部分 PSHSB 的活動之前是由無線電信局執行，尤其是規則制定和核照工作。增加推廣與協調工作以創造負責處理所有公共安全議題的單一局。

The rules established by the FCC are located in CFR Title 47. The section of these regulations that applies directly to LMR systems used by public safety entities is located in Part 90 of 47 CFR. The Part 90 rules govern the operation of radio systems, as well as the frequencies available for use, what types of agencies are eligible to use the frequencies, and the procedures for licensing these frequencies.
FCC 制定的規則記錄於 CFR 第 47 篇。這些規則當中，直接適用於公共安全項目使用的 LMR 之部分，記錄於 CFR 第 47 篇第 90 部分。第 90 部分的規則管理無線電系統運作，也管理可用頻率、有資格使用頻率的機構種類，以及這些頻率的核照程序。

While the FCC provides licensing and spectrum management for nonfederal users, the NTIA is the federal coordinating body. "Many Federal agencies use radio frequency spectrum to perform vital operations. NTIA manages the federal government's use of spectrum, ensuring that America's domestic and international spectrum needs are met while making efficient use of this limited resource."[38] "NTIA is also collaborating with the Federal Communications Commission to make available a total of 500 megahertz of federal and nonfederal spectrum over the next 10 years for mobile and fixed wireless broadband use. This initiative, to nearly double the amount of commercial spectrum, will spur investment, economic growth, and job creation while supporting the growing demand by consumers and businesses for wireless broadband services."[39]
FCC 為非聯邦使用者提供核照與頻譜管理，而 NTIA 是聯邦協調機構。「許多聯邦機構利用無線電頻率頻譜執行重要作業。NTIA 管理聯邦政府對頻譜的使用，確保滿足美國國內與國際頻譜需求，同時令此有限資源的使用有效率。」[38]「NTIA 與聯邦通信委員會合作，將於未來十年內，為移動式與固定是無線寬頻用途開放總共 500 兆赫的聯邦與非聯邦頻譜。這會令商業頻譜量增加近兩倍的倡議將刺激投資、經濟成長及就業機會，同

[38] http://www.ntia.doc.gov/category/spectrum-management.

時支援消費者與企業對無線寬頻服務的需求。」[39]

The use of RFs by the federal government, and those operating under federal authority such as national Urban Search and Rescue teams, is given by the Office of Spectrum Management (OSM) in the NTIA, a part of the Department of Commerce. The FCC does not set rules for use of radio spectrum by federal users but does coordinate use with the NTIA according to international law. While nonfederal agencies are not subject to NTIA regulation, they may be affected by these rules through partnerships and interoperability agreements, and all operations are subject to the authority under which they operate.
聯邦政府，以及國家搜救隊等在聯邦權限下作業的人，使用的 RF 是由 NTIA 的頻譜管理辦公室（OSM）所提供，NTIA 是商務部的一部分。FCC 不會針對聯邦使用者對無線電頻譜的使用制訂規則，但會根據國際法律死 NTIA 協調頻譜的使用。雖然非聯邦機構不受管於 NTIA 規定，但他們可能會透過夥伴關係和互操作性協議，受到這些規則的影響，所有作業都受管於其所屬權限。

Rulemaking
規則制定

When the FCC believes that a change is needed to the rules, generally it will first issue a Notice of Inquiry (NOI) asking for general information on the issues related to the change. Next, the commission will issue a Notice of Proposed Rulemaking (NPRM) outlining the proposed rule change. The NPRM allows the public to comment on the proposed change and proposed modifications. After the FCC reviews the comments and proposals, it may issue one or more Reports and Orders (R&O) that provide the final details on the rule changes. This process may repeat as necessary to refine the rule change. In addition, a type of appeals process is allowed, known as a Petition for Reconsideration. During the process, public presentations, comment documents, and expert testimony are heard by the FCC. Fire departments and professional organizations may participate in all portions of the process.
當 FCC 認為必須更改規則，FCC 通常會先發布意見諮詢公告（NOI），請求關於與更改相關議題的一般資料。接著，委員會會發布法規命定制定通知（NPRM），概述提議的規則改變。NPRM 讓民眾可提出關於該改變與修訂的意見。FCC 檢視意見和提議後，會發布報告與命令（R&O），提供關於規則更改的最終細節。必要時，可重複此程序已改善規則更改。此外，允許一種稱為訴請覆議的上訴程序。過程期間，FCC 會審理聆聽公開陳述、意見書和專家證詞。消防局與專業組織可參與過程的所有部分。

Licensing
核照

The FCC also governs the licensing of RFs to agencies, and this process is handled separately from the rulemaking process, although issues that arise during the licensing process may result in future rule changes.
FCC 也管理機構 RF 執照的核發，雖然核發程序期間產生的議題可能會導置規則於未來改變，此程序與規則制定程序是分開處理的。

The licensing process starts with the agency defining the requirements for communications systems, including the type of radio system, the frequency band needed, the number of users that will use the proposed system, and the number of frequencies or frequency pairs required.
核照程序的一開始是機構定義通訊系統的需求，包括無線電系統種類、需要的頻帶、將使用提議的系統之使用者數量，以及需要的頻率或頻率對數量。

After the requirements are defined, the agency finds the specific frequencies through a frequency search conducted by the agency, a consultant or a manufacturer. The FCC website has tools to help agencies search for frequencies, including the Universal Licensing System (ULS), which is used to search for existing licenses, as well as for processing applications. The ULS also can be used to search for other agency licenses for examples on preparing a new license. Specific design parameters will be required to license the frequencies, including the transmitter locations, tower height, antenna height, and transmitter power output. Transmitter power output must be specified as “Effective Radiated Power,” which increases the actual power output from the transmitter by a gain factor specific to the antenna used in the system.
定義需求之後，機構會透過由機構、顧問或製造商執行的頻率搜尋，找出特定頻率。FCC 網站有

[39] http://www.ntia.doc.gov/category/spectrum-management.

工具可幫助機構搜尋頻率，包括用以尋找現有執照和處理申請書的通用執照系統（ULS）。也可以利用 ULS 搜尋其他機構執照，做為準備新執照的範例。頻率執照核發需要特定設計參數，包括傳送器位置、塔台高度、天線高度及傳送器功率輸出。傳送器功率輸出必須具體指明為「有效輻射功率」，這會藉由系統採用的天線特定增益因子，提高傳送器的實際功率輸出。

After all the system parameters and frequencies are determined, an application for license is prepared and sent to a frequency coordinator. The FCC requires that almost all applications for two-way or paging radio station licenses be reviewed by a FCC-certified frequency coordinator before the applications can be submitted to the FCC. The coordinator performs many functions for both the applicant and the FCC. The coordinator can assist the applicant in the selection of channels and equally importantly ensure that all requested channels can be used without causing unacceptable interference to other licensees. The coordinator also reviews the entire application for accuracy, including information about the applicant, the proposed radio site and facilities, and compliance with applicable FCC rules and regulations.
確定所有系統參數與頻率之後，會準備執照申請表，並寄給頻率協調員。FCC 要求幾乎所有雙向或呼叫無線電站執照的申請書，必須先由 FCC 認證頻率協調員的檢查，才能提交給 FCC。協調員會為申請人和 FCC 提供許多服務。協調員可幫助申請人選擇通道，以及確保所有申請的通道可在不會對其他持照人造成干擾的情況下使用。協調員也會檢視整份申請書的準確度，包括申請人資料、提議的無線電場所與設施，及對適用 FCC 規則與規定的合規性。

The FCC created two radio service pools of channels, the industrial/business (I/B) pool and the public safety (PS) pool. The FCC recognized that mission critical communications require different coordination standards than general business channels that are heavily shared and certified different coordinators for each pool. To the extent possible, PS channels are coordinated to be either exclusive/semiexclusive in an area or to match regional and state plans for interoperability. Within the PS pool, there are several subcategories: (Each subcategory has been assigned a twoletter identifier.)
FCC 創造了兩個通道無線電服務池，即工業/商業（I/B）池和公共安全（PS）池。FCC 認可關鍵任務通訊需要不同於被大量分享的一般商業通道之協調標準，並為各池頒發合格證書給不同協調員。在允許範圍內，經過協調的 PS 通道是一個區域內的專屬/半專屬通道，或者是為互操作性而配合區域或州際計畫的通道。PS 池內有數個子類別：（各子類別都指配有二位字母辨識碼）

- Police(PP).
  警察（PP）。
- Fire(PF).
  消防（PF）。
- Forestry conservation(PO).
  林業保育（PO）。
- Highway maintenance(PH).
  高速公路維護（PH）。
- Special emergency(PS).
  特殊緊急事件（PS）。
- Emergency medical(PM).
  緊急醫療（PM）。
- Generaluse channels(PX).
  一般用途通道（PX）。

Except for PX channels, the FCC recognizes a home coordinator for each subcategory. The home coordinator has traditionally been the nonprofit association that represents the licensees in each category.
FCC 針對各子類別認可一個國內協調員。國內協調員傳統上是代表各類別的持照人之非營利組織。

For the PS pool, the FCC has certified four frequency coordinators, as follows:
針對 PS 池，FCC 已發合格證給四個頻率協調員，如下：

- PP:APCO.
  PP：APCO。
- PF: IAFC/International Municipal Signal Association (IMSA).
  PF：IAFC/國際城市信號協會（IMSA）。
- PO: Forestry Conservation Communications Association (FCCA).
  PO：林業保育通信協會（FCCA）。
- PH: American Association of State Highway and Transportation Officials (AASHTO).
  PH：美國州公路與運輸官員協會（AASHTO）。
- PM/PS: IAFC/IMSA.
  PM/PS：IAFC/IMSA。
- PX: Any of the above.
  PX：以上任一項。

The FCC allows any of the four certified coordinators to coordinate any public safety subcategory, but requires that if the coordinator is not the home coordinator, advice and consent are received from the home coordinator. The coordinators have settled on a $100 fee per channel, called an interservice fee, for the home coordinators' review. While other coordinators can coordinate a PF channel, the applicant will pay an extra $100 for that coordination versus having the coordination performed by IAFC.
FCC 允許四個合格協調員的任一個協調任何公共安全子類別，但規定若協調員不是國內協調員，會收到來自國內協調員的建議和同意。協調員決定為國內協調員的審查收取每個通道$100 的費用，稱為跨服務費用。雖然其他協調員可協調 PF 通道，但申請人必須額外支付$100，或由 IAFC 進行協調。

In addition, the IAFC rate for coordinating a PF channel is the lowest of the rate cards for any of the coordinators. It just makes good economic sense to use IAFC for coordination of fire or general use channels. And, because of its partnership with IMSA, as described below, interservice fees also do not apply to PM/PS channels.
此外，IAFC 的 PF 通道協調費用是任何協調員的最低價目。利用 IAFC 進行消防或一般用途通道的協調，在經濟上是合理的。因為 IAFC 與 IMSA 的合夥關係，如下文所述，跨服務費也不適用於 PM/PS 通道。

Once the application passes the frequency coordination process, the application is submitted to the FCC through the automated ULS. While the FCC does not charge public safety agencies for licenses, there is a cost associated with the frequency coordination. Agencies can enter the license information into the ULS and track it as it proceeds. The FCC uses a computer system to perform automated checks on the license and then will assign the license request to an examiner who will perform more extensive checks on the details of the application. The examiner then will either grant the license or return it to the applicant for modification or additional documentation. If the request does not conform to FCC rules, it may be rejected outright and will require a reapplication.
一旦申請通過頻率協調程序，申請書會透過自動 ULS 提交到 FCC。雖然 FCC 不會向公共安全機構收取執照費，但有與頻率協調有關的費用。機構可將執照資料輸入到 ULS，以追蹤進展。FCC 利用電腦系統自動檢查執照，然後將執照申請指派給一名審查員，他或她會對申請細節進行更多廣泛的檢查。審查員接著會准予執照，或者將其退還申請人以進行修訂或提供額外文件。若不符合 FCC 規則，申請可能會全部被拒絕，申請人必須重新申請。

If the application does not conform to the FCC rules in Part 90, the applicant may request a waiver of the rules. The waiver process is complicated, and waivers are not granted frequently. An example of a waiver that has been granted is the use of UHF TV Channels 14 and 16 for public safety use in the New York and Los Angeles metropolitan areas. These areas had significant needs for additional frequencies in the 1980s, before the 700 MHz and 800 MHz public safety bands were established. The agencies involved presented the needs along with extensive documentation on why the needs could not be fulfilled with current frequency allocations. Departments that wish to pursue a waiver must present a detailed, well-thought-out case to be successful.
若申請不符合第 90 部分的 FCC 規定，申請人可請求放棄規則。豁免程序相當複雜，且棄權鮮少被准予。一個棄權曾被准予的例子是，紐約和洛杉磯都會區為了公共安全用途而使用 UHF 電視頻道第 14 台和第 16 台。這些區域於 1980 年代需要大量的額外頻率，當時尚未建立 700 MHz 與 800MHz 公共安全頻帶。涉及的機構提出需求，以及大量文件關於為何無法利用現有頻率配置來滿足這些需求。希望實行棄權的部門必須提出詳細且完整的案子才能成功。

Federal Communications Commission Actions to Increase Public Safety Spectrum
聯邦通訊委員會提高公共安全頻譜之行動

Historically, all public safety systems used frequencies in the VHF low, VHF high, and UHF bands, with the systems progressing to higher frequencies as technology improved. Many fire and police departments in the U.S. still use radio systems in the VHF and UHF bands and have no plans to move to other bands. However, the population growth in large metropolitan areas has created rising demand for more RFs. In many areas of the country, all available VHF and UHF frequencies are assigned to agencies,

leaving no space for growth. The FCC, working with equipment manufacturers and public safety communications organizations, has developed several programs to increase the available frequencies for public safety communications.
過去所有公共安全系統都採用 VHF 低頻帶、VHF 高頻帶和 UHF 頻帶，隨著技術的進步，系統進展到較高頻率。美國許多消防局與警察局仍使用 VHF 和 UHF 頻帶的系統，且沒有移動到其他頻帶的計畫。然而，大型都會區的人口增長使得對更多 RF 的需求不斷上升。在美國許多區域，所有可用 VHF 和 UHF 頻率都分配給機構，因此沒有成長空間。

National Public Safety Planning Advisory Committee
國家公共安全規劃諮詢委員會

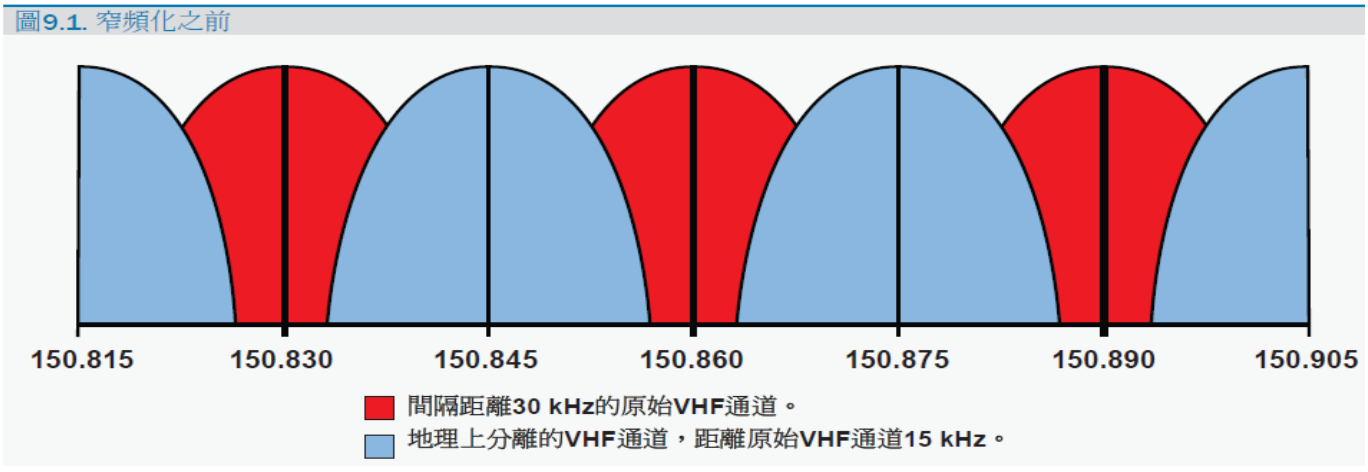
The first major expansion of frequencies allocated to public safety took place in 1986 when the FCC created the National Public Safety Planning Advisory Committee (NPSPAC) to develop frequency allocations on the 800 MHz band. Prior to the NPSPAC process, public-safety-licensed frequencies in the 800 MHz band were combined with commercial business and cellular companies, and the available frequencies were very limited. The NPSPAC frequencies were put under the control of 55 Regional Planning Committees (RPCs). The RPCs are responsible for creating regional frequency plans that take into account agency needs, including metropolitan, rural, and statewide, and are responsible for initial coordination of applications.
分配給公共安全的頻率首次於 1986 年進行大型擴展，當時 FCC 成立了國家公共安全規劃諮詢委員會（NPSPAC）以開發 800 MHz 頻帶的頻率分配。在 NPSPAC 程序啟動前，800 MHz 頻帶的公共安全持照頻率與商業企業和手機公司結合，可用的頻率非常有限。NPSPAC 頻率由 55 個區域計畫委員會（RPC）進行控制。PRC 負責制定考量機構需求的區域頻率計畫，包括都會區、郊區和州際，也負責申請的初步協調。

Narrowbanding Below 512 Megahertz
512 兆赫以下之窄頻化

The NPSPAC process provided additional frequency spectrum for new systems operating in the 800 MHz band, but most fire and police departments in the U.S. still operate in the VHF or UHF bands (Figure 9.1). To increase the available frequency spectrum for public safety in the VHF and UHF bands, the FCC began investigation into narrowing the bandwidth for frequencies in this band. NPSPAC 程序為 800 MHz 頻帶的新系統提供額外的頻譜，但美國多數消防局與警察局仍在使用 VHF 或 UHF 頻帶（**圖 9.1**）。為了增加 VHF 和 UHF 頻帶的可用公共安全頻譜，FCC 開始調查此頻帶中頻寬的窄化。

In the VHF band, channels were spaced 15 kHz apart, with transmitters operating with 25 kHz bandwidth. In addition, as shown in Figure 9.1, adjacent transmitters were separated geographically to minimize interference. It became apparent that as the population served by these departments grew, their spectrum needs would grow as well, and the existing band plan would become inadequate for the needs.
VHF 頻帶中，通道間隔距離為 15 kHz，傳送器以 25 kHz 頻寬運作。此外，如**圖 9.1** 所示，相鄰傳送器在地理上被分開以使干擾最小化。這些部門服務的人口明顯增加，他們的頻譜需求也會增加，而現有頻帶計畫會不足以滿足需求。

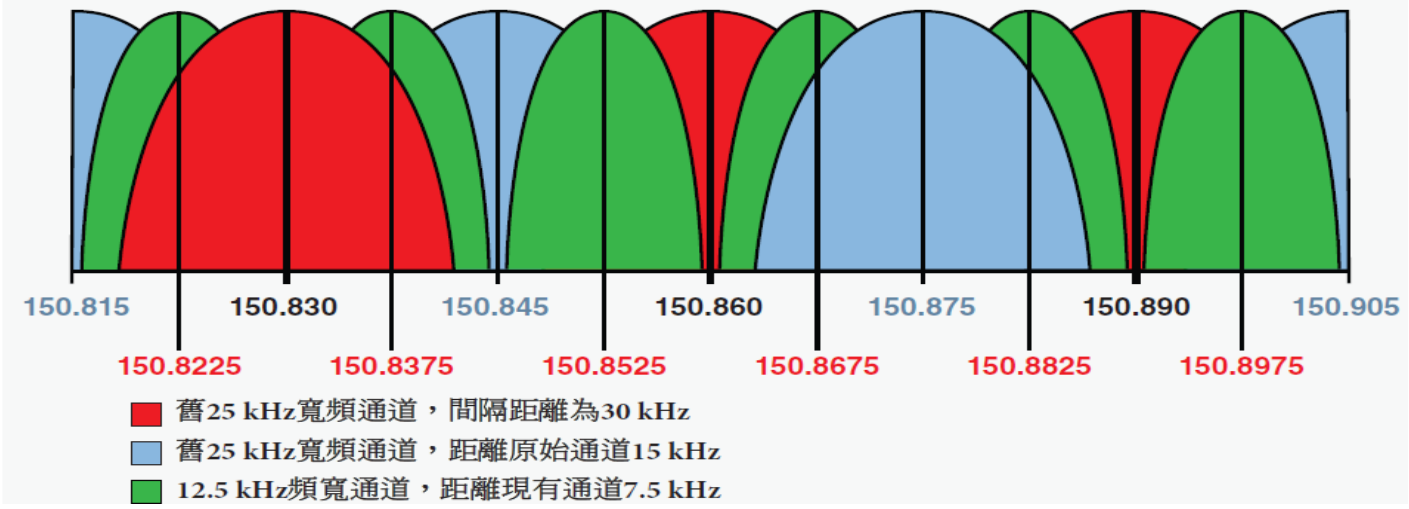
圖9.1. 窄頻化之前



With no unused spectrum available in these bands, the FCC proposed narrowing the bandwidth of the existing frequency assignments, dividing each existing frequency channel in half (Figure 9.2).
由於這些頻帶沒有可用的空閒頻譜，FCC 提議將現有頻帶分配頻寬窄化，將各個現有頻率通道分成一半（**圖 9.2**）。

Each frequency in the new plan was spaced 7.5 kHz from the previous and had a bandwidth limited to 12.5 kHz.
新計畫的每一個頻率與前一個頻率的距離為 7.5 kHz，而頻寬則限制在 12.5 kHz。

圖9.2. 窄頻化之後



The FCC developed a schedule in 1995 for migration from the current band plan to the new narrowband plan. This plan is often called “refarming” to relate it to changing the crops in a field. The schedule for refarming established by the FCC was divided into phases, with each phase increasingly restricting the use of wideband systems to encourage migration to narrowband.
FCC 於 1995 年針對從當前頻帶計畫遷移到新逮頻計畫，制定了一個計劃表。此計畫經常被稱為「重整（英文字義為重種）」，使其與田野的作物更換有關。FCC 制定的重整計畫表分成三個階段，每個階段都持續限制使用寬頻系統，以鼓勵遷移道窄頻。

The first phase began in 1997 with the FCC denying certification for equipment that operated with 25 kHz bandwidth if it did not also operate at 12.5 kHz or equivalent bandwidth. This prevented manufacturers from making equipment that would not be able to be used once the future phases came into effect. The FCC predicted that most (wideband) equipment manufactured before this date would become obsolete and unserviceable before the mandatory narrowband deadline.
第一階段於 1997 年開始，若以 25 kHz 頻寬運作的設備無法以 12.5 kHz 或等效頻寬運作，FCC 會拒絕頒發證書。這防止製造商生產未來階段實施後將無法使用的設備。FCC 預測，在此日期之前生產的多數設備於強置窄頻截止前會過時且不適用。

At the time of this original order, the FCC also made other orders with respect to expansion of existing systems, creation of new systems, and the manufacture and importation of equipment. These orders staggered the restrictions over several years in an attempt to make the transition to narrowband communications less painful to local agencies. Unfortunately, the complexity of the rules confused many agencies and in 2004, before the new rules took effect, the FCC modified the order to have two deadlines, one in 2011 and the other in 2013.
發布此原始命令時，FCC 也發布了其他關於現有系統擴展、新系統創造及設備製造與輸入的命令。這些命令在數年內動搖限制事項，企圖減少遷移到窄頻通訊的轉變為地方機構帶來的痛苦。可惜的是，規則的複雜性令許多機構感到困惑，所以 FCC 於 2004 年，即新規則生效前，修改了該命令，變成兩個截止期限，分別是 2011 年和 2013 年。

In January 2011, the FCC stopped accepting applications for new systems, modifications to existing systems, and transmitters that operated using a bandwidth greater than 12.5 kHz or equivalent. In addition, the FCC prohibited the manufacture or import of radio equipment that

was capable of operating on a bandwidth greater than 12.5 kHz or equivalent.
2011 年 1 月，FCC 停止接受新系統、現有系統修改及使用高於 12.5 kHz 或等效頻寬的傳送器之申請。此外，FCC 禁止製造或進口可用大於 12.5 kHz 或等效頻寬運作的無線電設備。

The final phase began in January 2013, and it prohibited the operation of radios and radio systems that did not comply with the narrowband requirements. All radios, portable, mobile, repeaters, and base stations that operated in the VHF or UHF bands would be replaced, and the systems they operated in would be redesigned by this date. The FCC's actions to refarm the VHF and UHF bands resulted in perhaps the most confusing set of orders ever from the FCC concerning public safety communications, resulting in many unnecessary system replacements. These replacements included departments transitioning to systems that did not meet their operational needs and were unnecessarily costly to procure, operate and maintain. Agencies were able to keep existing communications systems that were used for years, provided that they modernized the equipment and system design by transitioning to 12.5 kHz bandwidth frequencies and equipment prior to 2013.
FCC 重整 VHF 和 UHF 頻帶的動作，產生了有史以來最令人困惑的 FCC 公共安全通訊相關命令，導致許多不必要的系統替換。這些替換包括部門轉變到不符合其作業需求，且購買、運作、維修費用高的系統。機構能夠留下已使用多年的現有通訊系統，前提是他們必須於 2013 年前使設備與系統現代化，即轉變到 12.5 kHz 頻寬頻率與設備。

FurtherNarrowbanding
進一步窄頻化

The FCC has proposed further narrowing the bandwidth of channels below 512 MHz to 6.25 kHz bandwidth but has not issued rules related to a forced migration to this narrower bandwidth at the time of this publication. One of the reasons for this is the lack of FDMA subscriber equipment capable of operating at this narrower bandwidth. In the UHF and 700/800 MHz bands, repeater pairs are preallocated, leading to a simpler TDMA system implementation. In the VHF bands, there are no predefined transmit/receive pairs, making it difficult to aggregate sufficient channels to provide for fouror two-slot TDMA repeated systems. If spectrum use pressure continues, expect that the FCC will again visit the issue of narrowbanding below 512 MHz.
FCC 提議進一步將通道頻窄化到低於 512 MHz 到 6.25 kHz 頻寬，但 FCC 於此文發表前，尚未發布與此較窄頻寬的強制遷移有關之規則。其中一個原因是因為缺乏能夠於此較窄頻運作的 FDMA 用戶設備。在 UHF 和 700/800 MHz 頻帶，中繼器對是預先分配的，使得 TDMA 系統的實施較簡單。VHF 頻帶沒有預先定義的傳送器/接收器對，使得難以聚集足夠通道可提供給四槽或雙槽 TDMA 中繼系統。若頻譜使用壓力持續下去，預計 FCC 會再次探討窄頻化到低於 512 Mhz 的議題。

Public Safety Wireless Advisory Committee
公共安全無線通訊諮詢委員會

Although the NPSPAC process provided additional frequencies in the 800 MHz band, the need for more capacity became evident in the early 1990s. This increasing need for more frequency spectrum was not limited to nonfederal agencies, as the federal government had not made modifications to federal agency needs in many years. The FCC established the PSWAC in 1993 under direction from Congress to address the RF spectrum needs of federal, state and local agencies over the next five years, and over the next 15 years. The goal was to develop a plan to allocate additional spectrum for all users, as well as establish plans for communications interoperability between all levels of government.
雖然 NPSPAC 程序提供 800 MHz 頻帶的額外頻率，對更多容量的需求於 1990 年帶變得更為明顯。這不斷增加的頻譜需求並不限於非聯邦機構，因為聯邦政府已多年未修改聯邦機構。在國會的指示下，FCC 於 1993 年成立 PSWAC，以在接下來的五年和 15 年期間，處理聯邦、州與地方機構的 RF 頻譜需求問題。目標是針對所有使用者製定額外頻譜分配計畫，以及制定所有政府層級之間通訊互操作性的計畫。

The final report of the PSWAC recommended the allocation of 2.5 MHz of spectrum below 512 MHz for federal, state and local public safety interoperability, and the addition of approximately 25 MHz of new spectrum over the next five years and 70 MHz over 15 years for federal, state and local public safety use. Although to date only approximately one-third of the new spectrum requested has been allocated for state and local public safety use, this is more than any request in the last 20 years.
PSWAC 的最終報告建議將 512 MHz 以下頻譜的 2.5 MHz 分配給聯邦、州與地方公共安全互操作

性，並增加大約 25 MHz 和 70 MHz 的新頻譜，分別供聯邦、州與地方公共安全使用 5 年和 15 年。雖然目前要求的新頻譜只有大約三分之一是已分配給州與地方公共安全用途，但這已經比過去 20 年來的任何要求還要多了。

700 Megahertz Spectrum Allocation
700 兆赫頻譜分配

As a result of the PSWAC's recommendation that additional spectrum be allocated to public safety, the FCC allocated 24 MHz of new spectrum. This allocation, from 764 MHz through 776 MHz and 794 MHz through 806 MHz, was part of the spectrum previously allocated to TV Channels 60 through 69. This spectrum became available for use by public safety through the transition of television stations to digital systems. This portion of spectrum was chosen because it was adjacent to the existing 800 MHz band also used for public safety communications, and radio equipment could be designed easily to operate in both bands.
由於 PSWAC 建議分配額外頻譜給公共安全，FCC 分配了新頻譜的 24 MHz。這從 764 MHz 到 776 MHz 和 794 MHz 到 806 MHz 的分配，是過去分配給電視通道第 60-69 台的部分頻譜。透過從電視台到數位系統的轉變，此頻譜變有空，可用於公共安全用途。選擇此頻譜部分是因為它相鄰同樣用於公共安全通訊的現有 800 MHz 頻帶，所以可輕易設計出在這兩個頻帶運作的無線電設備。

The FCC issued an order that described the rules for the use of the new frequency band, as well as the new band plan in 1998. The order split the allocation of frequencies into four basic classes:
FCC 於 1998 年發布一項命令，其中說明新頻帶的使用規則及新頻帶計畫。該命令將頻率分配分成四個基本類別：

- General-use frequencies.
  一般用途頻率。
- State frequencies.
  州頻率。
- Interoperability frequencies.
  互操作性頻率。
- Wideband frequencies.
  寬頻頻率。

The general-use frequencies could be licensed by both state and local entities, and the allocation and use of the channels would be governed by an FCCapproved regional plan developed by stakeholders in the region. The state frequencies would be licensed to each state and would be allocated in any manner the state desired. The interoperability frequencies could be licensed by state, local and, to a limited degree, federal agencies, and the allocation and use of the frequencies would be governed by a plan produced by a State Interoperability Executive Committee (SIEC) in each state. The wideband channels were intended to provide the ability to develop regional and local high-speed data systems.
一般用途頻率可由州與地方個體申請核照，通道的分配與使用由區域內利害關係人制定的 FCC 認可區域計畫進行管理。州頻率的執照會發給各州，頻率會依各州希望的任何方式分配。互操作性頻率的執照可由州、地方與聯邦（在限定程度上）機構申請，頻率的分配與使用由各州州互操作性執行委員會（SIEC）制定的計畫進行管理。寬頻通道的用意是提供建立區域與地方高速資訊系統的能力。

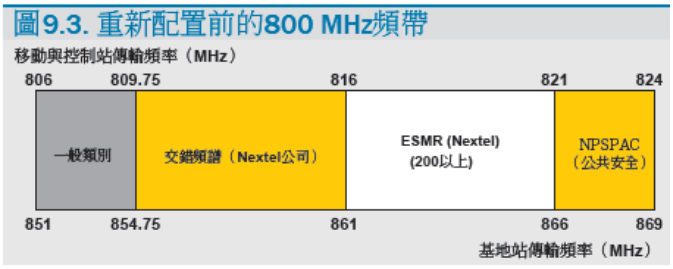
The FCC reconfigured the 700 MHz band plan in 1997, which modified the public safety narrowband (primarily voice) spectrum to be located at 769-776/799-805 MHz. The previously designated wideband spectrum was reconfigured and redesignated for broadband operation, with a guard band between broadband and narrowband spectrum segments. Subsequently, the public safety community, including the fire service, fought for and successfully obtained an additional 10 MHz of spectrum for broadband operation to support video and data. In summary, the 700 MHz band for public safety now consists of a total of 12 MHz for voice with a total of 20 MHz for broadband high-speed data and imaging, and 2 MHz dedicated to guard band between the voice and broadband operations to help minimize interference.
FCC 於 1997 年重新配置 700 MHz 頻帶計畫，將公共安全窄頻（主要語音）頻譜修改到 769-776/799-805 MHz。過去指定的寬頻頻譜被重新配置並重新指定給寬頻作業，寬頻與窄頻頻譜段之間有護衛頻帶。隨後，包括消防服務在內的公共安全社群努力爭取並成功獲得額外的 10 MHz 頻譜，用於寬頻作業以支援影片和數據。總而言之，用於公共安全的 700 MHz 頻帶現在包含用於語音的 12 MHz、用於寬頻高速資訊與影像的 20 MHz，以及語音和寬頻作業之間 2 MHz 的

護衛頻帶，這是為了幫助使干擾最小化。

800MegahertzReconfiguration
800 兆赫重新配置

The initial frequency allocations in the 800 MHz band were made available in 1974 by reallocating the frequencies used by TV Channels 70 through 83. This spectrum was available for use by public safety, business and industrial users, and cellular systems. The FCC allocated 70 channels to public safety and interleaved these with other channels for business and industrial users. Interleaving means that one channel was allocated to business, the next for industrial, and the next for public safety. This repeated, creating an allocation layered with public safety sandwiched between other users. Every public safety channel had a nonpublic-safety system on either side. Later, many of these channels were allocated to Specialized Mobile Radio (SMR) systems, which are private trunked radio systems used by businesses. Figure 9.3 shows the interleaved frequency allocation, with SMR systems on either side. The 800 MHz NPSPAC band is the block labeled Public Safety to the right of the Upper 200 Enhanced Specialized Mobile Radio (ESMR) block.
藉由重新分配電視通道第 70-83 台，於 1974 年空出 800 MHz 頻帶的原始頻率分配。該頻譜可供公共安全、商業與工業使用者及蜂巢式系統使用。FCC 將 70 個通道分配給公共安全，並將這些通道與其他供商業和工業使用者使用的通道交錯。交錯的意思是，一個通道分配給商業，下一個給工業，再下一個給公共安全。這順序一直重複，產生公共安全夾在其他使用者之間的層疊分配。每一個公共安全通道的兩側都有一個非公共安全系統。以後，這些通道有許多都會分配到專用移動式無線電（SMR）系統，這是企業使用的私人集群式無線電系統。**圖 9.3** 顯示交錯頻率分配，兩側都有 SMR 系統。800 MHz NPSPAC 頻帶是 Upper 200 強化專用移動式無線電（ESMR）區塊右邊標示公共安全的區塊。

圖9.3. 重新配置前的800 MHz頻帶



In the early 1990s, FleetCall (later to become Nextel) started to develop a digital SMR network that incorporated the same features as cellular systems. This system used frequencies in the SMR bands, as well as frequencies in the interleaved band. Traditional cellular systems were not allowed to operate in these bands, but FleetCall received waivers from the FCC to operate the new system. At the same time, the deployment of cellular systems was increasing at a rapid pace.
FleetCall（之後的 Nextel）於 1990 年代初期開始開發結合與蜂巢式系統相同性能的數位 SMR 網路。此系統採用 SMR 頻帶的頻率，也用交錯頻帶的頻率。傳統蜂巢式系統不被允許在這些頻帶運作，但 FleetCall 收到 FCC 的豁免書，可操作新系統。同時，蜂巢式系統的部署迅速增加。

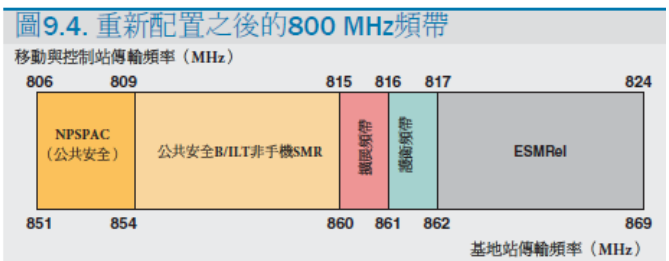
One of the two bands assigned to cellular systems, the Cellular A band, is directly adjacent to the NPSPAC 800 MHz band. The NPSPAC band is also adjacent to the Upper SMR band. With FleetCall systems on both sides of the interleaved band, and this and other systems interleaved — along with SMR systems and cellular sandwiching the NPSPAC band — public safety systems were in a bad place.
指定給蜂巢式系統的兩個頻帶之一，即手機 A 頻帶，直接相鄰 NPSPAC 800 MHz 頻帶。NPSPAC 頻帶也相鄰上 SMR 頻帶。FleetCall 系統位於交錯頻帶的兩側，這與其他系統交錯─MPSPAC 頻帶夾在 SMR 系統與蜂巢式系統中間─公共安全系統處於不好的位置。

Both the FleetCall system and cellular systems are designed with a large number (30 or more) of transceiver sites throughout the system's coverage area. Compare this with the typical public safety system with one or two sites. The public safety systems were bound to have interference, but none of the system operators that were likely to interfere with the public safety systems recognized the potential.
FleetCall 系統與蜂巢式系統於其覆蓋區域內都有大量（30 個或以上）收發器站。將這與擁有一個或兩個站的典型公共安全系統做比較。公共安全系統必定會有干擾，但可能干擾公共安全系統的系統操作者都沒有認清這可能性。

By the late 1990s, the interference problem with public safety systems in the 800 MHz band had become well-recognized, and agencies were demanding action to restore the ability to communicate on emergency incidents. To its credit, the FCC began a process to classify the problem and find a solution. At that time, the FCC ordered that systems operators in the affected bands must

take steps to minimize interference effects in 2004. The FCC also ordered that the 800 MHz band would be reconfigured to further minimize the interference from Nextel and Cellular A band systems under a process known as “rebanding.”
公共安全系統於 800 MHz 頻帶的干擾問題於 1990 年代後期成為公認的問題，機構要求採取行動，修復緊急事故現場的通信能力。FCC 開始執行一個程序，已將問題做分類並找出解決方案。FCC 當時命令受影響頻帶的系統操作者必須一步步地於 2004 年使干擾影響最小化。FCC 也命令重新配置 800 MHz 頻帶，以進一步令源自 Nextel 和手機 A 頻帶系統的干擾最小化，採取的程序稱為「頻帶再分配」。

Under the rebanding process, Nextel was to fund the effort of relocating existing systems in an equitable manner and in return would receive additional frequencies in the 1.9 MHz band. To supervise the rebanding process, the FCC appointed an independent consulting company, BearingPoint, as the Transition Administrator (TA). The TA had the responsibility of managing the process, including establishing the schedule, monitoring the process, and facilitating resolution of conflicts. The process was divided into four “waves” that grouped together the regions that would be reconfigured. All waves were scheduled to be reconfigured by the end of the second quarter of 2008 with the exception of Wave
4, which contained U.S./Canada or U.S./ Mexico border areas. The reconfiguration of these areas was subject to treaty negotiations that delayed the process
在頻帶再分配程序之下，Nextel 必須努力公平地將現有系統重新配置，而 Nextel 的回報就是 19. MHz 頻帶的額外頻率。為了監督頻帶再分配程序，FCC 指定一間獨立的顧問公司，即 BearingPoint，擔任轉型管理員（TA）。TA 負責管理該程序，包括制定計畫表、監控程序及協助衝突解決。該程序分成將會被重新配置的區域聚集在一起的四個「波」。計畫於 2008 年第二季之前將所有的波重新配置，除了包含美國/加拿大或美國/墨西哥邊界區的第 4 波。這些地區的重新配置受到延遲程序的條約談判之影響。

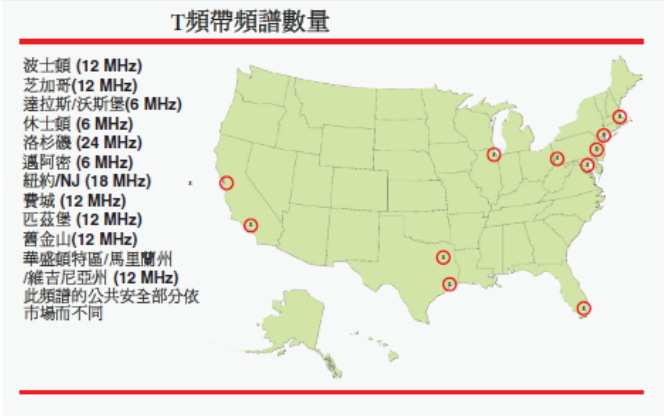


The reconfigured band in Figure 9.4 shows that the public safety portions of the new band would be isolated from the ESMR portion of the band where Nextel operated. In addition, the NPSPAC band had been relocated away from the Cellular A band and was much less likely to suffer significant interference from nonpublic-safety systems.
圖 9.4 的重新配置頻帶顯示，新頻帶的公共安全部分會與 Nextel 操作頻帶的 ESMR 部分隔離。此外，NPSPAC 頻帶已重新配置遠離手機 A 頻帶，受到源自非公共安全系統干擾的可能性較低。

T-Band
T 頻帶

The T-Band supplies a significant number of channels to support public safety operations as well as regional interoperability to 11 of the largest metropolitan areas. The 11 metropolitan areas are Boston, Chicago, Dallas, Houston, Los Angeles, Miami, New York, Philadelphia, Pittsburgh, San Francisco and the District of Columbia (Figure 9.5). The T-Band lies within the UHF spectrum between 470-512 MHz. As a result of the Middle Class Tax Relief and Job Creation Act of 2012, the FCC was ordered to recover and auction the T-Band spectrum by February 2021. Within two years of the auction close (early 2023), the FCC is required to clear public safety operations from this portion of the band. Currently, the FCC has placed a freeze on all new expanded T-Band operations for public safety and industrial and business operations. The challenge now is to remove all public safety off the T-Band, which is proving to be costly and complex due to spectrum allocation.
T 頻帶提供大量通道，支援公共安全以及區域互操作性給最大型都會區其中的 11 個，包括波士頓、芝加哥、達拉斯、休士頓、洛杉磯、邁阿密、紐約、費城、匹茲堡、舊金山和哥倫比亞特區（**圖 9.5**）。T 頻帶位於 UHF 頻譜，在 470-512 MHz 之間。因為 2012 年中產階級稅收減免與創造就業法案，FCC 被命令於 20121 年 2 月前恢復並拍賣 T 頻帶頻譜。拍賣結束後兩年內（2023 年初期），FCC 必須清除頻帶此部分的公共安全作業。FCC 目前已暫停用於公共安全及工業與商業運作的所有新擴展 T 頻帶作業。現在的挑戰在於將所有公共安全移離 T 頻帶，這是成本相當高的複雜行動，因為必須進行頻譜分配。

圖9.5. T頻帶位置



Stu Overby，MPSTC提供，國際APCO，T頻帶背景與NPSTC報告摘要，2013年8月21日

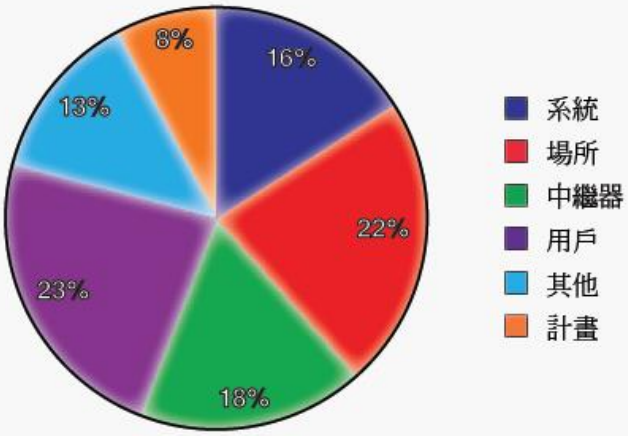
In March 2013, NPSTC convened a T-Band working group to study the giveback and its implications for public safety communications, including the potential costs of relocation efforts. The full report is available on the NPSTC website and cites costs, spectrum alternatives, and limited spectrum gains as potential limitations (SAFECOM T-Band Giveback pp.1-2).
NPSTC 於 2013 年 3 月召集 T 頻帶工作小組，研究回報與其對公共安全通訊的含意，包括重新分配的潛在成本。完整報告可見於NPSTC官網，場所費用、頻譜選擇及有線頻譜增益為潛在限制（SAFECOM T 頻帶回報，第 1-2 頁）。

The migration from T-Band presents a number of problems for local jurisdictions and their public safety responders. The two biggest issues are the likelihood that funding generated by the spectrum auction will not be sufficient to pay for the migration and that there may not be sufficient alternate spectrum available in these busy metro areas to migrate to. In the Boston area alone, over 6,000 public safety radios operate on the T-Band.
從 T 頻帶遷移為地方管轄機構與其公共安全應變人員帶來一些問題。兩個最大的問題是，頻譜拍賣得到的資金會不足以支付遷移費用的可能性，以及這些忙碌都會區可能不會有足夠的可用替代頻譜接受遷移。光是波士頓區，T 頻帶有超過 6,000 台公共安全無線電。

A 2015 study commissioned by the IAFF concluded that there were over 700 jurisdictions that would be impacted by the changes to T-Band use by their fire, EMS, and law enforcement responders.
由 IAFF 於 2015 年委託進行的研究推斷，T 頻帶改由消防、EMS 及執法應變人員使用，會影響超過 700 個管轄區。

A requirement of the act is that proceeds are to assist with spectrum relocation. However, the proceeds will not cover all costs associated with this. An estimate from 2013 expects costs to exceed 5.9 billion dollars for spectrum relocation (Figure 9.6). Private sector relocation costs are not considered, which may decrease the percentage of auction funding to be used for public safety spectrum reallocation.法案的規定之一是，收益必須資助頻譜的重新分配。然而，收益不足以支付所有與此動作相關的費用。2013 年的估算預計頻譜重新分配的費用會超過 59 億元（**圖 9.6**）。其中不考量私營部門的重新分配費用，私營部門的金額可能會降低拍賣資金用於公共安頻譜重新分配的比例。

圖9.6. $59億元費用的分析



Licensees are required by law to migrate from the T-Band spectrum to another unidentified spectrum. There are limited options for a replacement spectrum. The VHF, UHF and 700/800 MHz bands have few available channels. However, in response to Public Law 112-96, the FCC issued rules and guidance related to the required T-Band transition.
持照者依法必須從 T 頻帶頻譜遷移到另一個未知的頻譜。替換頻譜的選擇有限。VHF、UHF 和 700/800 MHz 頻帶只有少數可用通道。然而，FCC 發布與規定的 T 頻帶轉變有關之規則及指導，做為對公共法 112-96 的回應。

On Oct. 17, 2014, the FCC released the narrowband reserve channels (24 12.5 kHz channels) to general use under the administration of the RPC for the benefit of state and local public safety users. Public safety users still rely on LMRs for communication. At the time of this publication, Voice over LTE (VoLTE) and the National Public Safety Broadband Network (NPSBN) are not suitable options for

mission critical voice for public safety users.
於 2014 年 10 月 17 日，FCC 將窄頻保留通道（24 12.5 kHz 通道）釋放給由 RPC 管理的一般用途，這有益於州與地方公共安全使用者。公共安全使用者仍依賴 LMR 進行通信。此文發表時，LTE 語音承載（VoLTE）和國家公共安全寬頻網路（NPSBN）不是適合公共安全使用者關鍵任務語音通信的選項。

FCC Public Notice Jan. 9, 2015.
2015 年 1 月 9 日 FCC 公告。

- A five-year priority access window for T-Band incumbents to license the former reserve spectrum (from Jan. 9, 2015 to Jan. 9, 2020).
  T 頻道現任使用者有五年的耶先存取期可申請之前的保留頻譜(從 2015 年 1 月 9 日到 2020 年 1 月 9 日)。

- The date for filing RPC Plan Amendments to incorporate the former reserve spectrum (June 2, 2015).
  結合之前的保留頻譜的 RPC 計畫修訂之申請日期（2015 年 6 月 2 日）。

- The date by which certain licensees must reprogram their deployable trunked systems to operate on the former reserve channels. (See FCC Public Notice DA 15-34 for specific dates.)
  特定持照者必須為其可部署集群系統重新編程以在之前的保留通道運作之截止日期。（特定日期請見 FCC 公告 DA 15-34。）

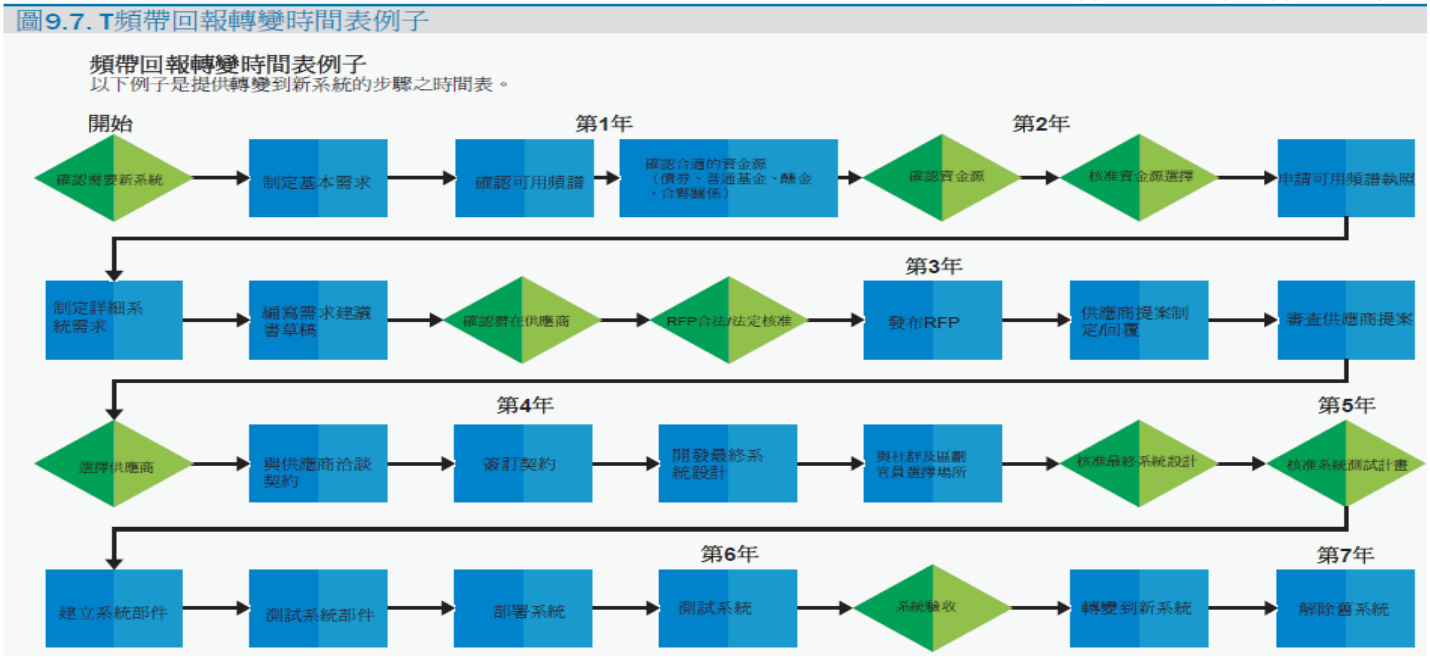
The FCC requires that T-Band incumbents seeking reserve channels (1) commit to returning to the Commission an equal amount of T-Band spectrum and (2) obtain RPC concurrence.
FCC 要求 T 頻帶現任使用者尋找保留通道，以(1)致力於歸還委員會等量的 T 頻帶頻譜，以及(2)獲得 RPC 贊同。

Grant Guidance
補助金指導

OEC encourages states to update Statewide Communications Interoperability Plans (SCIPs) to address FCC directives affecting current or planned public safety communications systems, including T-Band migration, and has advised grantees to consult the FCC, their SWIC, and their frequency coordinator during project planning to ensure projects or upgrades planned for systems operating in the T-Band are coordinated and align with the state's migration plans.
OEC 鼓勵各州更新州際通訊互操作性計畫(SCIP)以針對影響當前或規畫好的公共安全通訊系統之 FCC 命令，包括 T 頻帶遷移，並建議受資助者於計畫專案時，諮詢 FCC、他們的 SWIC 及他們的頻率協調員，以確保專案或 T 頻帶運作系統更新已配合並一致於與州的遷移計畫。

The following (Figure 9.7) is an example timeline providing proposed steps for transitioning to a new system.
以下（**圖 9.7**）例子是提供轉變到新系統的步驟之時間表。

圖9.7. T頻帶回報轉變時間表例子



Summary — Radio Spectrum Licensing and the Federal Communications Commission
摘要─無線電頻譜核照與聯邦通訊委員會

One problem that is common to all recommendations for increasing the spectrum allocated to public safety agencies is accurately defining "public safety agencies." Another lies in the politics of the allocations. Many state and local governments, and their communications managers in particular, lobbied to include "public service" or "public safety support" agencies in those eligible to license spectrum allocated to public safety.
所有針對增加公共安全機構頻譜分配的建議都有的一個問題是，對「公共安全機構」的準確定義。另一個問題在於分配的政治。許多州與地方政府及其通訊管理員都遊說應將「公共服務」或「公共安全支援」機構包含在有資格申請公共安全頻譜的機構清單中。

The result of this is that agencies that do not support the emergency response aspect of public safety are eligible for licenses under the new rules. This includes such diverse groups as school bus companies, road and highway maintenance crews, and public solid-waste disposal agencies. In essence, any state or local government workgroup is eligible for licensing spectrum allocated to public safety, no matter how removed the agency is from emergency response activities. The benefit to state and local governments is that they can build communications systems that support all divisions with spectrum allocated to public safety. Unfortunately, this is done by exploiting the public's understanding of what falls under the umbrella of public safety and ultimately reducing the spectrum available for emergency response.
這會使得不支援公共安全緊急應變部分的機構在新規則之下變成有資格申請執照的機構。其中包括各種不同的團體，如效車隊、道路與公路維修工作小組，及公共固體廢棄物處理機構。在本質上，任何州或地方政府工作小組都有資合申請分配給公共安全的頻譜，無論該機構與緊急應變活動的距離有多遠。州與地方政府的好處是，他們可建立支援所有使用公共安全頻譜的部門之通訊系統。可惜的是，這必須藉由利用民眾對估共安全項目的了解，最終會減少緊急應變可用的頻譜。

Not all of the responsibility for the lack of adequate spectrum for public safety response lies with the FCC or the various coordinating agencies. Public safety agencies themselves often perpetuate this inadequacy through their actions (or inactions). The insistence by many agencies to maintain "stovepipe" communications systems that duplicate the coverage of other systems and do not operate with neighboring agencies is one of the most egregious examples. The efficiency of frequency use could be increased dramatically if all agencies were committed to cooperative system development with the goal of maximum frequency use among all agencies in a system.
缺乏足夠的公共安全應變頻譜之責任並不完全在於 FCC 或不同的協調機構。公共安全機構本身經常透過其活動（或不活動）造就此不充份情況。許多機構堅持維持會複製其他系統覆蓋範圍的「煙囪」通訊系統，卻不與鄰近機構合作，這是最過分的例子之一。若所有機構致力於合作制系統開發，並以系統內所有機構的頻率使用率最大化為目標，頻率使用效率可大幅提升。

The FCC and communications equipment industry are driven by the need to accommodate additional users in a limited amount of radio spectrum and economic forces. Any technical change to spectrum use requirements has the possibility to affect the operational performance of a radio system, negatively or positively. The fire service has an opportunity to be a part of the solution to this issue through coordinated, organizational participation in the process. If the fire service cannot communicate its needs, or if the fire service voice is fragmented, then a solution will be imposed by others, and it is unlikely that that solution will meet all the operational needs of the service.
FCC 與通訊設備業的驅動力是必須將額外使用者納入有限的無線電頻譜和經濟力量。頻譜使用要求的任何技術變化都有可能會影響無線電系統的運作效能，無論是正面或負面影響。消防服務有機會透過於以經協調的組織參與此過程，成為問題解決方案的一部分。若消防服務無法溝通其需求，或者消防服務的語音會中斷，他人會強制實行某解決方案，而該方案會滿足所有服務作業需求的可能性非常低。

The FCC was ordered to recover and auction the T-Band spectrum by February 2021. Within two years of the auction close (early 2023), the FCC is required to clear public safety operations from this portion of the band.

FCC 被命令必須於 2021 年 2 月前恢復並拍賣 T 頻帶頻譜。拍賣結束後兩年內（2023 年初期），FCC 必須清除頻帶此部分的公共安全作業。

- A five-year priority access window for T-Band incumbents to license the former reserve spectrum (from Jan. 9, 2015 to Jan. 9, 2020).
  T 頻道現任使用者有五年的優先存取期可申請之前的保留頻譜（從 2015 年 1 月 9 日到 2020 年 1 月 9 日）。

- The date for filing RPC Plan Amendments to incorporate the former reserve spectrum (June 2, 2015).
  結合之前的保留頻譜的 RPC 計畫修訂之申請日期（2015 年 6 月 2 日）。

- The date by which certain licensees must reprogram their deployable trunked systems to operate on the former reserve channels. (See FCC Public Notice DA 15-34 for specific dates.)
  特定持照者必須為其可部署集群系統重新編程以在之前的保留通道運作之截止日期。（特定日期請見 FCC 公告 DA 15-34。）

The T-Band supplies a significant number of channels to support public safety operations aswell as regional interoperability to 11 of the largest metropolitan areas. The 11 metropolitan areas are Boston, Chicago, Dallas, Houston, Los Angeles, Miami, New York, Philadelphia, Pittsburgh, San Francisco and the District of Columbia.
T 頻帶提供大量通道，支援公共安全以及區域互操作性給最大型都會區其中的 11 個，包括波士頓、芝加哥、達拉斯、休士頓、洛杉磯、邁阿密、紐約、費城、匹茲堡、舊金山和哥倫比亞特區。

Section 10–
第 10 節–

First Responder Network Authority or FirstNet
第一應變人員網路管理機構或稱 FirstNet

History
緣由

Nationwide Public Safety Broadband Network
全國公共安全寬頻網路

In December 2006, the FCC made a statement of opinion in an NPRM:
FCC 於 2006 年 12 月在 NPRM 中的意見陳述：

> We believe that the time may have come for a significant departure from the typical public safety allocation model the Commission has used in the past … While this system has had significant benefits for public safety users, in terms of permitting them to deploy voice and narrowband facilities for their needs, the system has also resulted in uneven build-out across the country in different bands, balkanization of spectrum between large numbers of incompatible systems, and interoperability difficulties if not inabilities.
> 我們認為已是時候放棄委員會過去使用的典型公共安全分配模式…雖然這系統曾對公共安全使用者帶來顯著的好處，讓他們可為自己的需求部署語音與窄頻設施，彈系統也造成全國不同頻帶的不平均擴增，大量不相容系統之間的頻譜巴爾幹化，以及無能和互操作性困難。

This statement predicted the activities that would occur in April and June 2007, with the FCC's Proposed Rulemaking and Second Report and Order on the 700 MHz band. In this rulemaking, the FCC proposed to create a nationwide public safety broadband data system by rebanding the 700 MHz public safety band to reallocate the 10 MHz wideband frequency allocation and combine this with 10 MHz of new spectrum that would be auctioned. The FCC would allow a single nationwide licensee for the reallocated 10 MHz of existing spectrum and would auction the other 10 MHz of new spectrum, known as the D Block.
此陳述預測了於 2007 年 4 月和 6 月發生的事件，即 FCC 對 700 MHz 頻帶的擬定規則制定和第二報告與命令。FCC 於此規則制定提出，對 700 MHz 頻帶進行頻帶再分配，將 10 MHz 寬頻頻率重新分配並將此與會被拍賣的 10 MHz 新頻譜結合，藉以建立全國公共安全寬頻資料系統。FCC 會允許單一全國性持照者申請 10 MHz 現有頻譜的重新分配，並會拍賣其他 10 MHz 的新頻譜，稱為 D 區塊。

The auction would seek to find a bidder that would purchase the rights to the 10 MHz of D Block spectrum and would then have the rights to combine this with the 10 MHz of public safety spectrum to form a nationwide commercial and public safety network. The FCC rules stated that the network must meet the requirements of public safety agencies and appointed the Public Safety Spectrum Trust (PSST) Corporation to represent the interests of public safety. The PSST developed a Bidder Information Document (BID) that outlined the requirements the new system must meet. These specifications includedpriority access for public safety users, backup power and networking requirements, and other features necessary to provide a high-reliability system. The PSST also became the licensee for the 10 MHz of reallocated public safety spectrum.
拍賣找的投標者會購買 10 MHz D 區塊頻譜的使用全，會有權利將此與 10 MHz 公共安全頻譜結合，形成全國性商業與公共安全網路。FCC 規則規定該網路必須滿足公共安全機構與指定公共安全頻譜信脫（PSST）公司的需求，以代表公共安全的利益。PSST 建立了投標人資料文件（BID），其中概述了新系統必須達成的要求，包括公共安全使用者優先存取權、備用電力與網路需求，以及其他提供高可靠度系統所需的性能。PSST 也成為 10 MHz 重新分配工作安全頻譜的持照人。

The D Block auction occurred along with other auctions in the first quarter of 2008. There was one bidder for the D Block, but the reserve price (minimum bid) set by the FCC was not met, and D Block was not auctioned successfully. After the auction, there was some discussion that the requirements for the system set forth in the BID created too much uncertainty as to the cost of constructing the system. This, along with the uncertainty of how many public safety agencies

would participate, may have led to the unsuccessful auction.
D 區塊拍賣連同其他拍賣於 2008 年第一季舉行。D 區塊有一位投標人，但未達到 FCC 設定的保留價格（最低價格），所以未順利拍賣掉。拍賣會後有一些議論，認為 BID 提出的系統要求造成太多系統建造成本方面的不確定。再加上不確定會參與的公共安全機構數量，這或許就是拍賣失敗的原因。

In January 2015, the AWS-3 radio spectrum auction was held and generated $44.9 billion. The proceeds of the auction provided the funding for FirstNet and will finance technological upgrades to 911 emergency systems and contribute over $20 billion to deficit reduction.
AWS-3 無線電頻譜拍賣會於 2015 年 1 月舉行，當時獲得$449 億元。拍賣的收入提供資金給 FirstNet，也會支援更新到 911 緊急系統的技術升級，並將超過$200 億元投入赤字削減。

When the nationwide broadband network is successfully built, it will be the first system of its size built specifically for public safety requirements and could serve as an evaluation model for a possible nationwide voice system in the future.
全國寬頻網路順利建成後，會是同等規模系統中第一個專為公共安全需求建造的系統，可做為未來潛在全國語音系統的評估模式。

Formation of FirstNet
FirstNet 之形成

FirstNet40 is an independent authority within the U.S. Department of Commerce's NTIA. "Signed into law (P.L. 112-96, Title VI) on February 22, 2012, the Middle Class Tax Relief and Job Creation Act created the First Responder Network Authority (FirstNet). The law gives FirstNet the mission to build, operate and maintain the first high-speed, nationwide wireless broadband network dedicated to public safety. FirstNet will provide a single interoperable platform for emergency and daily public safety communications"41 (Figure 10.1).
FirstNet[40]是美國商務局 NTIA 內部的獨立管理機構。「於 2012 年 2 月 22 日簽屬生效（P.L. 112-96, Title VI），中產階級稅收減免與創造就業法案創造了第一應變人員網路機構（FirstNet）。法律賦予 FirstNet 的任務是打造、經營並維護專屬於公共安全的第一個全國性高速無線寬頻網路。FirstNet 會為緊急與日常公共安全通信提供單一互操作性平台」[41]（**圖 10.1**）。

[40] http://www.firstnet.gov/about.

[41] http://www.firstnet.gov/about.

圖 10.1. FirstNet 起點

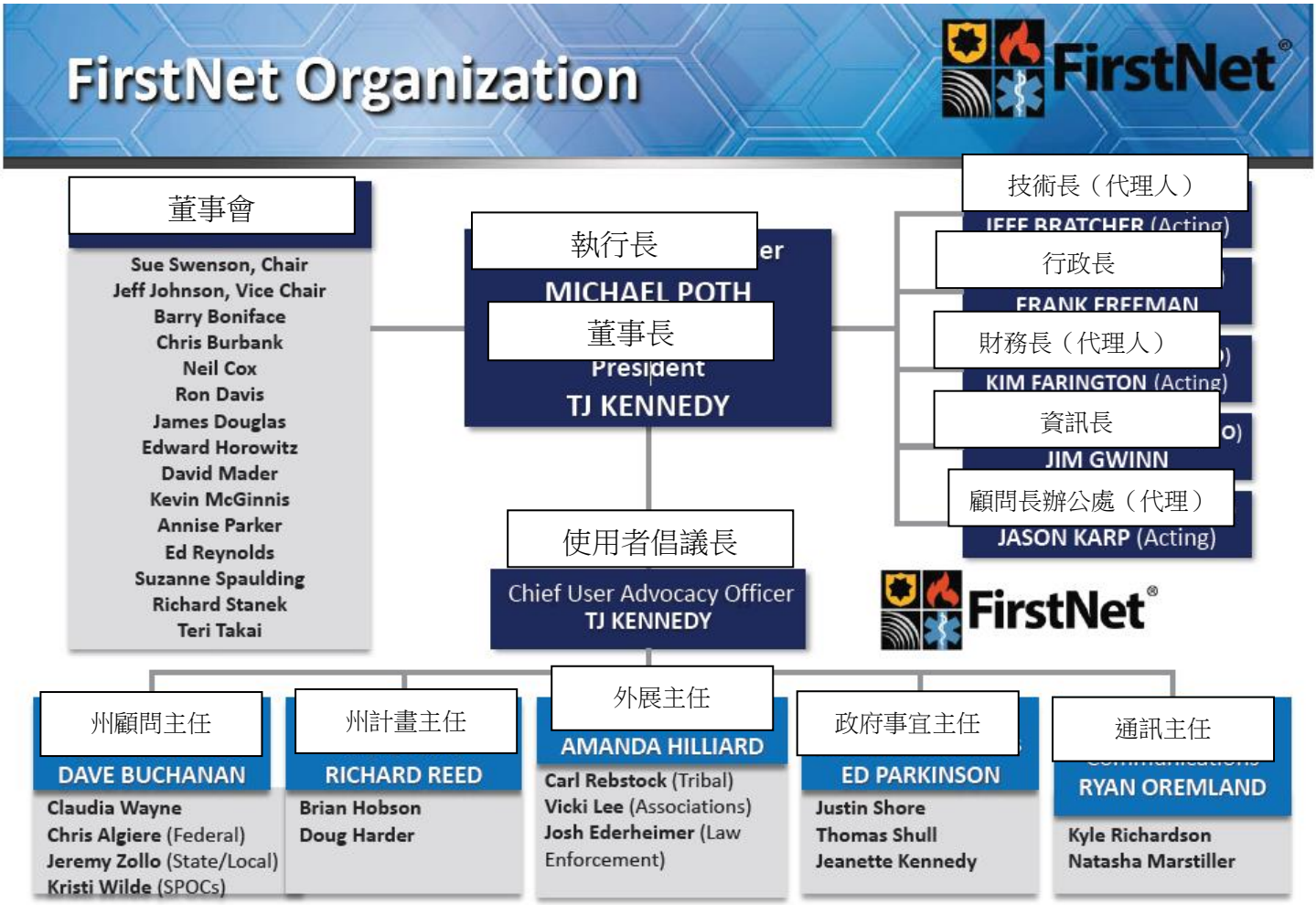
As noted in Figure 10.1, FirstNet is managed by a 15-member board of directors. The FirstNet board consists of:
如圖 10.1 所示，管理 FirstNet 的是由 15 位成員組成的董事會。第一屆 FirstNet 董事會成員包括：

- Secretary of Homeland Security (or designee).
  國土安全部部長（或指定人）。
- Attorney general of the U.S. (or designee).
  美國司法部長（或指定人）。
- Director of Office of Management and Budget (or designee).
  行政管理與預算局局長（或指定人）。
- Twelve individuals to be appointed by the Secretary of Commerce.
  由商務部部長委任的 12 位成員。
- The appointments shall have:
  委任限制：
  - Not fewer than three individuals to represent collective interests of states, localities, tribes and territories.
    州、地方、部落與領地集體利益的代表不得少於三人。
  - Not fewer than three individuals who have served as public safety professionals.
    曾擔任公共安全專家的人士不得少於三人。

The board is responsible for the strategic decisions regarding the direction of FirstNet.
董事會負責做出關於 FirstNet 管理的策略性決策。

In Figure 10.1, there is a 40-member PSAC that reports to the board on specific issues related to public safety operations. The members of this committee represent the voice of public safety and should be contacted regarding public safety issues. The listing of PSAC members can be found at http://www.firstnet.gov/about/public-safetyadvisory-committee.
圖 10.1 中，由 40 位成員組成的 PSAC 向董事會報告公共安全營運相關特定議題。此委員會的成員代表公共安全的聲音，關於公共安全的議題，應該連絡此委員會。PSAC 成員清單，請到 http://www.firstnet.gov/about/public-safety-advisor

y-committee。



As of Sept. 30, 2015, the FirstNet general manager reports the business of FirstNet to the board (Figure 10.2). The FirstNet organization is similar to a commercial telecommunications company.

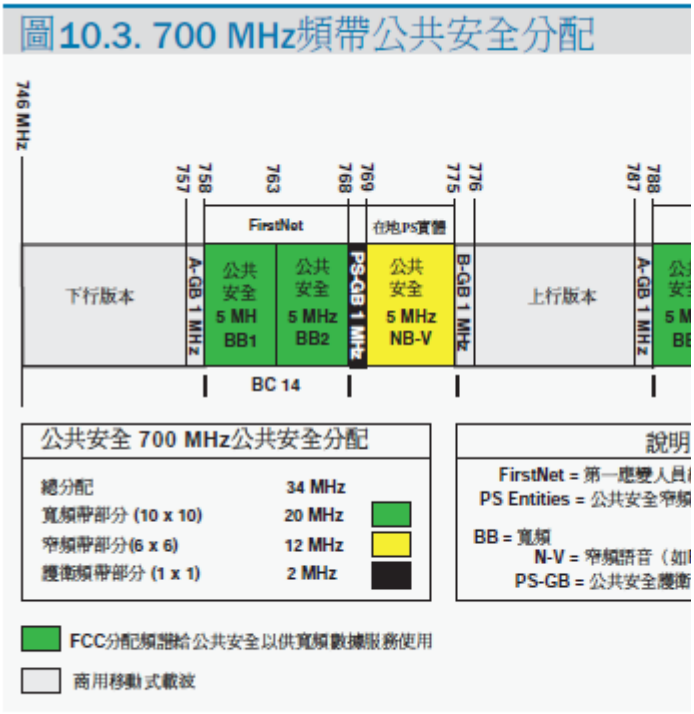
2015 年 9 月 30 日，FirstNet 總經理向董事會報告業務（**圖 10.2**）。FirstNet 組織類似於一間商業電信公司。

As part of the act, FirstNet was allocated 20 MHz of frequency spectrum to manage for deployment of the Radio Access Network that is part of the FirstNet system.

法案規定，FirstNet 必須分配 20 MHz 頻譜，以管理 FirstNet 系統下無線電存取網路的部署。

As you can see in Figure 10.3, the frequencies allocated are near some of the commercial carriers. Part of the cost reduction and containment strategy is investigating options that would allow FirstNet to share access of the assigned spectrum with commercial providers. At present, it is being looked at as a creative way to maximize the use of the spectrum and create funding streams for future sustainment. It is important to note that if shared, provisions in the new LTE standards would provide a mechanism to remove nonpublic safety from the frequencies in time of emergency. Public safety would always maintain priority in the system.

如**圖 10.3** 所示，頻率分配在一些商用載波附近。成本降低與控制策略有一部分是調查能讓 FirstNet 與商業供應商分享指定頻譜存取的選項。這目前被視為一個有創意的方法，可使頻譜使用最大化，並為未來存續製造資金流。必須注意的是，這分享動作會令新 LTE 標準的條款提供一個機制，於緊急事件發生時將頻率的非公共安全用途移除。公共安全在系統中會一直擁有優先權。



FirstNet頻率分配 [42]

"FirstNet was created to be a force-multiplier for first responders — to give public safety 21st century communication tools to help save lives, solve crimes and keep our communities and emergency responders safe. To do that, FirstNet will build a new Band Class 14 network designed tobe reliable, functional, safe and secure, and provide optimal levels of operational capability at all times. For the first time, public safety communications will be based on commercial standards. This will bring the benefits of lower costs, consumer-driven economies of scale and rapid evolution of advanced communication capabilities."[43]
「FirstNet 的創建是為了成為第一應變人員的力量倍增器─提供公共安全 21 世紀的通訊工具以拯救性命、破案，及保障我們的社群與緊急應變人員的安全。為了達到目的，FirstNet 會打造可靠、實用、安全且穩固的新頻帶 14 類別網路，並隨時提供最佳水平的操作能力。公共安全通訊將第一次以商業標準為基礎。這將帶來的好處包括較低的成本、消費者驅動規模經濟，以及先進通訊性能的迅速發展。」[42]

In the future, FirstNet may provide a single interoperable platform for emergency and daily public safety communications. The FirstNet network will fulfill a fundamental data transport need of the public safety community as well as the last remaining recommendation of the 9/11 Commission.
FirstNet 未來可能會提供一個單一互操作性平台給緊急與日常公共安全通訊。FirstNet 網路將滿足公共安全社群的基礎資料傳輸需求，以及實現 9/11 委員會的最後一項建議。

FirstNet is a data system being developed to meet the needs of first responders. It is envisioned as a 4G LTE system for public safety designed to be:
FirstNet 是一個資料系統，期開發是為了滿足第一應變人員的需求。此系統被預想為用於公共安全的 4G LTE 系統，特徵如下：

- Competitively priced.
  價格具競爭力。
- Highly survivable and accessible.
  耐受性與可及性高。
- Secure.
  安全。
- Public safety focused. Provide public safety
- functionalities, such as Mission Critical Voice.
  以公共安全為中心。提供公共安全功能，如關鍵任務語音。

Cost
成本

FirstNet has been allocated $7 billion for the buildout of the system. Telecommunications experts have differing opinions on the approach FirstNet will take to deploy the system, which will impact the system cost. While $7 billion is a large sum of money, it is a fraction of the cost that commercial carriers have invested in infrastructure. FirstNet is working with each state to develop requirements, inventory and available resources to share and identify the state stakeholder groups. FirstNet hopes to use sharing agreements to help contain build-out costs.
FirstNet 打造系統的任務獲得撥款$70 億元。電信專家對於 FirstNet 部署系統的方法有不同意見，因為採取的方法會影響系統成本。雖然$70 億元是一大筆錢，但這只是商業營運商已投入基礎建設的費用之一部分。FirstNet 與各州合作，建立需求、財產目錄與可用資源以分享並確認州利害關係人團體。FirstNet 希望利用分享協議來幫助控制擴建成本。

FirstNet, like the commercial providers, will be a subscriber-based system. Public safety is not

[42] http://www.firstnet.gov/network.

mandated to move data transport to FirstNet. FirstNet will be in direct competition with the commercial providers and will have to demonstrate the added value to warrant additional cost to the public safety community. FirstNet is mandated to be self-sustaining. This will require it to charge subscription fees like the commercial carriers to maintain, operate and upgrade the network. The FirstNet tenet states "To offer services that meet the needs of public safety at a cost that is competitive and compelling to users."
如同商業供應商，FirstNet 會是一個以用戶為中心的系統。公共安全未被命令必須將數據傳輸移動到 FirstNet。FirstNet 會直接與商業供應商競爭，而且會必須展示其附加價值以獲得公共安全社群的額外成本。FirstNet 依法必須是自立的。這使得 FirstNet 必須收取商用載波等訂費以維持、營運及更新網路。FirstNet 宗旨聲明：「以具競爭性且不可抗具的費用，提供滿足公共安全需求的服務」。

Accessibility
可及性

FirstNet is being designed to provide data access for public safety in times of emergency anywhere in the U.S. or U.S. territories. In recent history, the commercial systems have failed to provide connectivity when overwhelmed by spikes in usage from the general public. Current systems do not have priority built in to ensure public safety access during these high-traffic periods (Figure 10.4). This was documented during the Boston Marathon Bombing (April 2013) and the Virginia earthquake (August 2011). In both incidents, the cell systems were unable to handle the intense demand for services. FirstNet will move public safety off the commercial systems and be designed to handle public safety traffic during similar events or incidents.
FirstNet 的設計使其可於美國國內或美國領地發生緊急事件時，提供公共安全資料存取。商用系統過去無法在一般大眾使用率飆高時提供連接。現在的系統沒有內建優先性可在這些高流量期間確保公共安全存取（**圖 10.4**）。波士頓馬拉松爆炸案（2013 年 4 月）和維吉尼亞大地震（2011 年 8 月）的記錄即證實這點。在這兩大事件中，蜂巢式系統都無法處理對服務的密集需求。FirstNet 會將公共安全移離商用系統，其設計會使其可在類似事件或事故發生時處理公共安全流量。

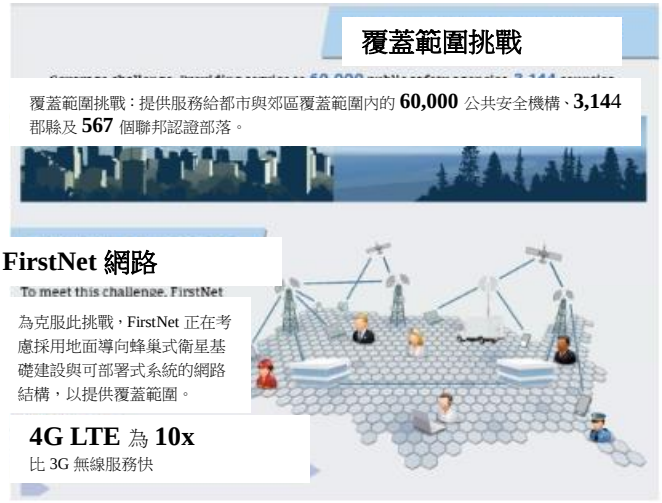


圖 10.4. 覆蓋範圍挑戰

A component of accessibility is system coverage. The system is required to cover all population centers as well as rural and wilderness areas. System design will include fixed infrastructure and deployable infrastructure to achieve the coverage goals. Options to achieve the coverage goals also include possible spectrum sharing with commercial carriers, but no specifics will be available until the system design is completed.
可及性的要素之一是系統覆蓋範圍。系統必須涵蓋所有人口中心和鄉野地區。為達到覆蓋目標，系統設計會包括固定基礎建設和可部署基礎建設。達到覆蓋目標的其他可選方法包括與商業載波分享頻譜，但這在系統設計完成後才會有詳細資料。

Survivability
耐用性

Being a public safety system, FirstNet is being designed to survive extreme weather and seismic events. Public safety radio systems are expected to be operable when these events happen to maintain the ability to respond to the needs of the public. This equates to building the infrastructure to public safety standards that require redundant power sources, hardened sites, towers that will survive extreme weather, and back haul connections that will remain intact. The NPSTC recently released a document "Defining Public Safety Grade Systems and Facilities"44 that describes the Public Safety Grade. The document covers physical properties of the radio sites, antenna masts, connectivity requirements, redundant power sources, and many others. The

document is a good reference for building voice radio systems sites as well.
身為一個公共安全系統，FirstNet 的設計使其可承受極度氣候與地震事件。這些事件發生時，預期公共安全無線電系統會運作，以維持回應大眾需求的能力。這等同於依照公共安全標準建造基礎建設，而標準要求必須有冗餘電源、加固場所、可承受極端氣候的塔台，以及會保持完整的回傳連接。NPSTC 最近發表了一份文件，即「公共安全等級系統與設施」[43]，其中說明公共安全等級。此文件內容包含無線電站的物理性質、天線桿、連接要求、冗餘電源等。此文件是建造語音無線電系統的好參考讀物。

Security
安全性

In this age of computer hacking, denial of service attacks, and data breeches, security is a key element of FirstNet. The system is being designed to provide data service for the law enforcement community as well as many other disciplines that have data security requirements. FirstNet is envisioned as a secure wireless data network with the security needed to allow transport of sensitive information. The elements of security are being developed but will be in place when FirstNet is deployed.
在這電腦駭客入侵、阻斷服務攻擊和數據外洩的時代，安全性是 FirstNet 的關鍵要素之一。系統的設計使其可提供數據服務給執法社群，以及許多其他有資料安全需求的領域。FirstNet 被預想為具有允許敏感資料傳輸所需的安全性之安全無線數據網路。安全性的要素正在被制定，但會在 FirstNet 部署時到位。

PublicSafetyFocus
公共安全重點

Mission Critical Voice is a capability that is under development. Mission Critical Voice was presented as a replacement for LMR systems. This is a capability that is being worked on and is not currently available. There are no definite dates for completion, and FirstNet has not been built. Based on these two factors, it is recommended to maintain current LMR systems until FirstNet and Mission Critical Voice are deployed. A component of Mission Critical Voice to be watchful for is off-network capabilities. FirstNet will operate a lot like the commercial systems today. We all realize that if we do not have system coverage, we do not have connectivity. Off-network communications is mandatory in the fire service application. If the system does not cover the interior of all buildings, which is a certainty, then off-network capability is required to maintain communications with all personnel on the fireground. The reason we use LMR systems is that they, in general, provide communications where commercial networks do not. For FirstNet Mission Critical Voice to replace LMR systems, it must either provide coverage everywhere or provide an off-network capability that would allow units to communicate directly without infrastructure.
關鍵任務語音是一項開發中的功能，是 LMR 系統的替代系統。此功能正在成形，目前尚不提供。沒有確定的完成日，而且尚未建造 FirstNet。根據這兩個因素，建議維持當前 LMR 系統直到 FirstNet 與關鍵任務語音完成部署。關鍵任務語音值得注意的構成要素之一是其離網功能。FirstNet 的運作會很像現在的商用系統。我們都知道，如果沒有系統覆蓋，就會沒有連接。離網通訊在消防應用是強制的。若系統不涵蓋所有建築物的內部，就會需要離網功能以維持與火場上所有人員的通信。我們會使用 LMR 系統是因為這些系統通常可在商用網路失效的地方提供通信。若 FirstNet 關鍵任務語音要替代 LMR 系統，就必須在所有地方提供覆蓋，或者提供可允許各單位在不需要基礎建設的情況下直接通信之離網功能。

The primary application for FirstNet is data transmission and Internet access. FirstNet could replace commercially provided data access needed for mobile computing used in CAD systems. Another application might be the data connectivity needed for fire station alerting.
FirstNet 的主要應用是資料傳輸與網際網路存取。FirsNet 可替代 CAD 系統行動計算所需的資料存取。另一個應用可能會是消防局警報所需的數據連接。

Possible Fire Service Uses
潛在消防用途

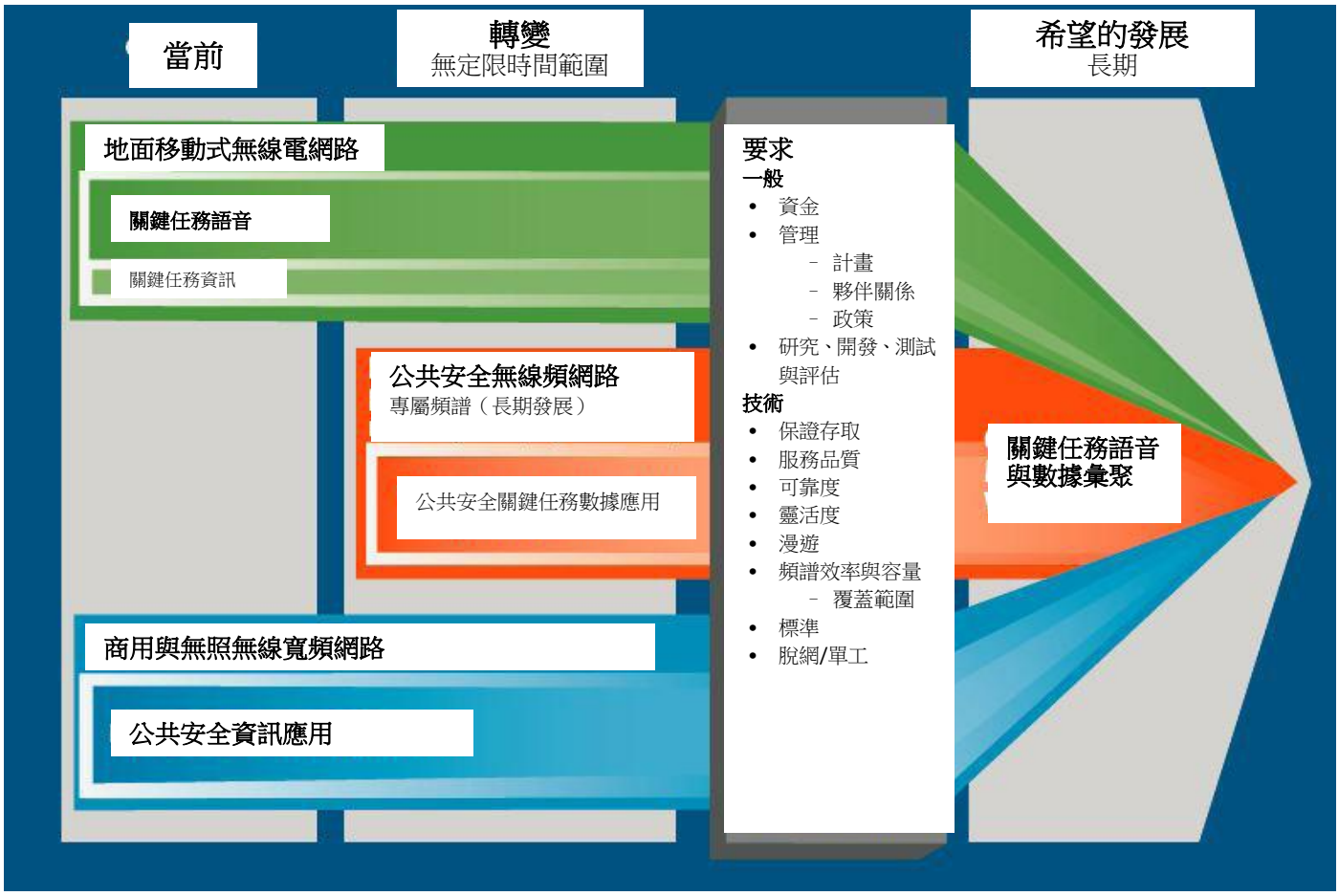
- Data connectivity for mobile computing/CAD.
  行動計算/CAD 的數據連接。
- Hot spot for vehicles.

43 http://www.npstc.org/download.jsp?tableId=37&column=217&id=3066&file=Public_Safety_Grade_Report_140522.pdf.

車輛熱點。
- Electronic patient care reporting.
  電子病患照護報告。
- Application based.
  以應用為中心。
  - CAD.
    CAD。
    - Hand-held dispatch.
      手持調度。
    - Accountability and location.
      管控與位置。
    - Monitoring.
      監控。
  - EMS.
    EMS。
    - Protocols.
      協議。
    - Drug doses.
      藥物劑量。
    - Pharmacologica lID.
      藥理學識別證。
  - Fire.
    消防。
    - Accountability and location of personnel.
      人員管控與位置。
    - Reference material (Emergency Response Guidebook, SOPs).
      參考資料（緊急應變手冊、SOP）。
    - Extrication (where to cut vehicles).
      脫困（車輛切割處）。

When smartphones entered the market, the number of applications was small when compared to present. Like the explosion of applications in the private sector, a similar explosion will occur when public safety embraces this technology platform (Figure 10.5).
智慧型手機上市時，應用數量現在少很多。如同於私營部門應用的爆發，公共安全接納此技術平台時也會發生類似的爆發（**圖 10.5**）。

圖 10.5. 公共安全通訊發展



Long term, it is envisioned that FirstNet will provide a technology convergence in the future. This concept would merge current data transport and LMR functions into the FirstNet technology platform as depicted in Figure 10.5. The convergence of technology is possible, but the fire service will need to validate and verify that the systems being proposed provide the capabilities needed to operate

in the firefighting environment. We also need to require capabilities that provide the safety margins required to operate safely on the fireground. Ruggedized devices must also be available to withstand the rigors of the firefighting environment.
長期而言，預想 FisrtNet 未來會提供技術融合。此概念會將現在的數據傳輸與 LMR 功能併入 FirstNet 技術平台，如**圖 10.5** 所示。這技術融合是有可能的，但消防服務會必須確認並證實提議的系統提供消防環境所需的功能。我們也必須要求可提供火場上安全操作所需的安全邊際之功能。耐用裝置也必須能夠承受嚴酷的消防環境。

Summary—FirstNet
摘要─FirstNet

Signed into law on Feb. 22, 2012, the Middle Class Tax Relief and Job Creation Act created FirstNet. The law gives FirstNet the mission to build, operate and maintain the first high-speed, nationwide wireless broadband network dedicated to public safety. FirstNet was allocated 20 MHz of frequency spectrum in the 700 MHz band to manage for deployment of the Radio Access Network that is part of the FirstNet system.
於 2012 年 2 月 22 日簽屬生效，中產階級稅收減免與創造就業法案創造了 FirstNet。法律賦予 FirstNet 的任務是打造、經營並維護專屬於公共安全的第一個全國性高速無線寬頻網路。700 MHz 頻帶的 20 MHz 頻譜被分配給 FirstNet，管理 FirsNet 系統下無線電存取網路的部署。

FirstNet in the future may provide a single interoperable platform for emergency and daily public safety communications. The FirstNet network will fulfill a fundamental data transport need of the public safety community as well as the last remaining recommendation of the 9/11 Commission.
FirstNet 未來可能會提供一個單一互操作性平台給緊急與日常公共安全通訊。FirstNet 網路將滿足公共安全社群的基礎資料傳輸需求，以及實現 9/11 委員會的最後一項建議。

FirstNet is a data system being developed to meet the needs of first responders. It is envisioned as a 4G LTE system for public safety designed to be:
FirstNet 是一個資料系統，期開發是為了滿足第一應變人員的需求。此系統被預想為用於公共安全的 4G LTE 系統，特徵如下：

- Competitively priced.
  價格具競爭力。
- Highly survivable and accessible.
  耐受性與可及性高。
- Secure.
  安全。
- Public safety focused. Provide public safety functionalities.
- 以公共安全為中心。提供公共安全功能，如關鍵任務語音。
- Mission Critical Voice: Off-network communications capability is mandatory.
  FirstNet has stated that Mission Critical Voice, which is most important to the fire service, will be one of the last elements to be brought on line.
  關鍵任務語音：離網通訊功能是**強制性的**。FisrtNet 已聲明，對消防服務而言最重要的關鍵任務語音會是上線的**最後**要素之一。

FirstNet is being designed to provide data access for public safety in times of emergency anywhere in the U.S. or U.S. territories. In recent history, the commercial systems have failed to provide connectivity when overwhelmed by spikes in usage from the general public.
FirstNet 的設計使其可於美國國內或美國領地發生緊急事件時，提供公共安全資料存取。商用系統過去無法在一般大眾使用率飆高時提供連接。

FirstNet is being designed to survive extreme weather and seismic events. Public safety radio systems are expected to be operable when these events happen to maintain the ability to respond to the needs of the public. FirstNet is also being designed with security features that will meet the needs of the fire service and more stringent requirements of law enforcement.
FirstNet 的設計使其可承受極度氣候與地震事件。這些事件發生時，預期公共安全無線電系統會運作，以維持回應大眾需求的能力。FirstNet 的設計使其具有安全性能，可滿足消防服務需求和更嚴力的執法要求。

The primary application for FirstNet is data transmission and Internet access. FirstNet could replace commercially provided data access needed for mobile computing used in CAD systems.
FirstNet 的主要應用是資料傳輸與網際網路存取。FirsNet 可替代 CAD 系統行動計算所需的資料存取。

Long term, it is envisioned that FirstNet will provide a technology convergence in the future. This concept would merge current data transport and LMR functions into the FirstNet technology platform. Maintaining current LMR systems is necessary until FirstNet technology is deployed, tested, and proven reliable in the fire service environment and equivalent coverage needed by the fire service is attained. As of the development of this report, FirstNet has not yet made decisions on the actual design of either the broadband network or the costs public safety agencies will incur for its use.

長期而言，預想 FisrtNet 未來會提供技術融合。此概念會將現在的數據傳輸與 LMR 功能併入 FirstNet 技術平台。當前 LMR 系統的維持是必須的，直到 FirstNet 技術已經部署、經過測試，並證實其於消防服務環境的可靠性，且已達到消防服務所需的覆蓋。此報告擬定時，FirstNet 尚未決定寬頻網路的實際設計，以及公共安機構的使用費。

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Glossary
詞彙

Analog FM Radio: operates by causing the transmitting frequency of the radio to change directly with the microphone audio. The transmitter frequency variations are proportional to the amplitude of the input audio.
類比 FM 無線電：運作是藉由令無線電傳輸頻率直接隨著麥克風語音變化。傳送器頻率變化與輸入音頻振幅成正比。

Association of Public Safety Communications Officers (APCO): serves the needs of public safety communications practitioners worldwide and the welfare of the general public as a whole by providing complete expertise, professional development, technical assistance, advocacy and outreach.
公共安全通訊官協會（APCO）：藉由提供完整專業知識、專業發展、技術協助、提倡與推廣，滿足全球公共安全通訊從事者的需求，以及一般大眾的福利。

Atmospheric Ducting: a horizontal layer in the lower atmosphere in which the vertical refractive index gradients are such that radio signals are guided or ducted and tend to follow the curvature of the Earth.
大氣波管效應：下大氣層中的水平層，其中垂直折射率梯度令無線電信號受到引導並跟隨地球曲度。

Base Station Radio: located at fixed locations and usually powered by AC utility power.
基地台無線電：位於固定地點，供電源通常是 AC 公用電力。

Bidirectional Amplifier (BDA): used to extend radio coverage within structures to the outside of structures.
雙向放大器（BDA）：用以將建築內部的無線電覆蓋範圍擴展到建築外部。

Channel Bandwidth: the amount of radio spectrum used by the signal transmitted by a radio.
通道頻寬：無線電傳輸信號使用的無線電頻譜量。

Continuous Tone-Coded Squelch System (CTCSS): mixes a subaudible tone with the audio from the microphone and transmits the resulting signal. When a radio receives a signal with tone-coded squelch, the CTCSS decoder attempts to match the tone present in the received signal with the desired tone. If the correct tone is present, the receiver is unsquelched and audio is routed to the speaker.
連續音頻靜噪碼系統（CTCSS）：混合次聲頻與麥克風的音頻，並將結果信號送出。無線電收到帶有語音靜噪碼的信號時，CTCSS 解碼器會試圖比對收到的信號與希望的信號。若正確的音頻存在，接受器的靜音會被取消，音頻會被發送到擴音器。

Decibel: a logarithmic unit used to express the ratio between two values of a physical quantity, often power or intensity.
分貝：用以表達兩個物理量（通常是功率或強度）之間的比例。

Directional (Yagi) Antenna: an antenna that radiates or receives greater power in one direction allowing for increased performance and reduced interference from unwanted sources.
定向（八木）天線：朝一個方向發射或接收更多功率的天線，可提高性能並減少來自不希望的來源之干擾。

Direct Radio System: When the signal is received from the radio initially transmitting the signal, the communication is direct. (That is, there is no intervening radio or system.)
直接無線電系統：收到來自原始信號傳輸無線電的信號時，通信是直接的。（也就是說，沒有干預無線電或系統。）

Downtilt Antenna: directional antenna tilted to increase energy immediately below the antenna while

reducing the maximum distance the signal will travel.
下傾天線：傾斜的定向天線，這是為了增加天線正下方的能量，同時縮短信號行進的最大距離。

Analog FM Radio: operates by cau sing the transmitt ing frequency of t he radio to chan ge directly wit h the microp hon e audio. The transm itter freq uency variat ions are prop ortional to th e amplitude of the input a udio . Association
動態重組：讓獲得授權的系統管理人員能從遠端將無線電分配到特定通話群組。

Emergency Alarm: When a user presses the emergency button on the portable, an emergency message is sent to any dispatchers using radio consoles.
緊急警報：使用者按下可攜式無線電上的緊急鍵時，緊急信息會被發送給使用控制臺的任何調度人員。

Emergency Call: a call that is initiated by an “emergency alarm” activation. The “emergency call” is a high-priority voice transmission in the trunked system. The emergency call elevates the talkgroup to a high priority to ensure communications with the initiator of the call.
緊急呼叫：由「緊急警報」啟動所發動的呼叫。「緊急呼叫」是集群式系統的主要優先語音傳輸。緊急呼叫將通話群組提升到優先處理等級，以確保與呼叫發動者的通信。

Federal Communications Commission (FCC): a federal governmental board charged with regulating broadcasting and interstate communication by wire, radio and television.
聯邦通訊委員會（FCC）：負責管理廣播與跨州有線、無線電及電視通訊。

Feedback: when radios operating in close proximity receive the transmitted signals from the receiving radios nearby. This creates a loop effect and introduces unwanted interference in the communications system. This is very common when operating on direct/simplex channels when the transmit and receive frequency is the same.
回饋：當無線電收到附近接收無線電發出的信息時，會產生循環效應，並將不要的干擾引入通訊系統。使用直接/單工通道時，若傳輸與接收頻率相同，這種情況相當普遍。

First Responder Network Authority (FirstNet): an independent federal government authority tasked with cost-effectively creating a nationwide broadband data network and providing wireless services to public safety agencies across the country. FirstNet is an independent authority within the U.S. Department of Commerce’s NTIA.
第一應變人員網路管理機構（FirstNet）：獨立的聯邦政府管理機構，任務是以有成本效益的方式打造一個全國性寬頻數據網路，並提供無線服務給全國公共安全機構。FirstNet 是美國商務部 NTIA 下的獨立管理機構。

Fixed-Site Antenna: antennas mounted on towers or buildings to provide the dispatch to or repeater coverage throughout the service area.
定點天線：架設於塔台或建築物上的天線，用以提供服務區內的調度或中繼器覆蓋範圍。

Frequency Coordination: a technical and regulatory process that is intended to remove or mitigate RF interference between different radio systems that use the same operational frequency.
頻率協調：一個技術與監管程序，用以移除或減少使用相同運作頻率的不同無線電系統之間的 RF 干擾。

First Responder Network Authority (FirstNet): an independent federal government authority tasked with cost-effectively creating a nationwide broadband data network and providing wireless services to public safety agencies across the country. FirstNet is an independent authority within the U.S. Department of Commerce’s NTIA.
半雙工通訊：使用兩個 RF 進行通訊。傳送無線電利用 1 號頻率進行傳輸，該訊號由中繼器接收。中繼器會在 2 號頻率重複該傳輸，此訊號由接收無線電進行接收。

IAFF Fire Ground Survival (FGS) Program: The purpose of the FGS program is to ensure that training for mayday prevention and mayday operations are consistent between all firefighters, COs and chief officers.
IAFF 火場生存（FGS）計畫：FGS 計畫的目的是確保所有消防人員、CO 與總隊長接受相同的 mayday 預防與行動的訓練。

First Responder Network Authority (FirstNet): an independent federal government authority tasked with cost-effectively creating a nationwide broadband data network and providing wireless services to public safety agencies across the country. FirstNet is an independent authority within the U.S. Department of Commerce's NTIA.
國際電機電子工程師學會（IEEE）：促進電子與資訊技術知識的創造、發展、整合、分享及應用之工程程序。

Interference: unwanted RF signals disrupt the use of your radio.
干擾：不希望的 RF 信號令無線電的使用中斷。

Intermodulation: frequency variation of two or more electromagnetic waves transmitted simultaneously through a nonlinear electronic system.
互調：同時透過非線性電子系統傳輸的兩個或以上電磁波之頻率變化。

International Electrotechnical Commission (IEC) Standards Ingress Protection (IP) Codes: IP codes are international standards that test for IP into an electrical enclosure.
國際電工委員會（IEC）異物防護（IP）代碼：IP 代碼是測試異物進入電氣外殼的國際標準。

International Municipal Signal Association (IMSA): designated as the frequency coordinator for all public safety agencies.
國際城市信號協會（IMSA）：委任為所有公共安全機構的頻率協調員。

Interoperability: the ability of public safety responders to share information via voice and data communications systems on demand, in real time, when needed, and as authorized.
互操作性：公共安全應變人員透過語音與數據通訊系統於收到請求時、即時、必要時及獲得授權時，分享資訊的能力。

Land Mobile Radio (LMR): wireless communications system intended for use by users in vehicles (mobiles) or on foot (portables).
地面行動無線電（LMR）：讓開車（移動式）或步行（可攜式）的使用者使用之無線通訊系統。

Military Standard 810 (MIL-STD): a standard for reliability and ruggedness, developed by the military, to provide an environmental test protocol that would prove qualified equipment would survive in the field.
軍用標準 810（MIL-STD）：可靠性與耐用性的標準，軍方制定此標準以提供可證明合格設備會在現場存活的環境測試準則。

Mobile Radio: Mobile radios are designed to be mounted in vehicles and get their power from the vehicles' electrical system. Generally, these radios have better antennas, receivers and provide higher power when transmitting from a vehicle.
移動式無線電：移動式無線電的設計是為了將其安裝在車輛內，並從車輛的電力系統取得電源。這種一般來說，這種無線電有較好的天線和接收器，且從車輛傳輸時會提供較高的功率。

Modulation: Modulation is the process of varying a higher frequency carrier wave to transmit information.
調變：調變是改變較高頻率載波以傳輸資訊的程序。

Multigroup Call: a call that transmits to two or more talkgroups simultaneously.
多群組通話：同時發送給兩個或以上通群組的呼叫。

Narrowbanding: an effort to ensure more efficient use of the VHF and UHF spectrum by requiring all VHF and UHF public safety and Industrial/Business LMR systems to migrate to at least 12.5 kHz efficiency technology by Jan. 1, 2013.
窄頻化：藉由要求所有 VHF 和 UHF 公共安全與工業/商業 LMR 系統於 2013 年 1 月 1 日前遷移到至少 12.5 kHz 有效技術，確保 VHF 和 UHF 頻譜的使用更有效率。

National Association of State Telecommunications Directors (NASTD): a member-driven organization whose purpose is to advance and promote the effective use of information technology and services to improve the operation of state government.
國家電信主管協會（NASTD）：一個成員驅動組織，目的是發展及促進資訊技術與服務的有效使用，以改善州政府作業。

National Fire Protection Association (NFPA): a U.S. trade association, albeit with some international members, that creates and maintains private, copyrighted, standards and codes for usage and adoption by local governments.
美國消防協會（NFPA）：雖然包含一些國際成員，但這是一個美國同業公會，負責制定和維護私有與版全標準及法規以供地方政府使用和採用。

National Institute of Standards and Technology (NIST): the federal technology agency that works with industry to develop and apply technology, measurements and standards..
國家標準暨技術研究院（NIST）：與業界合作以該發並應用技術、量測及標準的聯邦技術機構。

National Public Safety Telecommunications Council (NPSTC): a volunteer federation of 15 public safety organizations, whose mission is to improve public safety communications and interoperability through collaborative leadership. NPSTC's members are the organizations representing fire, EMS, law enforcement, transportation, and other telecommunications organizations (http://www.npstc.org/).
國家公共安全電信委員會（NPSTC）：由 15 個公共安全組織組成的志願聯盟，其任務是透過合作式領導，改善公共安全通訊與互操作性。MPSTC 成員是代表消防、EMS、執法及運輸的組織，以及其他電信組織（http://www.npstc.org/）。

National Telecommunications and Information Administration (NTIA): executive branch agency that is principally responsible by law for advising the president on telecommunications and information policies. NTIA is responsible for federal frequency coordination.
國家通信暨資訊管理局（NTIA）:依法主要負責向局長提出電信與資訊政策相關意見的行政部門機構。NTIA 負責聯邦頻率協調。

NFPA 1221: Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems.
NFPA 1221：*緊急服務通訊系統之安裝、維修與使用標準。*

NFPA 1561: Standard on Emergency Services Incident Management System and Command Safety.
NFPA 1561：*緊急服務事故管理系統與指揮安全之標準。*

NFPA 1802: Standard on Personal Portable (Hand-Held) Two-Way Radio Communications Devices for Use by Emergency Services
Personnel in the Hazard Zone.Personnel in the Hazard Zone.
NFPA 1802：*緊急服務人員於危險區域內使用的個人可攜式（手持）雙向無線電通訊裝置之標準。*

NIST Technical Note 1477: Testing of Portable Radios in a Firefighting Environment.
NIST 技術摘要 1477：可攜式無線電於消防環境之測試。

NIST Technical Note 1850: Performance of Portable Radios Exposed to Elevated Temperatures.
NIST 技術摘要 1850：暴露於高溫的可攜式無線電之效能。

Office of Emergency Communications (OEC): supports and promotes communications used by emergency responders and government officials to keep America safe, secure and resilient. The office leads the nation's operable and interoperable public safety and national security and emergency preparedness communications efforts.
緊急通訊辦公處（OEC）：支援並促進緊急應變人員與政府官員使用的通訊，維持美國安全性與恢復力。此組織引領國家操作性與互操作性公共安全及國家安全與緊急整備通訊作業。

Omnidirectional Antenna: a class of antenna that radiates radio wave power uniformly in all directions in one plane.
全向天線：於一個平面向所有方向一致性地發射無線電波功率的天線。

Over the Air Programming (OTAP): allows system administrators to program radios over the air.
空中編程（OTAP）：讓系統管理員可在空中進行無線電編程。

Over the Air Rekeying (OTAR): allows system administrators to rekey encryption codes over the air.
空中換鑰（OTAR）：讓系統管理員可在空中進行加密碼換鑰。

Personal Alert Safety System (PASS): monitors an emergency responder's motion and automatically emits an audible signal to summon aid in the event that the user becomes incapacitated or needs assistance.
個人安全警報系統（PASS）：監測緊急應變人員的動作，並在使用者無行動能力或需要協助時，發出音頻信號以呼叫救援。

Portable Radio: hand-held radios powered by rechargeable, replaceable battery packs.
可攜式無線電：由可充電、可替換電池組所驅動的手持無線電。

Private Call: allows one radio to call another radio and to carry on a conversation without any other radios hearing the conversation.
私人呼叫：讓一台無線電可呼叫另一台無線電並進行對話，任何其他無線電都無法聽到對話內容。

Project 25 (P25): a suite of standards for digital radio communications for use by federal, state/province, and local public safety agencies in North America to enable them to communicate with other agencies and mutual-aid response teams in emergencies.
計畫 25（P25）：一套標準，內容主要針對讓北美聯邦、州/省與地方公共安全機構可於緊急事件發生時，與其他機構和互助應對小組通信的數位無線電通訊。

Radio Alerting: feature that allows radios to be alerted to notify the user of incoming traffic.
無線電通知：讓無線電可收到通知，以告知使用者有新進流量。

Radio Console Equipment: used by dispatchers to control base station radios and repeaters and allow the dispatcher to receive and transmit on one or more radios simultaneously.
無線電控制臺設備：調度人員利用無線電控制臺設備控制基站無線電與中繼器，並同時接收和傳送一個或以上無線電。

Radio Frequency (RF): any frequency within the electromagnetic spectrum associated with radio wave propagation.
無線電頻率（RF）：任何與無線電波傳播相關電磁頻譜內的頻率。

Radio Spectrum: the range of electromagnetic frequencies used in radio transmission, lying between 10 kHz and 300,000 MHz.
無線電頻譜：無線電傳輸使用的電磁頻率範圍，介於 10 kHz 和 300,000 MHz。

Receiver Desensitization Interference/Receiver Overload: caused by nearby high-level transmitter signals that overload the initial parts of the radio's signals.
接收器鈍化干擾/接受器過載：是由附近使無線電接收器原始部件過載的高位準傳送器信號所造成的。

Receiver Multi-Coupler: a device for connecting several receivers or transmitters to one antenna in such a way that the equipment impedances are properly matched to the antenna impedance.
接收器多路耦合器：將數個接收器或傳送器連接到一個天線的裝置，連接方式令設備阻抗適當地符合天線阻抗。

Receiver Voters: compares the audio from all receivers and routes the audio from the receiver with the best audio quality to the dispatcher.
接收器選擇器：比較來自所有接收器的音頻，並將最佳音頻品質的語音傳給調度員。

Remote Speaker Microphone (RSM): a corded radio accessory that has a speaker/microphone combination that can attach closer to the user's mouth.
遠端喇叭麥克風（RSM）：具有可放置在使用者嘴部附近的喇叭/麥克風組合之有線無線電配件。

Repeated Radio System: the portable transmit frequency is received by the repeater and retransmitted on the portable receive frequency at a higher power to extend range or increase penetration.
中繼式無線電系統：可攜式無線電的傳輸頻率由中繼器接收，再以較高的功率從可攜式無線電接收頻率重新傳輸，以擴展範圍或增加穿透率。

Repeater Duplexer: a tuned electronic device that permits the use of the same antenna for transmitting and receiving.
中繼器雙工器：允許利用相同天線進行傳輸與接收的已調頻電子裝置。

Request for Proposal (RFP): a solicitation, often made through a bidding process, by an agency or company interested in procurement of a commodity, service or valuable asset to potential suppliers to submit business proposals.
需求建議書（RFP）：對購買商品、服務或有價資產有興趣的機構或公司透過投標向潛在供應商提出的請求，要求提交商業提案。

SAFECOM: mission is to improve designated emergency response providers' interjurisdictional and interdisciplinary emergency communications interoperability through collaboration with emergency responders across federal, state, local, tribal, and territorial governments, and international borders.
SAFECOME：任務是，透過與聯邦、州、地方、部落與領土政府的緊急應變人員之合作，改善指定緊急應變供應者的跨行政區與跨領域緊急通訊互操作性。

Radio Frequency (RF): any frequency within the electromagnetic spectrum associated with radio wave propagation.
選擇性關閉：可在無線電遺失或遭竊時，從遠端關閉無線電。

Short Message Service (SMS): Since the radios are digital, many trunked systems support sending short messages across the network.
簡訊服務（SMS）：由於無線電是數位式的，許多集群式系統支援在網路內傳送簡訊。

Simplex Communication: when one radio transmits and the other radio receives on the same RF channel.
單工通訊：在相同 RF 通道，一台無線電傳輸，另一台接收。

Simulcast Transmitter Systems: multiple transmitters simultaneously transmit on the same frequency to increase the coverage footprint or provide in-building penetration.
同頻共波傳送器系統：多個傳送器同時在相同頻率傳輸以增加覆蓋範圍或提供建築內穿透率。

Simultaneous Transmissions: multiple users trying to talk at the same time causing communications interference.
同時傳輸：多位使用者試圖同時說話，造成通信干擾。

Squelch Circuit: used to mute the output of the radio receiver when no desirable signal is present and unmute when a signal of the appropriate strength is present.
靜噪電路：沒有希望的訊號存在時，將無線電接收器的輸出消音，並在適當強度信號出現時取消靜音。

Talk-Around System: a radio accessory that attaches to the SCBA facepiece, may offer multiple talk-around channels that allow users to talk with each other in the hazard zone.
脫網系統：連接到 SCBA 面罩的無線電配件，可提供多個脫網通道讓使用者於危險區域內與彼此對話。

Talkgroup: equivalent of a channel on a conventional system. In a trunked system, there may be more talkgroups than RF channels. The design is based on the probability that not all channels are required simultaneously.
通話群組：等同於傳統系統的通道。集群式系統的通話群組可能多於 RF 通道。此系統的設計基礎是，有可能不會同時需要所有通道。

Telecommunications Industry Association (TIA): represents manufacturers and suppliers of global communications networks through standards development, policy and advocacy, business opportunities, market intelligence, and events and networking.
電信工業協會（TIA）：透過標準制定、政策倡議、商機、市場情報及社交活動，代表全球通訊網路的製造商與供應商。

Telephone Interconnect: allows users to answer or make calls to telephone users from the radio.
電話互連：讓使用者利用無線電接聽電話用戶的電話或打電話給他們。

TTerrain Blocking: materials such as metal and earth completely block radio waves due to their composition and density. Radio waves can travel through some materials such as glass or thin wood but the strength is reduced.
地形阻擋：金屬、土壤等物質的組成與密度會完全阻隔無線電波。無線電波可穿透玻璃、薄木等物質，但其強度會降低。

Time Division Multiple Access (TDMA): a channel access method for trunked radio systems. It allows several users to share the same frequency channel by dividing the signal into the different time slots.
分時多重接取（TDMA）：集群式無線電系統的通道接取方式，藉由將信號分成不同時槽，讓多位使用者可分享相同頻率通道。

Transmitter Combiner: allows multiple transmitters to connect to a single antenna.
傳送器合路器：讓多個傳送器可連接到單一個天線。

Trunked Radio Systems: trunking borrows technologic concepts from telephone systems to assign RFs to active calls, improving the spectrum efficiency
集群式無線電系統：集群借取電話系統的技術概念，將 RF 分配給行進中的通話，藉以改善頻率使用效率。

Ultra High Frequency (UHF): designation for the range of RFs in the range between 300 MHz and 3 gigahertz.
超高頻率（UHF）：300 MHz 與 3 吉赫之間的指定 RF 範圍。

Vehicular Repeater: a repeater that is mounted in a vehicle and is often used to enhance system coverage. This can be to provide more range or in-building penetration.
車載中繼器：架設於車輛內的中繼器，通常用以增加系統覆蓋，可提供更多覆蓋範圍或建築內穿透率。

Very High Frequency (VHF): designation for the range of RFs in the range between 30 MHz to 300 MHz.
非常高頻率（VHF）：30-300 MHz 的指定 RF 範圍。

Vocoder/Codec: the algorithm and electronic components that perform the function of converting analog voice to a digital data packet and also provide the decoding of the signal as well.
聲碼器（語音編碼器）或編解碼器將類比語音轉換成數位數據包及提供信號解碼的電子演算部件。

Voice Amplifier: a PPE accessory that attaches to the SCBA facepiece and amplifies the user's voice.
語音放大器：連接於 SCBA 面到的 PPE 配件，會將使用者聲音擴大。

Wavelength: the distance between the crests of an electromagnetic wave. Wavelength is a factor in determining antenna length.
波長：兩個波峰之間的距離。波長是決定天線長度的因素之一。

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Acronyms 縮寫

AASHTO	American Association of State Highway and Transportation Officials 美國州公路與運輸官員協會	**FEMA**	Federal Emergency Management Agency 聯邦緊急事務管理署
AHJ	authority having jurisdiction 擁有管轄權的管理機構	**FGS**	Fire Ground Survival 火場生存
ANSI	American National Standards Institute 美國國家標準協會	**FirstNet**	First Responder Network Authorityf 第一應變人員網路管理機構
APCO	Association of Public Safety Communications Officers 公共安全通訊官協會	**FM**	frequency modulation 調頻
BDA	bidirectional amplifier 雙向放大器	**FPIC**	fFederal Partnership for Interoperable Communications 聯邦可互用通訊夥伴關係
BID	Bidder Information Document 投標人資料文件	**FRG**	First Responders Group 第一應變小組
CAD	computer-aided dispatch 電腦輔助調度	**gpm**	gallons per minute 每分鐘加侖數
CDMA	code division multiple access 分碼多重接取	**GPS**	Global Positioning System 全球定位系統
CFL	compact fluorescent lights 一體式螢光燈	**HIPPA**	Heath Insurance Portability and Accountability Act 健康保險可攜與責任法案
CFR	Code of Federal Regulations 聯邦管制法規	**HSGP**	Homeland Security Grant Program 國土安全補助金計畫
CG	Channel Guard™ 通道護衛™	**Hz**	Hertz 赫茲
cm	Centimeter 公分	**IAFC**	International Association of Fire Chiefs 國際消防隊長協會
CO	Company Officer 消防隊隊長	**IAFF**	International Association of Fire Fighters 國際消防員協會
COML	Communications Unit Leader 通訊單位領導	**I/B**	industrial/business (radio service pool) 工業/商業（無線電服務池）
COMT	Communications Technician 通訊技術元	**IC**	Incident Commander 事故指揮官
CTCSS	Continuous Tone-Coded Squelch System 連續音頻靜噪碼系統	**ICT**	information and communications technology 資訊與通訊技術
DAS	Distributed Antenna System 分佈天線系統	**ID**	Identification 辨識證
dB	Decibel 分貝	**IDLH**	immediately dangerous to life and health 直接危害生命與健康
DCS	Digital-Coded Squelch 數位靜噪碼	**IEC**	International Electrotechnical Commission 國際電工委員會
DHS	U.S. Department of Homeland Security 美國國土安全部	**IEEE**	Institute of Electrical and Electronics Engineers 國際電機電子工程師學會
DVSI	Digital Voice System Inc. 數字語音系統公司	**IFC**	International Fire Code 國際消防法規
EMS	Emergency Medical Services. 緊急醫療服務	**IFSTA**	International Fire Service Training Association 國際消防服務訓練協會
ERU	Emergency Response Unit 緊急應變單位	**IMSA**	International Municipal Signal Association 國際城市信號協會
ESMR	Enhanced Specialized Mobile Radio 強化專用移動式無線電		
FCC	Federal Communications Commission 聯邦通訊委員會		
FCCA	Forestry Conservation Communications Association 林業保育通信協會		
FDMA	frequency division multiple access 分頻多重接取		

INCM	Incident Communications Manager 事故現場通訊主管	**OTAP**	over the air programming 空中編程
IP	Ingress Protection 異物防護	**OTAR**	over the air rekeying 空中換鑰
kHz	Kilohertz 千赫	**PASS**	Personal Alert Safety System 個人安全警報系統
LCD	liquid-crystal display 液晶顯示	**PL**	Private Line™ 私人 Line™
LED	light-emitting diode 發光二極體	**PPE**	personal protective equipment 個人防護設備
LMR	Land Mobile Rad 地面行動無線電	**PS**	public safety (radio service pool) 公共安全（無線電服務池）
LODD	line-of-duty death 因公殉職	**PSAC**	Public Safety Advisory Committee 公共安全諮詢委員會
LTE	Long Term Evolution 長期演進技術	**PSHSB**	Public Safety and Homeland Security Bureau 公共與國土安全局
MHZ	Megahertz 兆赫	**PSST**	Public Safety Spectrum Trust 公共安全頻譜信託
MIL-STD	Military Standards 軍用標準	**PSWAC**	Public Safety Wireless Advisory Committee 公共安全無線諮詢委員會
NASTD	National Association of State Telecommunications Directors 國家電信主管協會	**PTT**	push-to-talk 一鍵通
NFPA	National Fire Protection Association 美國消防協會	**RADO**	Radio Operator 無線電操作人員
NIFC	National Interagency Fire Center 國家林火協調中心	**R&O**	Reports and Orders 報告與命令
NIFOG	National Interoperability Field Operations Guide 國家互操作性現場作業指南	**RF**	radio frequency 無線電頻率
NIMS-ICS	National Incident Management System Incident Command System 國家事故管理系統事故現場指揮體系	**RFI**	request for information 資訊需求書
NIST	National Institute of Standards and Technology 國家標準暨技術研究院	**RFP**	request for proposal 需求建議書
NOI	Notice of Inquiry 意見諮詢公告	**RPC**	Regional Planning Committee 區域規劃委員會
NPRM	Notice of Proposed Rulemaking 法規命定制定通知	**rpm**	revolutions per minute 每分鐘轉速
NPSBN	National Public Safety Broadband Network 國家公共安全寬頻網路	**RSM**	remote speaker microphones 遠端喇叭麥克風
NPSPAC	National Public Safety Planning Advisory Committee 國家公共安全規劃諮詢委員會	**RVS**	receiver voter system 接收器選擇器系統
NPSTC	National Public Safety Telecommunications Council 國家公共安全電信委員會	**SCBA**	self-contained breathing apparatus 自給式呼吸器設備
NTIA	National Telecommunications and Information Administration 國家通信暨資訊管理局	**SCIP**	Statewide Communications Interoperability Plans 州際通訊互操作性計畫
ODP	Office for Domestic Preparedness 國內備災辦公處	**SIEC**	State Interoperability Executive Committee 州互操作性執行委員會
OEC	Office of Emergency Communications 緊急通訊辦公處	**SMR**	Specialized Mobile Radio 專用移動式無線電
OSM	Office of Spectrum Management 頻譜管理辦公室	**SOP**	standard operating procedures 標準作業程序
		SWIC	Statewide Interoperability Coordinator 州際互操作性協調員
		TA	Transition Administrator 轉型管理員
		TDMA	time division multiple access 分時多重接取

TIA	Telecommunications Industry Association 電信工業協會	**USFA**	U.S. Fire Administration 美國消防局
TIC	thermal imaging cameras 熱像儀	**VHF**	very high frequency 非常高頻率
UASI	Urban Areas Security Initiative 市區安全計畫	**VoLTE**	Voice over LTE LTE 語音承載
UHF	ultra high frequency 超高頻率	**VR**	vehicular repeater 車載中繼器
ULS	Universal Licensing System 通用執照系統	**Wi-Fi**	wireless fidelity 無限保真度
USDA	U.S. Department of Agriculture 美國農業部	**WMD**	weapons of mass destruction 大規模毀滅性武器