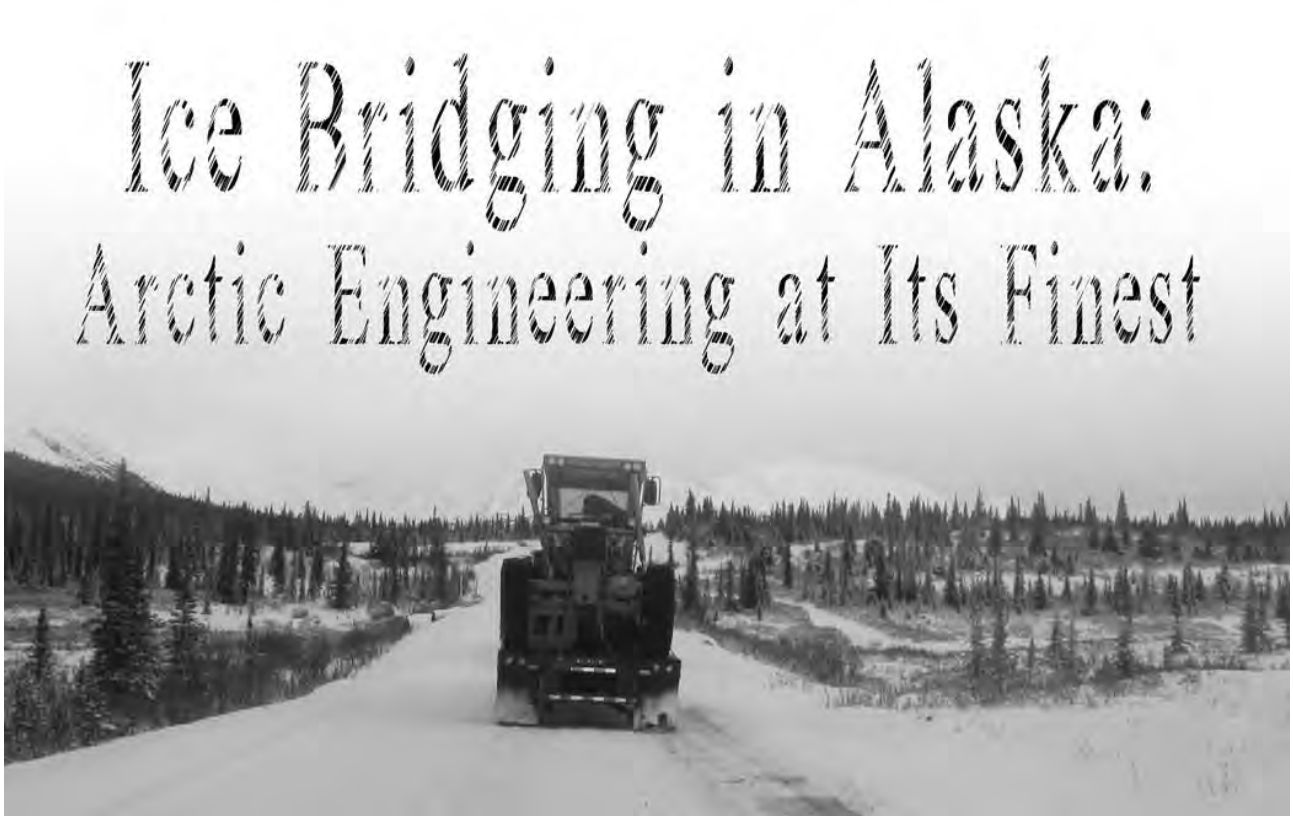

阿拉斯加冰橋-北「極」工兵

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An ice bridge is a frozen, man-made structure on the surface of a bay, river, lake, or sea. Exploiting the natural conditions found in an arctic environment, ice bridges provide access to remote areas that do not have permanent road networks. If constructed properly, the bridges can facilitate the efficient transportation of equipment and personnel to otherwise inaccessible areas, saving time and money.

冰橋係指海灣、河川、湖泊或海洋表面上的冷凍、人造結構。在北極地區發現利用這樣的自然狀態，冰橋提供那些沒有永久性道路的偏遠地區一個通道。假設建設得宜，冰橋可促進裝備與人員的運輸效率，到達難以進入的地方，省下時間和金錢。

Few Army engineers have the opportunity to train on a rare skill set—ice bridging

in an arctic environment. The 6th Engineer Battalion (Combat) (Airborne) was uniquely positioned for this opportunity, which provided valuable training for the unit's Soldiers and practical benefits for U.S. Air Force engineers in Alaska. Throughout January and February 2011, a task-organized team of 35 Soldiers from the battalion constructed an ice bridge over the Delta River at the U.S. Army Cold Regions Test Center at Fort Greely, Alaska.

很少有陸軍工兵人員有這樣的機會接受這難得的組合技術訓練—極地環境架冰橋。第 6 工兵營(戰鬥)(空降)是唯一有這機會提供士兵寶貴的訓練並給予在阿拉斯加的美國空軍工兵實質上的益處。2011 年整整 1 月及 2 月份，由 35 位來自這個營的士兵所組成的任務編組團隊，在阿拉斯加格林利堡的美國陸軍寒冷地區試驗中心建構一座橫跨戴爾塔河的冰橋。

Ice Bridging: A Lost Art
冰橋架設：消失的藝術

Enabling mobility is nothing new for Army engineers, but the weather conditions necessary to sustain an ice bridge are so extreme that the skill set is difficult to train. An analysis of potential contingency missions in cold-weather environments reveals a need for ice bridging as a capability within the force. Across the Army, there is a lack of existing doctrinal processes in ice bridging and arctic engineering in general. The 6th Engineer Battalion (Combat) (Airborne) recognized this deficiency and has made a concerted effort to institutionalize ice bridging as a capability.

提升機動力對美國工兵部隊而言不是件新鮮事，但如此極度的氣候環境是維持冰橋的必要條件，同時也是技術層面上最難訓練的一環。一個對於寒冷氣候環境下所做的潛在意外任務分析顯示，部隊中對於冰橋架設能力的需求。綜觀陸軍，找不到冰橋架設及一般極地工程的準則。第 6 工兵營(戰鬥)(空降)瞭解這樣的匱乏，並致力使冰橋架設成為一項能力。

Ice Bridging Test Bed
冰橋架設測試台

Due to its location in Alaska and its close working relationship with the Cold Regions Test Center, the 6th Engineer Battalion (Combat) (Airborne) is well suited to serve as the Army's subject matter expert in constructing ice bridges. According to U.S. Army Alaska policies, the battalion trains its Soldiers on cold-weather survival skills in courses taught at the unit level or at the U.S. Army Northern Warfare Training Center in Fort Wainwright, Alaska. This essential training equips Soldiers

with the individual skills required to operate in an arctic environment. The battalion also partners with the Cold Regions Test Center, providing operators to conduct cold-weather testing of engineer equipment and variants of the mine-resistant, ambush-protected vehicle.

因地理位置位於阿拉斯加且就近寒冷地區試驗中心，第 6 工兵營(戰鬥)(空降)非常適合做為陸軍冰橋架設的技術專家。根據美國陸軍阿拉斯加的政策，該營訓練他們的士兵在冰天雪地中求生技巧的課程，在單位內或位於阿拉斯加威來特堡的美國陸軍北部作戰訓練中心。這樣的一個基本訓練使士兵具單兵技巧，並足以在極地環境中執行作戰。該營也和寒冷地區試驗中心合作，提供操作員去執行工兵機械在寒冷氣候中的測試，以及防地雷反伏擊車輛的差異性。

Equipped with the skills to survive and operate in an arctic environment, the battalion undertakes an annual mission to construct an ice bridge across the Delta River or the Tanana River. The lack of any bridge crossing on these rivers makes ice bridging essential for the Air Force to conduct maintenance and construction on the Oklahoma Bombing Range and Blair Lakes Impact Area on the far side of both rivers.

具備這樣的技能在冰天雪地裡才能求生及執行任務，該營從事年度任務就是建構一座穿越戴爾塔河或是塔納納河的冰橋。由於缺乏任何可橫跨這兩條河的橋樑，使得冰橋對於空軍來執行維保及建構位於兩條河流遠方的奧克拉荷馬投彈場與布雷爾河彈著區顯得格外重要。

The ice bridge constructed in February 2011 was 1.2 miles across the Delta River and 75 to 100 meters wide. The battalion team pumped about 3 million gallons of water during the mission. The bridge was strong enough to allow for the transport of excavators weighing 165,000 pounds. As a direct result of these efforts, the Air Force 354th Civil Engineering Squadron (Range Maintenance) was able to—

■Grade and groom 26 miles of winter trail.

■Remove 12 destroyed target vehicles and 51 destroyed container express boxes.

■Construct four new hangar targets and a new fuel farm.

■Build 60 new Maverick tank targets and repair six damaged tank targets.

■Fabricate three MiG-29 and 19 antiaircraft artillery targets.

■Excavate and move 74,335 cubic yards of fill material while constructing—

o Four new antiaircraft artillery pads.

o 12 new hangar target pads.

o Six miles of new roads.

■ Remove 408,000 pounds of metal target residue.

■ Transport and use 26,975 gallons of diesel fuel.

這座穿越戴爾塔河流的冰橋建於 2011 年 2 月，長 1.2 英里、寬 75-100 公尺。在這項任務中，營工作隊抽出大約 3 百萬加侖的水。這座冰橋堅固到可承載重達 16 萬 5,000 磅的挖掘機。由於成果豐碩，空軍第 354 工兵中隊具有以下能力—

●可整理 26 英里長的冬天滑道

●可移除 12 輛毀壞的車輛及 51 個毀壞的貨櫃

●建構 4 座新的停機棚目標和新的燃料廠

●建立 60 個新的小牛坦克目標和維修六台損壞坦克目標

●組裝 3 台米格 29 和 19 個防空砲目標

●可挖掘及移動 74,355 立方碼填方材料同時建造—

○4 座新的防空砲發射臺

○12 座新的停機棚目標臺

○6 英里長的道路

●移除 40 萬 8,000 磅的金屬目標廢料

●運送及使用 2 萬 6,975 加侖的柴油

Challenges of Ice Bridging

冰橋架設的挑戰

Operating in a cold-weather environment presents unique challenges. The severe cold and gale force winds during Alaska's winter present some of the world's toughest construction conditions. Extreme cold weather can cause equipment malfunctions that are not normally present in warmer climates. Hoses can freeze and become stuck, various items can shatter if dropped, and vehicle brakes can freeze and become inoperable, among other challenges. These malfunctions can prolong construction timelines or endanger an entire mission. Using a small-unit support vehicle equipped with an arctic heater in the rear passenger cab or a warming shelter to keep idle equipment from freezing prevents malfunctions and saves the time it would take to bring equipment to operable temperatures. Routine maintenance is especially critical when operating in severe cold weather.

在酷寒氣候的環境下工作顯現無比的挑戰性。在阿拉斯加的冬天，氣候嚴寒且伴隨陣陣強風呈現出世上某些最嚴酷的建造環境。嚴寒氣候可導致機具故

障，對於在溫暖氣候地區而言是不常發生的。軟管會凍結且造成阻塞，各式各樣的物品如果掉落的話會粉碎，還有車輛煞車器會凍結而無法運作等，種種其他挑戰因素。這些故障會延長架設時間或是增加全般任務的危險性。使用小型的支援載具加裝北極加熱器於後座乘客位置或暖的遮蓋物，可防止閒置的機具冷凍故障，並且省下機具暖機的時間。當要在嚴寒的氣候下操作機具，例行性的保養絕對是必要的。

Safety is another consideration. Soldiers on this mission endured the harshest conditions imaginable, with significant risk of cold-weather injuries. After getting wet while pouring 100,000 gallons of water in temperatures of -26°F, one Soldier remarked that he felt like a “human popsicle,” a condition experienced daily by all of the Soldiers during the mission. The Army’s extended cold-weather clothing system was not adequate for the subzero temperatures encountered, so Soldiers combined standard Army-issued undergarments with commercial off-the-shelf outerwear. Special waterproof, breathable gloves were locally purchased to ensure dexterity while working with the moving parts on various pieces of equipment.

安全是另一項考量，士兵在任務中需忍受最嚴酷的環境，這是可想而知的，還有嚴寒氣候造成傷害的重大風險。當注入華氏溫度-26 的水 10 萬加侖時全身弄濕，一個士兵形容他像一支冰棒一樣，這是在這項任務中每一位士兵每天都會體驗到的。美軍野戰禦寒衣物在氣溫零下的環境是不足的，所以士兵結合美軍公發的內衣和現成的外套禦寒。特殊防水、且透氣的手套在當地可購得，可使雙手在搬運各式各樣的物品時身手較為敏捷。

Types of Ice Bridges
冰橋的類型

There are three types of ice bridges constructed in the arctic environment:

■Open water bridge.

■Suspended water bridge.

■Grounded ice bridge.

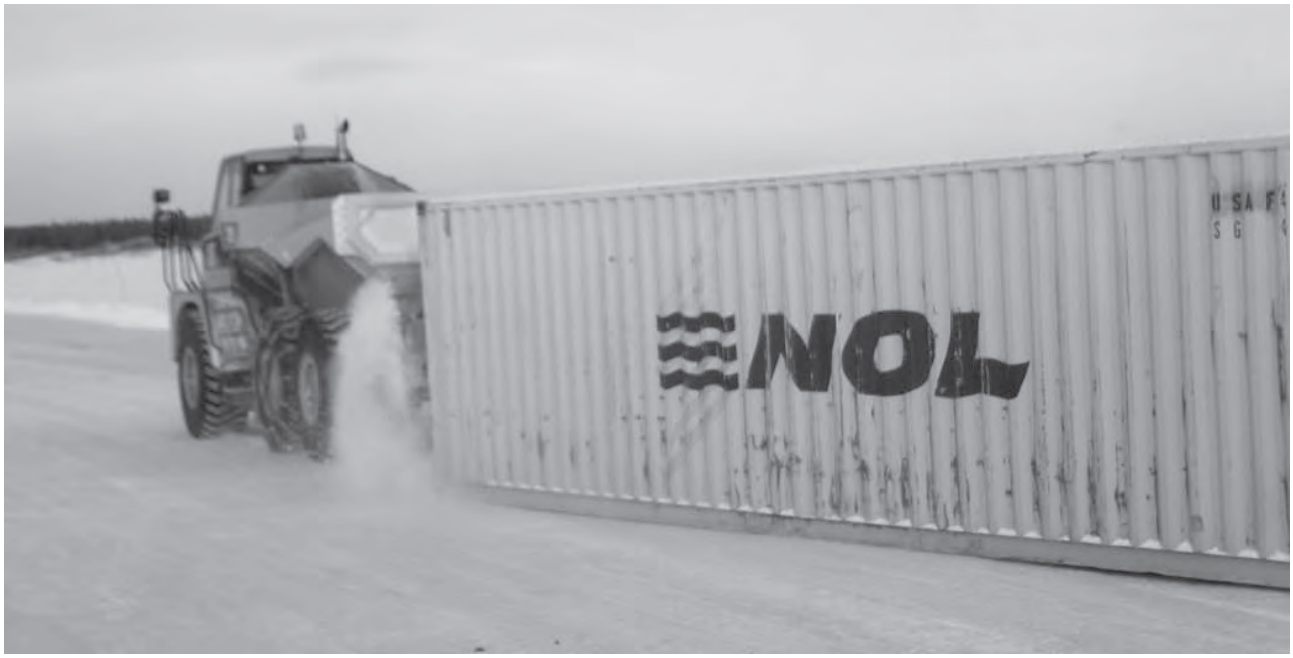
在極地環境下建構的冰橋有三種類型：

● 開放式水橋

● 懸吊式水橋

● 地面冰橋

A Soldier monitors a pumping station to ensure that the intake valve does not freeze shut.
一位士兵正在監看泵浦站，確認導入閥未被凍結。



A container express is dragged into position to be used as a target on the Oklahoma Bombing Range.
在奧克拉荷馬投彈場，一個貨櫃正被拖至定位來當作目標。

A Soldier drives a four-wheeler with an attached snowplow to construct an initial berm for the ice bridge. Two Soldiers in the foreground break up the rough surface with hand-tools.
一位士兵駕駛著四輪除雪車開出一條冰橋的初始狹道，在前方的兩個士兵使用工具敲碎厚重的表面冰層。

According to Field Manual (FM) 3-34.343, *Military Nonstandard Fixed Bridging,* "Engineers [can] create ice bridges by floating large sections of ice cut from the rear of the ice pack into a transverse position across the water gap. Ice bridges are only an expedient temporary measure."

根據野戰教範 3-34.343 「陸軍非制式固定架橋」，工兵(得)利用從後方冰群切離的大塊浮冰，當成橫向位置來建造橫跨水狹的冰橋。冰橋只是一個暫時的緊急措施。

The suspended water bridge is constructed when the intended gap crossing intersects a flowing river or a lake that has ice already established on it. The water under this type of bridge can degrade the thickness of the ice from the bottom upward, thus requiring constant monitoring of the ice. The grounded ice bridge constructed by the 6th Engineer Battalion (Combat) (Airborne) was a structure that closely resembled a road rather than a bridge. A grounded ice bridge is suspended over water in some areas, while grounded on top of a sand berm or dry portion of the river in other areas. A bridge of this type is usually constructed to cross large expanses of land.

懸吊式水橋建構在預定的峽谷上，穿過流動河域或冰湖。在這種橋下的水會讓冰層的厚度由底部向上降低，因此必須經常地監視冰層。第 6 工兵營建構的地面冰橋比較像道路而不是橋樑。當地面冰橋兩側頂端架在沙灘或河道乾枯的地方時，某些部分是懸吊在水上的，這種類型的橋常在通過廣闊的區域時建

構。

Four-Phase Construction Model
四階段建構模組

Construction of an ice bridge is a four-phase operation. The first three phases are berming, shaping, and pumping. After the bridge is constructed, the maintenance phase begins, sustaining the trafficability of the bridge to allow continued mobility along the lines of communication. Ice bridge construction does not follow a set doctrine, so the team developed its own standards and procedures to follow. The key to success lies in understanding the variables that are present: temperature fluctuations, water availability, terrain layout, and the amount and weight of the equipment needed to cross the gap. Only when these variables are understood and analyzed can the gap crossing be constructed.

冰橋的建構分為四個階段，前三個階段為「開道」、「成形」以及「抽水」，在橋完成建造後開始第四個「維護」階段，維持橋的通行狀態來延續整個交通線的暢通性。冰橋的建造並沒有一套準則可遵循，所以團隊發展屬於自己的標準及作業程序來遵循，成功的關鍵在於了解當前的變數：溫度、變動、可用水量、地形變化以及要穿過峽谷的裝備數量及重量，只有在了解並分析完這些變數後才能開始動工。

The common equipment used included M1088 tractor trucks; high-mobility, multipurpose, wheeled vehicles; shovels; mattocks; propane torches; and marking equipment. The mission-specific equipment included typhoon and general-purpose pumps, 3-inch rubber hoses, small-unit support vehicles, 5,000-gallon water trailers, and ice augers. All equipment had to be outfitted for cold weather by ensuring that appropriate fluids and engine block heaters were used.

常用裝備包含M1088牽引式卡車、高機動性多用途輪車、鏟子、鶴嘴鋤、丙烷噴燈、標記裝備。特殊任務裝備包含颱風用及通用幫浦、3英吋橡膠軟管、小單位支援車輛、5千加侖水車、冰鑽，所有的裝備必須能適應寒冷的天氣，確保液態及引擎段加熱器正常使用。

Phase I—Berming. The berming phase consists of snow-moving operations to create a barrier to stop overflow, which occurs when water below is under pressure, rupturing the ice and covering the surface with shallow water. The shallow water

freezes inconsistently and creates a less stable ice structure. The ice below the surface must be at least 36 inches thick for suspended ice or 12 inches thick for grounded ice. These thicknesses will hold the weight of a single D7 bulldozer and represent the minimal thickness to proceed with ice bridging operations using heavy equipment.

第一階段－開道：開道階段包含雪塊移動作業來形成障礙阻止溢流。這階段發生在當底下的水承受壓力，打破冰塊並在表層覆蓋一些水，水逐漸結凍後創造出一個不穩定的冰結構，在表層底下的冰，若是要採懸吊式冰橋，其厚度至少需36英吋厚；若採地面式則至少要12英吋厚。這個厚度將可承受一台D7推土機的重量－這也是冰橋架設作業使用重裝備的最小厚度。

Phase II—Shaping. The shaping phase aims to create an even distribution of water during the third phase. During the shaping phase, Soldiers hastily fill existing ravines, gullies, or crevices with snow, ice, or dirt. Water is then added and allowed to freeze overnight. This process decreases the natural variations in the terrain by filling the low areas with "icecrete," which is frozen water mixed with dirt, sand, or gravel. It can be worked in the same way as concrete, making solid fills that can then be expanded upon in the next phase.

第二階段－成形：成形階段旨在使第三階段的水平均分布。在這個階段，士兵們迅速地用冰或土填滿溝壑、溝渠或是裂縫，然後加水讓它凍結一整晚，這個過程藉由「混凝冰」填平低窪地區減少地形的自然變動，而這「混凝冰」是由水、泥土、沙、碎石混合結凍而成的，就跟混凝土的道理一樣，堅固地填平坑洞然後往下個階段邁進。

Phase III—Pumping. The pumping phase creates a uniformly smooth surface that will ultimately become the surface of the ice bridge. The goal is to create a consistent level of ice across the entire span of the ice bridge by pumping water from the river directly below or from a 5,000-gallon water trailer. This phase relies heavily upon layering ice at appropriate intervals to create strength and density so that it can support the weights that will cross the bridge. The battalion team used a 4.5-horsepower, 3-inch pump to pull water from the river and a water trailer.

第三階段－抽水：抽水階段使冰橋的表面最終變得均勻平滑，目的是藉由直接抽取河中或5千加侖水車的水，使得冰橋垮距的冰層一致。這個階段非常倚賴以適當的間隔堆疊冰層，建立足夠的強度及密度來支撐通過橋樑的重量，該營

的工作隊使用4.5匹馬力、3英吋泵浦從河裡及水車中抽水。

Phase IV—Maintaining. The maintenance phase involves monitoring the thickness of ice down the length of the bridge and ensuring that the ice does not degrade. To maintain the strength and thickness of the ice, a minimum of 1 inch of ice should be spread daily across the length of the bridge. The ice bridge can be degraded by wind damage from the top down or by the flow of the river current below.

第四階段－維護：維護階段包含監視橋下冰層厚度以及確保冰層未受侵蝕。要維持冰的強度及厚度，每天至少對橋從頭到尾都灑上一英吋厚的冰，冰橋可能因風蝕而從上或者河裡的水流而從下侵蝕。

Institutionalization of Ice Bridging Capabilities
冰橋架設能力的制度化

Due to the lack of existing doctrinal processes, the 6th Engineer Battalion (Combat) (Airborne) has several ongoing initiatives to institutionalize ice bridging across the force. Based on lessons learned from the ice bridging mission in January and February 2011, the battalion developed standing operating procedures that documented best practices and lessons learned. The success of the ice bridging mission has resulted in a greater understanding between Army and Air Force engineers. The deputy chief of staff–engineer of U.S. Army Pacific is assessing the feasibility of conducting a subject matter expert exchange program in which theater security cooperation objectives can be met by engaging partner nations on technical engineering topics. Ice bridging is a capability that could benefit a number of countries within the U.S. Pacific Command area of responsibility. If the program is approved, the battalion's expertise could be shared with friends and allies, supporting theater security cooperation objectives and further cementing ice bridging as a niche capability with utility far beyond Alaska.

因為現存準則工法的不足，第6工兵營(戰鬥)(空降)主動不斷地提倡要讓冰橋架設在全軍制度化，根據2011年1月及2月架橋任務中所獲得的經驗，該營發展出標準作業程序，提供最好的實作及學習經驗。冰橋架設任務的成功使得陸軍與空軍工兵彼此更加瞭解，美國陸軍太平洋區工兵副參謀長正做一項有關執行專家交流計畫議題的可行性評估，藉由與合作國從事工兵技術課題來達到戰區安全合作目標。冰橋架設可使許多在美國太平洋司令部責任區的國家受惠，若

此計劃獲批准，該營的專長就可與就能與贊助及同盟國們分享，支援戰區安全合作目標並進一步強化冰橋架設成為利基，功能與實用性遠超過在阿拉斯加。

Within months of completing the ice bridge across the Delta River, the battalion initiated planning for ice bridging operations during the winter of 2011–2012. Lessons learned will be applied to those operations in order to refine the tactics, techniques, and procedures to enable mobility across what would otherwise be severely restricted, or even impassable, terrain. As these tactics, techniques, and procedures are refined, the battalion will disseminate best practices and continue to take the lead in arctic engineering, providing a niche capability to an Army that may one day require mobility support during contingency operations in an arctic environment.

在完成跨越戴爾塔河的幾個月內，該營著手計劃要在2011-2012年的冬天進行冰橋架設作業，將學習到的經驗應用在這些作業中來精進戰術、技術及程序，確保不論是難行區或甚至是無法通行的地形都能機動。隨著些戰術、技術及程序的精進，該營將推廣最佳演練模式並持續地在極地工程中保持領導地位，也許某天陸軍在極地環境中突發作戰需要機動支援時，有適切的能力可以提供。

For more information concerning ice bridges, contact First Lieutenant Collin Russell at <*collin.russell@us.army.mil*>.

更多關於冰橋的資訊，請聯絡柯林.羅素少尉<collin.russell@us.army.mil>

作者簡介

羅素少尉是阿拉斯加州艾門多夫-理察森聯合基地第6工兵營(戰鬥)(空降)第56工兵連的排長。他是2011年2月負責架設跨越戴爾塔河冰橋的軍官，從工兵初級班畢業，擁有德州A&M大學歷史系學士學位。

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