

出國報告（出國類別：其他）

參加國際橋梁隧道及收費公路協會
(IBTTA)第 87 屆年會
出國報告

服務機關：交通部高速公路局
姓名職稱：王鴻基 正工程司
派赴國家/地區：加拿大
出國期間：108.9.13~108.9.20
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出國人員：王鴻基

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內容摘要：第 87 屆 IBTTA 年會於 2019 年 9 月 15 至 17 日在加拿大新斯科舍省 (Nova Scotia) 哈利法克斯(Halifax)舉行，本次年會以「收費業務的永續發展(Growing Your Toll Business in the Next Millennium.)」為主題，會中針對新科技、大數據及風險評估概念應用在公路橋梁資產管理之議題安排多場演講，介紹各國目前的實際執行狀況。此外，本屆年會另針對自駕車的技術進展對公路管理帶來的機會與挑戰安排多場專題演講，並將討論議題區分為 3 大主題以安排分組會議：1.科技與顧客(TECHNOLOGY/CUSTOMER)；2.交通運輸事業 (THE BUSINESS OF MOBILITY)；3.世界動態(THE WORLD AROUND US)。本報告綜整參加本屆年會之過程與見聞，將會議期間所參與之技術參觀、專題演講及分組會議中講者案例分享以及各國目前的應對與準備情形等，分述於前言、行程紀要、技術參觀、會議過程等章節，並於最後提出心得與建議，作為國內未來高速公路收費、交通管理及橋梁維護作業等相關業務推動之參考。

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壹、前言

一、 IBTTA 簡介

國際橋梁、隧道及收費公路協會（International Bridge, Tunnel & Turnpike Association，簡稱 IBTTA）成立於 1932 年，總部設於美國華盛頓特區(Washington, D.C.)，其成員來自於全球 26 個國家，超過 240 個公、民營機構，包括建築公司、工程公司、金融機構、顧問公司及設備製造商等。IBTTA 透過定期舉辦會議、論壇、研討會等場合，將成員聚集在一起分享創新的知識、想法與經驗，並將全球 71 個國家的收費公路統計資料，彙整蒐集後提供各國會員參考、應用，其統計資料之範圍與設施密度分布如圖 1 所示。

此外，在未來即將面對自動駕駛車輛的普及化、網路安全與 5G 高速通訊等議題時，IBTTA 也提供一個交流平台，讓各國收費公路管理單位、交通運輸同業以及對交通運輸基礎設施投資有興趣的投資者，可以分享這些新的挑戰所帶來的機會與願景。

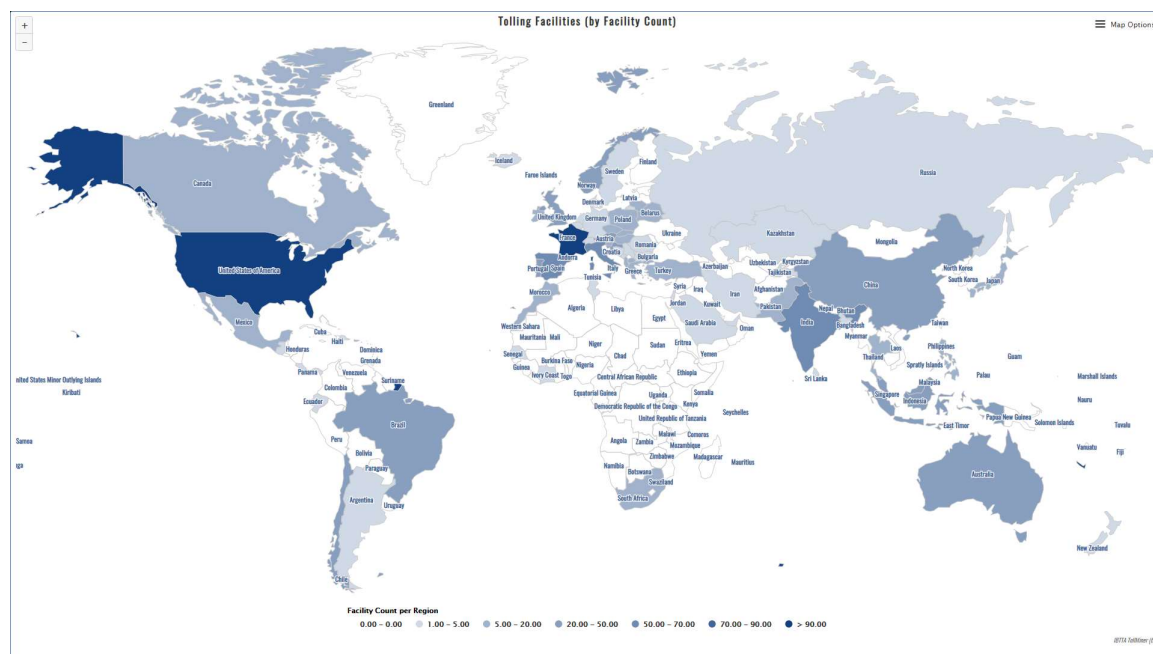


圖 1 IBTTA 收費公路設施資料庫統計資料分布範圍

二、 參加會議目的

第 87 屆 IBTTA 年會於 2019 年 9 月 15 至 17 日在加拿大新斯科舍省(Nova Scotia) 哈里法克斯(Halifax)舉行。本次年會以「收費業務的永續發展 (Growing Your Toll Business in the Next Millennium.)」為主題。今年年會在第 1 天安排技術參觀的對象為 1955 年完工的麥當勞大橋(Macdonald Bridge)，橋梁管理單位在每日上、下班尖峰時刻仍然維持大橋運作的情況下，利用夜間離峰時段施工的方式，逐段將嚴重鏽蝕的橋面板桁架系統及垂直吊索支撐系統分批更新置換，大幅度的延長這座高齡 64 歲的懸索橋壽命。

接下來的 2 天除了會場有各項電子收費(Electronic Toll Collection，ETC)產品、影像監視設備、動態地磅設備、自動化交通維持安全設備及資訊安全廠商等展覽攤位，展示各項先進設備產品及介紹後端資料安全管理系統，另安排多場演講針對公路橋梁資產管理、自駕車的技術進展對公路管理帶來的機會與挑戰等議題，介紹各國目前的應對與準備情形。

高公局為 IBTTA 的會員之一，本次奉派代表出席年會的目的，主要期望藉由參加年會的機會，瞭解國際收費公路創新科技的發展趨勢及他國公路橋梁的維護管理實務經驗，並將技術應用帶回國內，以作為未來公路橋梁維護管理業務推動之參考。

貳、行程紀要

一、 與會代表

本屆年會共有來自 19 個國家，561 位來自各國公營機構的收費公路管理單位、學者、顧問公司代表以及來自金融機構、交通運輸產業的設備廠商一起參與，其中以美、加兩國代表為主，約占全體出席代表的 9 成，東亞地區僅有我國、香港及日本派代表參與，各國與會單位及人員名單詳見附錄一。

二、 會議地點

本次年會選擇加拿大東岸新斯科舍省（Nova Scotia）的港口都市哈里法克斯（Halifax）舉辦，該市為一天然深水港，港口內陸上交通主要係依靠兩座跨港大橋（Macdonald Bridge 及 MacKay Bridge）連接，其中 Macdonald Bridge 係於 1955 年完工，2018 年剛剛完成橋面板桁架及垂直懸索系統的更新，橋梁管理單位為哈里法克斯港口橋梁公司（Halifax Harbour Bridges），亦即為本次年會主辦場合地主，會議第一天主辦單位即安排 Macdonald Bridge 的技術參觀行程。

其餘大會各項專題演講及贊助廠商產品展覽會場地則安排於哈里法克斯會議中心（Halifax Convention Center）舉行。

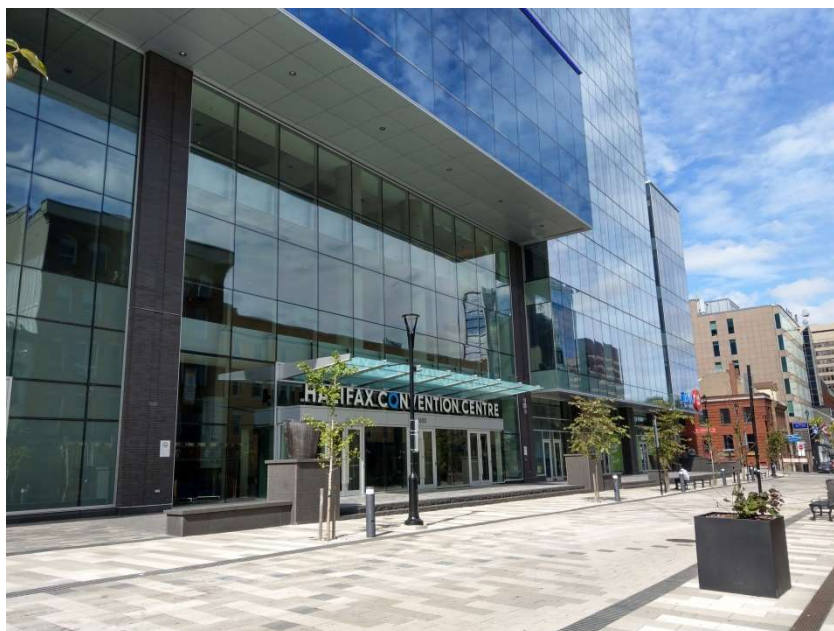


圖 2 IBTTA 第 87 屆年會舉辦會場
(Halifax Harbour Bridges)

三、 行程概述

本次出國行程自民國 108 年 9 月 13 日至 9 月 20 日，包含往返交通時間共為期 8 天，主要行程為參加 9 月 15 日至 9 月 17 日第 87 屆 IBTTA 年會，除參加各場相關專題演講外，並參加大會所安排的技術參訪行程，觀摩橋齡達 64 年的懸索吊橋維護更新作業成果，行程整理如表 1 所示。

表 1 出國行程表

日期	地點	活動內容
9 月 13 日	桃園→加拿大多倫多	去程，搭乘長榮航空自桃園機場飛抵多倫多機場轉機
9 月 14 日	加拿大多倫多→哈里法克斯	1. 上午:自多倫多機場轉乘加拿大航空國內線至哈里法克斯 2. 下午:參加 IBTTA 新成立的青年專業理事會 (Young Professionals' Council)
9 月 15 日	1.哈里法克斯麥當勞大橋 2.哈里法克斯會議中心	1. 上午:技術參觀 2. 下午:參加主辦單位為新進會員及首次參加 IBTTA 會議的出席代表舉辦之非正式歡迎茶會。
9 月 16 日	哈里法克斯會議中心	1. 上午:大會開幕式及專題演講 2. 下午:頒獎典禮及世界櫥窗分享
9 月 17 日	哈里法克斯會議中心	1. 上午: 哈里法克斯市長歡迎致詞及 IBTTA 會務報告 2. 下午:分組研討會
9 月 18 日	加拿大哈里法克斯→多倫多	返程，自哈里法克斯機場搭乘加拿大航空國內線至多倫多轉機
9 月 19 日~ 9 月 20 日	加拿大多倫多→桃園	返程，搭乘長榮航空自多倫多機場飛抵桃園機場

展覽會場總計有超過 35 家參展廠商，其專業領域從區塊鏈軟體、無線射頻製造到各式交通工程設施及車輛均有，提供各國與會者在各場演講的空檔，可以互相交流、了解目前新科技的發展與應用進程(圖 3、圖 4)。

本屆年會 9 月 16、17 兩天，分別由本屆 IBTTA 董事會主席 Christopher Tomlinson(圖 5)以及當地哈里法克斯市長 Mike Savage (圖 6)致詞揭開當天活動序幕。



圖 3 展覽會場及參展廠商活動照片



圖 4 筆者於展覽會場與參展廠商合影照片



圖 5 IBTTA 本屆董事會主席 Christopher Tomlinson 開幕式致詞



圖 6 哈里法克斯市長 Mike Savage 致歡迎詞

參、技術參觀

IBTTA 本屆年會選擇舉辦地點為加拿大哈利法克斯，為加拿大東岸的港口都市，港口內有 2 座跨港大橋，分別為 1955 年完工通車的 Macdonald Bridge 及 1970 年完工通車的 MacKay Bridge，橋梁管理單位為哈利法克斯港口橋梁公司(Halifax Harbour Bridges，簡稱 HHB)，該公司董事會 9 名成員均由當地省政府及市議會指派，其性質類似我國的公法人。

一、大提升計畫(The Big Lift)背景說明

其中 Macdonald Bridge 因橋面鏽蝕問題嚴重，橋梁管理單位 HHB 公司自 2009 年開始推動橋面板更換及橋梁延壽計畫，稱之為「大提升計畫(The Big Lift)」，計畫推動過程如表 2 所示。

表 2 大提升計畫(The Big Lift)推動過程

時間	計畫進程
2010	董事會核准 Macdonald Bridge 橋面板更換計畫
2011	先期規劃作業
2013 年 12 月	設計成果定稿
2014 年 6 月	發包選商作業完成
2015 年 3 月	現場施工作業開始
2015 年 6 月	橋面人行道及自行車道封閉
2015 年 10 月	橋面板第 1 節塊吊裝
2017 年 2 月	橋面板最後 1 節塊吊裝
2017 年 6 月	橋面人行道及自行車道重新開放
2017 年 12 月	橋梁夜間封閉施工作業全部結束
2018 年第 1 季	計畫結束

本計畫除更換橋面板及其桁架系統、垂直吊索支撐系統外，亦針對主吊纜(Main Cables)安裝除溼系統，以控制主吊纜鋼索可持續保持在 40%的相對溼度環境下，減少主吊纜(Main Cables)的鏽蝕速度，其除溼系統配置方式如圖 7 及圖 8 所示；除此之外，本座吊橋的主塔、主吊纜及錨定系統均仍維持其原始狀態，本計畫為歷史上第 2 次在維持橋梁日間通行功能的條件下，利用假日及夜間施工方式，將懸索吊橋橋面板全面置換的工程。

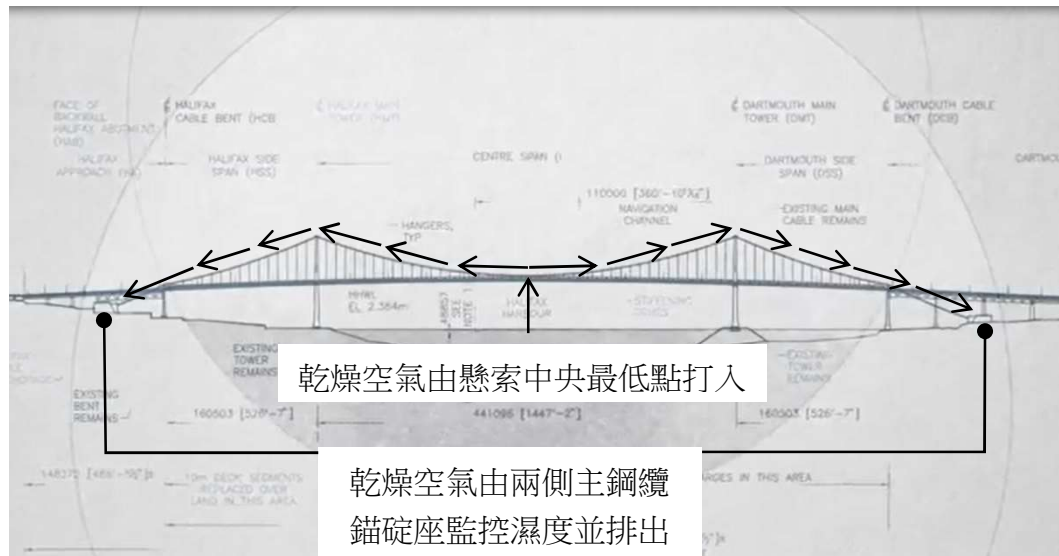


圖 7 Macdonald Bridge 主鋼纜除溼系統配置



圖 8 Macdonald Bridge 主鋼纜乾燥空氣打入主鋼纜懸索套管位置照片

二、現場參觀

本次主辦單位於年會第 1 天(9 月 15 日)早上即安排參觀完工後之 Macdonald Bridge 橋面板置換工程(The Big Lift)，該橋梁全長約 1.35 公里，橋面寬 11.5 公尺(採雙向各 1 車道，另有一調撥車道)，基本資料整理如表 3 所示。

與會代表分乘 2 輛遊覽車，第 1 站先至 Macdonald Bridge 吊橋南岸之錨碇基礎座機房參觀，可惜主辦單位為了安全理由，要求參觀者不可以拍攝機房內部設施及錨碇座狀況，無法以圖片展示這座高齡 64 歲吊橋鋼纜的維護狀況，以當日目視內部

設施情形，除機房混凝土表面有少部分肉眼清晰可見的非結構性裂紋外，錨碇座位置處的主鋼纜及保護套管表面並無任何鏽蝕現象，經當場請教負責維護管理大橋的 HHB 公司 Ahsan Chowdhury 總工程師表示，吊橋主鋼纜除了在 2010 年曾經打開一小段保護套管進行目視檢查外，並無安裝其他應力、應變或是振動監測設備，機房內亦僅看見溼度監測設備，控制鋼纜可以長期維持在相對濕度 40% 以下的環境。

表 3 Macdonald Bridge 基本資料表

建造日	1952 年
完工通車日	1955 年 4 月 2 日
橋長	1.35 公里
懸索橋跨度	主跨 441m，兩側邊跨各 160m
引橋段	北側 437m，南側 148m
橋塔	鋼構，92m 高
基礎	混凝土沉箱基礎
橋下航道寬度	110m
橋下航道淨高	51m
車道數	3
鋪面設計	主橋段採 5 公分厚環氧樹脂瀝青混凝土(Expoxy Asphalt) 引橋段採 5 公分厚高分子改質瀝青混凝土(PMA)
主吊索鋼纜	直徑 356mm(61 股 40mm 直徑鍍鋅鋼絞線)
垂直吊索鋼纜	直徑 54mm 鍍鋅鋼絞線



圖 9 Macdonald Bridge 南岸主鋼纜錨碇座機房照片

此外，在主鋼纜錨碇座機房內，發現除了吊橋主鋼索的錨碇座之外，另有平行主鋼索的裸鋼絞線，Ahsan Chowdhury 表示這是因為經過測量後發現，Macdonald Bridge 的兩座主橋塔，有向彼此傾斜的現象，因此在大提升計畫(The Big Lift)中，於錨碇座和邊跨墩柱之間增加了 2 條鋼纜，以避免兩座主橋塔之間的相向傾斜情形加劇，如圖 9、圖 10 所示。



圖 10 Macdonald Bridge 主鋼纜錨碇座與邊跨墩柱增設之拉固鋼索



圖 11 Macdonald Bridge 主橋橋面板(deck)系統更新後外觀(由南向北拍攝)

結束了錨碇座機房的參觀之後，主辦單位帶大家搭車至南岸引道橋，沿橋面步行約 1.35 公里，參觀完成後之橋面設施，如圖 12~14 所示，其中橋面欄杆的特殊造型設計引起筆者好奇，經 HHB 施工單位人員說明，係因為在橋面板更新計畫之前，曾經有路人從橋面跳下自殺，導致下方的加拿大軍方向橋梁管理單位提起求償訴訟，因此改建計畫中，特別沿著人行道外側增加了防止人員攀爬的橋欄杆。



圖 12 Macdonald Bridge 橋面人行道防自殺欄杆



圖 13 Macdonald Bridge 橋面模組型伸縮縫

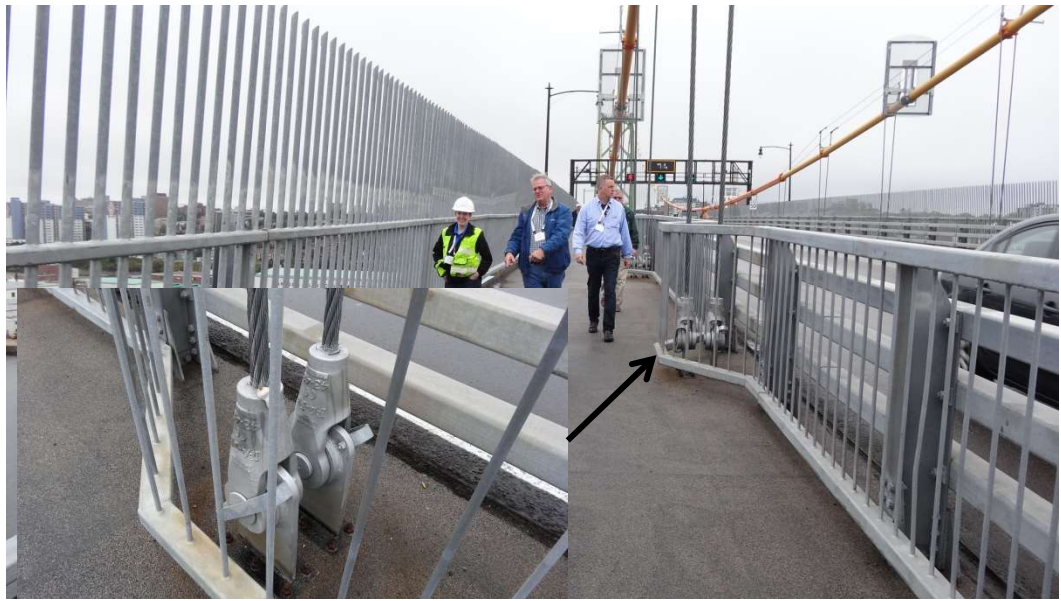


圖 14 垂直鋼纜與新設橋面接合部位

三、大提升計畫(The Big Lift)施工方式簡報

因為目前該計畫施工作業已經結束，不易想像當時的施工過程，所以主辦單位在一行人步行抵達橋梁北岸的 HHB 辦公室以後，即以簡報及影片介紹方式，說明大提升計畫(The Big Lift)的施工方式及過程。

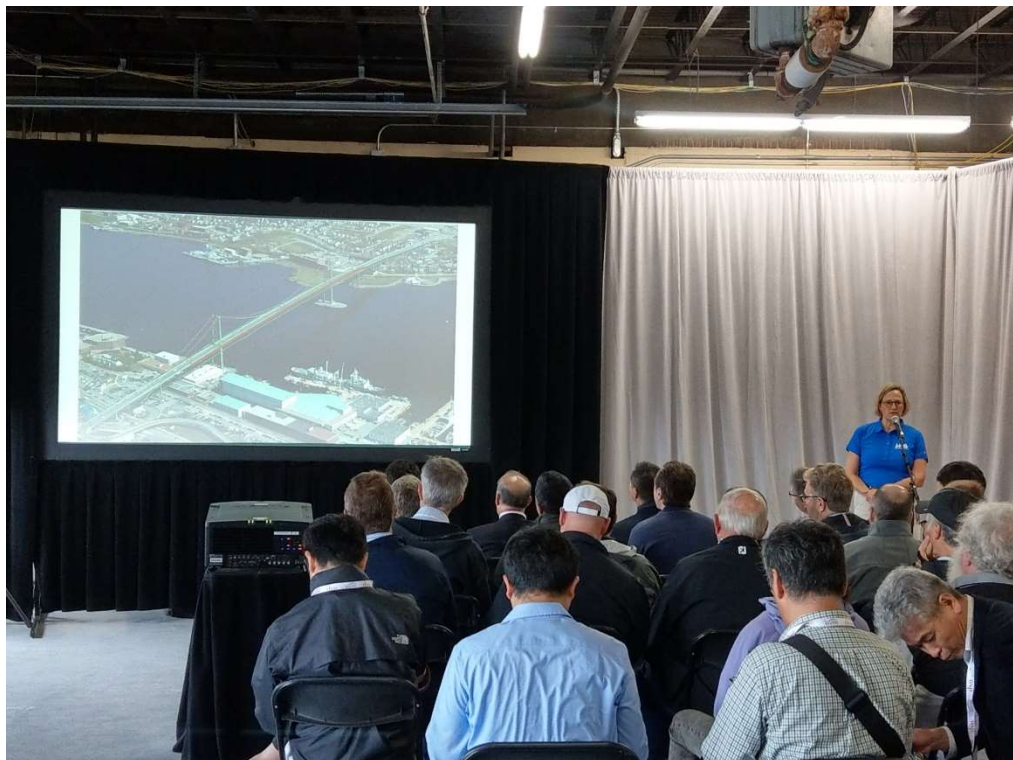


圖 15 HHB 簡報解說大提升計畫施工過程

圖 16 為 Macdonald Bridge 改建前的照片，大提升計畫即是利用夜間(19:30~翌日 05:30)及周末假日時段，將橋面板原有的下承式桁架系統(如圖 17 所示)，更新為圖 18 中的上承式桁架系統，日間仍持續開放往來車輛通行，施工期間僅須全程封閉橋梁兩側的人行道，以提供施工設備、機具及材料的置放空間。

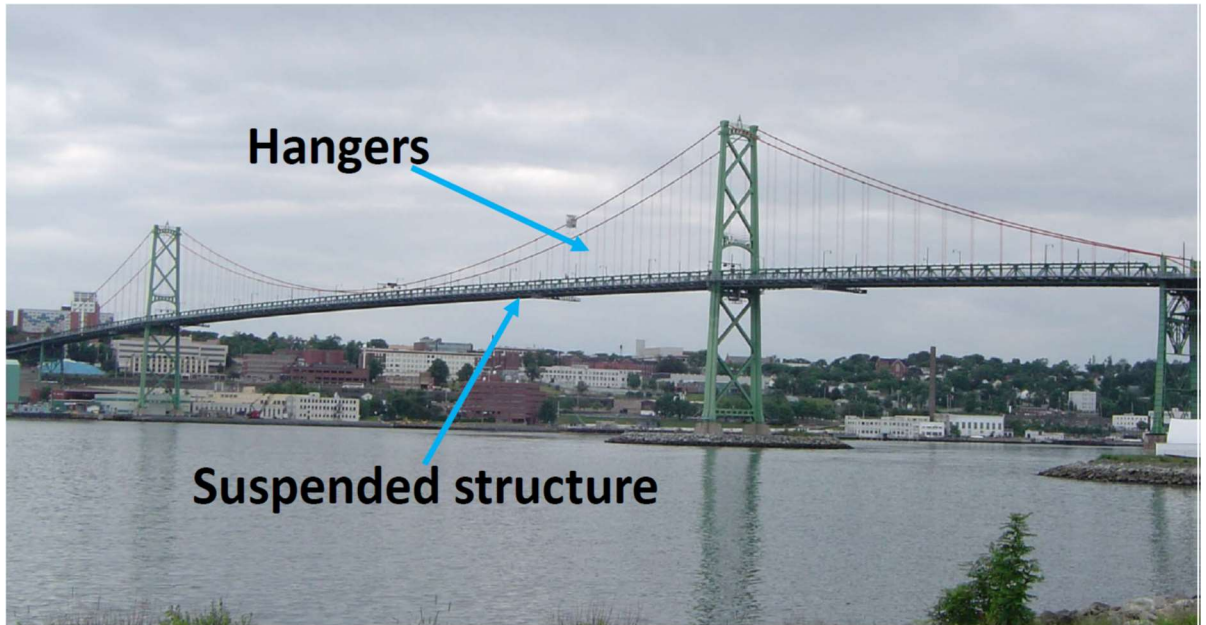


圖 16 Macdonald Bridge 改建前照片(摘自 HHB 簡報)

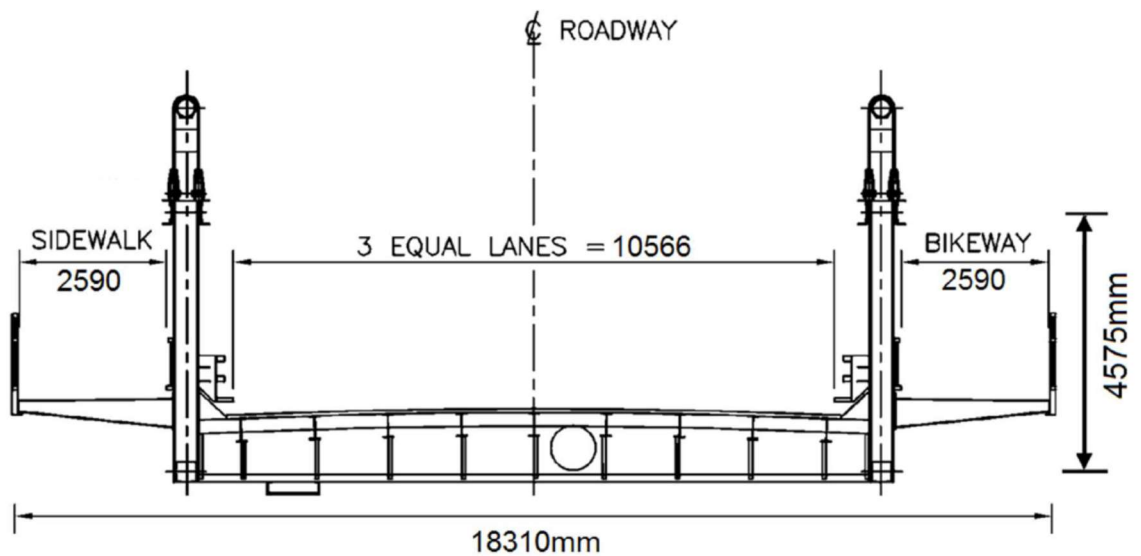


圖 17 Macdonald Bridge 原有的橋面板結構系統(摘自 HHB 簡報)

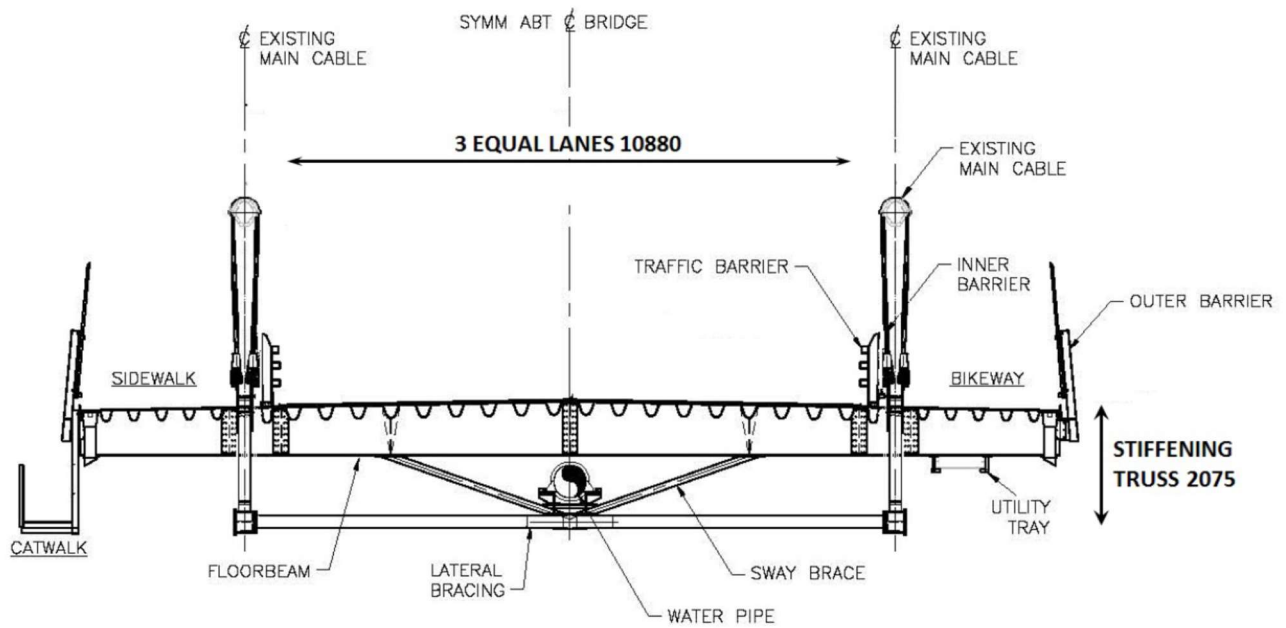


圖 18 Macdonald Bridge 更新後橋面板結構系統(摘自 HHB 簡報)

施工順序係由懸索橋北岸邊跨架設吊梁工作車(gantry)，工作車利用既有夾具將工作車自重及吊重傳遞至既有垂直鋼索，懸浮於既有橋面板系統上方，如圖 19、20 所示。



圖 19 大提升計畫吊梁工作車照片(摘自 HHB 簡報)

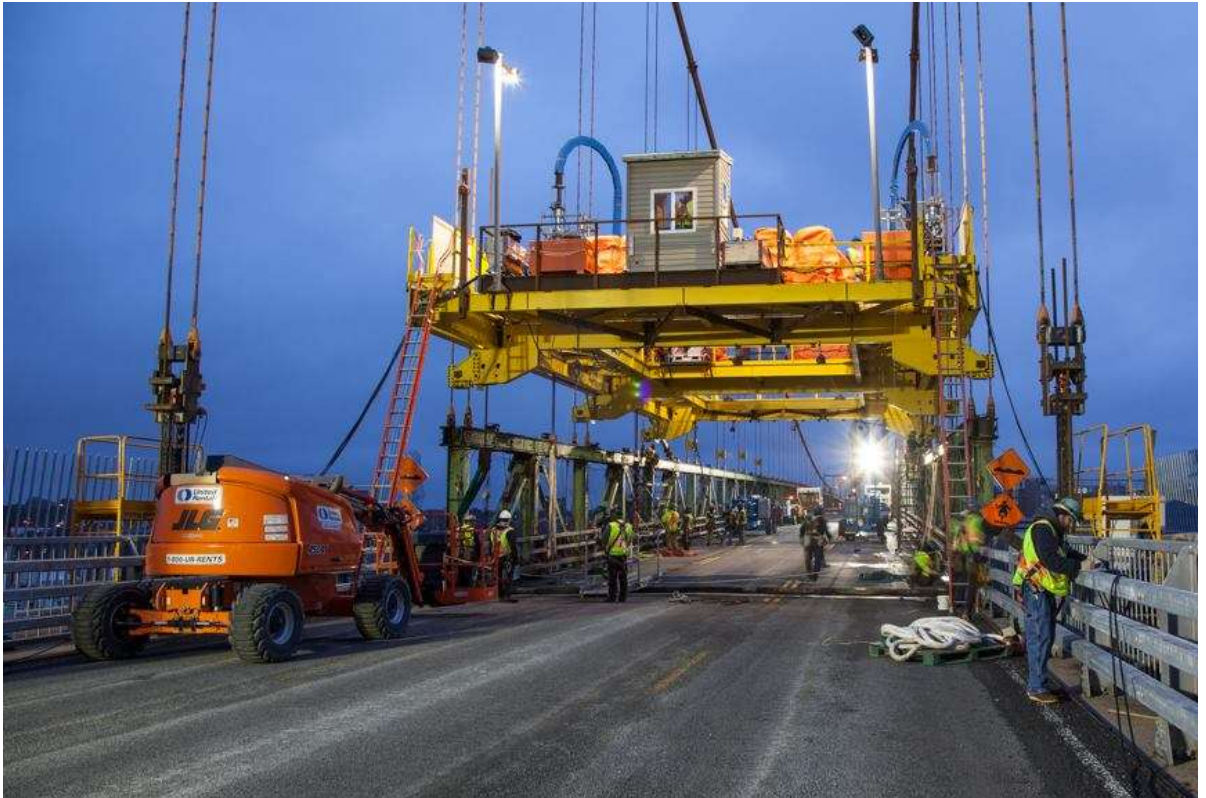


圖 20 大提升計畫吊梁工作車橫斷面照片(摘自 HHB 簡報)

夜間封閉時段，將一段長度約 10~20m 單元的舊橋面板切割後，吊掛於工作車上，緩緩下放置橋梁下方的大型駁船(barge)上，再利用工作車將已經預鑄完成的新橋面板單元自駁船上吊升，並與已吊裝完成之前跨橋面板焊接，俟橋面板銜接後即可開放車輛通行，如圖 21~23 所示。



圖 21 舊橋面板切除後吊放至橋下駁船照片(摘自 HHB 簡報)



圖 22 預鑄完成之新橋面自橋下駁船吊升銜接照片(摘自 HHB 簡報)

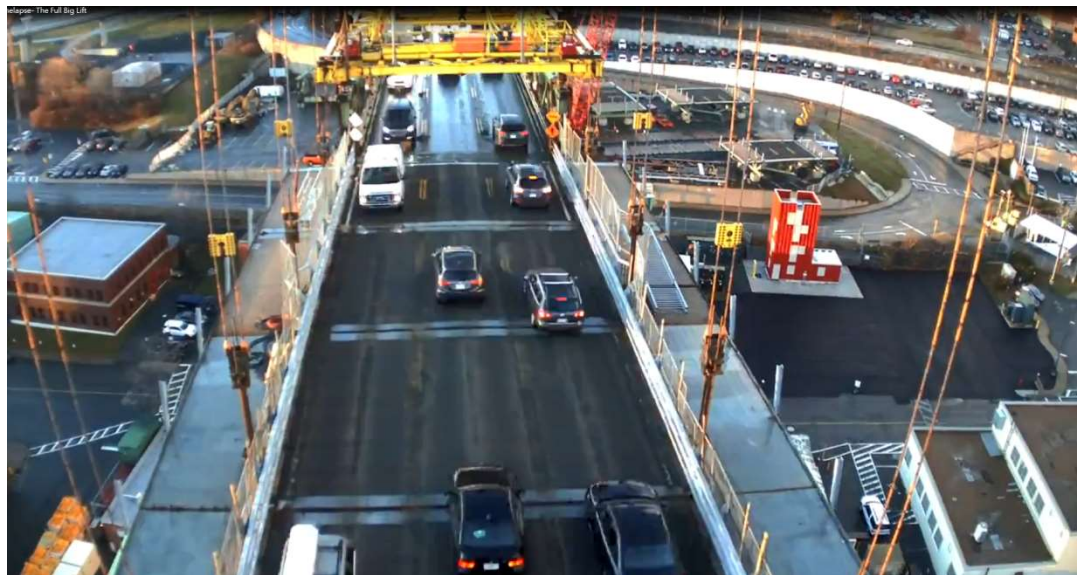


圖 23 新橋面板與前跨橋面板銜接完成後即開放通車(摘自 HHB 簡報)

如此以每周 2 單元的施工速率重複向南岸推進，於 2017 年完成全部 46 單元的橋面板置換工程。

HHB 公司於本計畫完成後，將施工過程中的照片紀錄彙整成冊，印製成一本攝影專輯，提供本次年會會員攜回，詳如附錄二。

肆、會議過程

一、開幕前會議

IBTTA 本屆年會於 9 月 14 日下午邀請所有與會代表參加新成立的专业青年委員會(Young Professionals' Council，簡稱 YPC)，本會議主要希望在一个非正式的、輕鬆舒適的環境下，替新一代的收費公路產業同儕們建立一個長久的社群合作關係，在會議中藉由資深會員擔任導師(mentor)的方式，介紹 IBTTA 可以帶給大家的資源，並引導大家以腦力激盪的方式，提供建議幫助 IBTTA 的永續發展以及年輕專業人才獲得經驗傳承，具體的建議包括網路研討會(Informative Webinars)、內部同儕指導(Internal/Peer-to-peer mentorship)、大學校園拓點(University Outreach)、舉辦 YPC 獨立會議(YPC Independent Conferences)、提供口語簡報演說技巧練習機會(Opportunities to practice presentation and speaking skills)等。

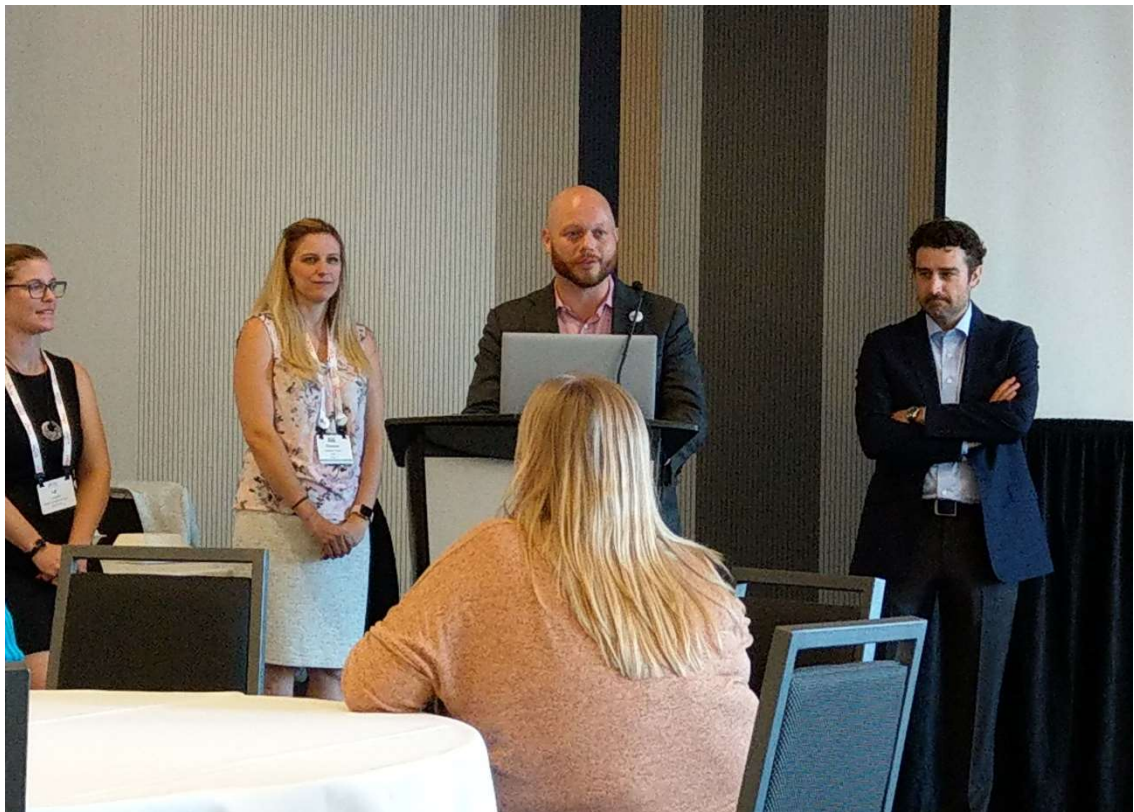


圖 24 YPC 會議過程照片

二、開幕典禮及專題演講

(一)、開幕致詞

本屆年會於 9 月 16 日正式揭開，首先由 HHB 公司總經理兼執行長(CEO)Steven Snider 代表地主歡迎各國會員來到加拿大哈利法克斯(Halifax)，並說明本次年會已經是 IBTTA 第 4 次選擇在 Halifax 舉辦活動，接者由本屆 IBTTA 主席 Christopher Tomlinson 代表主辦單位歡迎各國代表及參展廠商的出席，並摘要說明了接下來兩天各項活動的重點。



圖 25 HHB 公司 CEO Steven Snider(左)及 IBTTA 主席 Christopher Tomlinson 致詞

(二)、專題演講

接著主辦單位邀請美國前《華盛頓郵報》記者、北卡羅來納州羅利市《奧蘭多前哨報》和《新聞與觀察家》的記者兼編輯-查爾斯菲什曼（Charles Fishman）進行專題演講(Keynote Speech)，主講人曾贏得了無數獎項，包括三度獲得商業新聞界最負盛名的杰拉德·勒布獎（Gerald Loeb Award）。

Fishman 以美蘇冷戰期間，世界兩大強權的太空競賽過程為主題，訴說在蘇聯首先以太空船載人進入外太空地球軌道並安全返回地球後，美國總統約翰甘迺迪隨即於 1961 年 5 月 25 日向美國國會提出了一項大膽、前衛而且非常昂貴的計畫---阿波羅計畫，將在 1970 年以前派遣太空人登陸月球後，再安全返回地球。在約翰甘迺迪提出此一大膽計畫的當下，美國國家航空暨太空總署(NASA)的載人火箭僅有 5 分鐘的太空飛行經驗，沒有人知道月球表面是什麼樣子，也沒有人知道太空人在過程中會遇到甚麼狀況，NASA 必須在短短的 8 年內，解決成千上萬個問題。

最終，NASA 成功的在 1969 年 7 月 20 日以阿波羅 11 號完成登陸月球的壯舉，演講過程中，Fishman 詳細的解說阿波羅計畫所面對到的各種困難，以及如何在充滿創新的不確定性以及時間壓力下，維持住阿波羅計畫前進的動力與方向，事實上，這樣的故事在我們現在的身邊也一直不斷的上演，例如我們所面對的氣候變遷議題

等，Fishman 或是阿波羅計畫的故事，正提醒我們該如何聚焦解決處理所面對到的各式各樣問題。



圖 26 Charles Fishman 專題演講

(三)、橋梁資產管理

由於大跨度懸索橋的施工造價及維護成本均相當高昂，許多老舊橋梁的維護費用甚至是隨著橋齡呈指數成長，IBTTA 今年針對要如何透過以風險評估為基礎的資產管理計畫，進行橋梁的維護管理工作，邀請了美國、加拿大、丹麥等國家的橋梁管理單位及顧問公司，介紹各地橋梁管理單位的維護作業以及資產管理計畫，以提供各國橋梁管理當局作為日後橋梁養護工程作業的參考。以下分別就各講者的簡報內容摘要說明如後。

1. MTA Bridges and Tunnels 公司的資產管理演進

【主講人】：Justine Tietjen(簡報資料詳附錄三)

【單位】：紐約州紐約市 MTA Bridges and Tunnels 公司副總工程師

以交通量而言，MTA Bridges and Tunnels 公司是美國最大的橋梁和隧道收費機構，所轄管橋梁包含 4 座橋齡高達 55~83 年的懸索橋(銜接紐約市皇后區、布魯克林區)，

如圖 27 所示，其例行性的維護作業，如伸縮縫維修、油漆塗裝、橋梁墩柱清洗及排水疏通等工作，係採用契約外包方式委託辦理。

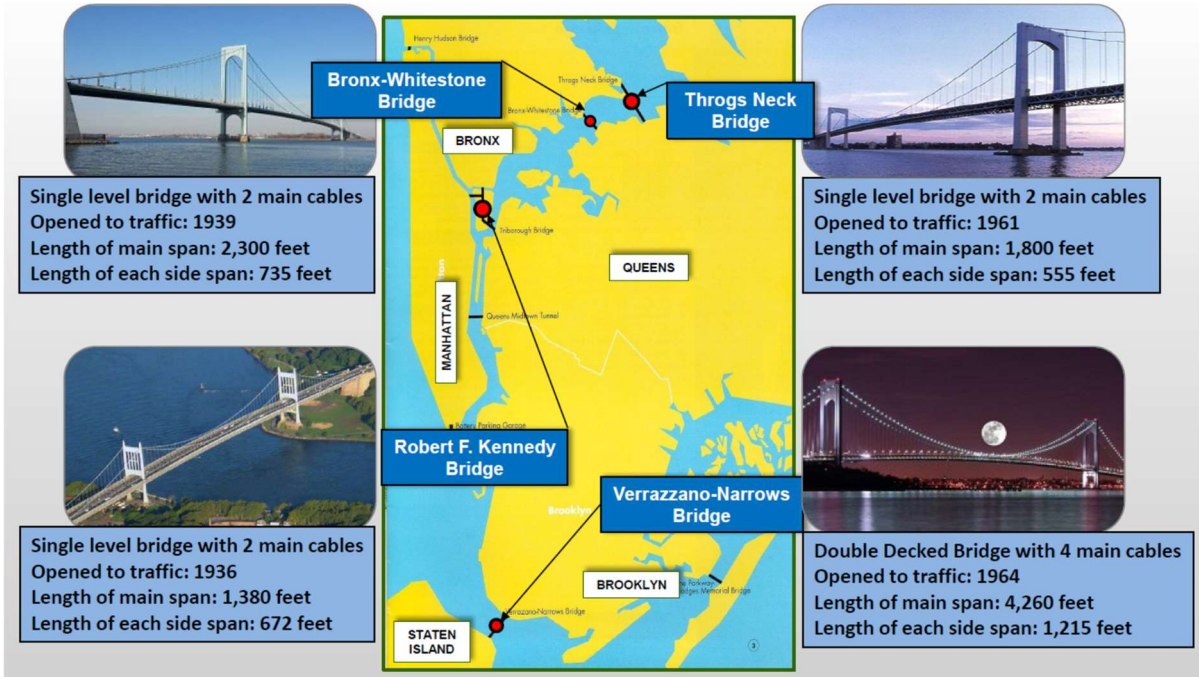


圖 27 MTA Bridges and Tunnels 公司所轄懸索橋位置

另外針對資產管理方式，則根據資產狀況的檢查結果、結構元件的風險分析、不同災害的危害度分析、新規範的適用行以及區域交通的需求等項目，訂定 20 年期的主計畫(Master Plan)，每隔 5 年則檢討更新主計畫內容。

資產狀況的檢查，除了依據聯邦政府強制規定每 2 年須辦理一次的例行性檢查外，並針對部分無法以目視評估的特殊重要元件安排特別檢查，例如懸索橋的主鋼纜狀況。

結構元件的風險分析，則是在資金有限的情況下，依據個別元件的風險評估結果，訂定風險優先數值(Risk Priority Number, RPN)，其數值之大小係由個別元件之重要性乘以脆弱性後決定，以針對 RPN 數值較高者優先進行維修、更新。

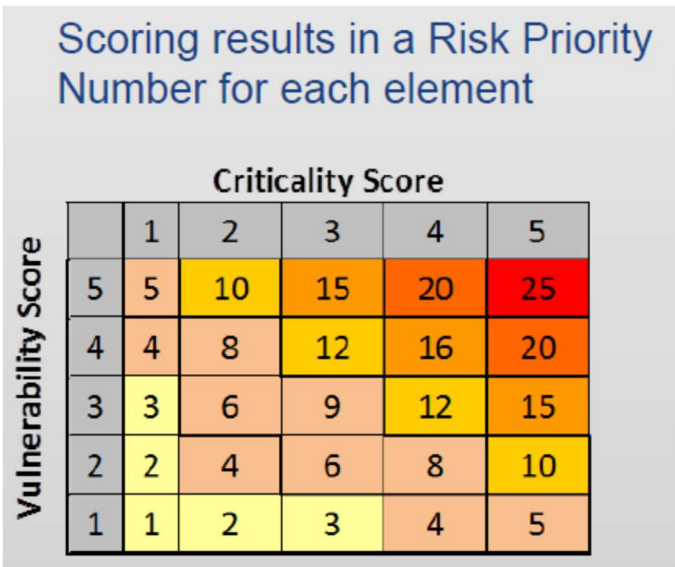


圖 28 結構元件風險評估矩陣圖

不同災害之危害度分析，則是考量橋梁受到不同種類天災、人禍的危害度評估，包括地震、颶風、車輛超載、火災、河道沖刷或船隻碰撞等因素之影響。

透過 20 年期主計畫的規劃以及每 5 年的滾動式檢討，MTA Bridges and Tunnels 不僅可以及時解決橋梁元件的惡化狀況，而且可以進行重大改善以消除結構功能上的過時設計，並適時改善當地區域的交通狀況。

2. 風險及資產管理

【主講人】：Barry Colford (簡報資料詳附錄四)

【單位】：AECOM 公司副總經理

目前各國橋梁、隧道、公路管理單位均面臨到越來越嚴峻的挑戰，包括設施的老化、氣候的變遷、環保意識的抬頭等等，要如何在人力、預算越來越受限的情形下，做更多的工作，便突顯了資產管理對各個國家公路橋梁管理者的重要性。

主講人首先定義何謂運輸資產管理，即是在全生命週期中，對交通運輸資產操作、維護、升級和擴充的系統化決策過程，特別是著重於利用充分的資訊，找出明確的目標進行資源的重分配，除了希望讓各項設施可以達到一定的服務水平外，也希望在資產的全生命週期下，達到支出成本最小化的目標。

講者介紹美國聯邦公路總署(FHWA)2005 年針對英國、紐西蘭、澳洲及加拿大等四國的公路管理單位，對路網資產管理的案例研究成果，說明各國現階段對風險及資產管理的處理方式。

英國

在英國推動資產管理最重要的動力之一，即是來自政府主管當局的運輸政策和會計程序的要求。

在過去的 25 年中，英國路網私有化亦使資產管理成為英國道路和橋梁管理的主要工具。關鍵績效指標(KPI)、風險分析和全生命週期成本計算則用來衡量績效並確定維護資源分配的優先順序。

紐西蘭

紐西蘭在路網管理的許多方面處於世界領先地位，良好的資訊和有效的管理至關重要，除了同樣採用關鍵績效指標(KPI)、風險管理和全生命週期成本計算等方法外，紐西蘭政府創新採用了以績效表現為基礎的維護合約，建立了一套以績效導向為主的資產管理決策架構。

澳洲

澳洲新南威爾斯公路路網管理採用外包方式管理，當需要辦理公路路網和道路容量的擴展時，則使用收益與成本分析比較來證明投資的合理性。

公路橋梁等基礎建設的資產管理，則依照資產的種類決定分析程序，並透過風險管理流程確定資產管理項目的投資優先順序。

加拿大

加拿大亞伯達省自 1990 年代中期，將公路橋梁設施管理外包給私人公司，資產管理計畫亦是透過風險評估分析，系統性的識別基礎設施弱點，並據以重新調整維護資源的分配。

FHWA 的個案研究得出的結論是，風險概念需要更有系統地納入美國資產管理工作中，風險評估及風險管理為資產管理的關鍵工作。

風險分析亦是採用風險優先數值(Risk Priority Number, RPN)，RPN 則是由脆弱性矩陣(Vulnerability Metrics)及重要性矩陣(Criticality Metrics)的乘積決定。此外，基礎設施的主管機關則可能希望將 PESTLE 可能包含的所有風險納入（政治 political，經濟 economic，社會 social，技術 technical，法律和環境 legal and environmental）。

3. 哈里法克斯港灣橋梁資產管理的過去、現在及未來

【主講人】：Ahsan Chowdhury (簡報資料詳附錄五)

【單位】：Halifax Harbour Bridges 公司總工程師

Halifax Harbour Bridges 公司轄管港口內兩座大型懸索橋及其引道，16 座輔助結構及收費設施(含建築)，以往該公司對其設施的管理養護方式可以分為以下 6 個步驟：

- A. 年度例行檢查或專案檢查:填寫檢查報告資料卡，建立橋梁資產基本資料。
- B. 建議維護作業內容:依據現場檢查結果，於檢查報告資料卡填寫維護建議及優先順序(如表 4 所示)。
- C. 詳細評估:針對較嚴重或是較重要之部分，進一步詳細評估，並率定後續須修復/翻新/置換之範圍。
- D. 提出資本支出計畫:針對須大幅度置換、更新之資本支出工作，擬定建設計畫並提出預算，提報董事會核定。
- E. 設計及發包。
- F. 展開現場之新建/修復/翻新/置換作業施工。

表 4 HHB 年度檢查報告資料卡

Number ID	Element	Location	Maintenance Recommendation	Maintenance Type	Priority
2018-AMM-3	Bearings	HAb (free)	Continue to monitor the bearings.	Monitor Condition	1-3y
2018-AMM-5	Bearings	H2 (fixed)	Reposition longitudinal restraints prior to undertaking vertical bearing replacements in the future (if required).	Bearing Repair	7y+
2018-AMM-10	Bearings	D3 (fixed)	Continue to monitor the bearings.	Monitor Condition	1-3y
2018-AMM-12	Bearings	D5 (free)	Continue to monitor the bearings.	Monitor Condition	1-3y
2018-AMM-16	Bearings	DAb (free)	Continue to monitor the bearings.	Monitor Condition	1-3y
2018-AMM-17	Expansion Joints	HAb, HCB, DCB, DAb	Clean debris from joint.	Bridge Cleaning	< 1y
2018-AMM-18	Expansion Joints	D5	Repair or replace the expansion joint gland.	Expansion Joint Repair	< 1y
2018-AMM-20	Expansion Joints	DCB	Monitor gland on north side.	Expansion Joint Repair	< 1y
2018-AMM-21	Girder Span Access	HGS b/w Pier H1 and HCB	Clean and repair coatings at welded connections.	Minor Steel and Coating Repair	4-7y
2018-AMM-22	Girder Span Access	Pier D5	Fix the access doorways at Pier D5.	Access Maintenance	1-3y
2018-AMM-23	Girder Span Access	HGS/DGS	Consider modifying floor hatches to facilitate safe operation.	Access Maintenance	1-3y

目前該公司針對各項橋梁元件的檢查、評估作業方式，已經逐漸修改為以風險分析為基礎的量化評分，由各橋梁元件的整體重要性因子(Global Importance Factor, GIF)，以及橋梁元件的危害衝擊加權指標(Weighted Average Defect Impact, WADI)，求得各元件的風險優先數值(Risk Priority Number, RPN)，即 $RPN = GIF * WADI$ ，並依據 RPN 數值建議維護處理時機，如圖 29 所示。

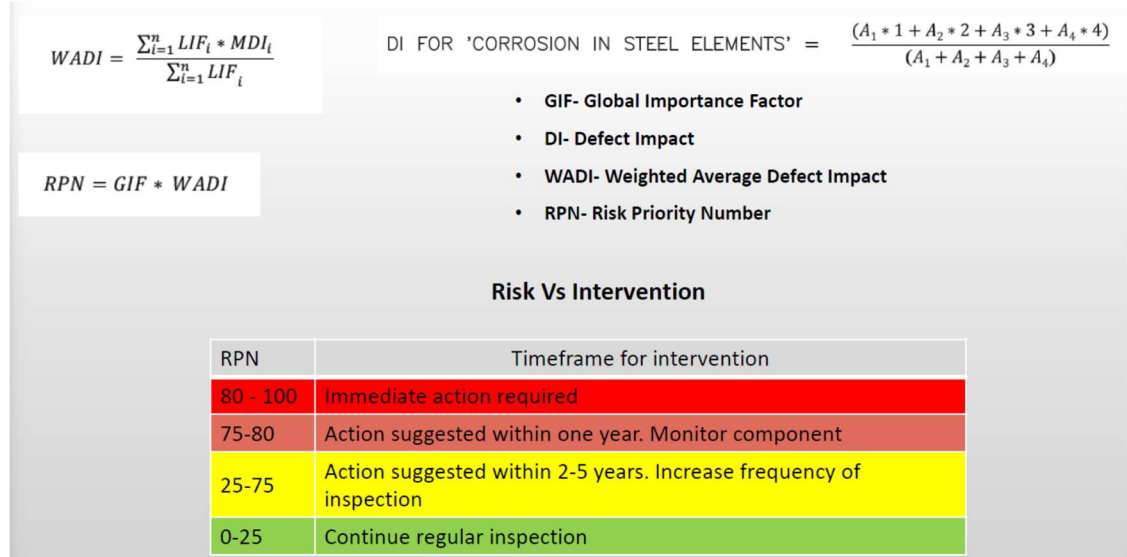


圖 29 結構元件 RPN 數值與處理時機建議

表 5 則為 2016 年與 2017 年改採用以風險評估為基礎的作業方式後，各元件檢查後的 RPN 數值與處理建議。

表 5 HHB 採用風險優先數值 RPN 評估成果

Date (dd/mm/yyyy)	Segments Inspected	GIF	WADI	RPN	Timeframe for Intervention
03/06/2016	H1	20	1.38	27.60	Action suggested within 2-5 years. Increase frequency of inspection
28/06/2016	M4	20	1.28	25.60	Action suggested within 2-5 years. Increase frequency of inspection
24/05/2017	D12	20	1.55	31.06	Action suggested within 2-5 years. Increase frequency of inspection
24/05/2017	1/2 D13	20	2.23	44.62	Action suggested within 2-5 years. Increase frequency of inspection
28/06/2017	M1	20	1.04	20.80	Continue regular inspection
24/05/2017	1/2 M2	20	2.29	45.80	Action suggested within 2-5 years. Increase frequency of inspection
28/06/2017	1/2 M2	20	1.00	20.00	Continue regular inspection
24/05/2017	1/2 M3	20	1.60	32.10	Action suggested within 2-5 years. Increase frequency of inspection
11/07/2017	D14	20	1.03	20.51	Continue regular inspection
11/07/2017	1/2 D15	20	1.01	20.28	Continue regular inspection
21/08/2017	1/2 D15	20	1.08	21.63	Continue regular inspection
21/08/2017	1/2 D16	20	1.12	22.30	Continue regular inspection
30/08/2017	1/2 M22	20	1.04	20.79	Continue regular inspection
30/08/2017	M23	20	1.01	20.21	Continue regular inspection

4. 透過數位資產管理、數據和新科技優化總體擁有成本

【主講人】：Lars Fuhr Pedersen (簡報資料詳附錄六)

【單位】：Sund & Bælt 公司技術總監

Sund & Bælt 是一家由丹麥國有控股的工程公司，負責目前歐洲最大橋梁(世界的 3 大)-斯托伯爾特橋(STOREBÆLT BRIDGES)的營運管理，橋梁主跨徑長達 1624m，懸索橋橋塔高 254m，橋下船隻通航徑高 65m，施工期程 12 年，由政府擔保融資貸款興建，鐵路、公路共構使用，每年通行乘客約 2,500 萬人次，橋下通行船隻超過 25,000 艘。

主講者以該公司實際經營管理斯托伯爾特橋的經驗，介紹大數據資料處理、無人機、AI 人工智慧等各項新科技，將資產管理數位化、總體擁有成本（Total Cost of Ownership, TCO）最佳化的應用方式，並說明在該座橋梁資產管理上的實際應用效益。

TCO 基本上為幫助管理單位瞭解所擁有資產全生命週期支出成本的財務模型 (Financial Model)，Sund & Bælt 公司係採用 IBM 公司所開發的 MAXIMO 軟體，它是集企業資產管理系統、服務管理系統、IT 資產管理系統於一體的套裝軟體，透過 MAXIMO 軟體結合基本技術資料、營運維護成本、財務成本以及服務水準，幫助使用者掌握所擁有的資產狀況、將總體資本支出最佳化，並合理預估未來資本投資計劃的總體支出成本。

基本技術資料:包含資產編號(ID)、型式、位置(GIS)及重要性等資料。

營運維護成本:包含維護工單歷史、維護工單種類、維修成本等資料。

財務成本:包含興建投資成本、折舊等資料。

服務水準:包含火車班次頻率等資料。

MAXIMO 軟體運作概念如圖 30 所示。

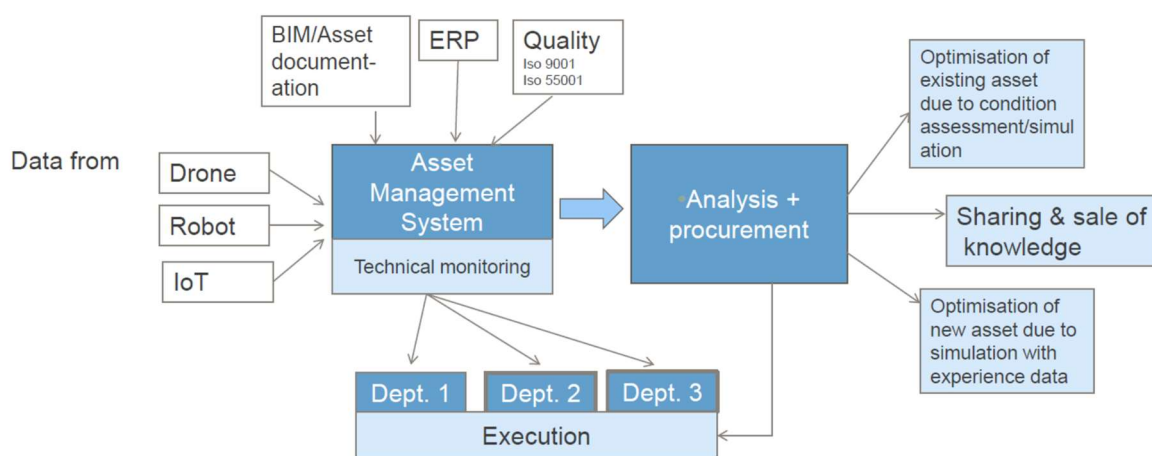


圖 30 MAXIMO 軟體資產管理概念圖

此外，透過無人機或是機器人等新科技應用於橋梁維護工作，亦可大幅減少人力成本的支出，增加維護作業的效率。

以橋梁檢測為例，以往採用人工作業方式，需要搭配大量的臨時設施及安全裝備，檢測完成後亦需要大量的時間將照片資料下載分類儲存，尤其是人員不易到達的深山、海上，更大幅度降低作業效率(如圖 31 所示)，現在改以無人機攝影，不僅人員作業之安全性較高，亦可以輕鬆建立橋梁的 3D 模型，亦可透過搭配 AI 人工智慧判釋照片，自動標註橋梁瑕疵位置及型式，作業流程如圖 32 所示。

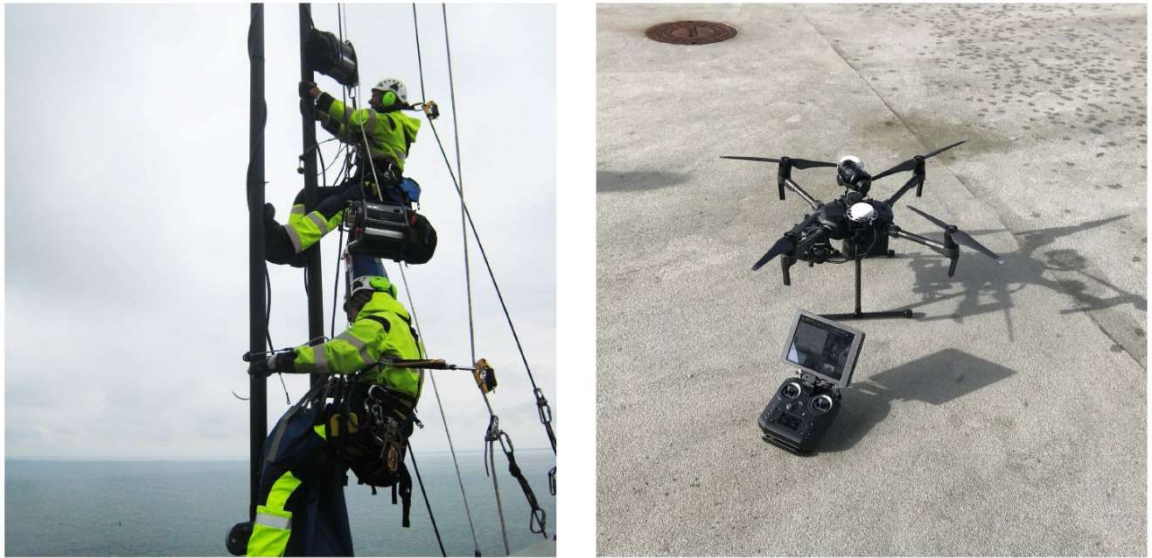


圖 31 傳統人工作業與無人機進行橋梁檢測工作之差異

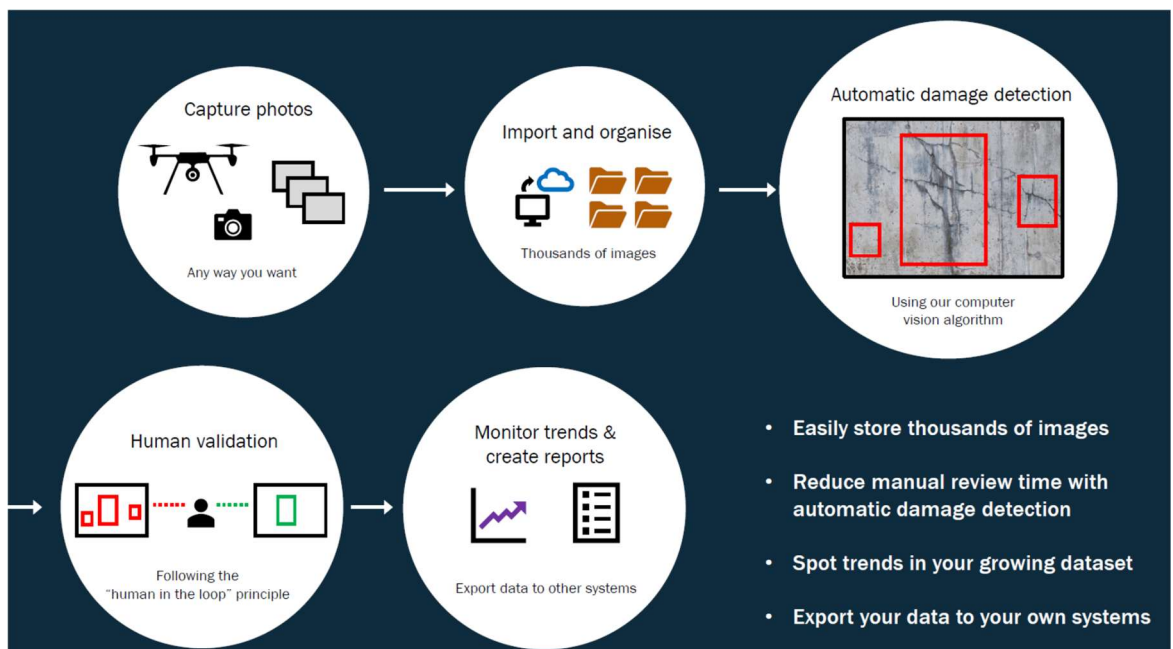


圖 32 無人機進行橋梁檢測之作業流程

Sund & Bælt 公司透過這套企業資產管理系統以及各項新科技的應用，不僅大幅

減少了重複表單的填寫，亦可隨時輕鬆的在系統上進行 GIS 圖面與財務成本分析的介面整合，以斯托伯爾特橋(STOREBÆLT BRIDGES)的營運管理資料來看，相較於 2005 年的再投資預算(Reinvestment Budget)，現在已經大幅減少 45%，如圖 33 所示。

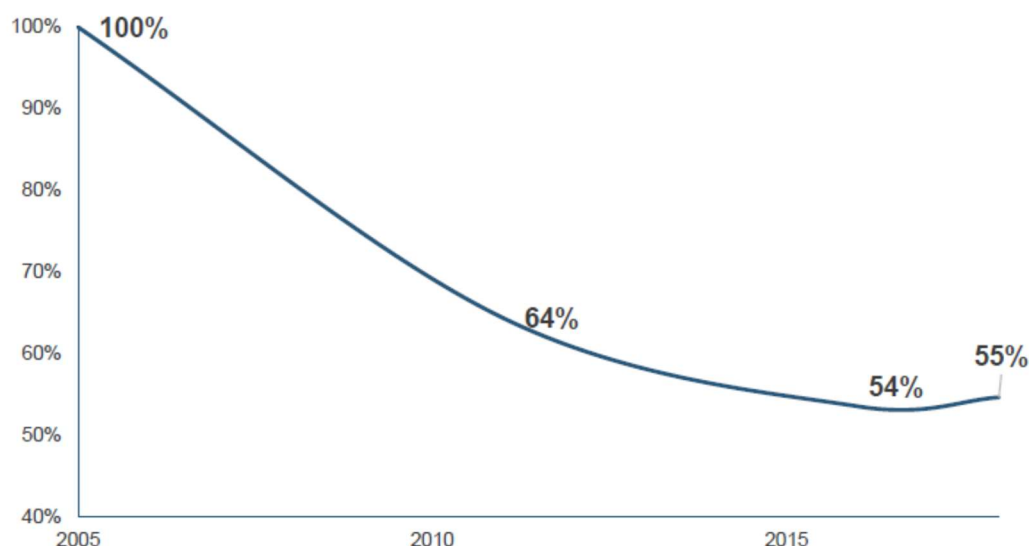


圖 33 斯托伯爾特橋(STOREBÆLT BRIDGES)再投資預算指標

三、2019 年收費卓越獎

2019 年收費卓越獎共分 6 類獎項：管理及財務獎 (Administration & Finance)、客戶服務及行銷推廣獎 (Customer Service & Marketing Outreach)、社會責任獎 (Social Responsibility)、技術獎 (Technology)、收費工程及維護獎 (Toll Operations, Engineering & Maintenance)，以及私部門創新獎 (Private Sector Innovation) 等，並再從上述各類技術獎之得主中，選出一個作為本年度之年度首獎 (The President's Award)。大會頒獎情形及得獎案例分享情形如下。

(一)、 管理及財務獎 (Administration & Finance)

得獎計畫: P3 Innovative Financing of the I-395 Virginia Express Lanes

得獎單位: Transurban North America

計畫概述:

Transurban 公司與維吉尼亞州交通廳(VDOT)為長期合作夥伴，共同努力解決其交通壅塞問題(維吉尼亞州東部銜接華盛頓 D.C.區域為全球 20 個最擁擠的城市之一)，目前維吉尼亞州內跨城市運輸的 I-495 及 I-95 快速公路(Express Lanes)長達 72 公里的動態收費路網即是交由 Transurban 公司維護管理，如圖 34 所示。

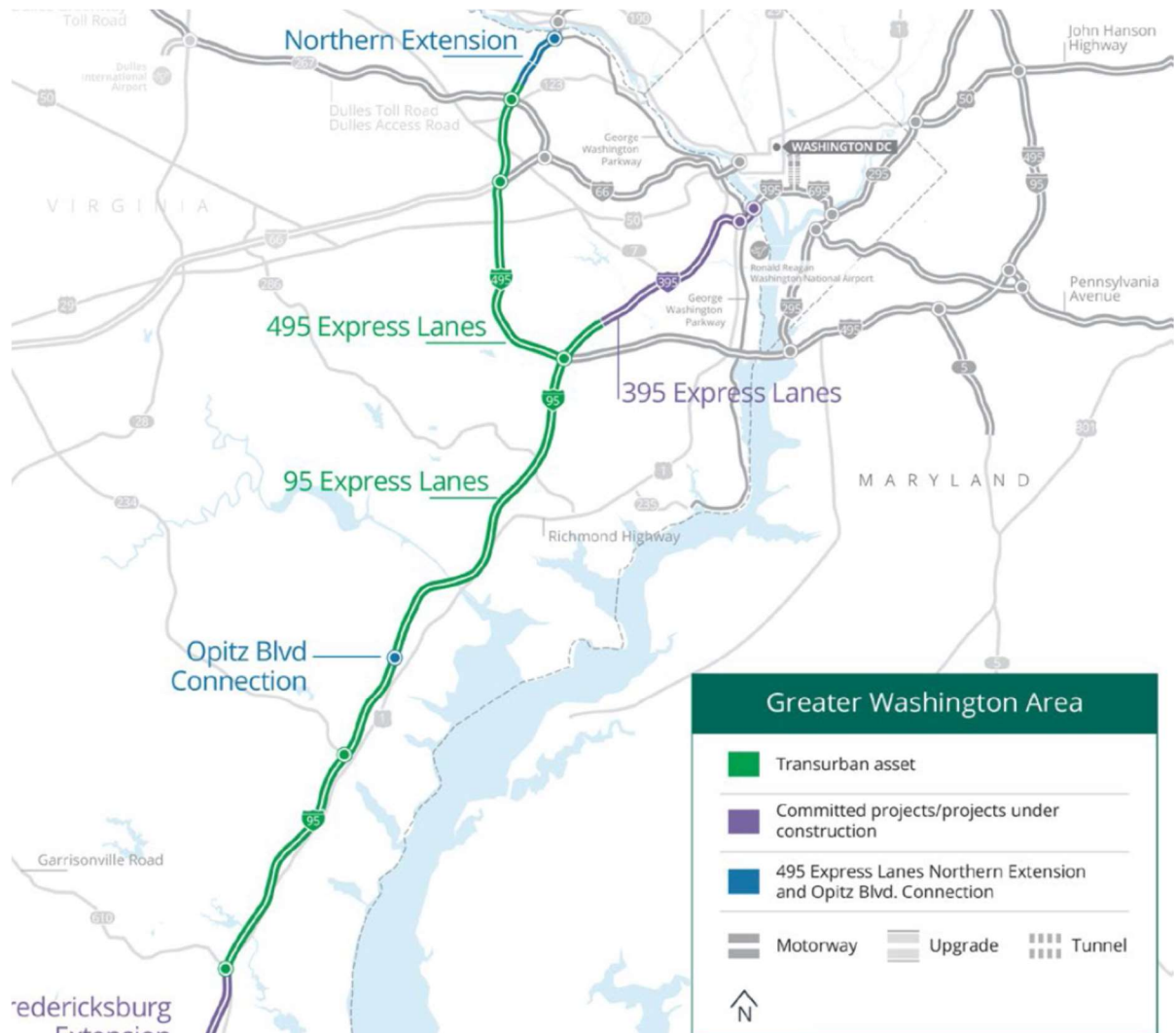


圖 34 Transurban 公司經營管理路網範圍

圖 34 中經過人口稠密區的 I-395 快速公路計畫原本已經遭到否決，在 Transurban 公司成功經營 I-495 及 I-95 快速公路的激勵下又再度復活。Transurban 針對 I-395 的開發，建造，運營和維護工作提出了完整周密的構想，並利用多方融資以及發行債券創新融資方式，成功獲得聯邦運輸委員會(Commonwealth Transportation Board)的批准，並於 2019 年第 3 季通車，本計畫不僅透過增設彈性調撥 HOV 車道改善了地區交通，也因為計畫的興建，增加當地 600 個工作機會與超過 5 億美金的經濟活動，另外除了增加每年 1500 萬美金的通行費收入外，由於 I-395 的通車，也大幅改善了 I-95 快速公路的壅塞狀況，使得信用評等機構標準普爾(S & P)和惠譽(Fitch)將 Transurban 公司所發行債券信用評級升級 1 等，亦增加了 I-395 計畫的財務價值。

(二)、客戶服務及市場推廣獎(Customer Services & Marketing

Outreach)

得獎計畫: Communication Planning, Outreach and Execution for the Selmon West Extension Project

得獎單位: Tampa Hillsborough Expressway Authority

計畫概述:

本屆獲獎單位為佛羅里達坦帕希爾斯伯勒高速公路管理局 (THEA)，獲獎計畫為 Selmon West 延伸線計畫，這是 25 年來第三次嘗試推動該計畫，以減少該州甘迪林蔭大道(Gandy Boulevard)沿線的交通擁塞，較早期的路線規劃須要大量拆除計畫道路沿線的房屋和企業，造成了地方社區居民的激烈反對。

當 THEA 於 2009 年重新啟動計畫時，工程師提出了沿既有甘迪林蔭大道(Gandy Boulevard)中線設置高架道路的方案，如圖 35 所示，以適應狹窄的道路並保持周圍建築物的完整性。

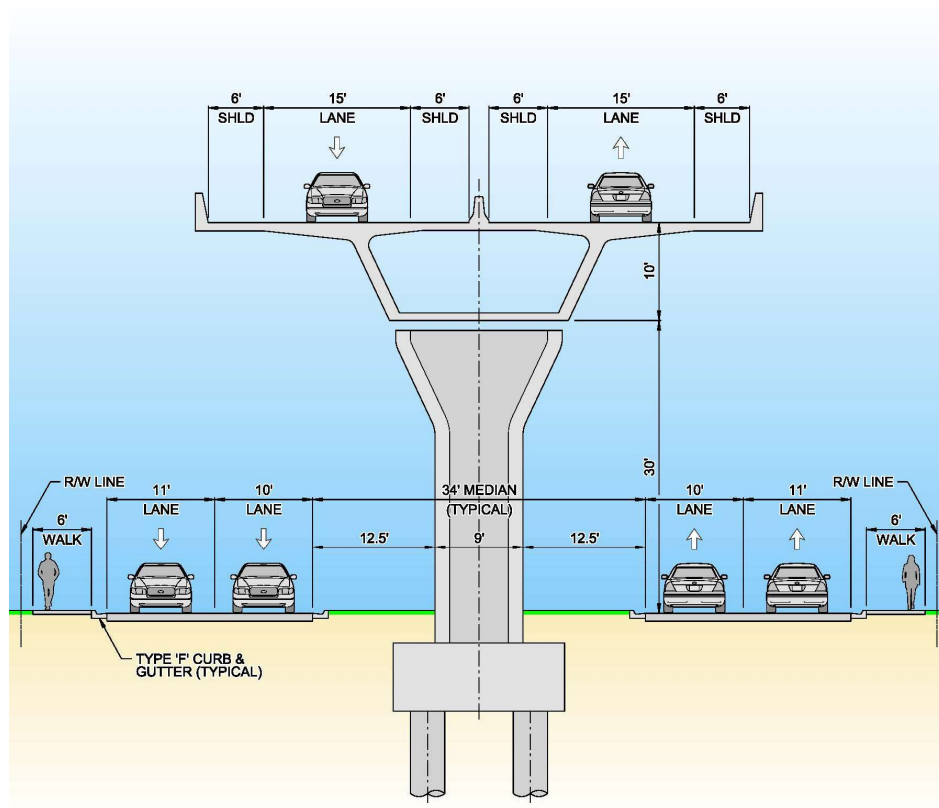


圖 35 Selmon West 延伸線計畫橋梁剖面圖

由於當時在 2008 金融危機之後，人口增長及交通需求減緩，且該計畫仍然使企業和社區居民感到緊張，因此持續被擱置。直到 2014 年，當地人口顯著增長加劇了

交通擁堵，並在發生重大颶風的情況下引發了人們對疏散準備工作的擔憂。THEA 藉此與當地領導人緊密合作，重新引入高架道路設計，此時 THEA 團隊改變了方法，改與當地居民及企業攜手合作，除了施工開始之前讓民眾得到充分的訊息和參與，並積極參與社區活動，例如舉辦行銷甘迪活動(Shop Gandy!)即是希望吸引更多顧客光顧 Gandy Boulevard，以幫助當地企業在 Selmon Extension 的建設過程中蓬勃發展，降低那些認為會受到施工負面影響的企業擔憂，THEA 因此慢慢得到了當地四個商會的認可，以及鄰近社區居民的支持

(三)、 社會責任獎 (Social Responsibility)

得獎計畫: Wekiva Parkway (State Road 429)

得獎單位: Central Florida Expressway Authority、Quest Corporation of America、Florida Department of Transportation

計畫概述:

佛羅里達州中部每年有 250 萬以上的人口和 7200 萬遊客來此旅遊，因此需要完成 25 英里長的 Wekiva Parkway (429 號州際公路)，以緩解日益擁擠的區域公路網。

佛羅里達中央高速公路管理局 (CFX) 為此啟動了一個耗資 16 億美元的全電子收費公路計畫，該計畫將尖端的交通運輸科技與環境保護、社會創新相結合，幫助保護了具有生態重要性的威基瓦(Wekiva)河周圍的野生動植物和其他自然資源。

另外與佛羅里達州交通運輸廳 (FDOT) 第五區處以及佛羅里達州的收費公路企業合作，本計畫以 2004 年《威基瓦公園大道和保護法》為指導，該法規定了佛羅里達州以前從未見過的環境保護措施。根據該法律，CFX 和 FDOT 購買了原定用於開發的 3,400 英畝保護地，修建了 1.5 英里的野生動物橋梁以取代兩條小隧道，抬高了路面以減少車輛與野生動物的碰撞，並限制了環境敏感區的交流道數量，大幅幫助保護了威基瓦(Wekiva)河周圍的環境。

(四)、 技術獎 (Technology)

得獎計畫: CAAR

得獎單位: Pennsylvania Turnpike Commission

計畫概述:

賓夕法尼亞州收費公路委員會(Pennsylvania Turnpike Commission, PTC)開發的新地理信息系統 (GIS) 結合互聯網(Web)的應用，可以幫助值班人員對賓夕法尼亞州收費公路上的交通流量和車行時間快速做出積極反應。

以往該單位的計算機輔助 (CAD) 調度系統資料庫僅用於追蹤賓夕法尼亞州收費公路的各個路段的消防車輛和救護車 (EMS)，賓夕法尼亞州收費公路委員會(PTC)的地理資訊分析團隊與交通(Traffic)、工程(Engineering)和運營(Operation)等部門(簡稱 TEO)共同開發了一套工具，以提高交通管理介面操作的視覺化。

賓夕法尼亞州收費公路委員會(PTC)與社群導航軟體 Waze、氣象預報軟體

AccuWeather、交通分析軟體 INRIX 和網路科技公司 Verizon 合作，以取得網路即時數據資料，搭配其開發的 GIS 應用軟體介面，可以即時顯示數據資料、CCTV 影像視頻、照片、氣象雷達影像、風、車行速度、天氣、交通狀況以及公路管理單位救災與搶修車輛位置。

這些整合後之視覺化數據資料可以幫助交通控制中心值班人員快速識別重大交通事故。使用此工具軟體，PTC 可以迅速的取得(Catch)資料、採取行動(Act)、分析(Analyze)和審查(Review)資訊，所以將此計畫簡稱（CAAR）。

(五)、收費營運及維護工程獎 (Toll Operations, Maintenance & Engineering)

得獎計畫: Customer Relationship Management System

得獎單位: Illinois Tollway

計畫概述:

2012 年，伊利諾伊州收費公路啟動了一項重大資本計畫，該計畫要建立一個新的客戶關係管理（Customer Relationship Management，CRM）系統，該系統必須能夠處理收入和通行費交易的增長。

此外，更進一步希望打造伊利諾州收費公路的第一條無現金公路，在芝加哥和伊利諾伊州羅克福德交流道之間，建置第一條 62 英里長的州際新無現金公路。本計畫從資本計畫開始之時起，該機構就一直在為收費業務的數量和複雜性的顯著增長做準備，預估到 2027 年，交易量預計將增長至少 45%，收入至少增長 50%。大量增加了後台需求。

為了應對挑戰，收費公路與埃森哲有限責任公司（Accenture LLP）簽訂了契約，購買了一套新的客戶關係管理(CRM)系統，該系統應用最新的業務規則、客戶自助服務功能、最新和先進的車道科技、增強的網路安全性，以及範圍更廣的外部合作夥伴，包括其他州的收費機構、信用卡公司和維護管理單位之間的操作溝通協議。

目前該系統已有超過 15 億美元的通行費和違規罰款收入，平均每天有 160 萬用戶和 280 萬筆通行費交易紀錄，其中 88%以上是通過 I-PASS 或 E-ZPass 等電子化交易工具。

(六)、私部門創新獎 (Private Sector Innovation)

得獎計畫: Central United States Interoperability Hub (CUSIOP Hub)

得獎單位: Electronic Transaction Consultants Corporation (ETC)

計畫概述:

由於美國收費公路的主管機關各州都不相同，甚至每一個州不同公路的維護管理及收費廠商都不一樣，因此跨州的公路管理及收費方式均不相同，如果沒有一套整合後的系統，民眾在各州之間的通勤，將衍生同一輛車上必須安裝多種收費裝置

的困擾，不利於未來推動全面電子化收費的目標。

為了解決前面提到的問題，德克薩斯中部地區交通管理局（CTRMA）、本德堡縣收費公路管理局（FBCTRA）、哈里斯縣收費公路管理局（HCTRA）、堪薩斯收費公路管理局（KTA）、俄克拉荷馬州收費公路管理局（OTA）、北德克薩斯收費公路管理局（NTTA）和德克薩斯交通局（TxDOT）等 7 個收費公路主管機關便組成了美國中部互操作性（Central United States Interoperability, CUSIOP）聯盟，委託電子交易顧問公司（Electronic Transaction Consultants Corporation, ETC）負責設計、開發、測試和建置符合美國國家各州跨區交易（National Interoperability, NIOP）的標準協定，以利未來各州的公路收費交易文件、報告內容與對帳紀錄可以輕易的整合交換。其理念為以各州為區域的樞紐，各區域樞紐與與全國各地的利益相關業者，皆遵循由 IBTTA 的互操作性委員會制定的國家標準，以達成為來推展至全國通用的目的，如圖 36 所示。

2017 - CUSIOP Hub (National Interoperability)

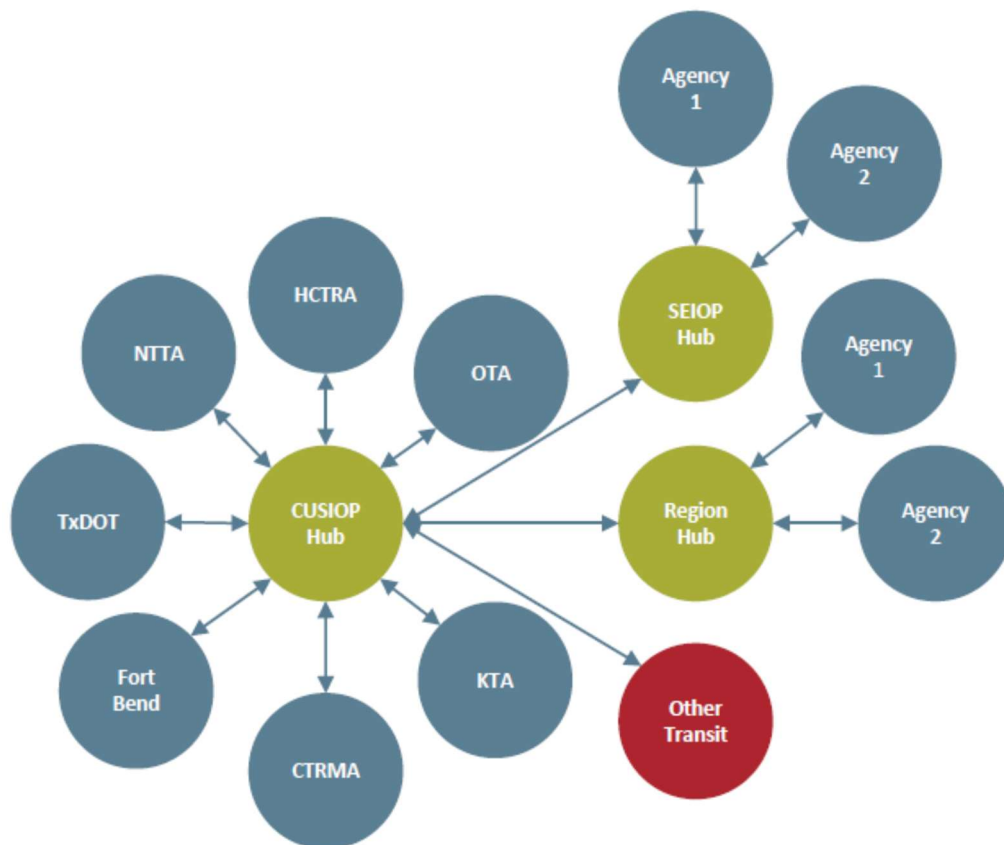


圖 36 CUSIOP Hub 溝通理念

這是第一個滿足國家互操作性（NIOP）新標準的多州樞紐架構，為美國其他地區也遵循這一標準做好了準備。此外，CUSIOP 未來亦可應用於其他不同領域，該平台可以擴展為處理來自非收費機構和服務的數據，例如交通，乘車共享和商業停車場，針對 AI 人工智慧和無人車的發展，定位裝置的應用是下一個需要發展的目標，

包含塞車狀態下的收費費率調整議題，將隨著新科技的進步而變得具有討論空間。

由於 CUSIOP 成員機構的領導和 ETC 的創新設計，使七個成員機構目前達到了國家標準的 95%，並且該系統有望在 2019 年末達到 100% 的相容性。迄今為止，CUSIOP 已處理了近 10 億筆交易和超過 10 億美元的收入。

四、世界櫥窗

由於國際橋梁、隧道及收費公路協會（IBTTA）的前身為成立於 1932 年的美國收費橋梁協會（American Toll Bridge Association，ATBA），直至 1964 年才更名為 IBTTA，其中“I”(International)係期望能將全世界各國的收費公路橋梁管理經驗納入協會，讓協會可以更茁壯、資源更豐富，惟迄今其會員仍大多以美國各州的公路主管機關、營運管理機構為主，有感於此，法國 AETC 總裁 Alain Estiot 今年別出心裁的建議，在本屆 IBTTA 年會中邀請所有參與的國家，各指派一位代表，於 2019 年收費卓越獎頒獎典禮後，上台發表 3 分鐘的自由演說，以讓其他與會各國會員及參展廠商代表可以快速的認識各個會員國。

IBTTA 本屆年會另外邀請了專業的漫畫家，在各國代表上台演說的 3 分鐘時間裡，同時將演說的內容以漫畫形式呈現並投射於大螢幕中，這是一個有趣、創新且帶有一點幽默成份的體驗，雖說大會並沒有強制要求各國會員均派員參加，但是與會的 19 個國家中，有 16 個國家與會成員派出代表參加，因我國僅有筆者參加本屆年會，故由筆者代表上台報告。



圖 37 世界櫥窗(World Showcase)各國代表合影

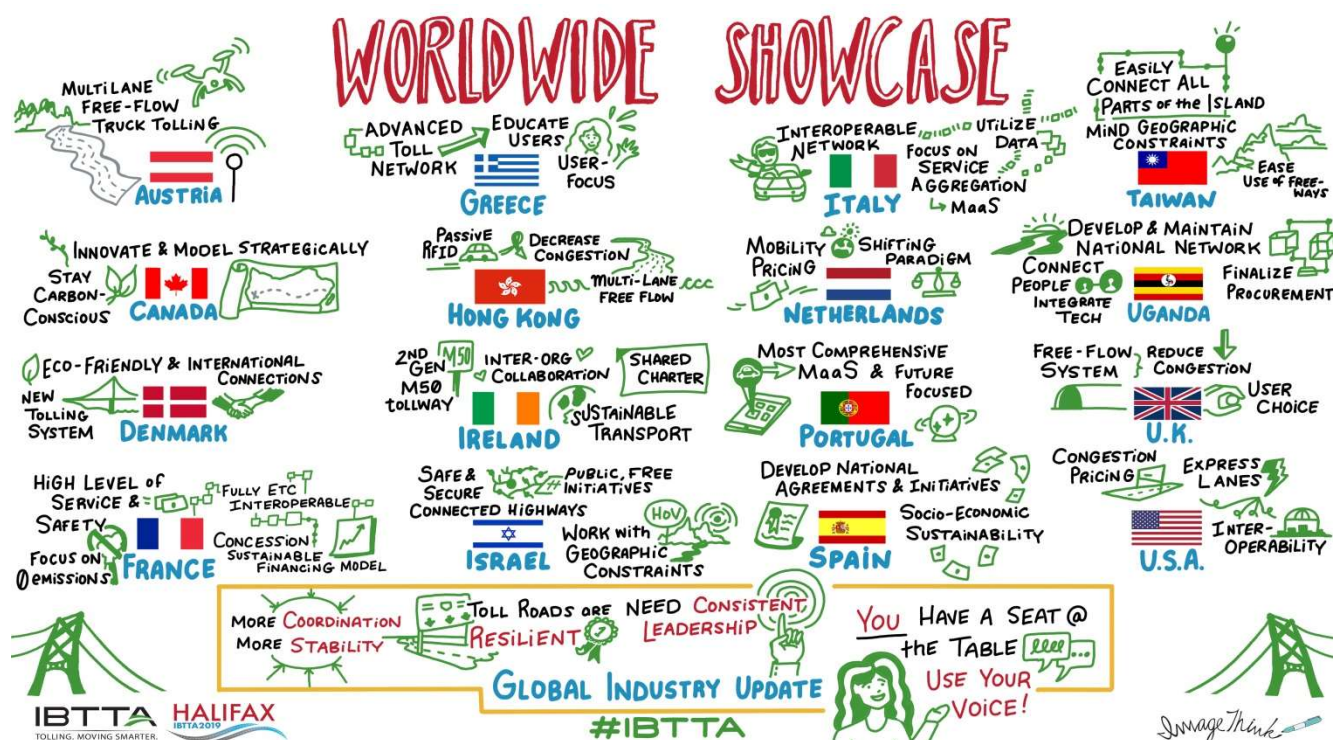


圖 38 世界櫥窗(World Showcase)現場即興漫畫

圖 38 即為漫畫家在各國代表演說完成當下所完成的即興漫畫作品，有關我國的介紹內容，位於畫面右上角位置。

五、分組會議

本屆年會分組會議分為 3 大主題：1.科技與顧客(TECHNOLOGY/CUSTOMER)；2. 交通運輸事業(THE BUSINESS OF MOBILITY)；3.世界動態(THE WORLD AROUND US)。以下針對筆者選擇參加之場次主題進行摘要說明。

(一)、The Impacts of a Driverless Future

本場講座由美國馬里蘭州的交通運輸規劃專業公司 The Traffic Group, Inc.(TTG) 創辦人兼執行長 Wes Guckert 依據美國目前的交通統計資料，提出自動駕駛車輛可能對未來交通運輸帶來的衝擊與影響。

1. 車禍次數及死亡率下降

自 1899 年以來，美國已有超過 360 萬人死於車禍事故，至今每年仍有大約 8,000 名 16~20 歲的年輕生命死於車禍事件，在自駕車普及後，預估可減少 90%以上的死亡事故。

2. 公共運輸使用模式的改變

自動駕駛技術的普及可能改變公共運輸的使用行為，比起軌道公共運輸系統，自動駕駛在大量生產後，擁有成本低、時間短、彈性大的優勢，加以 Uber/Lyft 等網路運輸公司的崛起、都會區人口集中的趨勢、電子商務物流需求的成長，可能導致未來都會地區的交通壅塞情形難以改善。

但是對屬於封閉式道路、沒有紅綠燈、沒有機車與行人的高速公路而言，自動駕駛車輛的速度及安全性優勢會更加的明顯，當自駕汽車與共享方式結合運用，例如客運業者在交流道附近的轉運站推出自駕長途客運，甚至利用自動駕駛車輛專用車道，預計將可有效提升高速公路運具使用率，改善高速公路的塞車情形。

3. 停車空間釋出

自動駕駛車輛的普及，搭配網路運輸公司以及共享汽車的服務，將使買車的需求減少，減少都會區民眾對停車位的需求，原本住宅及商業區中的停車空間將可釋出轉為其他用途，城市中的車道數量與街道寬度也可縮減，路邊亦可減少停車格位，釋出的空間可以轉為人行道、腳踏車道或是綠帶用途。

(二)、 Making the Robots Pay

本場講座由美國德州的電子收費公司 BancPass, Inc. 技術長 Glen Deitiker 針對自動駕駛車輛與共享汽車的發展趨勢，可能對未來交通運輸產業及公路收費帶來的衝擊，並提出他的建議。

1. 汽車角色的變遷

講者引用彭博社的報導指出，隨著自動駕駛車輛的推出，個人擁有專屬私有車輛的觀念，已經逐步下滑，汽車數量即將達到尖峰。全球汽車製造大廠福特公司也表示，預估其新推出的自動駕駛車將會大賣，但是也預測這樣的榮景僅會持續 4 年。

2018 年中國有 5.5 億人口使用了超過 100 億次滴滴打車的服務，這數字是 Uber 全球服務次數的 2 倍，新世代年輕人對汽車的認知已經與以往不同，現在人們選擇的是交通服務，而不是擁有汽車。

當自動駕駛或機器人駕駛車輛的費用比自己(或請人)駕駛的費用更低時，自動駕駛出租車(Robot Taxi)將變得更普及，大家除了不必再負擔燃油及牌照稅負、保險費與汽車保養維修費用這些成本外，都會區的人也不必再為了找尋停車位煩惱，屆時汽車銷售數字將大幅度下降。

2. 公路收費業務的影響

目前汽車運輸服務的形態已經越來越多樣化，車主、租賃者、駕駛人與後座乘客之間的權利義務關係也會有越來越多的灰色地帶，尤其是當自動駕駛車輛出現以後，過路費的繳納責任要如何有效率的從汽車擁有者轉嫁到使用者身上，避免浪費太多時間、成本在催繳作業，甚至避免成為呆帳，便成為一項課題。

由於講者本身即為電子收費業者，針對這樣的趨勢，講者建議在未來可以利用以雲端為基礎的網路(區塊鏈)，提供車輛所有權人註冊，當汽車租賃給其他人駕駛時，可以透過手機 APP 綁定支付方式，將費用支付責任向下傳遞給駕駛人，當駕駛人載客(後座使用者)時，同樣透過手機 APP 綁定支付方式，將費用支付責任向下傳遞給後座使用者，如果後座使用者結束旅途離開車輛時，則將費用支付責任向上傳遞回駕駛人，以此方式將付費責任動態傳遞給每一段使用車輛的人，除了可以在技術上落實使用者付費的精神，當收到過路費帳單時，系統也可以即時決定繳費責任，減少催繳爭議及稽催成本。

(三)、C-Roads Italy – First Steps Towards the Deployment of C-ITS

Technologies

歐盟已經啟動了一個名為 C-Roads 的計畫，它由歐盟成員國和道路運營商聯合推進，旨在測試和實施跨境協調及互用的 C-ITS 服務(協同智慧運輸系統)，允許道路上的車輛與其他車輛、交通標識、路邊基礎設施及其他道路使用者「通話」，進行資訊分享。例如，車輛緊急剎車時可自動向其他車輛發出預警；司機可以得知前方交通壅塞、避開道路施工路線、附近停車位等信息，還可以知道下一個綠燈所需要的等待時間。

本場講座係由義大利的電子收費公司 Autostrada del Brennero SpA 計畫經理 Ilaria De Biasi 主講，介紹義大利第一條高速公路(A22)邁向協同智慧運輸系統(C-ITS)道路的經驗與建議。

義大利 A22 高速公路全長 314 公里，含 30 座隧道(12.6 公里)及 144 座高架橋(31.2 公里)，設置 23 處收費站，22 個服務區，預計在 2017~2020 的 4 年期間，測試車輛與路側設施之整合(V2I)，以及車輛與車輛(V2V)間所形成網路之協同運作成效，以觀察車聯網(V2X)在實際高速公路上應用，及其對交通安全、交通運輸效率以及環境產生的衝擊。

C-ITS 的基礎建設中，最重要的部分即是通訊網路的建置，在義大利 A22 高速公路的 C-Roads 計畫中，網路建設標準係運用混合型通訊 4G 基地台(提供長距離通訊)，搭配已在歐盟測試多年，趨於穩定的 ETSI ITS-G5 DSRC(提供車輛與車輛之間以及車輛與交通設施之間的短距離即時通訊)。

另外在 A22 高速公路沿線設置了 53 處路側單元(Road Side Unit)，透過 DSRC 無線傳輸提供車輛與交通基礎設施(V2I)之間的資訊傳送與接收，並採用乙太網路供電技術(Power Over Ethernet, POE)，提供以安全為導向的資訊服務(即 C-ITS Day-1 Services)，包含以下各項：

1. 道路施工警示

即時提供道路施工資訊，包含移動式施工位置、車道封閉位置及數量、預估施工預警資訊等。

2. 危險路段提醒

提供資訊內容包含發生車禍事故路段、前方交通壅塞提示、車流量統計資料、天氣狀況提醒、道路狀況提醒(如天雨路滑、路面積雪結冰等)、注意行人或動物提示、路中障礙物即時通知等。

3. 車內指示牌(In-Vehicle Signage)

將路段速限的資訊、資訊可變標誌內容以及其他指示或限制牌面資訊傳送至智慧車輛內部顯示。

此外，A22 高速公路也是義大利第一條提供卡車自動跟車科技上路測試的公路，透過衛星導航及 DSRC 無線傳輸技術，以每 0.04 秒的頻率讓所有的車輛交換動態資訊，同步控制數輛卡車所組成車隊的加、減速，以避免發生追撞事故，並可大幅縮減車隊間跟車間距。

講者根據其實際執行經驗，提出道路管理單位在未來協同智慧運輸(C-ITS)道路發展的過程中，仍有許多艱困的挑戰需要克服：

- ◆ 未來路上的每一部智慧汽車，都代表了許多感測器，將提供大量的數據資料，如何同步、快速的處理這些資訊，以及回饋精確的數據資料給用路人(或車)便成為管理單位的挑戰。
- ◆ 每一部車輛所提供資訊的內容，都涉及個人資料，資料的所有權歸屬需要確認及保障。
- ◆ 大量資訊的交換過程中，除了個資保護的需求之外，許多資訊都與行車安全息息相關，網路安全議題將越來越重要。
- ◆ 未來智慧公路的運作，需要大量的依賴電子系統的穩定運作，如果系統不穩定甚至崩潰當機，勢必造成交通紊亂，甚至造成事故，因此系統崩潰當機的備援處理方案，也是管理單位需要正視的挑戰。

伍、心得與建議

- 一、國道 1 號高速公路自 1970 年代起陸續完工啟用迄今，公路橋齡已近 50 年，橋梁維護工程的份量與角色已益形重要，相較於早年以克服地形、地貌、斷層破碎帶等天然條件為主的新建工程而言，維護工程在施工過程中，須要盡量維持既有橋梁功能，減少對用路人的干擾，以降低對現有交通狀況的衝擊；本次年會主辦單位安排的技術參觀活動，即是加拿大哈里法克斯港口橋梁公司(HHB)，針對所轄橋齡逾 60 年的麥當勞大橋(Macdonald Bridge)進行風險評估後，所採取之主動式升級維護管理措施，施工過程中所面臨的最大挑戰，便是如何在一邊維持其每日上、下班尖峰時段及日間運輸功能的情況下，一邊進行橋面板及垂直吊索的更新，我國高速公路目前雖無相同橋型的懸索吊橋，但是 HHB 在維護工程進行過程中所面對的阻力，以及對工區周邊社區居民溝通的努力，均可作為未來高速公路維護工程的施工參考。
- 二、自從本(108)年 10 月 1 日發生南方澳斷橋事件後，我國橋梁維護與管理工作的重要性廣為各界所重視，此一議題亦恰為本屆年會中主辦單位所安排討論的主題之一，各國橋梁管理單位除了介紹各自在維護管理作業中如何運用大數據資料處理、無人機、AI 人工智慧等新科技之外，大家另外都同樣須要面對公路橋梁設施的逐年老化、氣候的變遷、環保意識的抬頭等外在環境變動的挑戰，要如何在人力、預算越來越受限的情形下，做更多的工作，幾乎是各個國家公路橋梁管理者的努力目標，因此以風險評估為基礎的資產管理計畫，進行橋梁的維護管理工作規劃，已是各國的趨勢，透過風險評估分析，系統性的識別基礎設施弱點，並據以重新調整維護資源的分配，除了希望讓各項設施可以達到一定的服務水平外，也希望在資產的全生命週期下，達到支出成本最小化的目標。
- 三、本次年會中，丹麥 Sund & Bælt 公司技術總監 Lars Fuhr Pedersen 在介紹該公司經營管理歐洲最大的斯托伯爾特跨海大橋(STOREBÆLT BRIDGES)的管理經驗時，說明如何透過建立平常維護管理基本資料庫的努力，將資產維護成本、財務成本管理數位化，以幫助管理單位瞭解所擁有資產全生命週期支出成本的財務模型，令人印象深刻，其中該公司以無人機攝影方式進行橋梁檢測，不僅可以建立跨海橋梁的 3D 模型，亦可搭配 AI 人工智慧判釋照片，自動標註橋梁瑕疵位置及型式，相較於以往採用人工作業方式，不僅人員作業之安全性較高，更大幅度增加作業效率，經查國內工研院亦有類似技術，或可做為本局後續針對跨河或是山區不易通達位置處之橋梁，進行橋梁檢測作業之參考。
- 四、自動駕駛車可說是近年當紅 AI 發展領域，全球科技業者及世界各大車廠，無不戮力研發自動駕駛車輛，爭相投入資源進行相關技術研究。高速公路封閉沒有紅綠燈的環境，尤其適合於無人車的行駛，當自動駕駛車的技術發展達到一定水平後，

民眾要求開放無人車上高速公路的聲量勢必越來越大，各國亦紛紛展開對自駕車出現的配套法規研擬，德國、新加坡等國已經修法允許自駕車在特定條件下上路，美國部分州亦已開放自駕車測試的法規，如何因應自動駕駛車輛對公路運輸帶來的衝擊，也是各國收費公路管理單位正共同面臨的課題，例如自動駕駛技術的普及可能使客運業者的成本與人為風險降低，是否將改變民眾對公共運輸的使用行為，另外如何營造友善自駕車的環境，如何利用自駕車的安全與效率特性對交通運輸帶來的好處，替公路管理單位與用路人創造雙贏的結果，應是公路主管機關未來不得不面對的課題。

- 五、目前自動駕駛車輛的研發，業界的重心放在如何讓車子去適應環境，係以車輛的軟、硬體設備適應現有的交通環境，並進行外部環境的辨識與決策，但是國際上智慧型運輸系統發展的趨勢已經慢慢走向物聯網(Internet of Things)概念的協同式智慧型運輸系統(Cooperative ITS, C-ITS)發展，以進行更高階交通控制，追求更安全、更順暢、更環保的智慧運輸服務，因此對智慧運輸公路基礎設施的需求勢必將逐漸增加，例如高速的通訊網路、穩定的電源供應、充分的路況資訊和高精確度的 3D 地圖等，以我國目前針對高速公路收費的費率差異，主要係以車型(小型車、大型車、聯結車)分類，而不是以所提供之服務項目收費，衡諸世界各國收費公路所共同面臨的困擾，均是在既有設施的收費過程中遭遇困難，如在新建道路上訂定收費標準，則會遇到相對較小的阻力，因此在面對未來智慧型運輸公路建置、養護過程可預見的大量資本投入，或可在智慧運輸公路建置與服務初期，即建立分級服務的使用者付費概念。
- 六、台灣現行規範車輛上路的《公路法》、《道路交通管理處罰條例》等相關法規，多以要求駕駛人全權負責車輛操控安全為法條精神，在未來自動駕駛車輛的普及後，目前道路交通事故的責任歸屬界線，恐將漸趨模糊並不易立即判定，駕駛人的定義亦將面臨爭議，在肇事責任尚未有法規制訂明確處理機制的情況下，公路設施、路況資訊提供的正確性與維護責任漸趨重要，尤其是當大部分的車輛都需要依靠 AI 人工智慧與公路基礎設施頻繁溝通，並且仰賴公路設施提供高速、穩定與正確的資訊而得以運作時，用路人對高速公路上各項設施穩定性的需求，將與捷運、高鐵等軌道運輸設施的穩定性一般重要，一旦設施故障、當機、斷電時，其對高速公路交通運輸管理的影響層面，將遠大於目前依賴人力駕駛的狀況，因此設施管理養護工作的角色與責任，在可預見的未來勢必愈來愈吃重。
- 七、未來的每一部自駕車本身即是許多感測器的結合，除了在行駛的過程中會一直不斷的製造數據資料外，亦將會蒐集、分析、傳遞大量其他車輛的資料與公路設施的路況、氣候等資訊，當然也會包含許多用路人的個人資訊，因此未來智慧公路在面臨巨量資料的快速處理需求時，有關於資通訊安全以及個人隱私保障等議題亦將愈來愈受到重視。在本次年會中，已有講者點出目前應用於金融貨幣的區塊鏈技術，具有開放透明、資料不易被入侵竄改、不會重覆交易等優點特性，應用於交通運輸業中的資料傳輸，將有助於資料同步與管理、有價文件數位化、流程

自動化等作業，並提升效益並降低管理成本，值得我國持續關注區塊鏈技術在交通運輸產業上的應用發展。

- 八、藉由本次參與 IBTTA 年會的經驗，除了可以觀摩其他國家對於收費公路維護管理的工程技術，也經由大會安排的各場次專題演講，可以了解國際間對於收費公路資產維護管理的不同做法、現階段全球關注的自動駕駛車發展課題、歐美先進國家智慧運輸(ITS)的發展進程、協同式智慧型運輸系統(C-ITS)道路實質推動的經驗，以及其他國家在面對下一世代創新科技應用時所做的準備。綜合而言，透過參與專業性國際會議，確實可達到蒐集國際間收費公路管理技術與應用經驗之目的，並提供全球科技發展趨勢對交通管理與增進交通運輸安全上之運用與願景，建議未來應可持續參與。

陸、附錄

- 附錄一 與會人員名單
- 附錄二 大提升計畫(The Big Lift)攝影專輯
- 附錄三 Evolution of Asset Management at MTA Bridges and Tunnels
- 附錄四 Risk and Asset Management
- 附錄五 Halifax Harbour Bridges-“Bridge Asset Management”-Past-Present and Future
- 附錄六 Optimizing TCO Through Digital Asset Management, Data and New Technologies

附錄一

與會人員名單



TOLLING. MOVING SMARTER.

87TH ANNUAL MEETING AND EXHIBITION

*Halifax, Nova Scotia, Canada
September 15-17, 2019*

Meeting Registration List

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Please note: The attached registration list is for official IBTTA use only. To respect the privacy of our Delegates, we restrict the amount of contact information that is published. A complete registration list with limited contact information will be sent to attendees after the meeting.

This list represents a total of 548 delegates and exhibitors registered as of 9/9/2019.
For your convenience, IBTTA staff in attendance are also included.

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First Name	Last Name	Organization	Title	Country	Member Type
Tori	Bentkover	A10 Associates, LLC	Chief Operating Officer	USA	Non-Member
Jessica	Tocco	A10 Associates, LLC	CEO	USA	Non-Member
Sidney	Edmonds	Accenture LLP	Transit and Transportation Lead	USA	Sustaining Member
Martin	Malone	Accenture LLP	Technology Consultant	USA	Sustaining Member
Gary	Markle	Accenture LLP	Director	USA	Sustaining Member
Rowan	Miranda	Accenture LLP	Managing Director-Health & Public Service	USA	Sustaining Member
Jesse	Samberg	Accenture LLP	Sr. Advisor	USA	Sustaining Member
John	Vasilj	Accenture LLP	Managing Director	USA	Sustaining Member
Ricardo	Almeida	Accenture, Consultores De Gestao, S.A.	Principal Director	Portugal	Non-Member
Barry	Colford	AECOM	Vice President and Preservation Practice Leader for Comp	USA	Sustaining Member
Kevin	Cornish	AECOM	Senior Vice President	USA	Sustaining Member
Victoria	Dewey	AECOM	Director of Toll Operations and Delivery Excellence	USA	Sustaining Member
Robert	Edelstein	AECOM	Senior Vice President	USA	Sustaining Member
Jordi	Graells	AECOM	Senior Advisor	USA	Sustaining Member
Rowdy	Kemnitz	AECOM	Director, Operations and Maintenance	USA	Sustaining Member
Carrie	Mackenzie	AECOM	Project Manager	USA	Sustaining Member
Shawn	Moore	AECOM	Senior Toll System Specialist	USA	Sustaining Member
Suzanne	Murtha	AECOM	Associate Vice President, Connected and Automated Tech	USA	Sustaining Member
Brad	White	AECOM	Vice President	USA	Sustaining Member
Ronald	Wilson	AECOM	Director of Operations	USA	Sustaining Member
Richard	Young	AECOM	Vice President, Project Manager	USA	Sustaining Member
Alain	Estiot	AETC	Principal	France	Honorary Member
Massimo	Schintu	AISCAT (Associazione Italiana Società Concessionarie Autostrade e Trafori)	Executive Director	Italy	Group Member
Emanuela	Stocchi	AISCAT (Associazione Italiana Società Concessionarie Autostrade e Trafori)	Director of International Affairs	Italy	Group Member
Sharon	Adair	Alliance for Toll Interoperability	Vice President	USA	Partner
Barbara	O'Connor	Alliance for Toll Interoperability	Director of Business Development	USA	Partner
Maria	Johnson	AllianceOne Receivables Management Inc.	SVP Business Development	USA	Sustaining Member
Phil	Silver	Amazon Web Services	Transportation Leader - State & Local Government	USA	Associate Member
Gavin	O'Donnell	Arup	Associate Director	Ireland	Non-Member
David	O'Keeffe	Arup	Director, Intelligent Transport Solutions	Ireland	Non-Member
Christophe	Boutin	ASFA (Association Professionnelle Autoroutes et Ouvrages à Péage)	Executive Director	France	Group Member
Malika	Seddi	ASFA (Association Professionnelle Autoroutes et Ouvrages à Péage)	Director of International Affairs	France	Group Member
René	Moser	ASFINAG	Head of Strategy, International Affairs & Innovation	Austria	Operator Member
Amanda	Corson	Atkins N.A.	VP/Director, Consulting Services Practice	USA	Sustaining Member
Thomas	Delaney	Atkins N.A.	Vice President	USA	Sustaining Member
Rami	Harb	Atkins N.A.	Vice President	USA	Sustaining Member
Ted	Hull-Ryde	Atkins N.A.	Vice President, BD&S, DOT	USA	Sustaining Member
Thomas	Lowe	Atkins N.A.	Senior Division Manager	USA	Sustaining Member
Francis	O'Connor	Atkins N.A.	Senior Vice President, Director of National Tolls	USA	Sustaining Member
Jennifer	Tsien	Atkins N.A.	Program Director	USA	Sustaining Member
Wally	Caldwell	Atlantic Highways Management Corporation Limited	General Manager	Canada	Non-Member
Francisca	Almeida	A-to-Be, powered by Brisa	Marketing Manager	Portugal	Associate Member

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First Name	Last Name	Organization	Title	Country	Member Type
Henrique	Cordeiro	A-to-Be, powered by Brisa	VP Sales, USA	Portugal	Associate Member
Duarte	Marques	A-to-Be, powered by Brisa	Business Development Manager	Portugal	Associate Member
José	Medeiros	A-to-Be, powered by Brisa	Business Development Manager	Portugal	Associate Member
Luis	Nunes	A-to-Be, powered by Brisa	Chief Sales Officer	Portugal	Associate Member
Eduardo	Ramos	A-to-Be, powered by Brisa	CEO	Portugal	Associate Member
Pedro	Sobral	A-to-Be, powered by Brisa	Business Development Manager	Portugal	Associate Member
Jason	Wall	A-to-Be, powered by Brisa	Chief Executive Officer, USA	USA	Associate Member
Jeffrey	Wolff	A-to-Be, powered by Brisa	Vice President	USA	Associate Member
Ilaria	De Biasi	Autostrada del Brennero S.p.A	Project Manager	Italy	Group Member
Gustavo	Baez	Baez Consulting, LLC	President	USA	DBE/WBE/MBE/SBE Member
Danie	Botha	Bakwena Platinum Corridor Concessionaire (PTY) LTD	Pavement & Contracts Engineer	South Africa	Non-Member
Glenn	Deitiker	BancPass, Inc.	Chief Technology Officer	USA	Associate Member
John	Freund	BancPass, Inc.	President	USA	Associate Member
Andrew	Fremier	Bay Area Toll Authority, Metropolitan Transportation Commission	Deputy Executive Director, Operations	USA	Operator Member
Ken	Hoang	Bay Area Toll Authority, Metropolitan Transportation Commission	Deputy Project Manager	USA	Operator Member
Winnie	Lum	Bay Area Toll Authority, Metropolitan Transportation Commission	Financial Analyst	USA	Operator Member
Jim	Macrae	Bay Area Toll Authority, Metropolitan Transportation Commission	Principal Project Manager - Express Lanes	USA	Operator Member
Victor	Wong	Bay Area Toll Authority, Metropolitan Transportation Commission	Financial Analyst	USA	Operator Member
Nisa	Hester	Bechtel Infrastructure Corporation	Project Coordinator	USA	Associate Member
John	Tarascio	Bechtel Infrastructure Corporation	Construction Manager	USA	Associate Member
John	Andrews	Bestpass, Inc.	President & CEO	USA	Associate Member
Joe	Clavelle	Bestpass, Inc.	Vice President, Business Development	USA	Associate Member
Heather	Nolan	Bestpass, Inc.	Senior Vice President of Product & Strategy	USA	Associate Member
Warren	Askew	Blue Water Bridge Canada	Chief Operating Officer	Canada	Operator Member
Gabriel	Calvert	BRiC-TPS LLC	Program	USA	Associate Member
Chris	Hurley	BRiC-TPS LLC	Chief Financial Officer	USA	Associate Member
Rukesh	Maharaj	BRiC-TPS LLC	COO	USA	Associate Member
Isabel	Meharry	Buffalo & Fort Erie Public Bridge Authority	Director	USA	Non-Member
Ron	Rienas	Buffalo & Fort Erie Public Bridge Authority	General Manager	USA	Non-Member
Joseph	Andl	Burlington County Bridge Commission	Deputy Executive Director	USA	Operator Member
Stanley	Ozalis	Burlington County Bridge Commission	Director of IT and ETC	USA	Operator Member
James	Shanahan	CardConnect	President-CardConnect East	USA	Associate Member
Rush	Taggart	CardConnect	Technical Sales Executive	USA	Associate Member
David	Aron	CDM Smith	Planner V	USA	Sustaining Member
James	Beattie	CDM Smith	CSL / Senior Program Manager	USA	Sustaining Member
Yagnesh	Jarmarwala	CDM Smith	Senior Project Manager	USA	Sustaining Member
Kamran	Khan	CDM Smith	Senior Vice President	USA	Sustaining Member
Marwan	Madi	CDM Smith	National Technology Practice Lead	USA	Sustaining Member
Christopher	Mwalwanda	CDM Smith	Vice President, Client Service Manager, Toll Finance & Tec	USA	Sustaining Member
Edward	Regan	CDM Smith	Senior Vice President	USA	Sustaining Member
Terri	Slack	CDM Smith	Vice President, National Toll Program Manager	USA	Sustaining Member
William	Chapman	Central Texas Regional Mobility Authority	Chief Financial Officer	USA	Operator Member

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First Name	Last Name	Organization	Title	Country	Member Type
Jeffrey	Dailey	Central Texas Regional Mobility Authority	Deputy Executive Director	USA	Operator Member
Dee Anne	Heath	Central Texas Regional Mobility Authority	Director of External Affairs	USA	Operator Member
Steve	Pustelnyk	Central Texas Regional Mobility Authority	Director of Community Relations	USA	Operator Member
David	Singleton	Central Texas Regional Mobility Authority	Board Member	USA	Operator Member
Jeffrey	Holland	Chesapeake Bay Bridge-Tunnel District	Executive Director	USA	Operator Member
John	Malbon	Chesapeake Bay Bridge-Tunnel District	Commissioner	USA	Operator Member
Thomas	Meehan	Chesapeake Bay Bridge-Tunnel District	Commission Vice President	USA	Operator Member
Frederick	Stant	Chesapeake Bay Bridge-Tunnel District	Commissioner	USA	Operator Member
Michael	Giambra	Chubb	Vice President, Inland Marine - Engineered Risks	USA	Associate Member
Eric	McWhorter	Citilog	Business Development Manager – North America West	USA	Non-Member
Ryan	Eskridge	CMI Group	Director of Sales	USA	Associate Member
Tawnya	Clark	Cofiroute USA, LLC	Chief Operating Officer & Chief Commercial Officer	USA	Sustaining Member
David	Hartt	Cofiroute USA, LLC	Senior Vice President, IT	USA	Sustaining Member
Gary	Hausdorfer	Cofiroute USA, LLC	President & Chief Executive Officer	USA	Sustaining Member
Gabriel	Valadez	Cofiroute USA, LLC	Program Manager	USA	Sustaining Member
Craig	Bettmann	Cogensia	Senior Vice President, Client Solutions	USA	Associate Member
Patrick	Riley	Cogensia	Vice President, Business Development	USA	Associate Member
Richard	Mudge	Compass Transportation and Technology		USA	Associate Member
Buzz	Holland	Computer Aid, Inc. - Tolls Practice	Senior Business Consultant	USA	Sustaining Member
Clayton	Howe	Computer Aid, Inc. - Tolls Practice	Director Business Development	USA	Sustaining Member
Marc	Deflin	Conduent Transportation	Senior Director	USA	Sustaining Member
Scott	Doering	Conduent Transportation	Vice President and General Manager	USA	Sustaining Member
Joy	Jacob	Conduent Transportation	Marketing Manager	USA	Sustaining Member
Ken	Philmus	Conduent Transportation	Senior Director, Global Business Development	USA	Sustaining Member
David	Schnell	Conduent Transportation	Senior Director	USA	Sustaining Member
Andrew	Tate	Conduent Transportation	Director, Sales - Tolling	USA	Sustaining Member
Reid	Kuhn	CSG Systems	Sales Director	USA	Associate Member
Michael	Woods	CSG Systems	Client Business Executive, Customer Communications Manager	USA	Associate Member
Joe	Custer	Cubic Transportation Systems, Inc.	VP, Finance & Strategy	USA	Sustaining Member
Tim	Morrison	Cubic Transportation Systems, Inc.	Services Operations Director	USA	Sustaining Member
Chris	Walsh	Cubic Transportation Systems, Inc.	Sr Solutions Architect	USA	Sustaining Member
Ian	Woodroffe	Cubic Transportation Systems, Inc.	Sr VP, Strategy & Business Development	USA	Sustaining Member
Andrew	Joyce	CVO Holding Company, LLC	Program Manager	USA	DBE/WBE/MBE/SBE Member
Joseph	Soliz	CVO Holding Company, LLC	Business Development Manager	USA	DBE/WBE/MBE/SBE Member
Jason	Morrison	Daktronics	Transportation Niche Manager	USA	Non-Member
Lauren	Willoughby	Darlington Partners	Senior Investment Associate	USA	Non-Member
George	Christopher	Douglas Stuart LLC	CEO	USA	DBE/WBE/MBE/SBE Member
Mario	Toscano	Drive Engineering Corp.	President, Sr. ITS/Traffic Engineer	USA	DBE/WBE/MBE/SBE Member
Donald	Cohrs	Dulles Greenway (TRIP II)	Chief Operating Officer	USA	Non-Member
Eric	Hunn	Duncan Solutions, Inc.	VP, Tolling, DMV Services and Collection Services	USA	Associate Member
Francoise	Bergan	E-470 Public Highway Authority	Board Member	USA	Operator Member
Jessica	Carson	E-470 Public Highway Authority	Director of Operations	USA	Operator Member

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John	Diak	E-470 Public Highway Authority	Board Member	USA	Operator Member
Steven	Douglas	E-470 Public Highway Authority	Board Member	USA	Operator Member
Bill	Holen	E-470 Public Highway Authority	Board Member	USA	Operator Member
Kenneth	Kreutzer	E-470 Public Highway Authority	Board Member	USA	Operator Member
Roger	Partridge	E-470 Public Highway Authority	Board Member	USA	Operator Member
Tim	Stewart	E-470 Public Highway Authority	Executive Director	USA	Operator Member
Charles	Tedesco	E-470 Public Highway Authority	Board Member	USA	Operator Member
Heidi	Williams	E-470 Public Highway Authority	Board Member	USA	Operator Member
Ramon	Borges	EAC Consulting, Inc.	ITS/Tolling Solutions Lead Engineer	USA	Associate Member
Enrique	Crooks	EAC Consulting, Inc.	President	USA	Associate Member
Andrew	Pierce	EAC Consulting, Inc.	Senior Project Manager	USA	Associate Member
Naoki	Kobayashi	East Nippon Expressway Company Limited	General Manager	Japan	Operator Member
Arata	Shirato	East Nippon Expressway Company Limited	Manager	Japan	Operator Member
Tomomichi	Takahashi	East Nippon Expressway Company Limited	Managing Director/Senior Executive Officer/Operation Di	Japan	Operator Member
Yuki	Terada	East Nippon Expressway Company Limited	Chief Manager	Japan	Operator Member
Martin	Stone	Egis	Chief Operating Officer, Business Development	USA	Sustaining Member
Imran	Virani	Egis	CFO	France	Sustaining Member
Madeline	Washington	Egis	Controller	USA	Sustaining Member
David	Sullivan	Elizabeth River Crossings, OpCo LLC	Director of Revenue	USA	Operator Member
Mahrokh	Arefi	emovis	CEO (U.S.)	USA	Associate Member
Daniel	Freitas	emovis	IT Manager	USA	Associate Member
Sylvain	Gaudreau	emovis	Support & Services Manager	USA	Associate Member
Serge	Le Yannou	emovis	Head of Central Support & Services	USA	Associate Member
Charlie	Mitchell	emovis	Senior Program Manager	USA	Associate Member
Juan	Rodriguez	emovis	Project Manager	USA	Associate Member
Benoît	Rossi	emovis	Head of Marketing & Communication	France	Associate Member
David	Blackstock	ETC	Manager, Software Delivery	USA	Sustaining Member
Simon	Cheng	ETC	Executive Vice President, Back Office Systems	USA	Sustaining Member
Kevin	Holbert	ETC	Executive Vice President, Business Development	USA	Sustaining Member
Bret	Kidd	ETC	CEO	USA	Sustaining Member
Colleen	Laless	ETC	Marketing Communications Manager	USA	Sustaining Member
Randy	Moore	ETC	Vice President, Business Development	USA	Sustaining Member
Raj	Nagaraju	ETC	Director, Back Office Systems	USA	Sustaining Member
Tom	Owen	ETC	Executive Vice President, Roadside Solutions	USA	Sustaining Member
Julia	Waterson	ETC	Executive Vice President of Finance	USA	Sustaining Member
Saida	Williams	ETC	Director, Marketing and Business Development	USA	Sustaining Member
Richard	Adler	E-Transit, Inc.	President	USA	Associate Member
Kevin	Harbarger	Eurofins MET Laboratories, Inc	Senior Business Development Executive	USA	Associate Member
P.J.	Wilkins	E-ZPass Group/IAG Service Corp.	Executive Director	USA	Associate Member
Ron	Fagan	Fagan Consulting	Managing Partner	USA	Associate Member
Claudio	Occhipinti	Fagan Consulting	Senior Transportation Systems Consultant	USA	Associate Member
Robert	Redding	Fagan Consulting	Senior Transportation Consultant	USA	Associate Member

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First Name	Last Name	Organization	Title	Country	Member Type
Nanette	Harrell	Faneuil, Inc.	Managing Director - Transportation, Head of Digital	USA	Sustaining Member
Anna	Van Buren	Faneuil, Inc.	President & CEO	USA	Sustaining Member
Sascha	Schoell	FEIG ELECTRONIC GmbH	Key Account Manager	Germany	Non-Member
Frank	McCartney	FGM Consulting	Principal	USA	Honorary Member
John	Flynn	Fiserv	Sales Executive	USA	Non-Member
Cherian	George	Fitch Ratings	Global Head of Infrastructure and Project Finance	USA	Sustaining Member
Scott	Monroe	Fitch Ratings	Director	USA	Sustaining Member
Anne	Tricerri	Fitch Ratings	Associate Director	USA	Sustaining Member
Danny	Lengyel	Fortran	VP	Canada	Non-Member
Hung Ji	Wang	Freeway Bureau	Branch Chief of First Engineering Office	Taiwan Republic of China	Operator Member
Michael	Holder	Gannett Fleming	Vice President, Transportation Services	USA	Associate Member
Jason	McCartney	Gannett Fleming	Project Manager	USA	Associate Member
Keith	Mullins	Gannett Fleming	Vice President	USA	Associate Member
Matthew	Schiemer	Gannett Fleming	Vice President	USA	Associate Member
Jeff	Weiss	Gannett Fleming	Senior Toll Consultant	USA	Associate Member
Andrew	Passen	GC Services Limited Partnership	Director, Business Development	USA	Non-Member
Jeffrey	Mulder	Gentex Corporation	Product Engineer	USA	Non-Member
Patricia	Horan	GeoPat Consulting LLC	Principal	USA	DBE/WBE/MBE/SBE Member
Richard	Carrier	GeoToll, Inc.	CEO	USA	Associate Member
Kirk	Logan	Global Agility Solutions	Vice President of Client Services	USA	Associate Member
Martin	Tyson	Global Agility Solutions	Chief Revenue Officer	USA	Associate Member
William	Doughty	Greenman-Pedersen, Inc.	Project Manager / Team Leader	USA	Sustaining Member
Paul	Forte	Greenman-Pedersen, Inc.	Director of Special Projects	USA	Sustaining Member
Joseph	Nemmer	Greenman-Pedersen, Inc.	Executive Vice President / WNY Branch Manager	USA	Sustaining Member
Peter	Blight	Halifax Harbour Bridges	Colliers Project Manager	Canada	Operator Member
Bill	Book	Halifax Harbour Bridges	Board Member	Canada	Operator Member
Ahsan	Chowdhury	Halifax Harbour Bridges	Bridge Engineer	Canada	Operator Member
Vicki	Harnish	Halifax Harbour Bridges	Board Member	Canada	Operator Member
Kathy	Jourdain	Halifax Harbour Bridges	Consultant	Canada	Operator Member
Cheryl	Kempton	Halifax Harbour Bridges	MACPASS Supervisor	Canada	Operator Member
Shawn	Laba	Halifax Harbour Bridges	Tolling Supervisor	Canada	Operator Member
Daryl	Lowe	Halifax Harbour Bridges	Operations Manager	Canada	Operator Member
Alison	MacDonald	Halifax Harbour Bridges	Communications Manager	Canada	Operator Member
Lisa	Mackinnon	Halifax Harbour Bridges	Finance Supervisor	Canada	Operator Member
Janet	MacMillan	Halifax Harbour Bridges	Board Member	Canada	Operator Member
Michael	McFeters	Halifax Harbour Bridges	Chief Financial Officer	Canada	Operator Member
Sheri	Murphy	Halifax Harbour Bridges	Manager, Tolling & Technology	Canada	Operator Member
Dave	Power	Halifax Harbour Bridges	HHB Safety Consultant	Canada	Operator Member
Frank	Robinson	Halifax Harbour Bridges	Maintenance Engineer	Canada	Operator Member
Steven	Snider	Halifax Harbour Bridges	General Manager & CEO	Canada	Operator Member
Stephan	Heimburg	Hardesty & Hanover, LLC	Highway Practice Lead	USA	Non-Member
Jamshid	Raofi	Hardesty & Hanover, LLC	Business Development	USA	Associate Member

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First Name	Last Name	Organization	Title	Country	Member Type
Vince	LoBianco	Harris & Harris, Ltd	Vice President, Sales	USA	Associate Member
Dennis	Bruce	HDR	Principal Economist	Canada	Associate Member
Andrew	Cadmus	HDR	Toll Operations Consultant	USA	Associate Member
Carrie	McInerney	HDR	Section Manager ATST	USA	Associate Member
Carita	Parks	HDR	Senior Communications Coordinator	USA	Associate Member
Carl	Wong	HDR	Associate Vice President	Canada	Associate Member
Joey	Yang	HDR	Director of Transportation Technology	USA	Associate Member
Bill	Halkias	HELLASTRON (Hellenic Association of Toll Roads Network)	IRF President	Greece	Group Member
Stavros	Stavris	HELLASTRON (Hellenic Association of Toll Roads Network)	President	Greece	Group Member
Paul	Richard	Highway 104 Western Alignment Corporation	General Manager	Canada	Non-Member
Koji	Hokke	Highway Toll Systems Co., Ltd.	General Director	Japan	Associate Member
Shingo	Miyamoto	Highway Toll Systems Co., Ltd.	Deputy Manager	Japan	Associate Member
Naoki	Ohta	Highway Toll Systems Co., Ltd.	Board Member	Japan	Associate Member
Akira	Saigo	Highway Toll Systems Co., Ltd.	Senior Manager	Japan	Associate Member
Takeshi	Wada	Highway Toll Systems Co., Ltd.	Senior Engineer	Japan	Associate Member
Snehal	Ambare	HNTB Corporation	Project Manager	USA	Sustaining Member
Nicholas	Antonucci	HNTB Corporation	Vice President	USA	Sustaining Member
Phillip	Brake	HNTB Corporation	Senior Vice President	USA	Sustaining Member
Scott	Cooper	HNTB Corporation	Vice President, National Toll Practice Consultant	USA	Sustaining Member
Tim	Cote	HNTB Corporation	Associate Vice President	USA	Sustaining Member
James	Drapp	HNTB Corporation	Vice President	USA	Sustaining Member
James	Ely	HNTB Corporation	National Tolls Advisor	USA	Sustaining Member
Spencer	Franklin	HNTB Corporation	Vice President	USA	Sustaining Member
Tim	Garrett	HNTB Corporation	Vice President	USA	Sustaining Member
Brad	Guilmino	HNTB Corporation	Director of Advisory	USA	Sustaining Member
Stephen	Haag	HNTB Corporation	Chief Information Officer	USA	Sustaining Member
Kevin	Haboian	HNTB Corporation	Chief Sales Officer	USA	Sustaining Member
Arthur	Hadnett	HNTB Corporation	Regional Growth Officer	USA	Sustaining Member
Richard	Herrington	HNTB Corporation	Vice President, National Toll Sector Director	USA	Sustaining Member
Kevin	Hoeflich	HNTB Corporation	Chairman, Toll Services	USA	Sustaining Member
Greg	Hulsizer	HNTB Corporation	Vice President, Toll Market Practice Leader, West Division	USA	Sustaining Member
Thomas	Hutchinson	HNTB Corporation	Associate Vice President	USA	Sustaining Member
Mike	Inabinet	HNTB Corporation	Central U.S. President	USA	Sustaining Member
Steve	Knobbe	HNTB Corporation	Vice President	USA	Sustaining Member
Kristi	Lafleur	HNTB Corporation	Consultant	USA	Sustaining Member
Tanya	Langman	HNTB Corporation	Director of Financial Services	USA	Sustaining Member
Roland	Lavallee	HNTB Corporation	Vice President	USA	Sustaining Member
Alex	Lawrason	HNTB Corporation	Associate Vice President	USA	Sustaining Member
Gregory	Le Frois	HNTB Corporation	Senior Vice President	USA	Sustaining Member
Christopher	Lester	HNTB Corporation	Deputy Office Leader	USA	Sustaining Member
Chris	Lory	HNTB Corporation	VP, Tolls Practice Leader	USA	Sustaining Member
John	Lynch	HNTB Corporation	Associate Vice President	USA	Sustaining Member

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Douglas	Mann	HNTB Corporation	Senior Vice President	USA	Sustaining Member
Stephen	Novosad	HNTB Corporation	Associate Vice President	USA	Sustaining Member
Mary Jane	O'Meara	HNTB Corporation	Vice President	USA	Sustaining Member
Daniel	Papiernik	HNTB Corporation	Toll Practice Leader / Mid-Atlantic, Associate Vice-Preside	USA	Sustaining Member
Heather	Reavey	HNTB Corporation	Vice President	USA	Sustaining Member
Robert	Slimp	HNTB Corporation	CEO	USA	Sustaining Member
Alberto	Sosa	HNTB Corporation	Vice President	USA	Sustaining Member
Michael	Sweeney	HNTB Corporation	Executive Vice President	USA	Sustaining Member
David	Talley	HNTB Corporation	Policy and Financial Consultant	USA	Sustaining Member
Emily	Tapia-Lopez	HNTB Corporation	Director of Strategic Initiatives	USA	Sustaining Member
Lisa	Thompson	HNTB Corporation	Vice President	USA	Sustaining Member
Alan	Williamson	HNTB Corporation	Senior Project Manager - Program Management	USA	Sustaining Member
Kary	Witt	HNTB Corporation	Vice President	USA	Sustaining Member
George	Zilocchi	HNTB Corporation	Consultant	USA	Sustaining Member
Usha	Elyatamby	IBI Group	Director, Intelligent Systems	Canada	Sustaining Member
Donovan	Guin	IBM	US Lead, Tolling & Congestion Charging	USA	Sustaining Member
Cheryle	Arnold	IBTTA	Web Services and Event Production	USA	IBTTA Staff
Ancilla	Brady	IBTTA	Director, Membership & Business Development	USA	IBTTA Staff
Kristin	Bromberg	IBTTA	Marketing Manager	USA	IBTTA Staff
Bill	Cramer	IBTTA	Communications Director	USA	IBTTA Staff
Neil	Gray	IBTTA	Director of Government Affairs	USA	IBTTA Staff
Lisa	Jewell	IBTTA	Research Specialist	USA	IBTTA Staff
Pat	Jones	IBTTA	Executive Director and CEO	USA	IBTTA Staff
Wanda	Klayman	IBTTA	Deputy Executive Director	USA	IBTTA Staff
Terri	Lankford	IBTTA	Membership & Business Development Manager	USA	IBTTA Staff
Cindy	Norcross	IBTTA	Director, Research & Technology	USA	IBTTA Staff
Cathy	Pennington	IBTTA	Chief Financial Officer	USA	IBTTA Staff
Harry	Smith	IBTTA	Meeting Registrar, Member Services Manager	USA	IBTTA Staff
Anna	Sohriakoff	IBTTA	Meetings Manager	USA	IBTTA Staff
Tamara	Seaver	Icenogle Seaver Pogue, P.C.	Shareholder	USA	Associate Member
José	Alvarez	Illinois Tollway	Executive Director	USA	Operator Member
John	Mashia	IMS, Inc	President & COO	USA	Associate Member
Lee	Vanderpool	IMS, Inc	CEO	USA	Associate Member
Mark	Vanderpool	IMS, Inc	Director of Business Development	USA	Associate Member
Brian	Patno	Indra	Director, Transportation USA	USA	Associate Member
Scot	Goettsch	INEX TECHNOLOGIES	VP of Sales, Global Tolling Solutions	USA	Associate Member
Alex	Sarin	INEX TECHNOLOGIES	Vice President of Product Development	USA	Associate Member
Arthur	Korfin	Innovative Products LLC	President	USA	Associate Member
Geoff	Korfin	Innovative Products LLC	Vice President	USA	Associate Member
Johnny	Redman	Intercomp Company	Transportation & Enforcement Manager	USA	DBE/WBE/MBE/SBE Member
Marc	Ott	International City/County Management Association	Executive Director	USA	Non-Member
Peter	Federhko	International Road Dynamics, Inc.	Vice President of North America Sales	Canada	Non-Member

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First Name	Last Name	Organization	Title	Country	Member Type
Rish	Malhotra	International Road Dynamics, Inc.	Regional Manager	Canada	Non-Member
Mark	Bandy	Jacobs Engineering Group	Regional Solutions Leader - Americas West	USA	Sustaining Member
Stan	Cann	Jacobs Engineering Group	Director of Transportation	USA	Sustaining Member
Michael	Werner	Jacobs Engineering Group	Program Director	USA	Sustaining Member
Carol	Bozarth	Jafa Technologies, Inc.	President	USA	DBE/WBE/MBE/SBE Member
Robert	Frank	Jafa Technologies, Inc.	Senior Toll Consultant	USA	DBE/WBE/MBE/SBE Member
Edward	Mulka	Jafa Technologies, Inc.	Executive Vice President	USA	DBE/WBE/MBE/SBE Member
Frank	Long	JAI Traffic Solutions	Director of Sales, Traffic Solutions	USA	Associate Member
Richard	Schlittler	JAI Traffic Solutions	ITS Field Engineer	USA	Associate Member
Altamash	Ahmed	Kapsch TrafficCom	Vice President- Back Office Solution Center, NA	USA	Sustaining Member
Christopher	Body	Kapsch TrafficCom	Vice President, Sales - NE Region	USA	Sustaining Member
Nicole	Busse	Kapsch TrafficCom	Senior Manager, Marketing & Communications	USA	Sustaining Member
Robert	Corion	Kapsch TrafficCom	Senior Vice President Delivery and Operations	USA	Sustaining Member
Edward	Fuchs	Kapsch TrafficCom	Director of Pricing Management	USA	Sustaining Member
Don	Hicks	Kapsch TrafficCom	Vice President, Sales and Business Development - Souther	USA	Sustaining Member
Raman	Jafroudi	Kapsch TrafficCom	Director of Sales, Canada	USA	Sustaining Member
JB	Kendrick	Kapsch TrafficCom	Senior Vice President	USA	Sustaining Member
Tim	Klaw	Kapsch TrafficCom	Sr. Pre-Sales Engineer	USA	Sustaining Member
Steve	Little	Kapsch TrafficCom	Mid-Atlantic Regional Manager	USA	Sustaining Member
Chelsie	McKittrick	Kapsch TrafficCom	Marketing Communications Project Manager	USA	Sustaining Member
Christopher	Murray	Kapsch TrafficCom	President & CEO	USA	Sustaining Member
Jaymin	Patel	Kapsch TrafficCom	Solution and Product Manager, Tags, Readers, Antennas	Canada	Sustaining Member
Andrew	Peppard	Kapsch TrafficCom	Director, Sales	USA	Sustaining Member
Duffy	Sardo	Kapsch TrafficCom	Vice President eCommerce & Digital Business	USA	Sustaining Member
Thomas	Siegl	Kapsch TrafficCom	Director Product Delivery	Austria	Sustaining Member
Darby	Swank	Kapsch TrafficCom	Vice President of Electronic Tolling Solutions	USA	Sustaining Member
Daniel	Toohey	Kapsch TrafficCom	Vice President Sales, Program Manager - E-ZPass	USA	Sustaining Member
Richard	Van Hyning	Kapsch TrafficCom	Regional Technical Delivery Manager	USA	Sustaining Member
Lee	Ensminger	KCI Technologies, Inc.	Project Manager	USA	Non-Member
Elizabeth	Yue	Kentucky Transportation Cabinet	Innovative Finance Analyst	USA	Operator Member
Mary	Doherty	Keville Enterprises Inc.	Office Manager	USA	DBE/WBE/MBE/SBE Member
Christine	Keville	Keville Enterprises Inc.	President & CEO	USA	DBE/WBE/MBE/SBE Member
Jess	Helmlinger	Kistler Instrument Corporation	Business Director	USA	Non-Member
Julia	Bennett-Ward	KPMG LLP	Manager	USA	Associate Member
Cesar	Diaz-Plaza Perez	KPMG LLP	Director, Deal Advisory	USA	Associate Member
Christopher	Melton	Kyra Solutions, Inc.	VP / Managing Director	USA	Sustaining Member
Devang	Patel	Kyra Solutions, Inc.	VP of Consulting & Projects	USA	Sustaining Member
Catherine	Larson	Larson Consulting Associates LLC	CEO	USA	DBE/WBE/MBE/SBE Member
Marie-Florence	Chandonnet	LeddarTech	Account Manager	Canada	Non-Member
Dominic	Otis	LeddarTech	Field Application Engineer	Canada	Non-Member
Nathan	Maloney	Leonardo/ELSAG LPR Solutions	Vice President, Marketing & Communications	USA	Associate Member
Ben	Miller	Leonardo/ELSAG LPR Solutions	VP International and New Business Development	USA	Associate Member

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First Name	Last Name	Organization	Title	Country	Member Type
Laura	Huizinga-Barton	Lindsay Transportation Solutions	Regional Manager	USA	Associate Member
Brian	Harms	Linebarger Law Firm	Toll Operations Director	USA	Sustaining Member
James	Harris	Linebarger Law Firm	Partner & National Tolls Director	USA	Sustaining Member
Billy	Rodgers	Linebarger Law Firm	National Marketing	USA	Sustaining Member
Stuart	Rankin	Louis Berger U.S.	Engineer	USA	Sustaining Member
Jignesh	Patel	Lumenor Consulting Group	President	USA	Non-Member
Bruce	Van Note	Maine Department of Transportation	Commissioner	USA	Operator Member
Erin	Courtney	Maine Turnpike Authority	Public Outreach & Marketing Manager	USA	Operator Member
Douglas	Davidson	Maine Turnpike Authority	CFO and Treasurer	USA	Operator Member
John	Sirois	Maine Turnpike Authority	Director of Finance	USA	Operator Member
Richard	Somerville	Maine Turnpike Authority	Director of E-ZPass Operations	USA	Operator Member
William	Yates	Maine Turnpike Authority	Director of IS and Communications	USA	Operator Member
John	O'Neill	Maryland Transportation Authority	Chief Operating Officer	USA	Operator Member
Mohamed	Meguid	McGill University	Professor	Canada	Non-Member
Stephan	Andriuk	Miami-Dade Expressway Authority	Deputy Executive Director/Director of Toll Operations	USA	Operator Member
Javier	Rodriguez	Miami-Dade Expressway Authority	Executive Director	USA	Operator Member
Juan	Toledo	Miami-Dade Expressway Authority	Deputy Executive Director/Director of Engineering	USA	Operator Member
Larry	Bankert, Jr.	Michael Baker International	Associate Vice President, Toll Services	USA	Sustaining Member
Christine	Caruso	Milligan Partners LLC	Project Manager	USA	Associate Member
Keziah	Cruz	Milligan Partners LLC	Management Analyst	USA	Associate Member
Dave	DiAngelo	Milligan Partners LLC	Toll Systems Specialist	USA	Associate Member
Kevin	Ko	Milligan Partners LLC	Blockchain Developer	USA	Associate Member
Matt	Milligan	Milligan Partners LLC	Managing Partner	USA	Associate Member
Tyler	Milligan	Milligan Partners LLC	Managing Partner	USA	Associate Member
Jack	Opiola	Mobility Plus LLC	President/CEO	USA	Associate Member
Justine	Tietjen	MTA Bridges and Tunnels	Deputy Chief Engineer	USA	Operator Member
Dave	Sullivan	Multilink, Inc.	DOT / Transportation President	USA	Associate Member
Michael	Burchell	Neology	Technical Sales Engineer	USA	Sustaining Member
William	DeSena	Neology	Program Manager	USA	Sustaining Member
Sean	Zeng	Neology	VP Business Development	USA	Sustaining Member
John	Keller	New Jersey Turnpike Authority	Executive Director	USA	Operator Member
Takeo	Nakamura	NEXCO-Central	Management Officer	Japan	Operator Member
Atsushi	Onishi	NEXCO-Central	Employee	Japan	Operator Member
Hidemitsu	Yumoto	NEXCO-Central	Director	Japan	Operator Member
Kenneth	Bieger	Niagara Falls Bridge Commission	Chief Executive Officer	USA	Non-Member
Stephanie	Dafoe	Niagara Falls Bridge Commission	Manager of Human Resources, Security & Agency Relations	USA	Non-Member
Lew	Holloway	Niagara Falls Bridge Commission	Director	USA	Non-Member
Barton	Maves	Niagara Falls Bridge Commission	Commissioner	Canada	Non-Member
Charles	McShane	Niagara Falls Bridge Commission	Commissioner	Canada	Non-Member
Marvin	Butler	North Carolina Department of Transportation, Turnpike Authority	Deputy Director	USA	Operator Member
James	Eden	North Carolina Department of Transportation, Turnpike Authority	Executive Director	USA	Operator Member
Tim	Carter	North Texas Tollway Authority	Board Member	USA	Operator Member

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James	Hofmann	North Texas Tollway Authority	Executive Director and CEO	USA	Operator Member
John	Mahalik	North Texas Tollway Authority	Board Member	USA	Operator Member
Benton	Tempas	Northwest Parkway LLC	IT Director	USA	Operator Member
David	Ling	Nova Scotia Department of Transportation and Infrastructure Renewal	Toll Operations Manager	Canada	Non-Member
Troy	Webb	Nova Scotia Department of Transportation and Infrastructure Renewal	District Director	Canada	Non-Member
Lauren	Hakos	Ohio Turnpike and Infrastructure Commission	Training and Development Manager	USA	Operator Member
Anthony	Yacobucci	Ohio Turnpike and Infrastructure Commission	Chief Engineer	USA	Operator Member
David	Machamer	Oklahoma Turnpike Authority	Assistant Executive Director, PIKEPASS and Toll Operation	USA	Operator Member
Kirk	Avila	Orange County Transportation Authority	General Manager	USA	Operator Member
Ellen	Lee	Orange County Transportation Authority	Project Manager	USA	Operator Member
Blanca	Perez-Marin	Parsons Corporation	Senior Project manager	Canada	Associate Member
Marcus	Flores	Passport Labs, Inc.	Associate Product Manager	USA	Associate Member
Khristian	Gutierrez	Passport Labs, Inc.	Chief Revenue Officer	USA	Associate Member
Zach	Toomey	Passport Labs, Inc.	Sales Executive	USA	Associate Member
Tom	Wiese	Passport Labs, Inc.	Director, Tolling & Transit	USA	Associate Member
Tom	DiGiacomo	Payit, LLC	Director of Business Development	USA	Associate Member
Mike	Wons	Payit, LLC	Chief Client Officer	USA	Associate Member
Harold	Worrall	PayTollo	Consultant	USA	Associate Member
Abenezer	Yohalashet	PayTollo	Head of Tolling	USA	Associate Member
Philip	Mennell	Penn Credit Corporation	Senior Business Development Executive	USA	Associate Member
George	Nyikita	Pennoni Associates Inc.	Senior Consultant	USA	Associate Member
Jeffrey	Purdy	Pennoni Associates Inc.	Associate Vice President	USA	Associate Member
Mark	Compton	Pennsylvania Turnpike Commission	Chief Executive Officer	USA	Operator Member
Kenneth	Juengling	Pennsylvania Turnpike Commission	GeoAnalytics Information Officer	USA	Operator Member
Myneca	Ojo	Pennsylvania Turnpike Commission	Director of Diversity and Inclusion	USA	Operator Member
Christopher	Parker	Pennsylvania Turnpike Commission	Traffic Operations Manager	USA	Operator Member
Stacia	Ritter	Pennsylvania Turnpike Commission	Director of Policy & Fare Collection	USA	Operator Member
Timothy	Scanlon, PE	Pennsylvania Turnpike Commission	Director of Traffic Engineering and Operations	USA	Operator Member
Craig	Shuey	Pennsylvania Turnpike Commission	Chief Operating Officer	USA	Operator Member
Robert	Taylor	Pennsylvania Turnpike Commission	Chief Technology Officer	USA	Operator Member
Fred	Kowell	Port of Hood River	Chief Financial Officer	USA	Operator Member
Michael	Burgess	Prime AE Group, Inc.	Sr. Vice President	USA	Non-Member
Michael	Tamer	Proponisi	Chief Executive Officer	USA	Associate Member
Scott	Thomas	Proponisi	Senior Partner	USA	Associate Member
Reddy	Patlolla	P-Square Solutions LLC	President	USA	DBE/WBE/MBE/SBE Member
Shane	Savgur	P-Square Solutions LLC	Vice President, System Engineering	USA	DBE/WBE/MBE/SBE Member
Kenneth	Kolberg	PSS	Roadway Safely Consultant	USA	Associate Member
Adam	Leigh	PSS	Safety Consultant	USA	Associate Member
David	McKee	PSS	Vice President of Sales and Marketing	USA	Associate Member
Craig	McLwee	Q-Free	Director of Tolling Product Development	USA	Associate Member
Jos	Nijhuis	Q-Free	CEO	Netherlands	Associate Member
Bill	Rapp	Q-Free	Executive Vice President of Tolling Solutions	USA	Associate Member

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First Name	Last Name	Organization	Title	Country	Member Type
Mary	Brooks	Quest Corporation of America, Inc.	Vice President	USA	DBE/WBE/MBE/SBE Member
Jill	Cappadoro	Quest Corporation of America, Inc.	Vice President	USA	DBE/WBE/MBE/SBE Member
Robert	Combs	RapidToll Systems, Inc.	President	USA	Associate Member
Richard	Dunne	Raytheon HTMS	Business Development Director, NMS Product Support, In	USA	Sustaining Member
Seamus	McCormick	Raytheon HTMS	Director of HTS	USA	Sustaining Member
Colleen	Murphy-Vincent	Raytheon HTMS	Operations & Growth Lead – HTS	USA	Sustaining Member
James	Bird	Red Fox ID LTD	Senior Field Technician	United Kingdom	Associate Member
Steve	Bird	Red Fox ID LTD	Chief Executive Officer	United Kingdom	Associate Member
Paul	Lowry	RevSpring	Director, Business Development	USA	Non-Member
Kathryn	Coleman	Rhode Island Turnpike and Bridge Authority	Manager of Tolling and Operations	USA	Operator Member
Buddy	Croft	Rhode Island Turnpike and Bridge Authority	Executive Director	USA	Operator Member
Kathryn	O'Connor	Rhode Island Turnpike and Bridge Authority	Director of Tolling and Operations	USA	Operator Member
Eric	Offenberg	Rhode Island Turnpike and Bridge Authority	Director of Engineering	USA	Operator Member
Joi	Dean	Richmond Metropolitan Transportation Authority	Chief Executive Officer	USA	Operator Member
Theresa	Simmons	Richmond Metropolitan Transportation Authority	Director of Operations	USA	Operator Member
Mark	Feltham	RideFlag Technologies, Inc.	CTO	Canada	Associate Member
Mike	Papineau	RideFlag Technologies, Inc.	President	Canada	Associate Member
Stephanie	Blanco	Riverside County Transportation Commission	Capital Projects Manager (Toll)	USA	Operator Member
Aaron	Hake	Riverside County Transportation Commission	External Affairs Director	USA	Operator Member
James	Burnett	RK&K	Director	USA	Sustaining Member
David	Raines	RK&K	Senior Manager – Toll Practice Lead	USA	Sustaining Member
Fred	Bergstresser	Royal Truck & Equipment	Government Accounts Manager	USA	Non-Member
Tom	Livingston	RRD	Strategic Sales Executive	USA	Associate Member
Michael	Davis	RS&H	VP, Tolls and Technology Service Group Leader	USA	Associate Member
Kevin	Palmer	RS&H	VP, Tolls Technology Leader	USA	Associate Member
Chelsea	Scheid	RS&H	Structural Engineer	USA	Associate Member
Stephen	Sayle	Sayle Group	CEO	Canada	Non-Member
Susan	Buse	SBuse Consulting	President	USA	DBE/WBE/MBE/SBE Member
Mike	Willingham	Sebring Airport Authority	Executive Director	USA	Non-Member
María	Moreno	SEOPAN	International Department Director	Spain	Group Member
Tad	Galloway	SICK, Inc.	Account Executive	USA	Associate Member
Brian	Owens	SICK, Inc.	Account Manager	Canada	Associate Member
George	Thiel	SICK, Inc.	Account Executive	USA	Associate Member
Max	Crumit	SlotChannelUS, LLC	Principal	USA	Non-Member
Elizabeth	Kaufman	SmartBrief	Account Director	USA	Non-Member
Michael	Brown	Southwest Research Institute	Institute Engineer	USA	Non-Member
Rick	Gobeille	Stantec Consulting Services Inc.	Senior Principal	USA	Sustaining Member
Liz	Horta	Stantec Consulting Services Inc.	Transportation Consultant	USA	Sustaining Member
Suzanne	Seegmuller	Stantec Consulting Services Inc.	Senior Transportation Specialist	USA	Sustaining Member
Richard	Armstrong	Star Systems International, Ltd	Managing Director, Star Systems America	USA	Associate Member
Julie	Cooper	Star Systems International, Ltd	Senior Executive Manager - EMEA	Hong Kong	Associate Member
Stephen	Lockhart	Star Systems International, Ltd	Chief Technology Officer	USA	Associate Member

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Diane	Gutierrez-Scaccetti	State of New Jersey Department of Transportation	Commissioner	USA	Operator Member
Heather	Aquino	State Road & Tollway Authority	Deputy Executive Director	USA	Operator Member
Annie	Gillespie	State Road & Tollway Authority	Director of Engineering	USA	Operator Member
Mary	Sallach	State Road & Tollway Authority	Director of Strategic Initiatives	USA	Operator Member
Christopher	Tomlinson	State Road & Tollway Authority	Executive Director and Board Secretary	USA	Operator Member
Ken	Edwards	Strait Crossing Bridge Limited	Manager of Information Systems	Canada	Non-Member
Lars Fuhr	Pedersen	Sund & Baelt Holding	Technical Director, CTO	Denmark	Non-Member
Kevin	Bennick	SWC Group	Vice President of Business Development	USA	Associate Member
Jeff	Hazzard	SWC Group	COO / President	USA	Associate Member
Jeff	Hurt	SWC Group	CEO	USA	Associate Member
Daniel	Alvarez	Tampa-Hillsborough Expressway Authority	Board Member	USA	Operator Member
Vincent	Cassidy	Tampa-Hillsborough Expressway Authority	Chairman of the Board	USA	Operator Member
Sue	Chrzan	Tampa-Hillsborough Expressway Authority	Director of Public Affairs & Communications	USA	Operator Member
Robert	Frey	Tampa-Hillsborough Expressway Authority	Director of Planning and Innovation	USA	Operator Member
Anna	Quinones	Tampa-Hillsborough Expressway Authority	Project Manager	USA	Operator Member
Joseph	Waggoner	Tampa-Hillsborough Expressway Authority	CEO/Executive Director	USA	Operator Member
Laura	Cardaiolo	Tattile Srl	PM Traffic	Italy	Non-Member
Jim	Kennedy	Tattile Srl	VP Business Development - ALPR	USA	Non-Member
Donald	Halvorsen	TE Connectivity	Business Development Manager	USA	Non-Member
Miso	Mihajlovski	TE Connectivity	Account Manager	USA	Non-Member
Francesco	Del Pizzo	Telepass SpA	Chief Sales Officer	Italy	Sustaining Member
Lisa	Gauvin	The CCS Companies	Vice President, Partnership Development	USA	Associate Member
David	Ulrich	The CCS Companies	SVP Partnership Development	USA	Associate Member
Thye	Lee	The Federal Bridge Corporation Limited	Vice President, Engineering and Construction	Canada	Operator Member
John	Lopinski	The Federal Bridge Corporation Limited	Director	Canada	Operator Member
Colleen	Sim	The Federal Bridge Corporation Limited	Operations Manager	Canada	Operator Member
Mark	Muriello	The Port Authority of New York & New Jersey	Deputy Director, Tunnels, Bridges & Terminals	USA	Operator Member
Wade	Dorland	The Seaway International Bridge Corporation, Ltd.	General Manager	Canada	Operator Member
James	Wheeler	The Seaway International Bridge Corporation, Ltd.	Manager, Maintenance & Technical Services	Canada	Operator Member
Wes	Guckert	The Traffic Group	President & CEO	USA	Non-Member
Robert	Horr	Thousand Islands Bridge Authority	Executive Director	USA	Operator Member
Susan	Mowers	Thousand Islands Bridge Authority	Manager, IT	USA	Operator Member
Timothy	Sturick	Thousand Islands Bridge Authority	Deputy Executive Director	USA	Operator Member
Richard	Arce	TollPlus LLC	COO & CCO	USA	Sustaining Member
Mark	Cantelli	TollPlus LLC	VP, Head of Global Delivery	USA	Sustaining Member
Antoine	Cogez	TollPlus LLC	CFO	USA	Sustaining Member
Suresh	Kakarla	TollPlus LLC	CEO	USA	Sustaining Member
Saïd	Majdi	TollPlus LLC	Senior Solution Architect	USA	Sustaining Member
Jason	Stein	TollPlus LLC	VP, Business Development	USA	Sustaining Member
Ilze	Stander	Trans African Concessions (PTY) Limited	Chief Financial Officer	South Africa	Non-Member
Shimon	Avraham	Trans Israel	Vice President, Concessions	Israel	Non-Member
Greg	Blocker	TransCore, LP	Vice President, International Toll and ITS	USA	Sustaining Member

IBTTA Annual Meeting and Exhibition
Attendee Registration List - By Organization :: September 15 - 17, 2019 :: Halifax, Nova Scotia

First Name	Last Name	Organization	Title	Country	Member Type
Don	Brady	TransCore, LP	Vice President of Business Development	USA	Sustaining Member
Scott	Brosi	TransCore, LP	AVP, Sales	USA	Sustaining Member
Chris	Eeles	TransCore, LP	Vice President, Program Manager	USA	Sustaining Member
Paula	Flowers	TransCore, LP	VP, Legal Affairs	USA	Sustaining Member
Kelly	Gravelle	TransCore, LP	EVP, Chief Technical Officer	USA	Sustaining Member
Yousuf	Kamal	TransCore, LP	Manager, Marketing & Business Development	USA	Sustaining Member
Alice	Klemashevich	TransCore, LP	Associate Vice President	USA	Sustaining Member
Robert	Landry	TransCore, LP	Vice President	USA	Sustaining Member
Barry	Mickle	TransCore, LP	Tolls Program Director	USA	Sustaining Member
Ricky	Nefzer	TransCore, LP	Executive Vice President and General Manager	USA	Sustaining Member
Sean	Persaud	TransCore, LP	VP and Managing Director, North East	USA	Sustaining Member
Dick	Schnacke	TransCore, LP	Vice President, Industry Relations	USA	Sustaining Member
Jim	Wilson	TransCore, LP	Southeast Tolls Program Director	USA	Sustaining Member
Rachel	Cahill	Transport Infrastructure Ireland	Tolling Chief Finance Officer	Ireland	Operator Member
Cathal	Masterson	Transport Infrastructure Ireland	Head of Tolling	Ireland	Operator Member
Samuel	Johnson	Transportation Corridor Agencies	Chief Toll Operations Officer	USA	Operator Member
Michael	Kraman	Transportation Corridor Agencies	Chief Executive Officer	USA	Operator Member
Amy	Potter	Transportation Corridor Agencies	Chief Financial Officer	USA	Operator Member
Michael	Discenza	Transurban	CFO-North America	USA	Operator Member
Adam	Greenhouse	Transurban	Treasury	USA	Operator Member
Trisha	Cinquini	TrustCommerce	Sr. Solutions Consultant	USA	Non-Member
Jee	Kim	TTI Consulting	Business Development Coordinator	USA	Associate Member
Michael	Kolb	TTI Consulting	Principal	USA	Associate Member
Stanley	Weiss	TTI Consulting	Principal	USA	Associate Member
Payman	Dargahi	TxDOT	Toll Operations Manager	USA	Operator Member
Eric	Golynsky	UBS Financial Services, Inc.	Executive Director	USA	Associate Member
Michael	Lexton	UBS Financial Services, Inc.	Managing Director	USA	Associate Member
Julius	Kanyamunyu	Uganda National Roads Authority	Business Development Specialist	Uganda	Operator Member
Jeffrey	Kidwell	UScontracting, Inc.	Senior Integration Engineer	USA	Non-Member
Kevin	Maynard	UScontracting, Inc.	Director of Commercial Products	USA	Non-Member
Philip	Underhill	Verra Mobility	Senior Vice President, Strategic Partnerships	USA	Sustaining Member
Jeremy	Orawiec	Versilis Inc.	Business Development Executive	Canada	Associate Member
Marie-Claude	Séguin	Versilis Inc.	Vice President	Canada	Associate Member
Dan	Schlaff	Via	Urban Mobility Strategist	USA	Non-Member
Andrew	Bunn	Virginia Department of Transportation	Student	USA	Operator Member
David	Caudill	Virginia Department of Transportation	Division Administrator, Tolling Operations Division	USA	Operator Member
Patty	Rubstello	Washington State Department of Transportation	Assistant Secretary, Urban Mobility & Access	USA	Operator Member
Lisa	Goldberg	Weris, Inc.	Talent Acquisition Manager	USA	DBE/WBE/MBE/SBE Member
Melanie	Harrison	Weris, Inc.	Business Development	USA	DBE/WBE/MBE/SBE Member
Zongwei	Tao	Weris, Inc.	President	USA	DBE/WBE/MBE/SBE Member
Christopher	Tremblay	Windsor Detroit Borderlink Limited	Manager, Maintenance & Plant Operations	Canada	Non-Member
Carlos	Campo	WSP USA	Assistant Vice President	USA	Sustaining Member

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First Name	Last Name	Organization	Title	Country	Member Type
Robert	Clifford	WSP USA	Vice President, Area Manager	USA	Sustaining Member
Jeffrey	Heilstedt	WSP USA	Senior Vice President - National Director of Tolling Service	USA	Sustaining Member
David	Huter	WSP USA	Transportation Program Manager	USA	Sustaining Member
Thomas	Krueger	WSP USA	Director of Back Office Tolling Operations	USA	Sustaining Member
Michael	Mangione	WSP USA	Senior Vice President	USA	Sustaining Member
Patrick	McGowan	WSP USA	Senior Vice President, Director Mobility Operations	USA	Sustaining Member
Philip	Miller	WSP USA	Associate Vice President	USA	Sustaining Member
Markell	Moffett	WSP USA	Transportation Operations Strategy Specialist	USA	Sustaining Member
David	Sparks	WSP USA	Director Toll Operations	USA	Sustaining Member
Christopher	Swenson	WSP USA	Assistant Vice President	USA	Sustaining Member
Victor	Teglasi	WSP USA	Senior Supervising Engineer	USA	Sustaining Member
John	Trotta	WSP USA	National Director Client Services	USA	Sustaining Member
Matthew	Woodhouse	WSP USA	Consultant	USA	Sustaining Member
David	Andalcio	Wynndalco Enterprises, LLC	CEO	USA	DBE/WBE/MBE/SBE Member
Mark	Burris	Zachry Department of Civil Engineering, Texas A&M University	Herbert D. Kelleher Professor and Associate Department I	USA	Non-Member

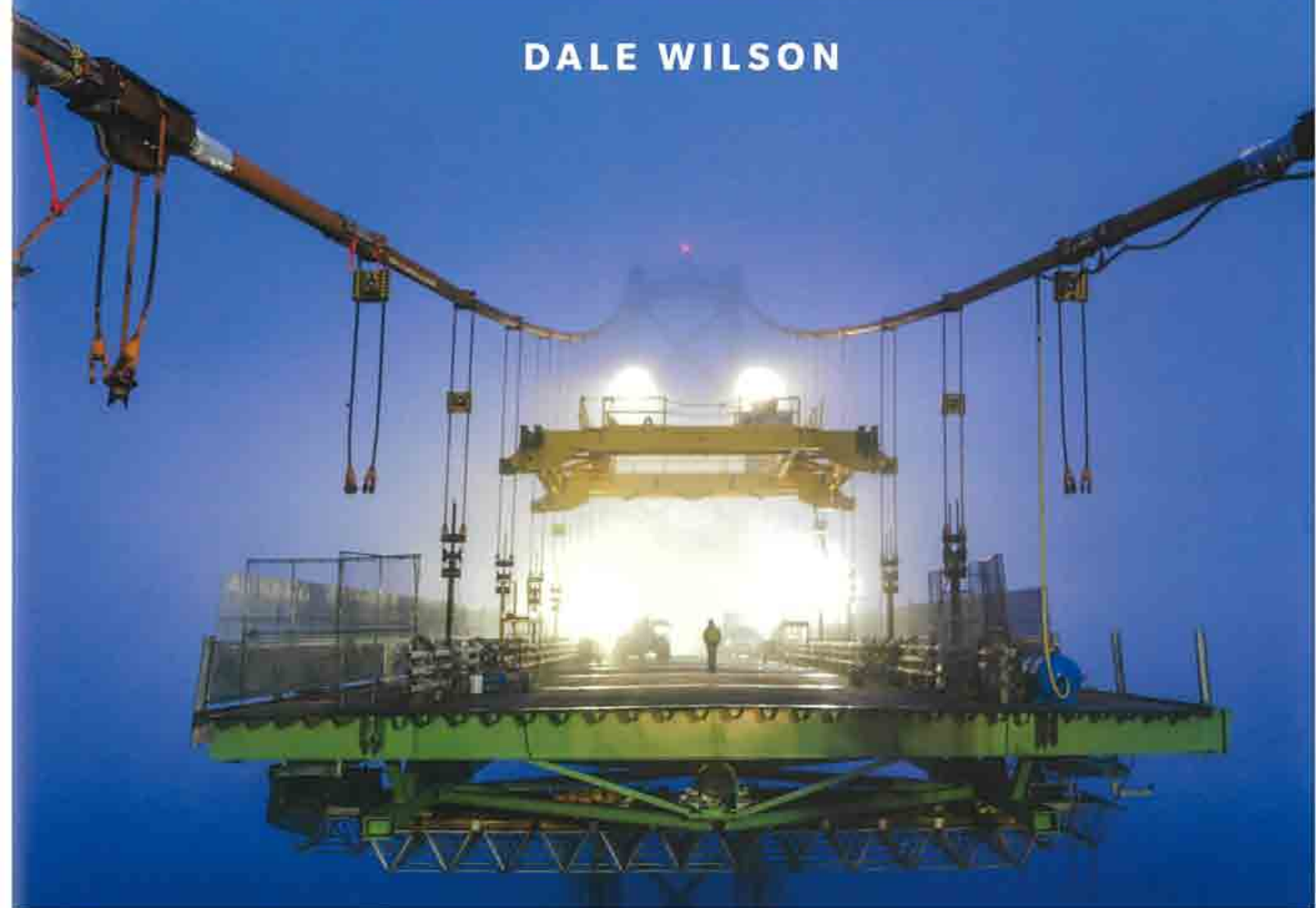
附錄二

大提升計畫(The Big Lift)攝影專輯

THE BIG LIFT

REDECKING THE MACDONALD BRIDGE

DALE WILSON



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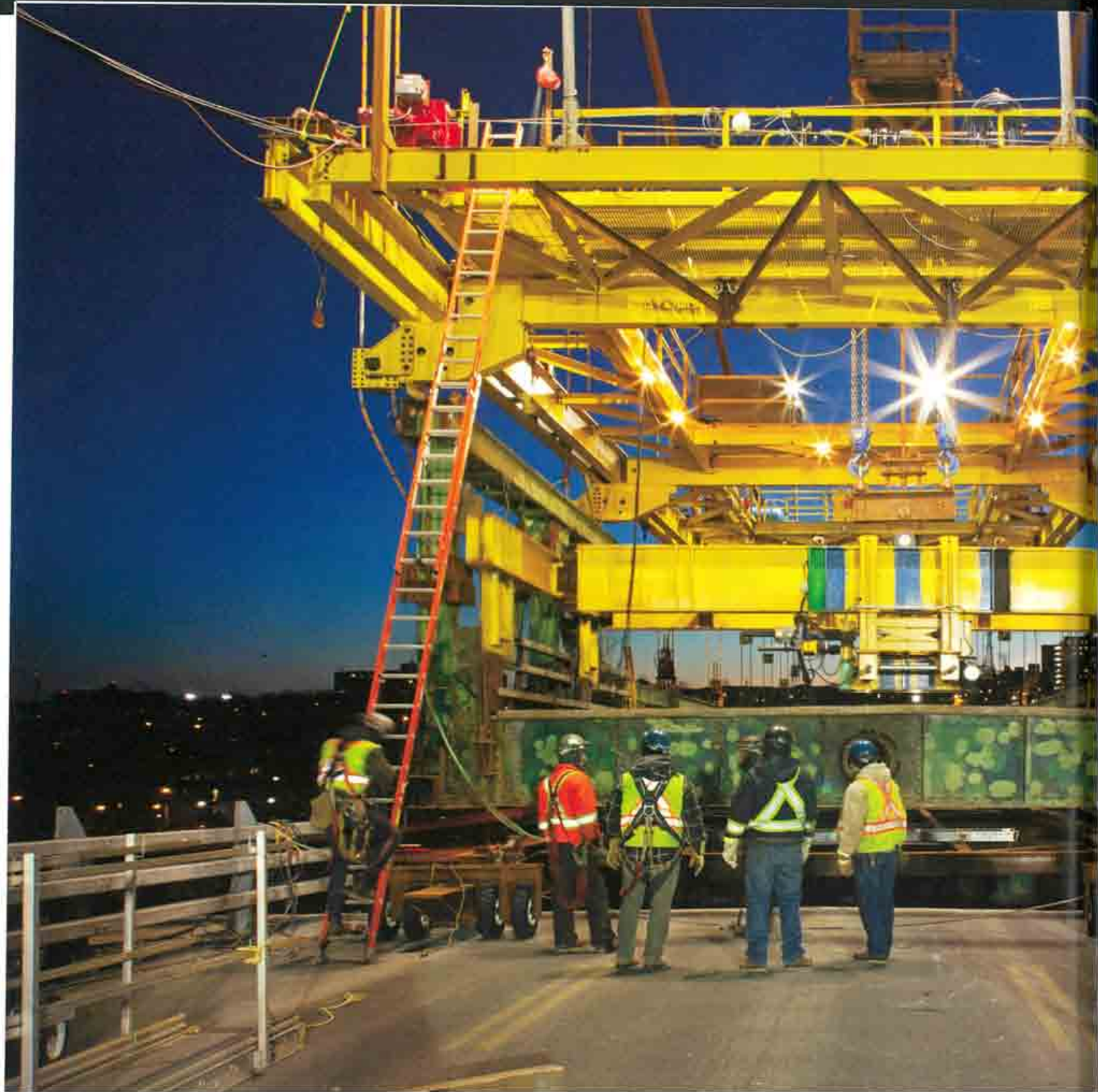
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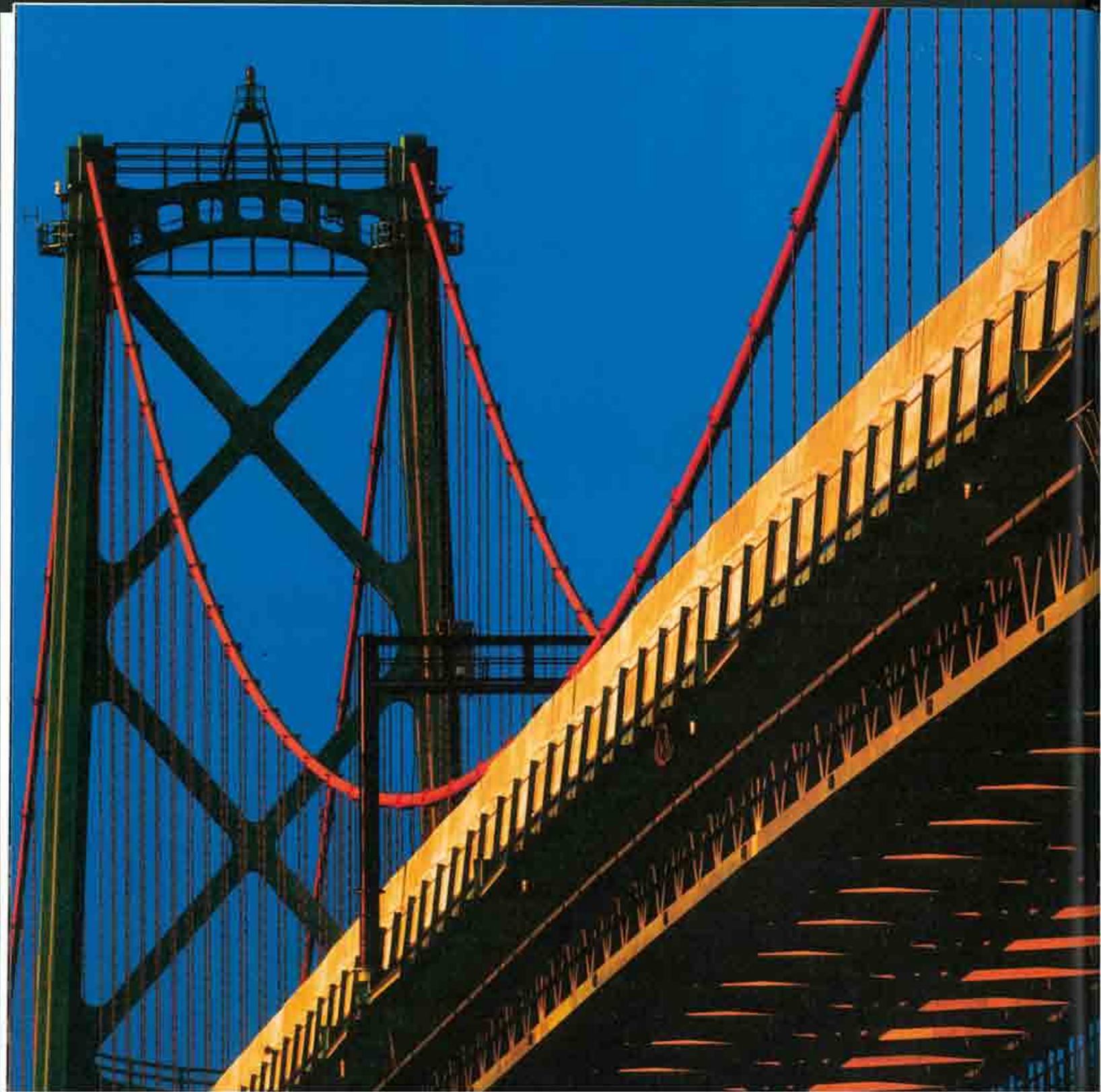
This book is dedicated to the engineers and Ironworkers:
those who design and those who build the design.





THE BIG LIFT

REDECKING
THE MACDONALD
BRIDGE





FOREWORD

THE STORY OF THE BIG LIFT begins in the mid-1990s when the Halifax-Dartmouth Bridge Commission was planning to add a third lane to the Macdonald Bridge to relieve growing traffic congestion. At that time the engineers said there was no need to replace the deck because it was serviceable for another 15 to 20 years.

Fast forward to 2009. The board of commissioners, under the leadership of then board chair, Tom Calkin, approved the design engineering for the Macdonald Bridge suspended spans deck replacement project, now known as the Big Lift. The bridge was safe but the time had arrived to replace the suspended spans to reduce maintenance and extend the life of the bridge.

Thus began an eight-year project: five years of planning and engineering and almost three years of construction. It included replacing most of the infrastructure on the suspended span of the bridge: the road deck, the floor beams, the stiffening truss and the suspender ropes.

Construction projects usually mean disruption and the Big Lift was no exception. I want to thank the bridge users and people who live and work around the bridge for your patience.

I also want to thank our board of commissioners, chaired by Wayne Mason, for their leadership and strong governance. And to HHB employees, all of whom have been involved in the success of this project. Finally, to the project partners and the men and women who worked through all the worst weather Mother Nature could throw at them.

The interest the Big Lift has generated locally, nationally and internationally has been fascinating to witness. It's been a once-in-a-lifetime project and an engineering feat.

With this project complete the Macdonald Bridge will serve our community for at least another generation.

Enjoy this collection of photos.

Steve Snider
General Manager and CEO
Halifax Harbour Bridges





AN EXTRAORDINARY STORY

You're going to do what? You plan on removing each section of bridge deck, lower it to a waiting barge, lift the replacement section from a second barge, do this all over a weekend and open the bridge to commuters by Monday morning? And this has only been done once before in the world – and in weather conditions far less severe than those in Halifax? Seriously?

Nearly two years after that first informal briefing, I stand with hundreds of residents enjoying the tailgate party-like atmosphere on the Dartmouth waterfront looking up at the first gaping hole in the bridge deck. Somehow, seemingly defying physics, the Angus L. Macdonald Bridge is stronger than before and is a testament to the incredible expertise and professionalism of those working to deliver this story.

The extraordinary in this story comes with names like Murray (Walrus) Marten, Jon Eppell, Lesley Mercer and Cowboy Joe. These are the ironworkers, engineers, operations administrators and traffic control staff, and the hundreds more like them. They come from Cuba, Ireland, United States, Venezuela and the many corners of Canada and Nova Scotia.

They have worked in the stifling heat of the paving shed, the finger-numbing cold of –30 degree temperatures, endured rain coming in sideways and the mid-summer sun scorching their already burned necks. Once the pencils and slide rules are pushed aside, the metal fabricated and the deck segments replaced, and all the layers of production are peeled back, the Big Lift story is of these extraordinary people.

This is their story.

Dale Wilson

June, 2017



THE VISIONARIES

IN 1796, when prosperous Dartmouth businessman Jonathan Tremain looked across Halifax Harbour, it is highly unlikely he considered the 1.5 kilometre wide harbour was at one time the much narrower Sackville River. He wanted an efficient way to transport his goods to the lucrative Halifax market. Mr. Tremain never completed his vision of building the first bridge across the Harbour despite an Act of legislation giving him the authority to do so.

One can only imagine the conversations Arthur W. Godfrey and John Starr had as they stood on the shoreline near current day Tufts Cove in 1842. Not unlike Mr. Tremain before them, it is unlikely they considered how the scrubbing and scouring action of the previous two million years of glacial activity shaped the sub-surface topography of the Narrows. Much to their disappointment it would be the siltation from the latest glacier—the Wisconsin—that would render the harbour floor unsuitable to support their dream of constructing a bridge. So ended their notion of finding an efficient way to transport goods to the Halifax market. Mr. Starr would later become famous as the industrialist behind Starr Manufacturing, and the Starr Skate.

Finally, in 1884, the feat of traversing the harbour was accomplished when the Intercolonial Railway completed a wooden train bridge that crossed from Tufts Cove in Dartmouth to Richmond on the western shore. Starr Manufacturing did have a prominent role when they constructed what is believed to be the first swing bridge designed and constructed in Canada, allowing continuous vessel passage to and from Bedford Basin. The first commercial crossing was in 1885 when a railcar load of sugar began its journey from the refinery in Woodside bound for Vancouver. A September gale in 1891 would overpower the bridge and it collapsed. It was promptly rebuilt but collapsed again just two years later and the project was abandoned. The railway ultimately built a spur line between Shearwater and Windsor Junction along the eastern shore of the harbour.

Just as the ebb and flow of the tides that twice daily influence the sea level of the harbour, so too was there a rise and fall in the level of bridge construction dialogue during the early part of the 20th century. Various boards of trade, commercial interests and citizen groups began advancing the initiative again, until federal politicians decreed they were not interested in infusing money in the bridge project. Again, any hope of building a bridge was stalled.

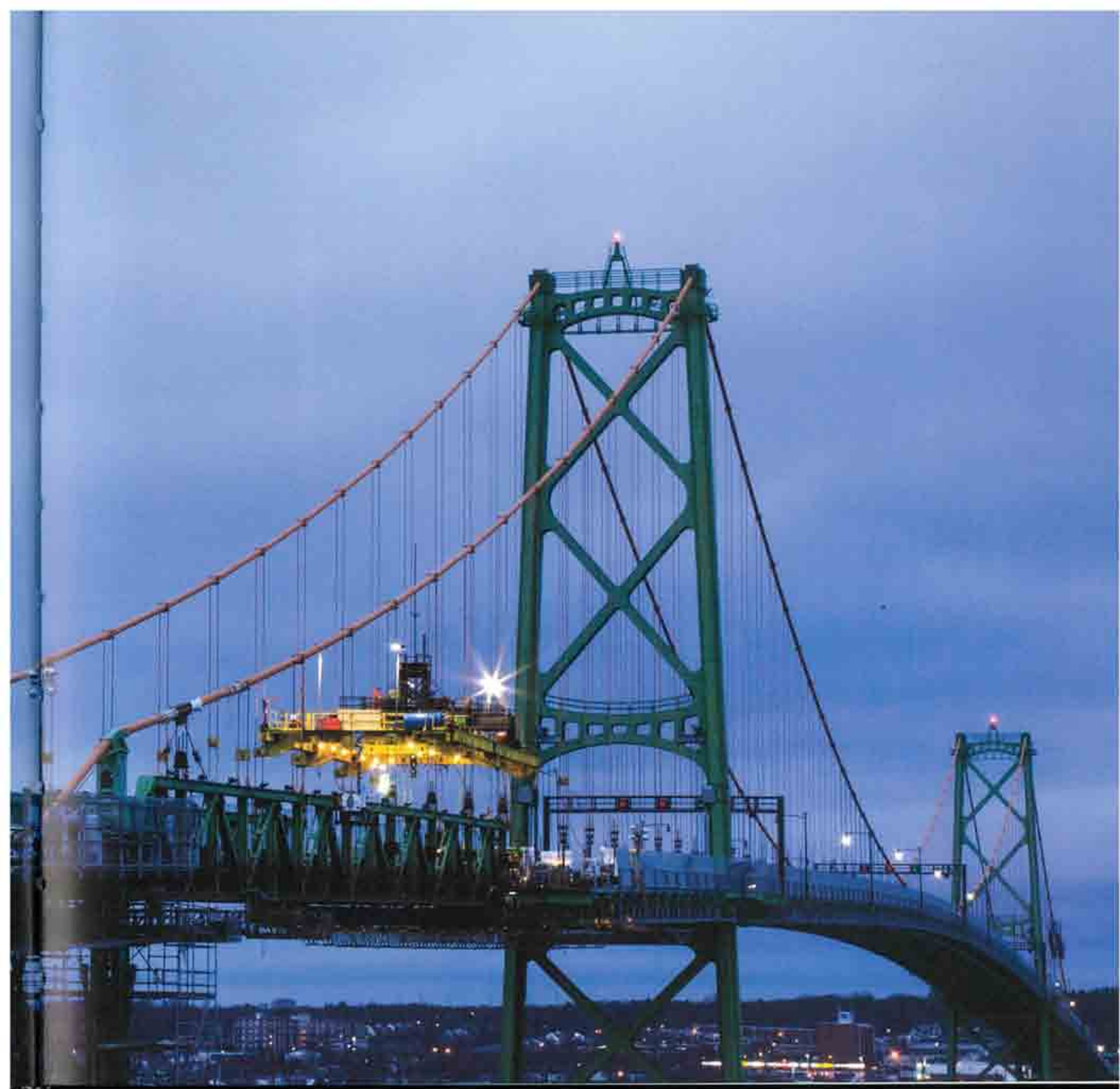
Local interest groups long realized an efficient means of transporting goods and people between the cities of Halifax and Dartmouth would improve the economies of the region. It would not be until the end of World War II, and a provincial government bent on providing economic stimulus, was the conversation reinitiated with vigour and conviction. On March 1, 1952 Premier Angus L. Macdonald turned the sod and proclaimed: *When the work is completed it will be a boon and convenience to thousands, nay, hundreds of thousands, of traveller.* Unfortunately, Premier Macdonald did not live to see his dream come to fruition. Thirty seven months later his wife, Agnes Macdonald, would cut the opening ribbon amid the skirl of bagpipes, twirl of majorette's batons and the scarlet and serge of Mounties and Bengal Lancers.

Surely even the most ardent advocate could not have imagined the positive social engineering impact the Angus L. Macdonald Bridge would generate. Within a very short time the town of Dartmouth incorporated as a city, complete with all the conveniences of a growing population. Within just six years the population of Dartmouth more than doubled. Suburbia also expanded at a rapid pace and the traffic lanes leading to the tolls were bumper to bumper with cars. Officials estimated the Macdonald Bridge would carry one million vehicles per year when it opened. In its first year of operation the bridge witnessed 2.5 million vehicle crossings, and today the Macdonald Bridge accommodates more than 12 million crossings annually.

Just as Premier Macdonald's estimate of hundreds of thousands of travellers was far too conservative, most certainly Tremain, Starr and Godfrey could never have envisioned in their wildest imaginations the positive economic impact the span would have on both sides of Halifax harbour, and indeed, the province of Nova Scotia.

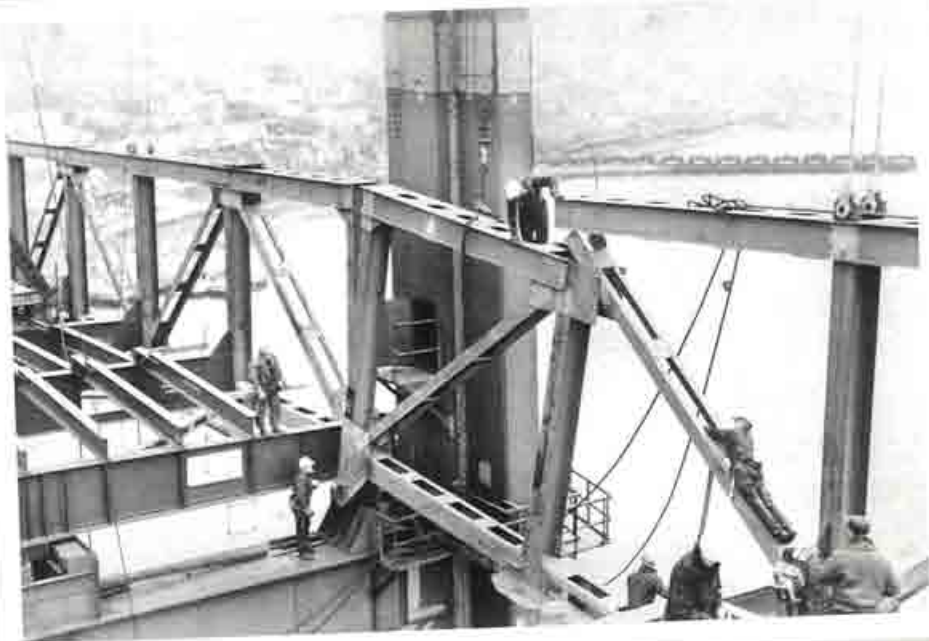
The Big Lift extends the life of the *Old Bridge* making it new again, carrying out exactly what those early visionaries imagined: efficiently and effectively moving people and goods to and fro in a safe manner.



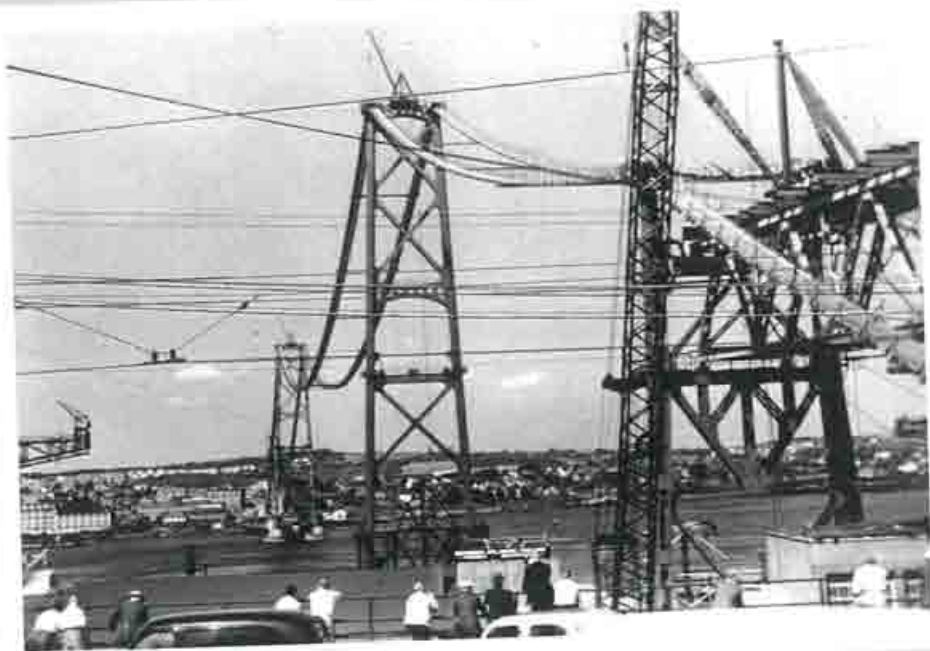














SATURDAY, OCTOBER 17, 2015 was a gorgeous autumn day. Onlookers of all types and stripes congregate along every nook and cranny of Dartmouth's Shore Road in search of the perfect vantage point as D1 is lowered to the waiting barge. Before long this previously quiet neighbourhood was hosting the tailgate-like-party, complete with traffic congestion.





SEEMINGLY DEFYING PHYSICS, and with a gaping hole in the bridge deck, the nearly two-year long process of strengthening and extending the lifespan of the Macdonald Bridge begins with the replacement of Section D1.

Holding the separated bridge together, the yellow lifting gantry awaits the early morning crew change to hook on to the replacement section below. By Monday morning the new section will have been replaced, *buttoned down*, and the bridge returned to morning commuters rushing to work.

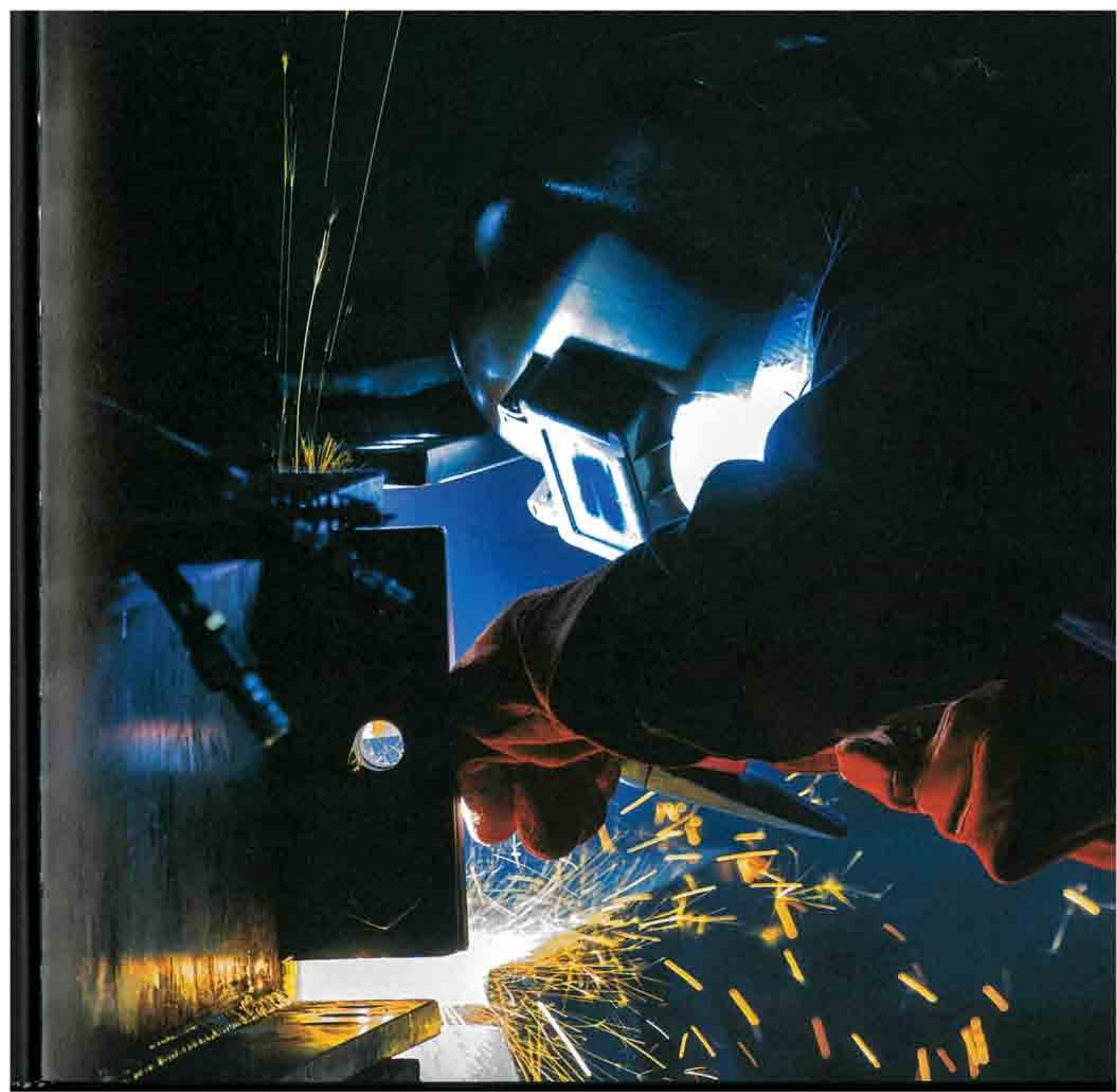
This process will be duplicated another 30 times as the Dartmouth and mid-span segments are completed. The final 16 segments on the west side of the Halifax tower will follow a similar process.

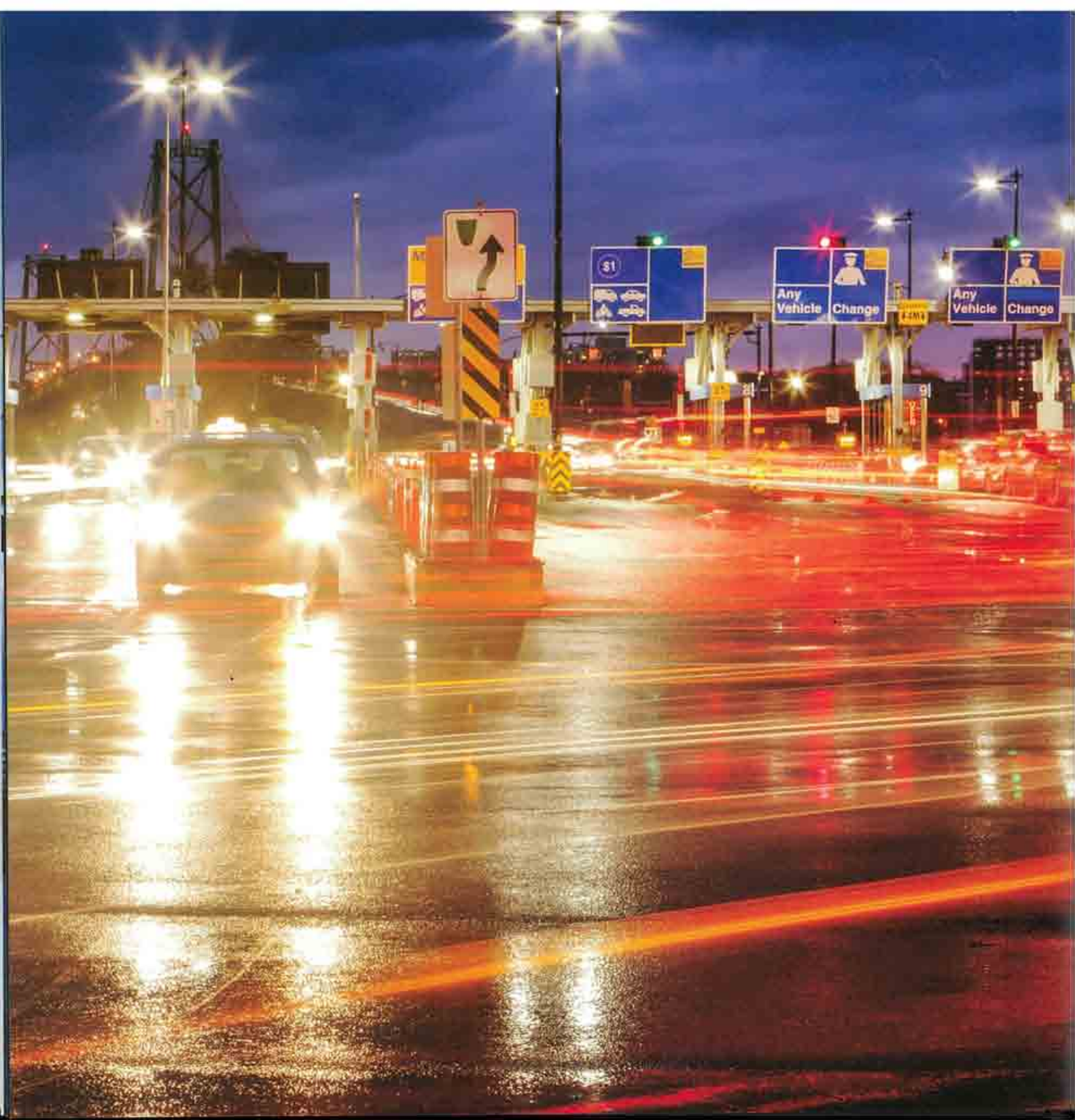
The Halifax segments will be lifted by a crane located in the Royal Canadian Navy Dockyard and then transported along the bridge deck to the gantry to be lowered into final position.

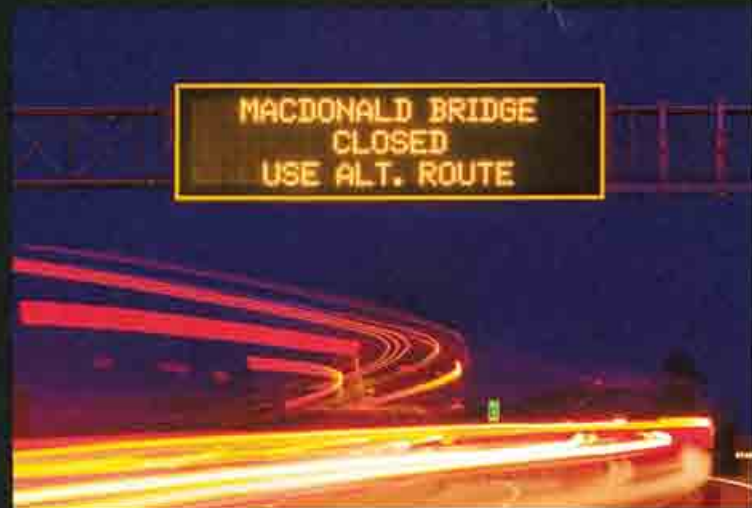
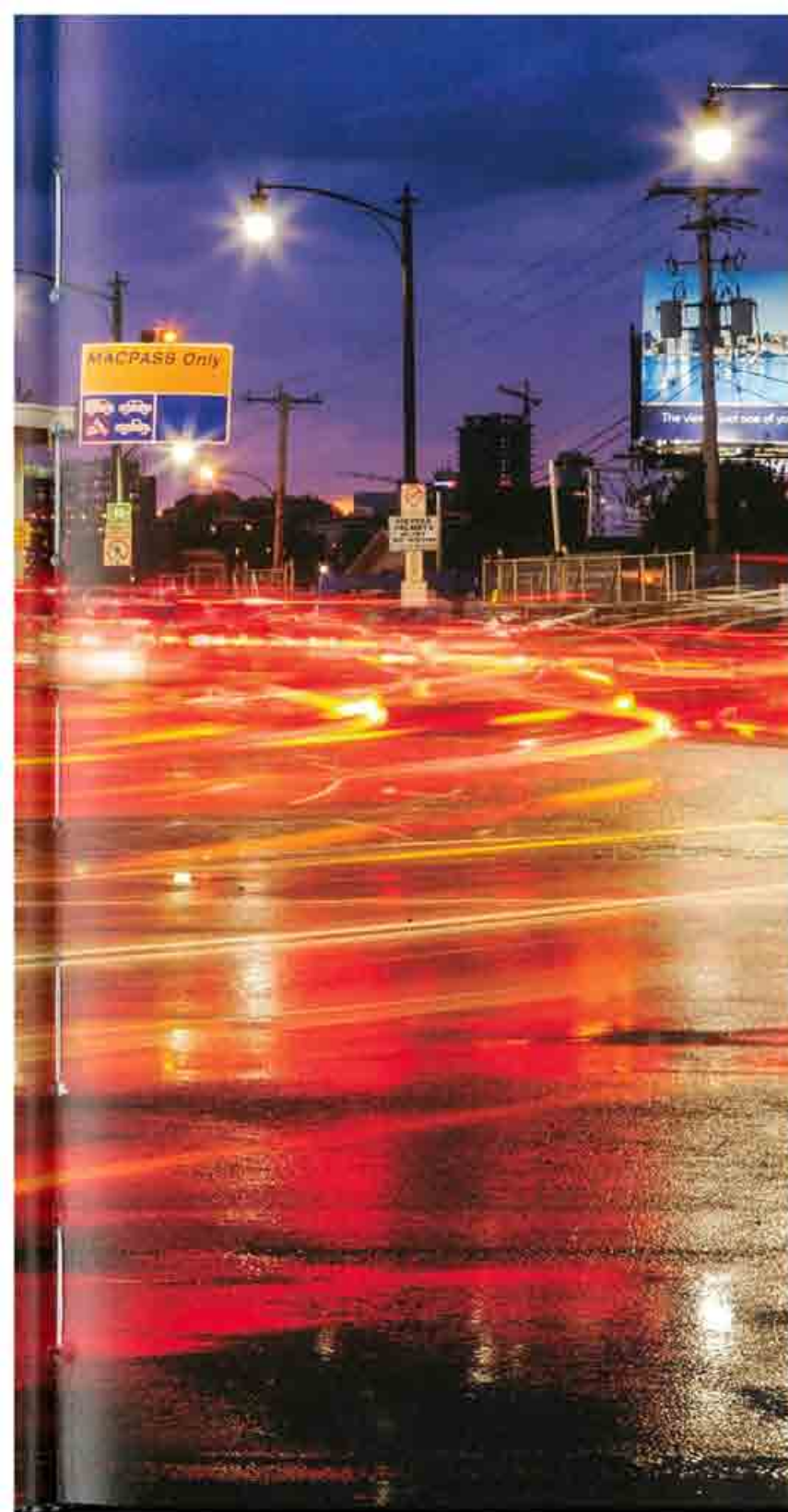


SLOWLY MOVING ALONG its computer generated track, a plasma cutter makes the first cuts in the fabrication process. The superheated electrically ionized gas cuts through the steel like a hot knife passing through cold butter. Thickness of the steel can vary between 10, 12 and 14mm thick, depending upon where the steel might be located in the segment.

Once a sheet of steel enters the Cherubini Metal Works main fabrication plant in Woodside, it will progress through nine workstations, and take approximately two weeks of production time to complete one segment.





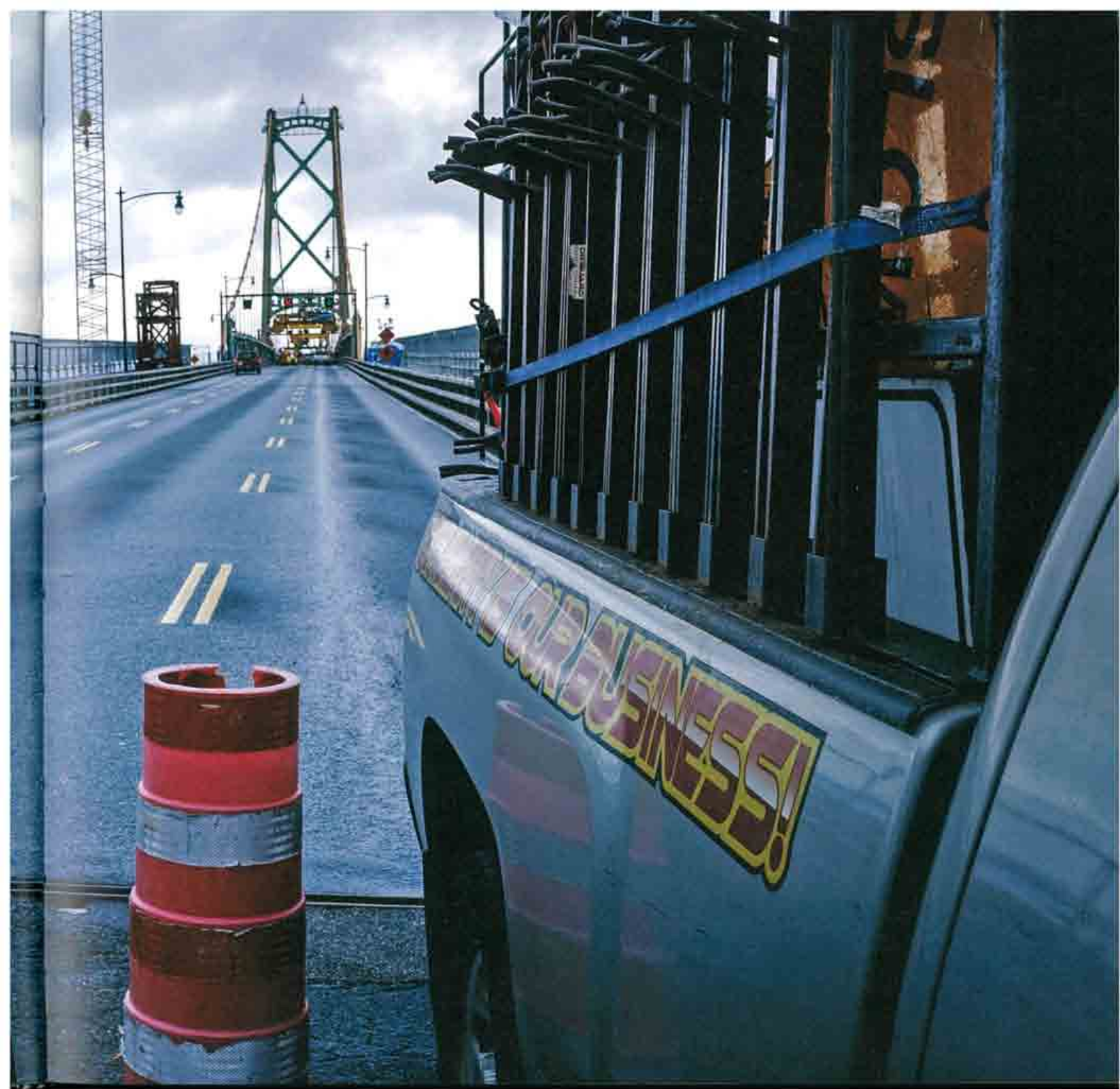


WHEN THE FIRST SOD WAS TURNED at the intersection of North and Barrington Streets on March 1, 1952, planners estimated the Macdonald Bridge would facilitate up to 1 million vehicle crossings per year. Little could they have imagined the “Old Bridge” would eventually accommodate an average of 48,000 vehicle crossings per weekday (over 12 times the estimated amount). On April 2, 2017 — the 62nd anniversary of its opening — a total of 656,144,863 vehicles had crossed the Macdonald Bridge.

On the evening of October 16, 2015, at 6:50pm, when the photo at left was made, commuters were going about their daily business. Ten minutes later strategically positioned highway sign boards informed drivers the Macdonald Bridge was closed.


Within minutes of the bridge closing, heavy equipment and workers proceeded through the toll booths to commence work on Section D1 — the first deck section scheduled for replacement — and the much anticipated first “Big Lift.”



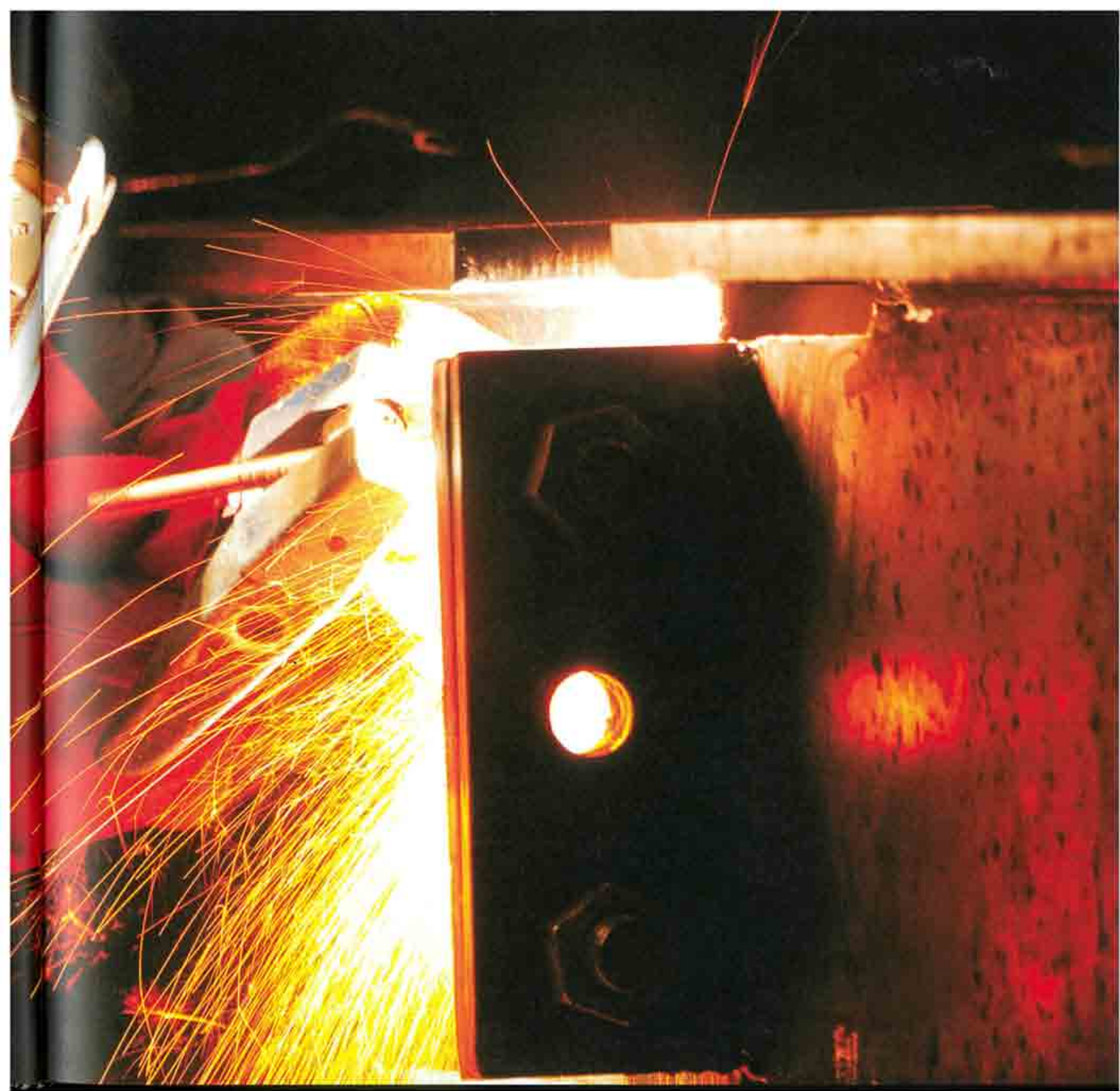








Welding at Cherubini Metal Works
main fabrication plant in Woodside.



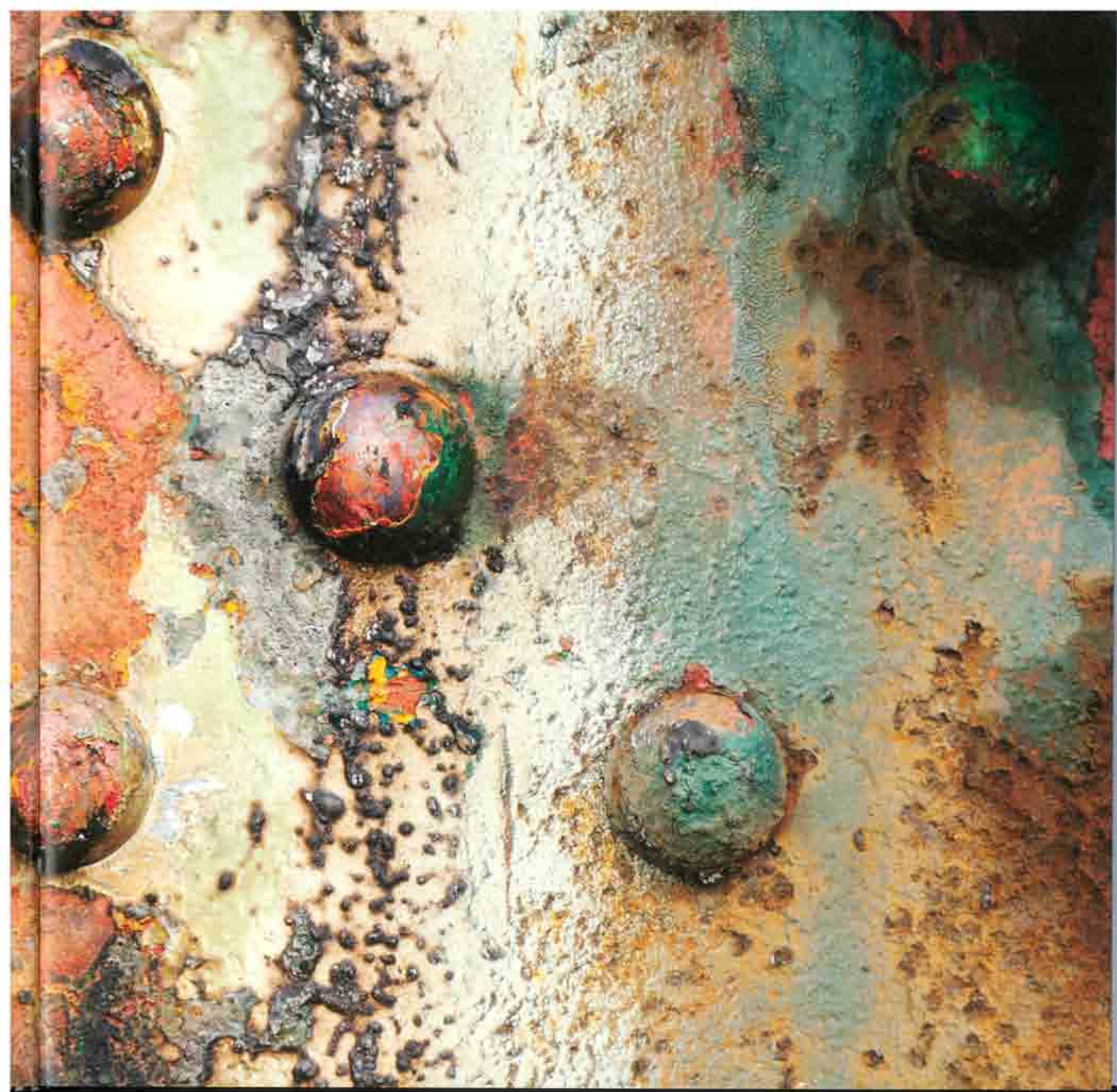


LIKE A MONSTER LOBSTER CLAW, the "shear jaws" attachment on the Cat excavator make quick order of the removed deck sections.

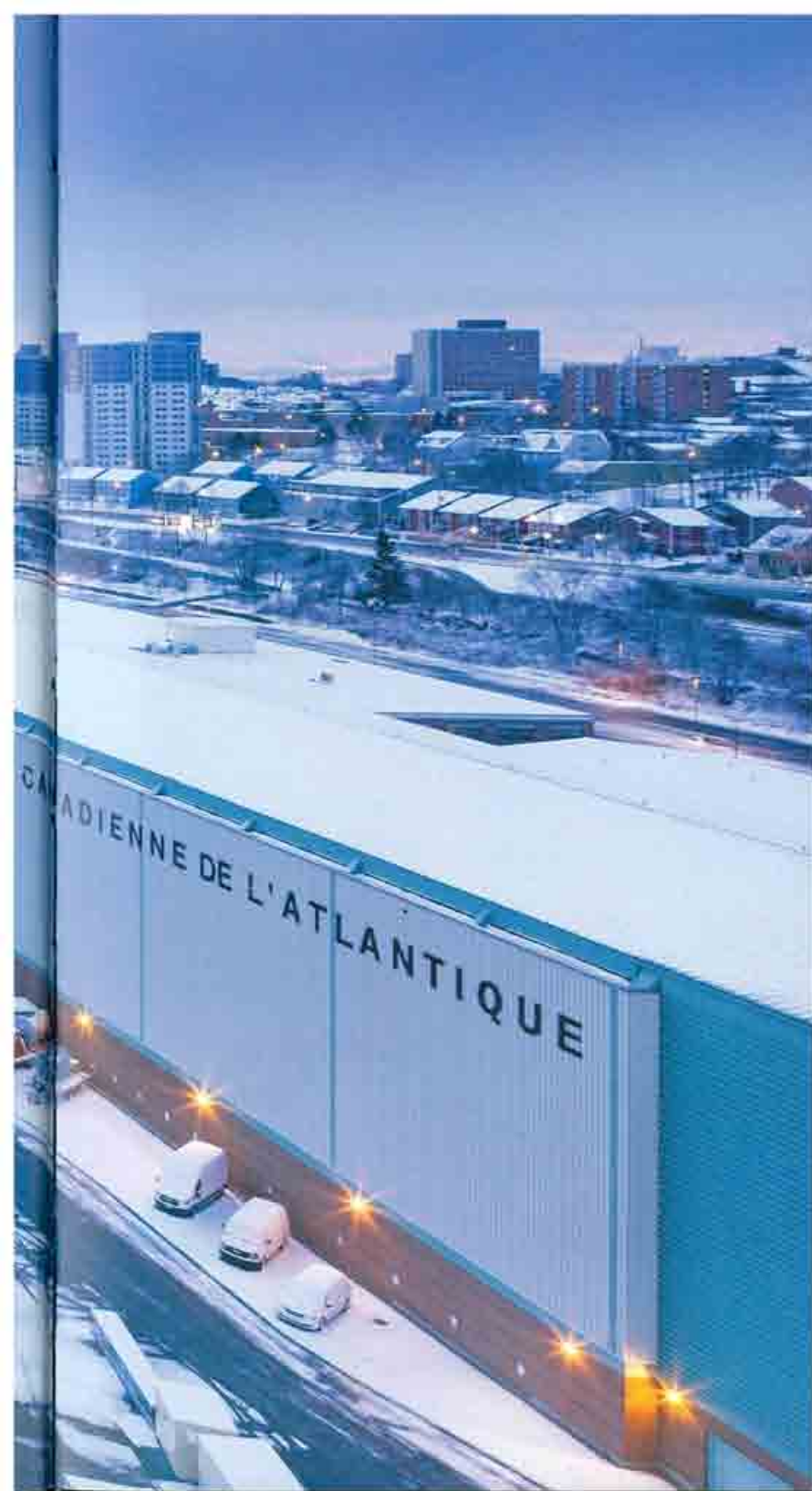
In a matter of a few hours each section is dissected and chopped into one metre lengths, loaded onto trucks and hauled to Dartmouth Metals Burnside facility. Next, the pieces are loaded into containers and shipped to one of several smelter ovens. The "Old Bridge" is then molten into new metal to start a new life, thus completing the recycling process.

It was a strategic decision to recycle and reuse as much of the removed sections as practical, resulting in approximately 99% of all metal receiving a second life. Rumour has it that the remaining 1% of steel were the original rivets saved as souvenirs by some of the crews.









WHEN THE NORTHERN WIND bites through the frost with mind-numbing effectiveness, feet are as cold as the steel upon which they are planted and the generators have sputtered their last cough and gone quiet, it can be said: *it is cold.*

Such was the case on this quiet Sunday morning in January when the temperature and wind combined forces to plummet the mercury to a teeth-rattling -32 degrees.

On such mornings, as an ironworker looks south toward the mouth of Halifax Harbour and views Georges, McNabs and Lawlor Islands, it is easy to allow the mind to drift much farther to the tropical islands of the Caribbean.

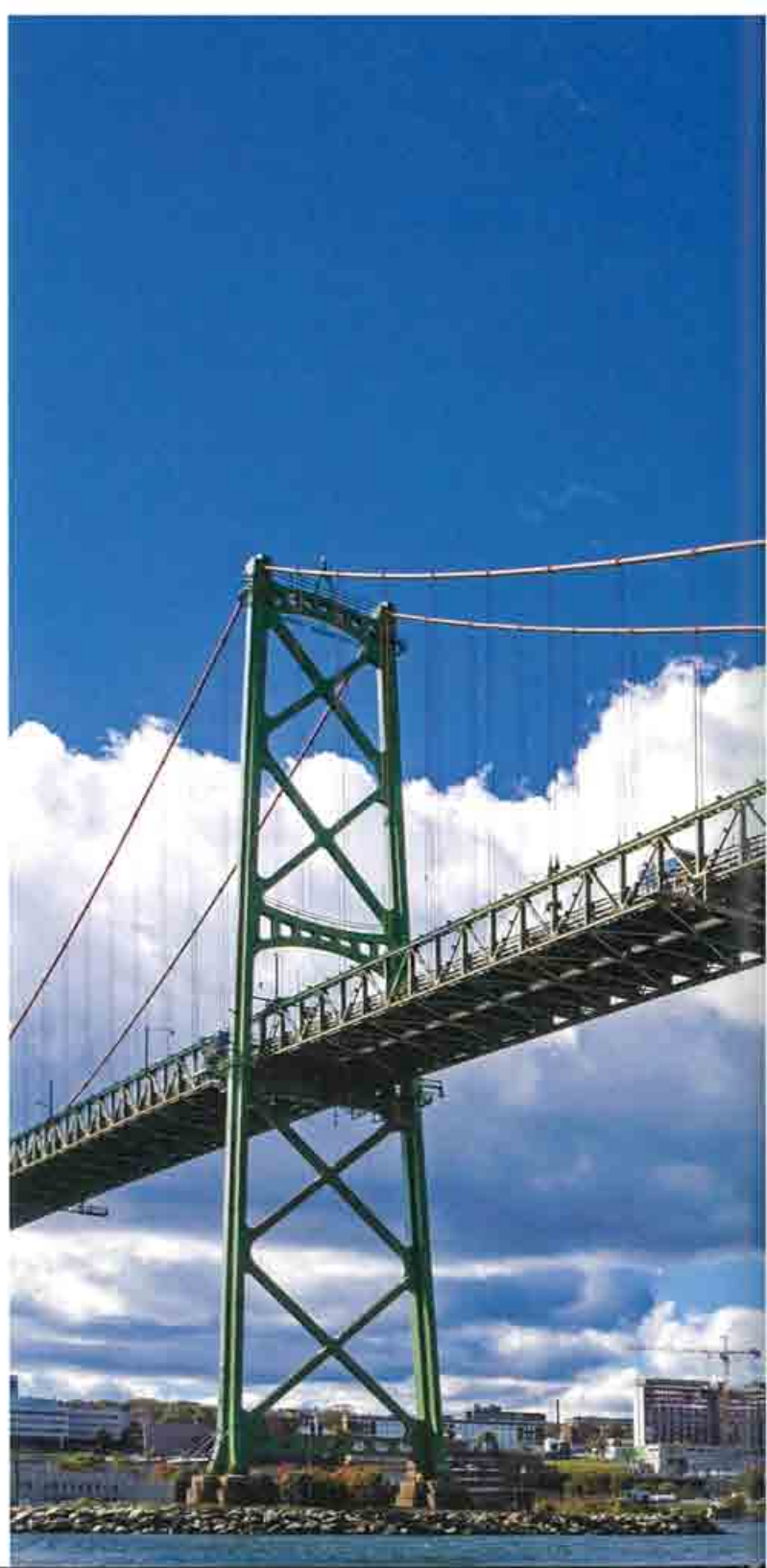




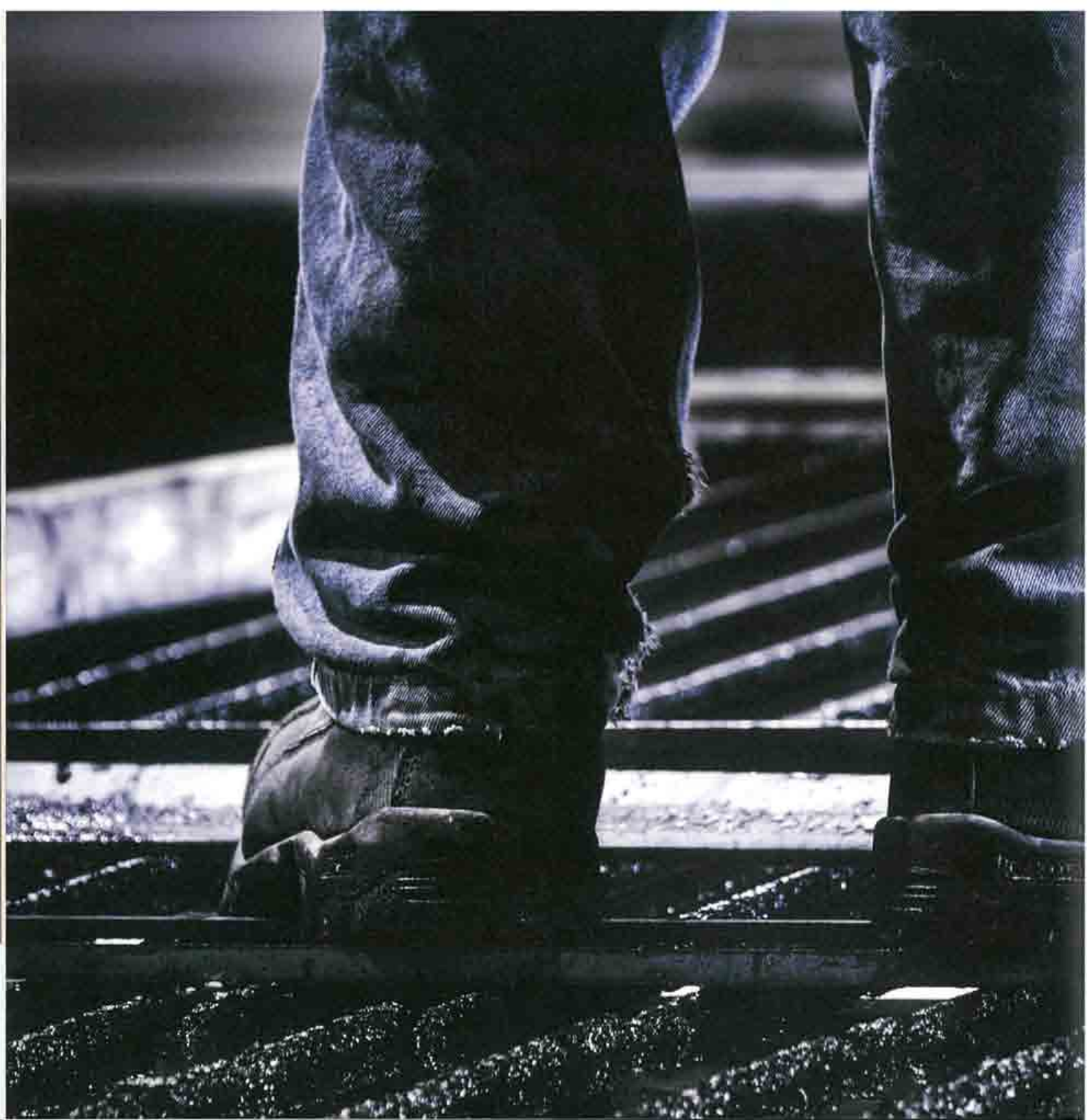


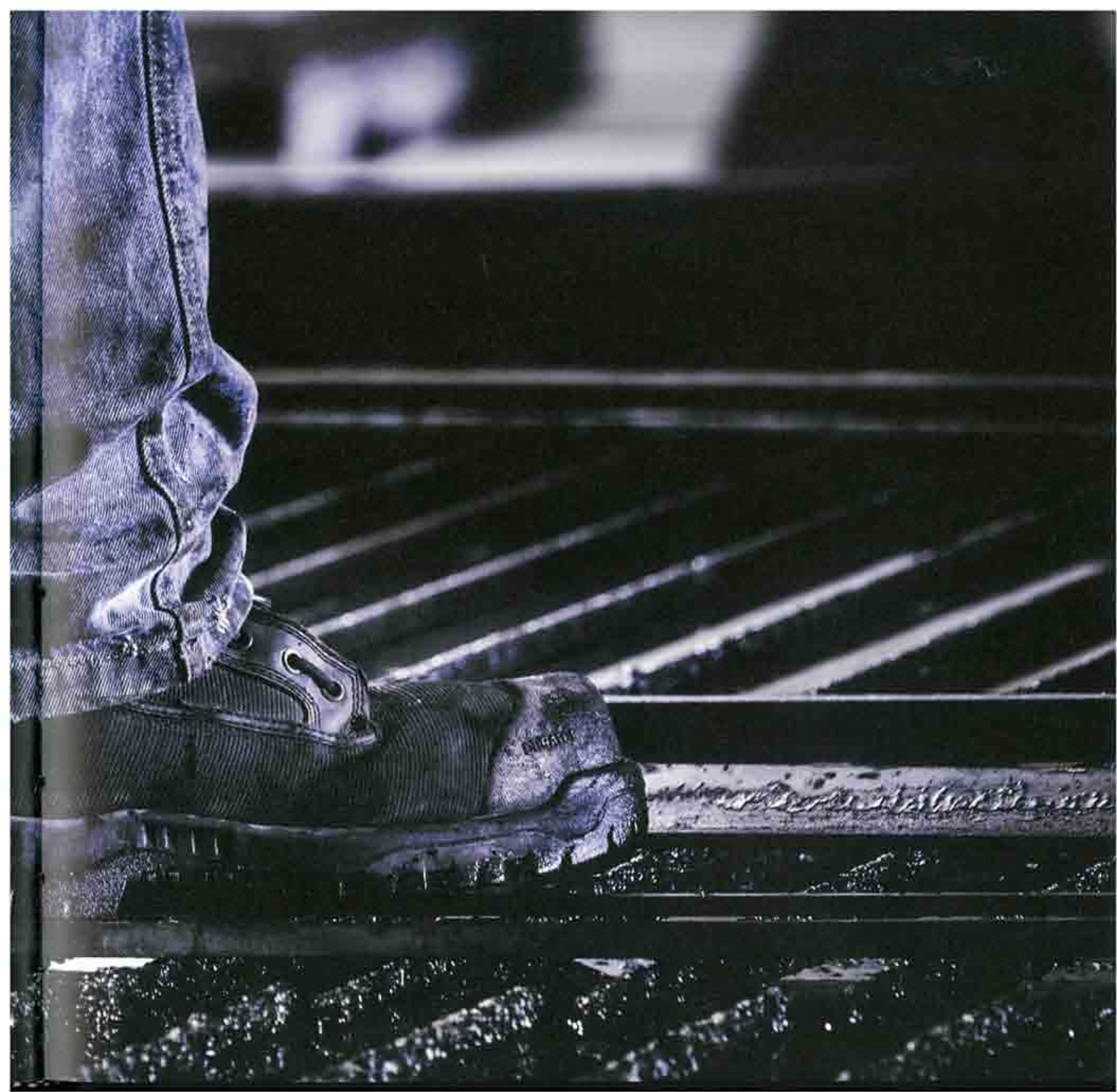


ON SUNDAY MORNING, October 18, 2015
Section D1 started its ascent, and by mid-afternoon
was being bolted in position. Over the next
16 months, 45 more sections will have been
replaced. Ultimately, two sections would be
replaced per weekend as crew expertise advanced.







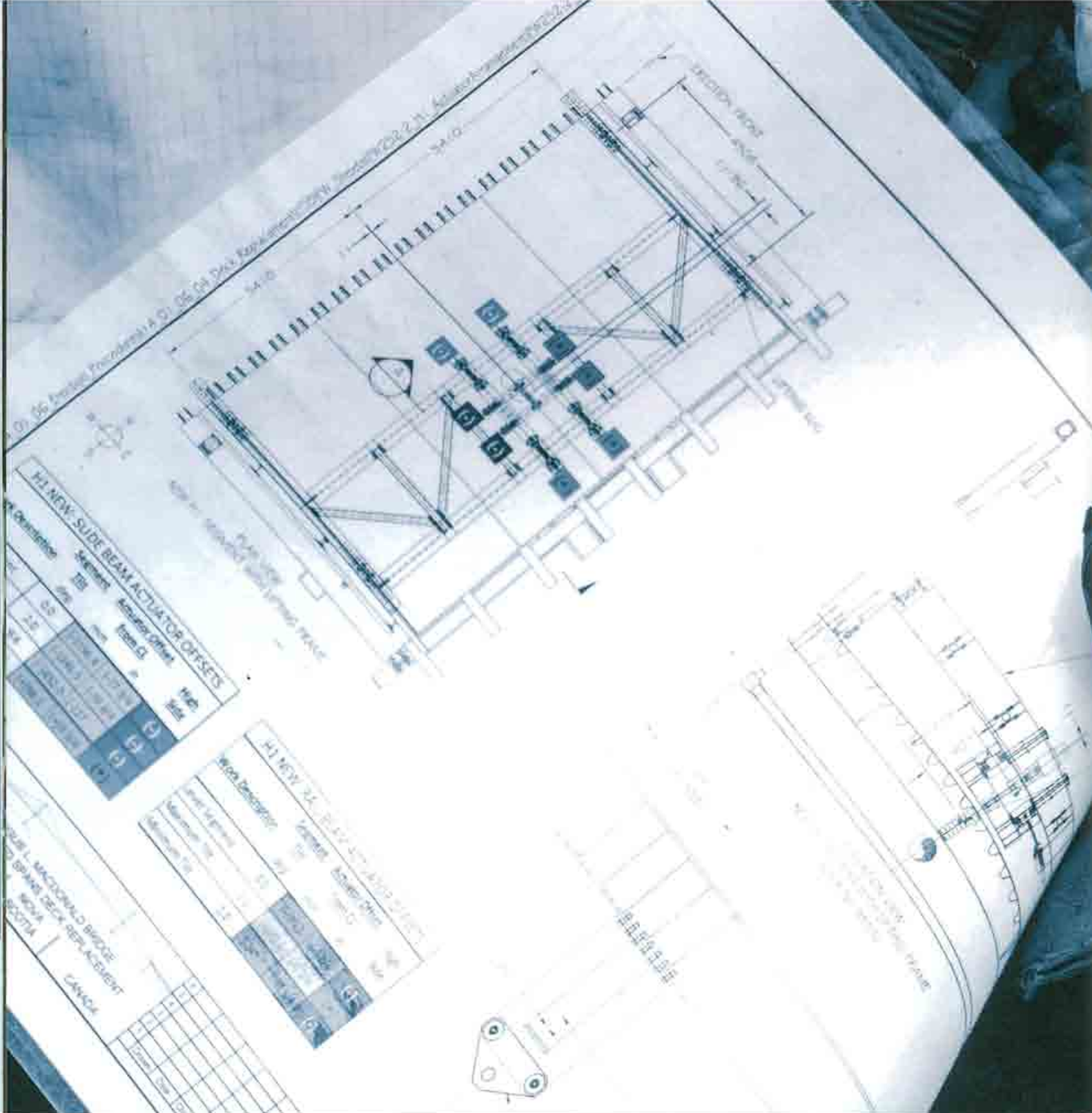






UPON COMPLETION OF FABRICATION each section is transported across the yard at Cherubini Metal Works and enters the paint facility. The section would remain with the painters an average of four days, dependent upon humidity and temperature. Prior to moving to the paving facility located next door, the painters would thoroughly inspect the dried paint and apply any small touch-ups as necessary.

Painting the deck sections consumed approximately 40,000 litres of paint. The pedestrian and bicycle lanes required an additional 10,000 litres.



H1 NEW SLIDE BEAM ACTUATOR OFFSETS

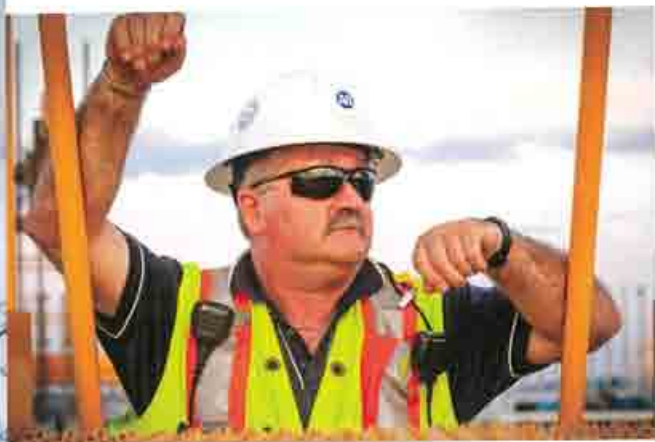
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H1 NEW 2x12 SLIDE BEAM ACTUATOR OFFSETS

Quantity	Segment	Actuator Offset	Notes
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1	100	100	

BRIDGE L. MACDONALD BRIDGE
 GRAND DECK REPLACEMENT
 CANADA





THE THERMAL LANCE is the device that created the great cascading light show each weekend.

The lance is a long steel tube packed with alloy steel or aluminum rods. When the rod is ignited with an oxyacetylene torch, it quickly reaches the very high temperatures required for cutting the steel. The ironworker controlling the lance can adjust the heat and cutting speed by regulating the high-pressure oxygen that travels down the length of the now melting rod.

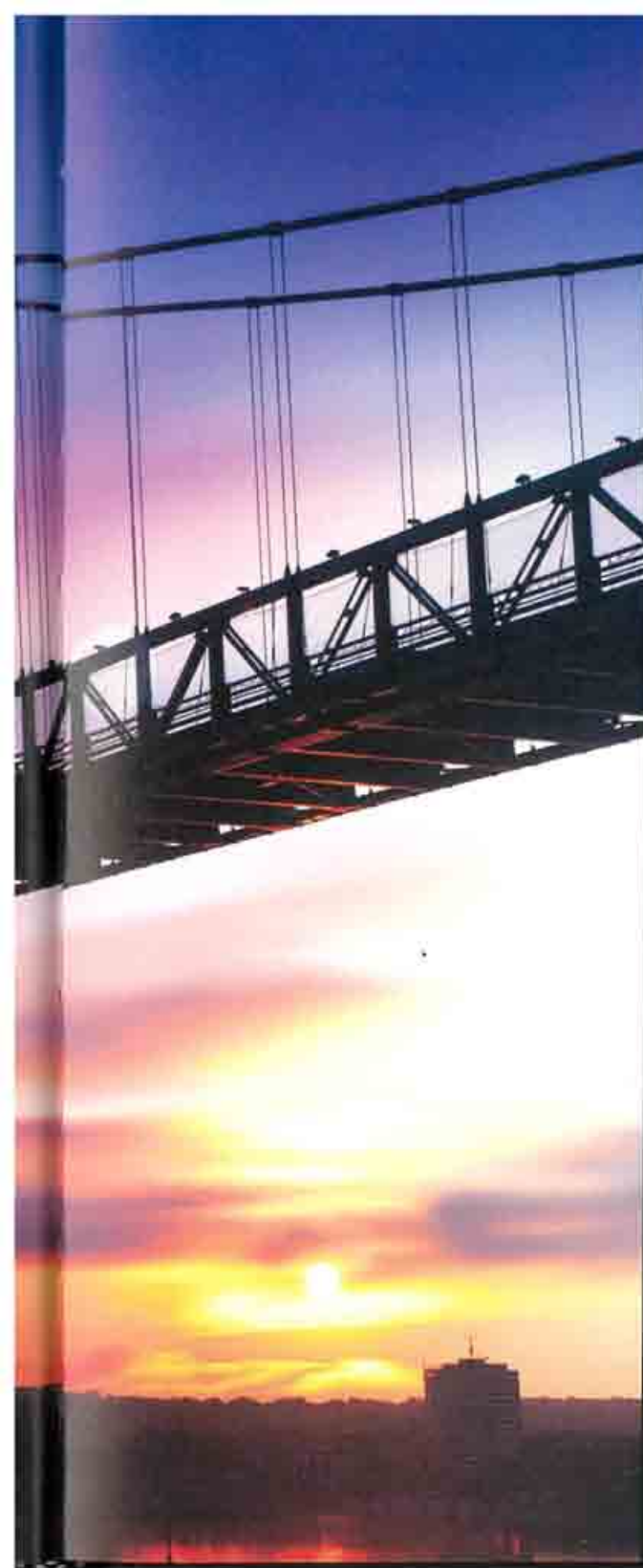












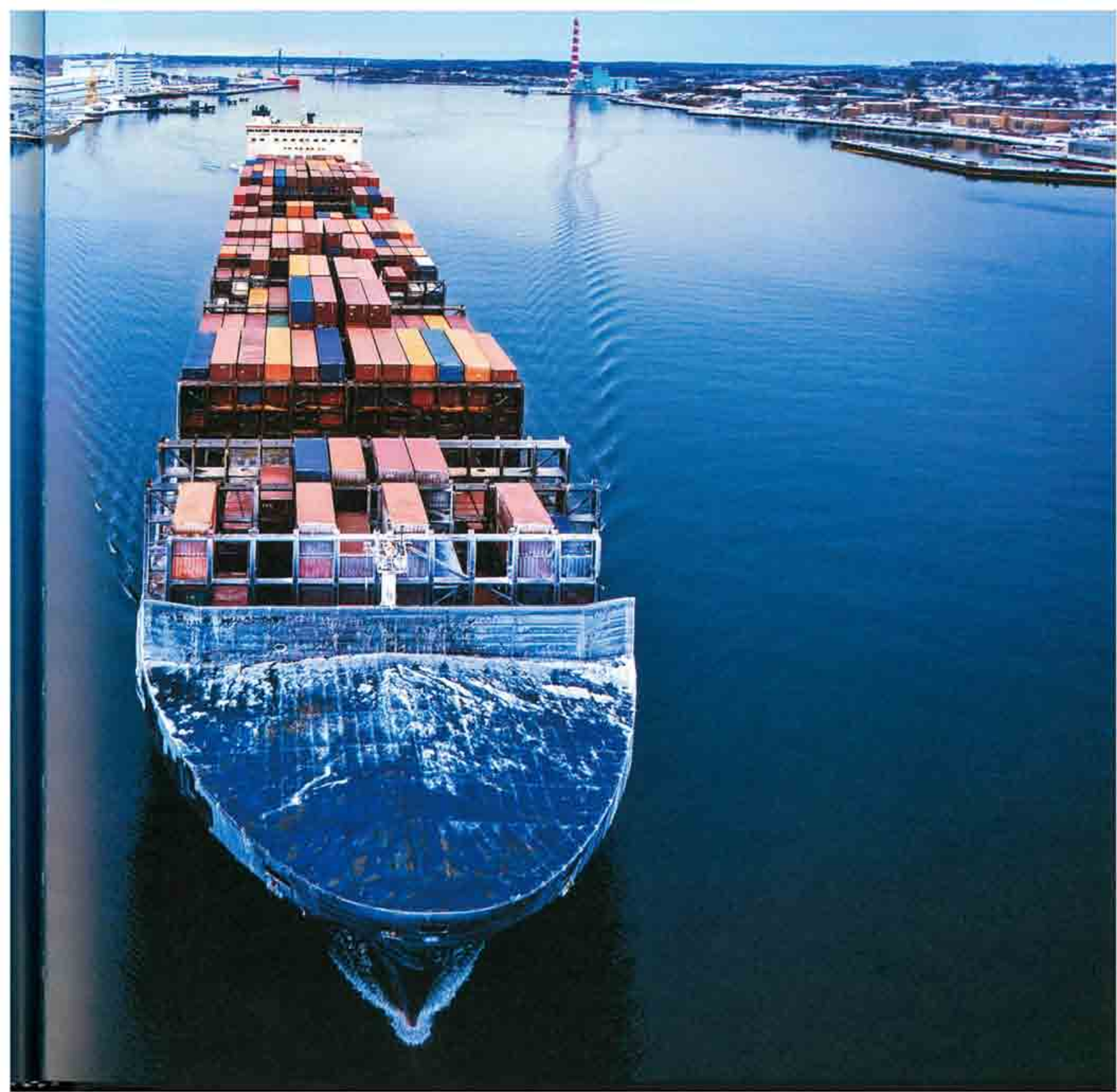
WITH THE DAILY CITY BUSTLE still an hour or so away, workers on the bridge deck are blessed with a mosaic of colour as the sun shines its first rays of the day on downtown Dartmouth.

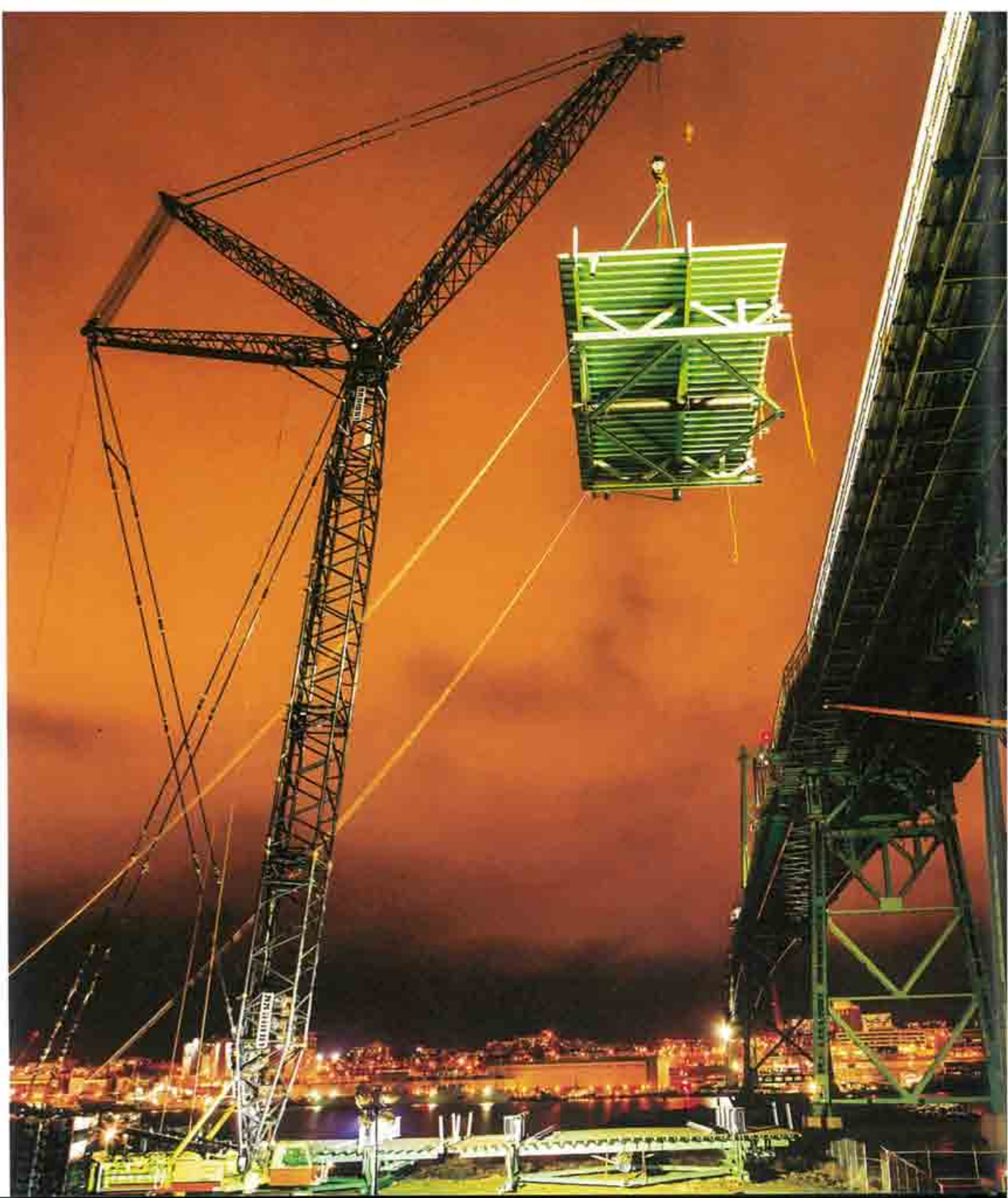
As each deck segment is replaced, the final elevation is adjusted by raising or lowering the suspension cables with hydraulic jacks. Transit levels ensure the final elevation is kept within tolerance.

AS THE PORT OF HALIFAX increases its shipping capacity, the frequency and size of the vessels also increase. In order to be prepared for future growth of these large ships — often exceeding 290 metres in length — specifications called for the deck of the Macdonald Bridge to be two metres higher than the Old Bridge at mid-span.

The *ACL Atlantic Conveyor* is a regular visitor to Bedford Basin and the Fairview Cove Container Terminal.





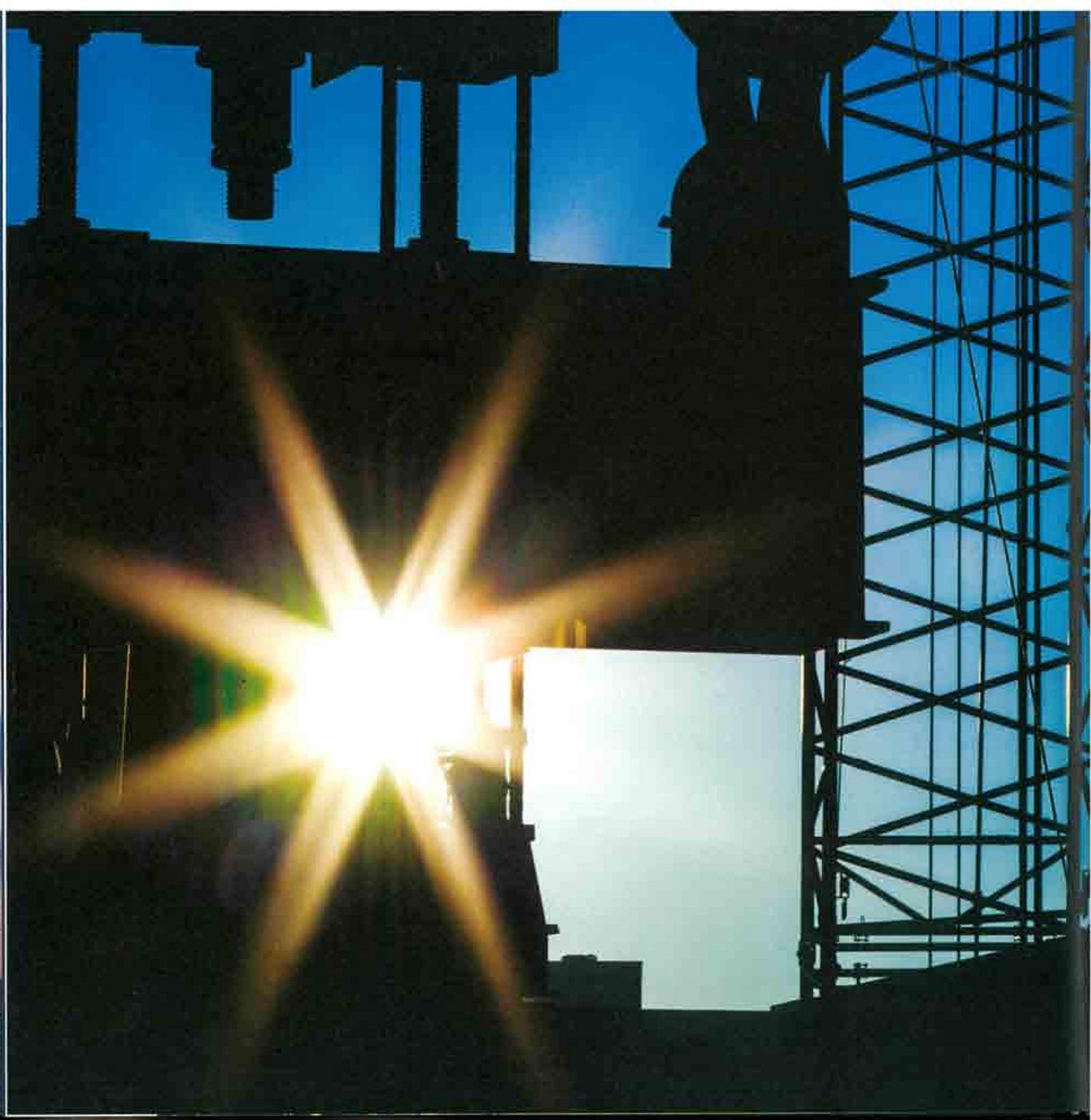


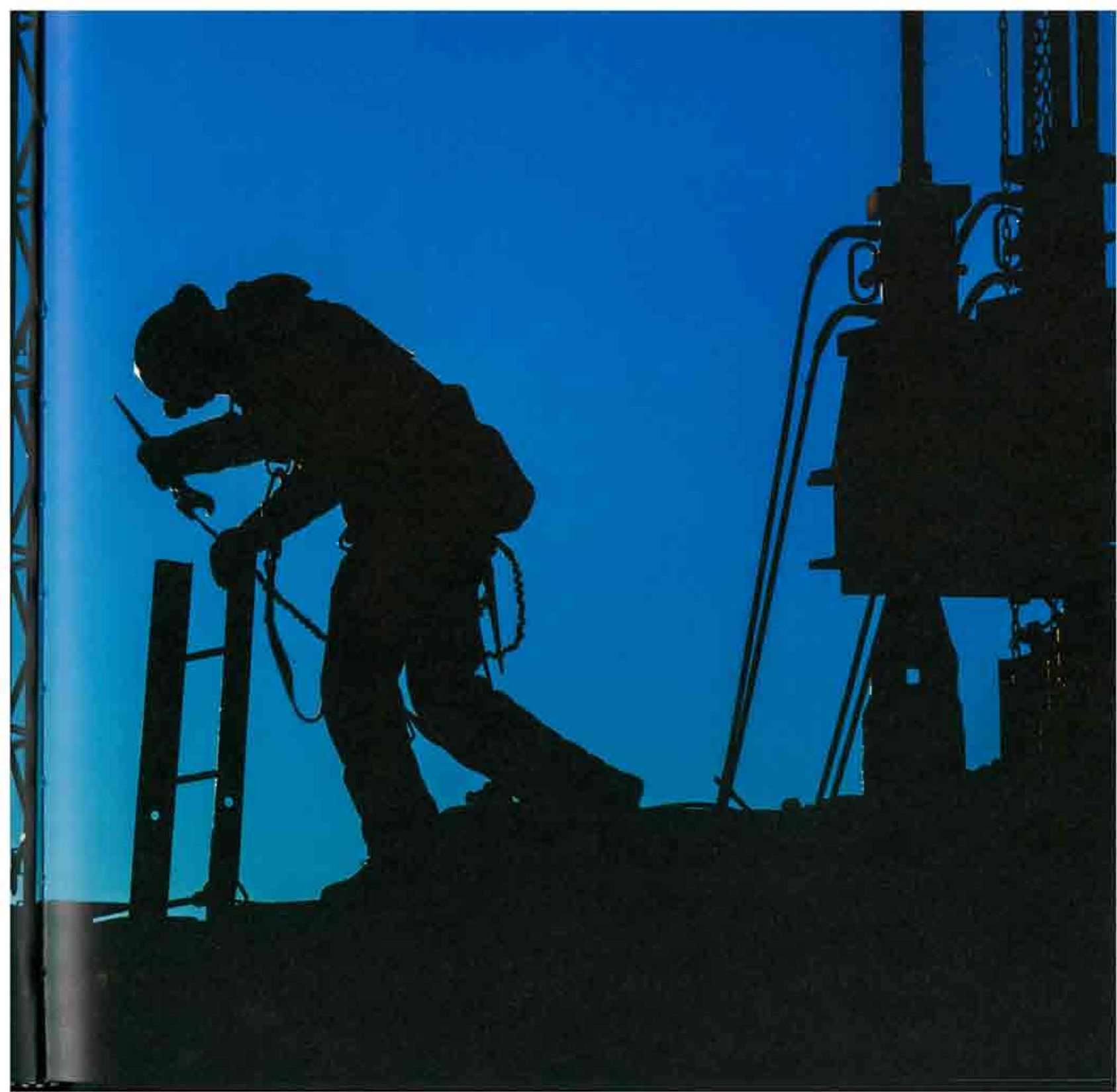
SIXTY TONNES OF STEEL known as Section 31 dangles from the massive Manitowoc 16000 crane used to move the section from the Dartmouth yard to the bridge deck.

Once each section is craned above and cleared of the suspension cables it is then meticulously lowered to the waiting Self Propelled Modular Transporter (SPMT). Like a centipede on steroids, the multi-wheeled, articulating SPMT traverses the length of the bridge to the Halifax side. At this point a second smaller crane lowers S-31 to a segment of the Navy Dockyard that has been reserved for the Big Lift project.

As much work as possible throughout the Big Lift project was contracted to local companies, benefitting the local and Nova Scotia economy. The SPMT, a dream toy of any remote-controlled car aficionado, was supplied and operated by Total Transport & Rigging of Halifax.



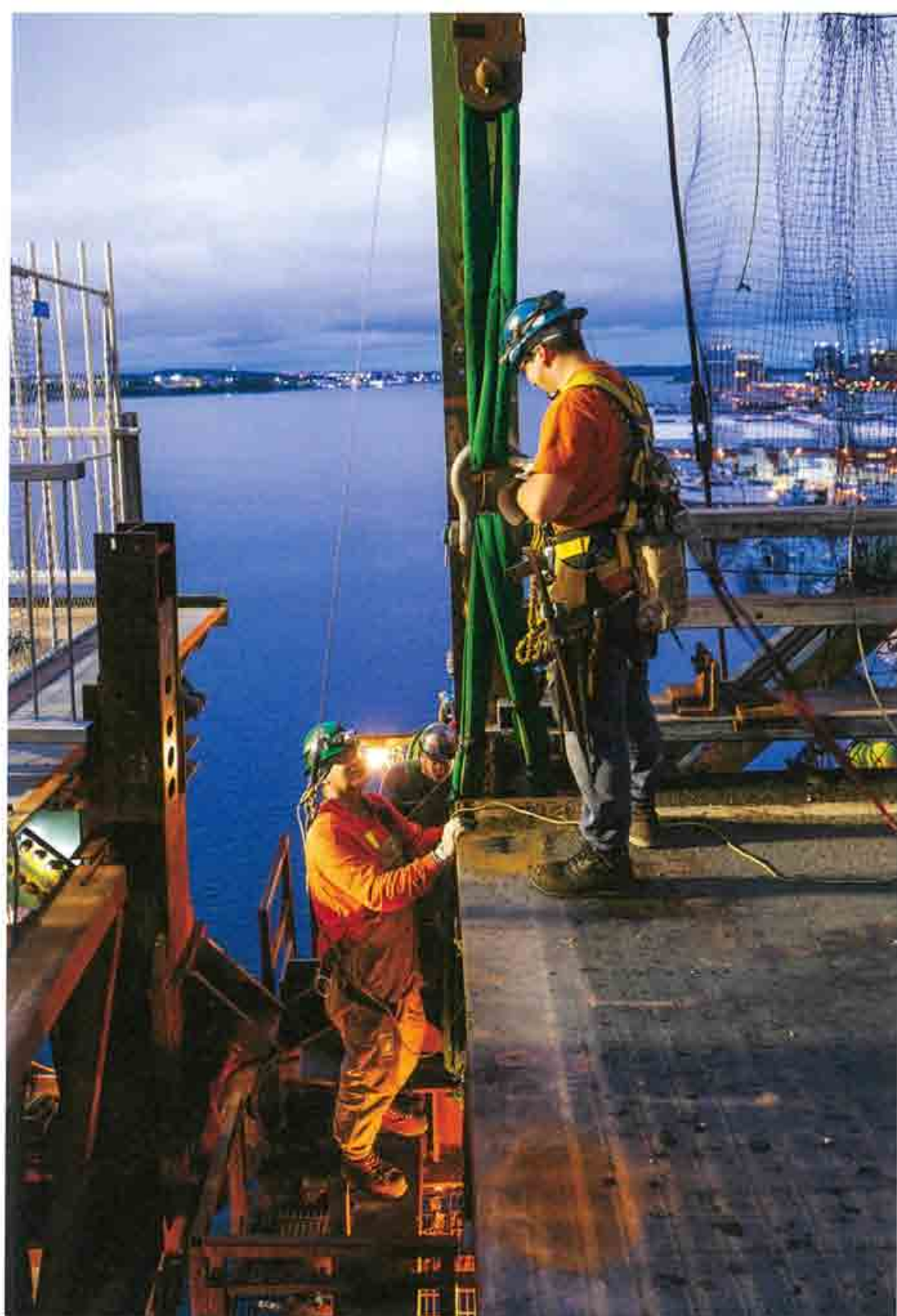




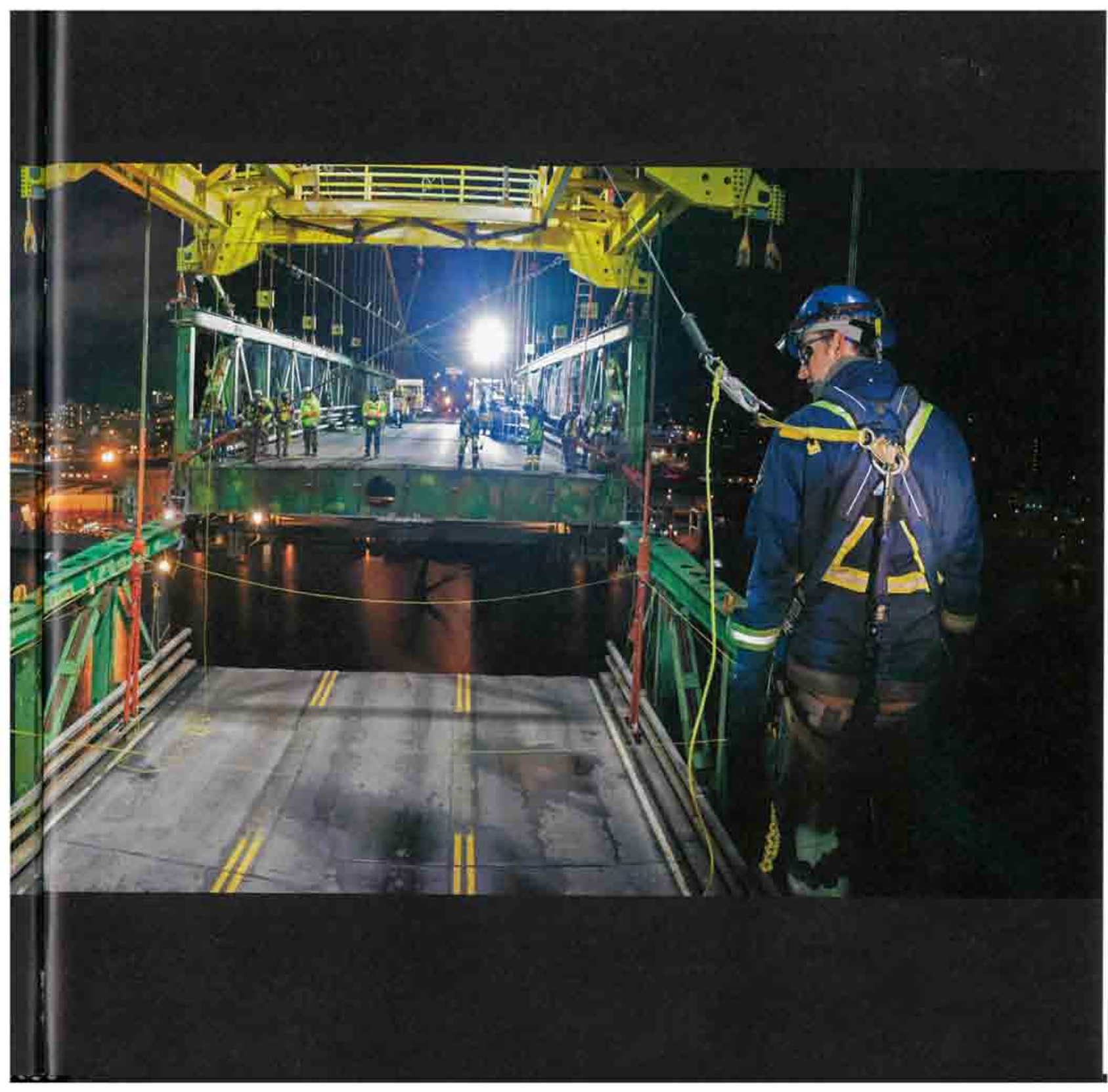












Local
732





BY LOOKING CAREFULLY along the length of the curvature of the guardrail it is possible to see precisely the centre point of the span.













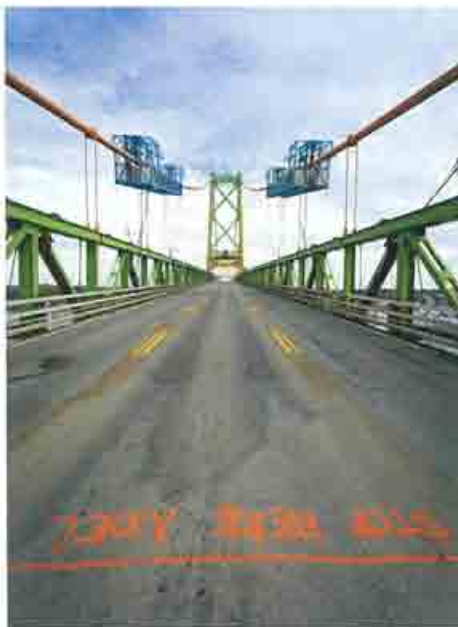
AN IRONWORKER FROM LOCAL 752

goes to his office wearing the tools of his trade.

The tool belt is sometimes called a riggers belt or a structural belt, and often times is labelled a pain in the back. The belt when completely outfitted can often exceed 7.5 kilograms, and must be balanced in order to allow the worker to keep his equilibrium ensuring personal safety when working on narrow beams at great heights.

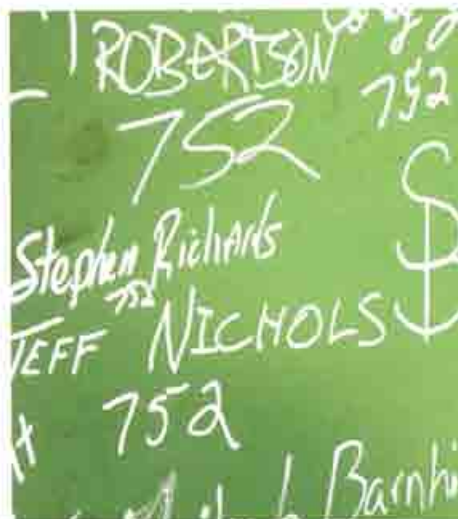
Personal Protection Equipment (PPE) and appropriate safety training was a requirement for all personnel on the job site.

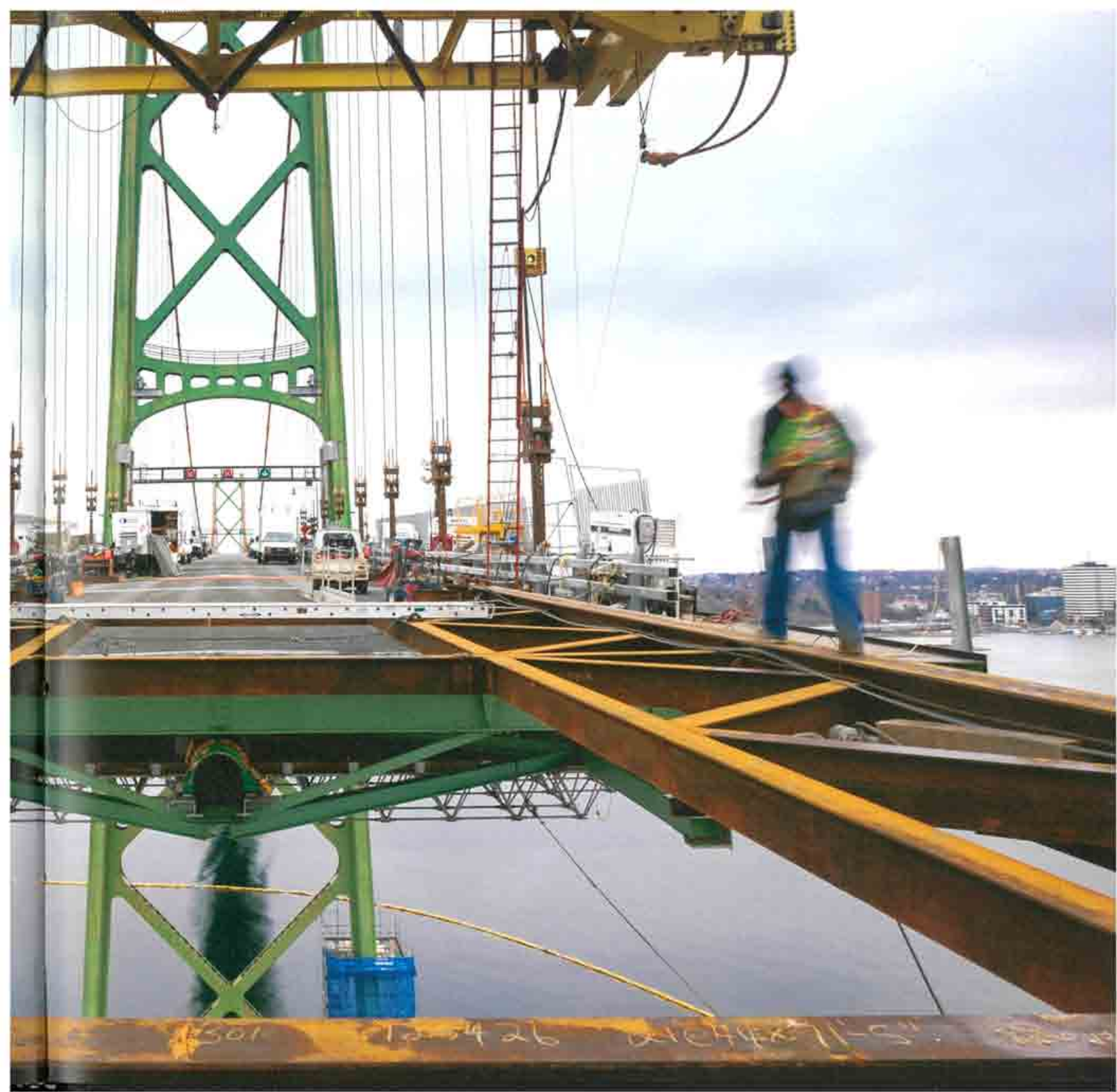
There was a fine balance required on particularly cold days between tools, PPE and warm clothing to ensure worker safety and comfort.



ONE CAN ONLY IMAGINE why Noel should stop here. Many messages were written between the workers on the steel during the Big Lift project. Some were technical, others were instructional, and others were... colourful.

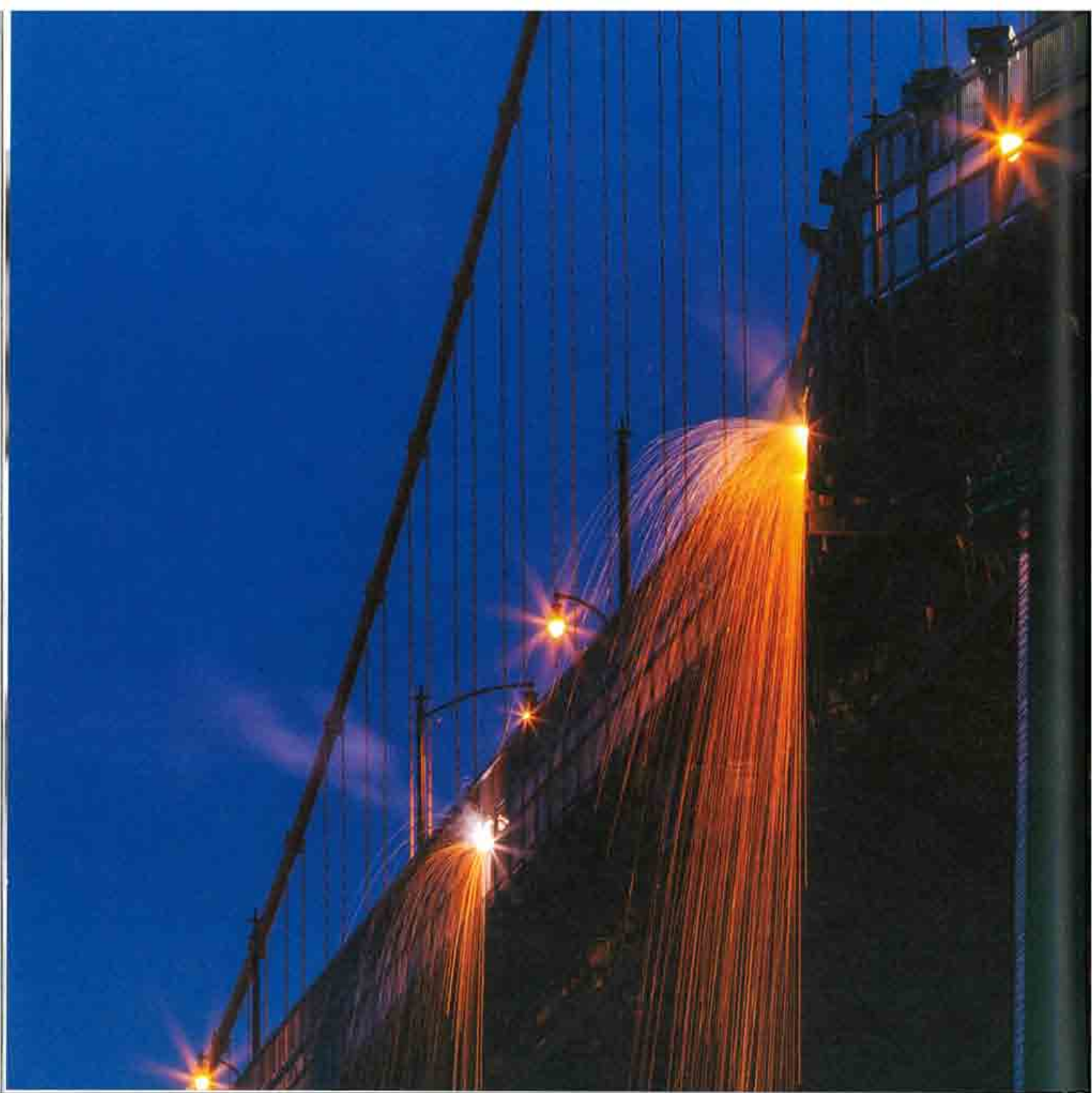
Section 46, the last section to be raised, is signed by Ironworkers Local 752 prior to being lifted into position.



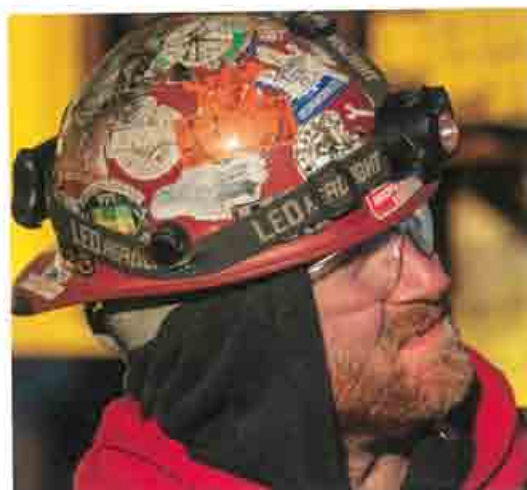




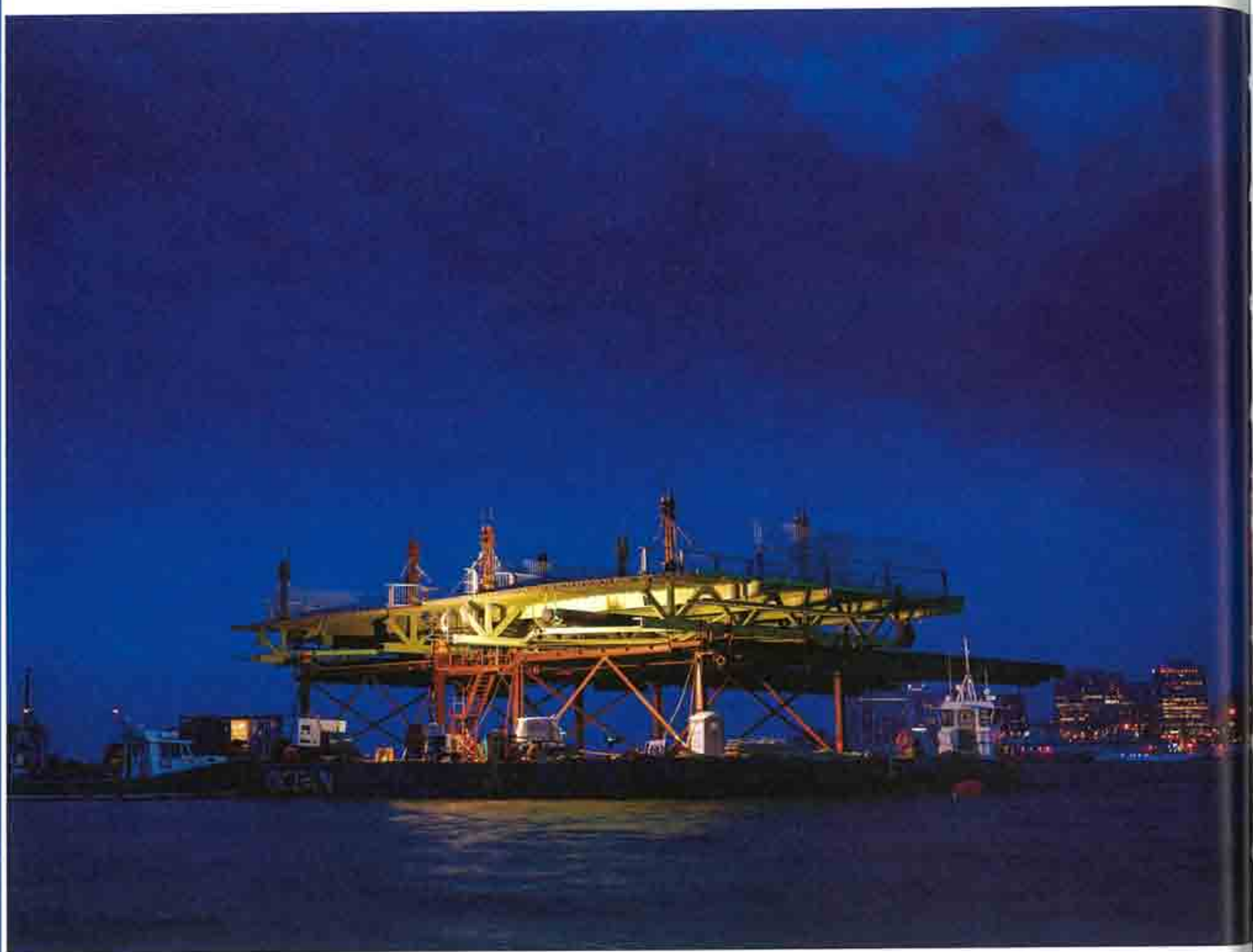










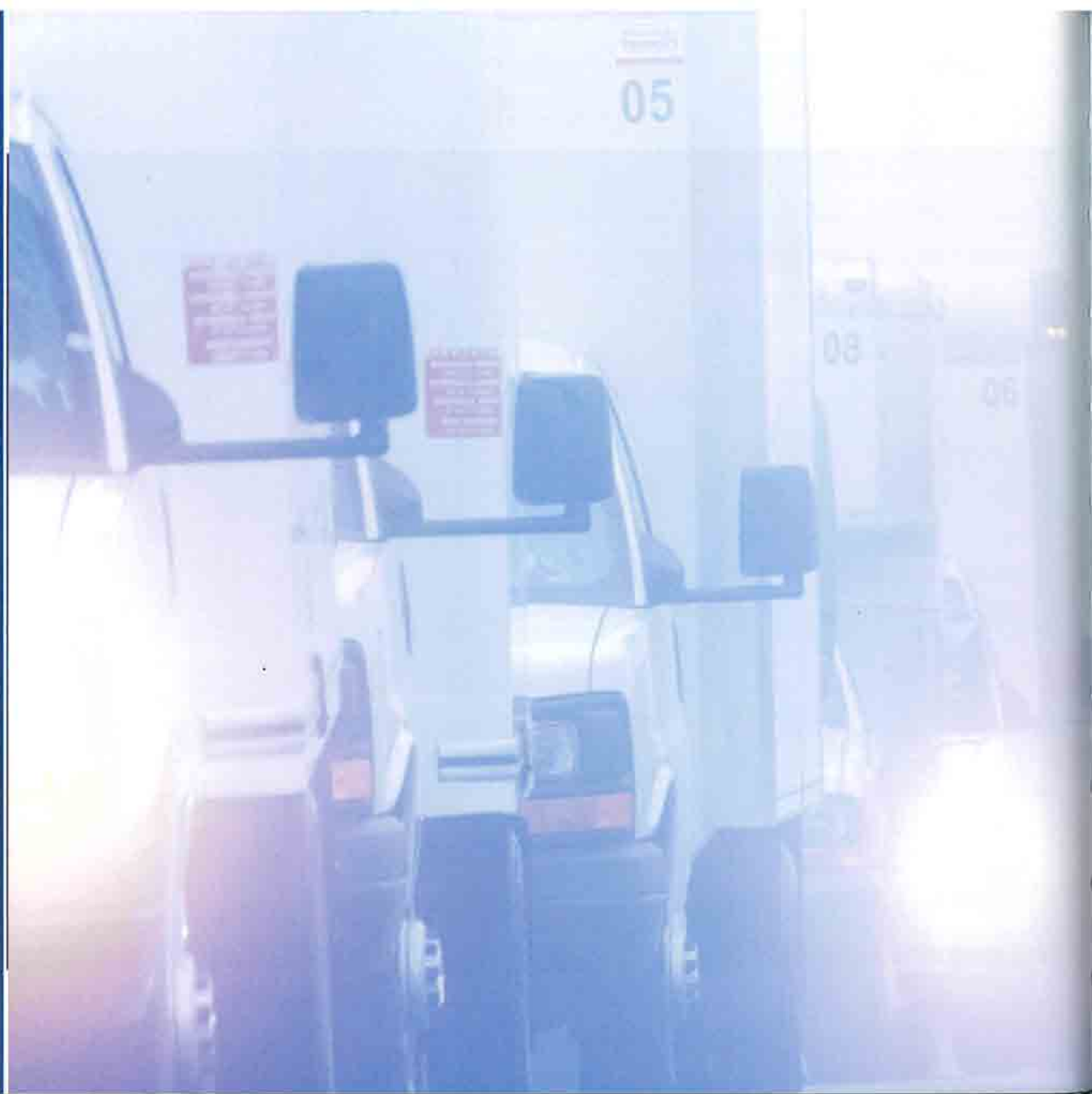




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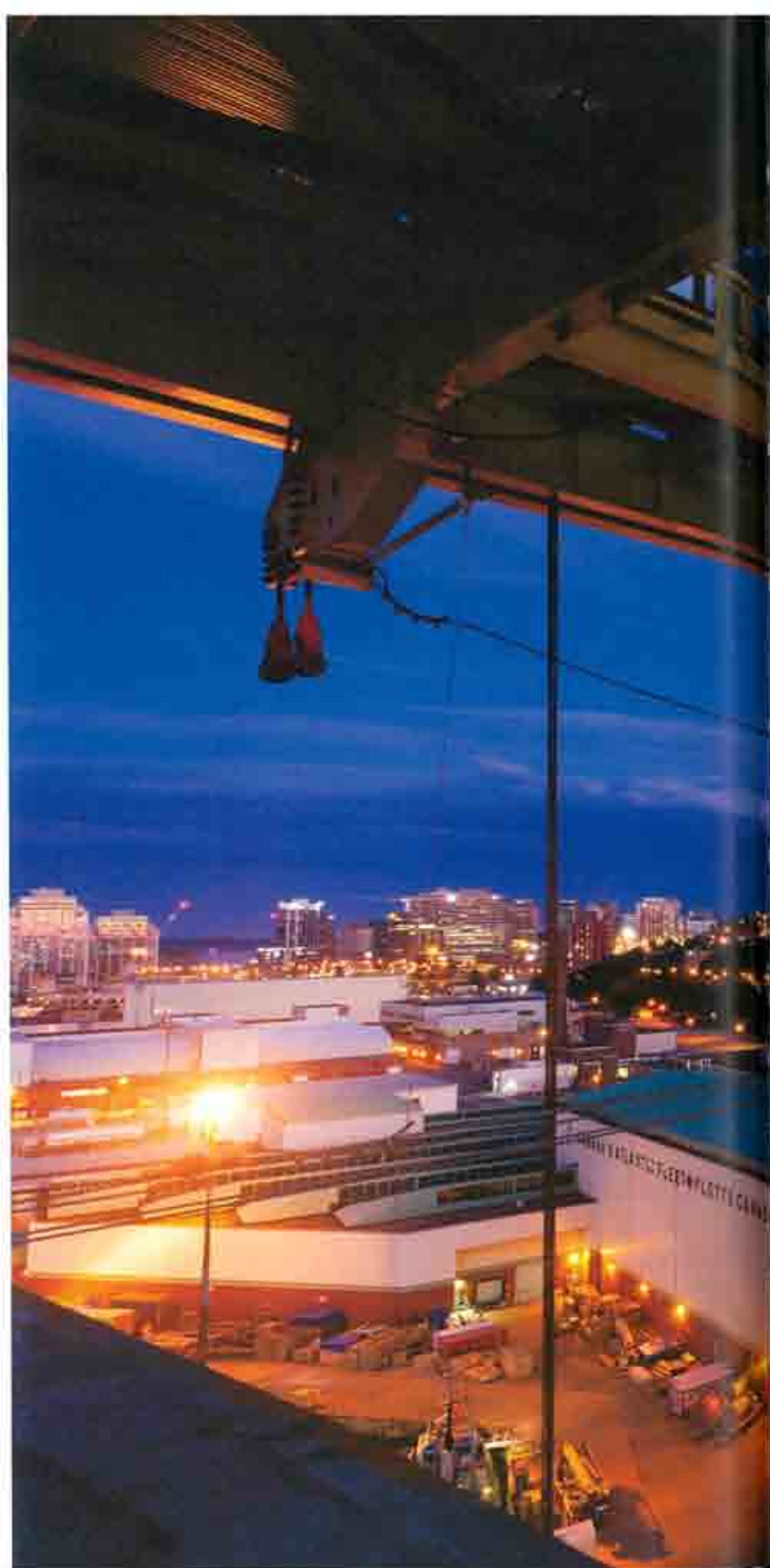
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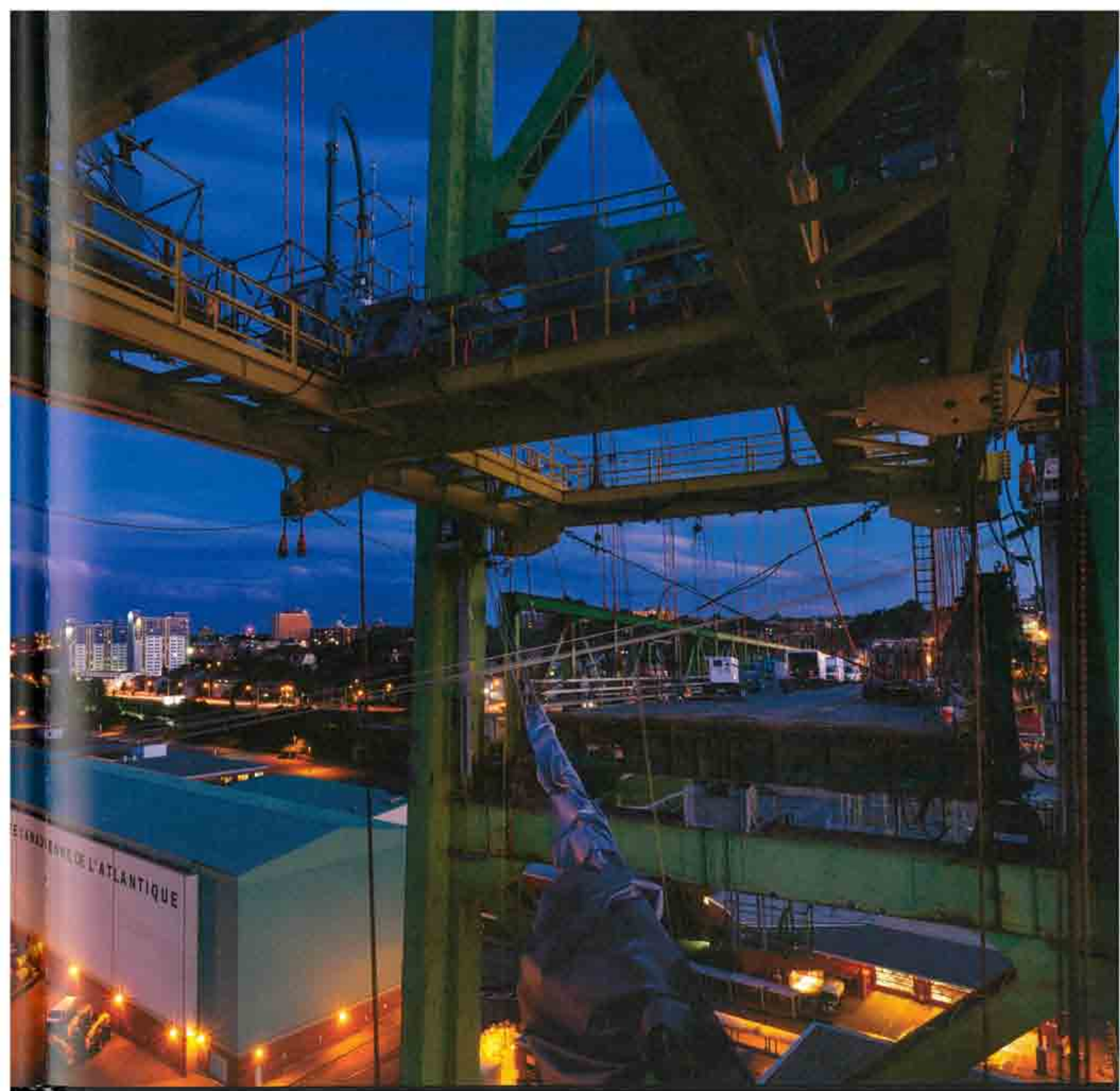
06



FDR, otherwise known as fog, drizzle, rain was an all too frequent companion that workers had to endure.











PEDAL POWER has evolved to an important mode of moving people back-and-forth across Halifax Harbour. During the closure a continuously-operating shuttle service was provided to transport cyclists and pedestrians.

The first section of the bridge to be removed was a small portion of the pedestrian walkway, as seen on the facing page. The sidewalk and bike lanes were repurposed as hiking and trail bridges around Nova Scotia.

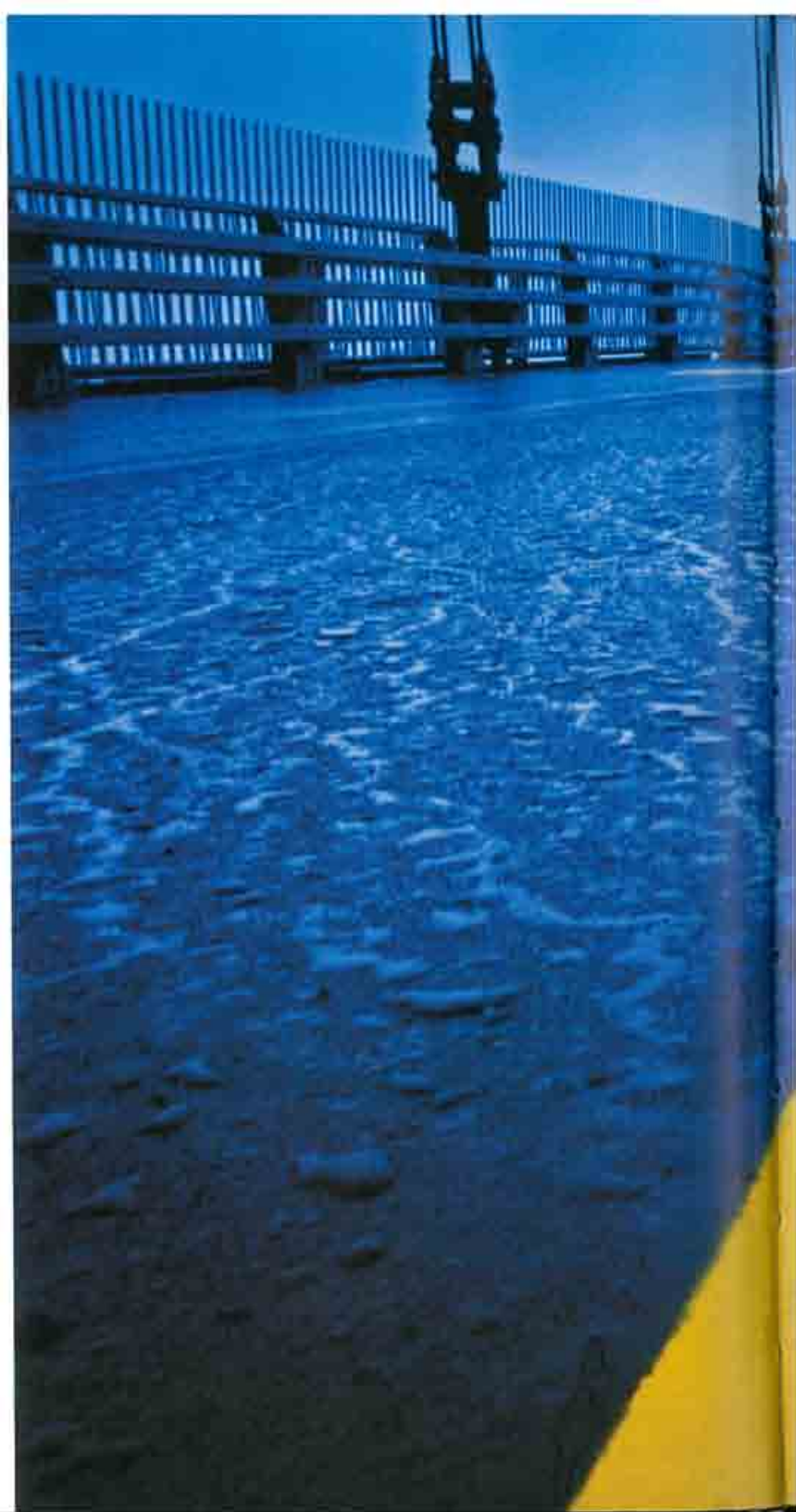
When the Macdonald Bridge opened in 1955, the toll for a pedestrian was a nickel, the cyclist was charged a dime and a horse and rider was 25 cents. Today cyclists and pedestrians travel for free, and horses are no longer permitted to cross the bridge.

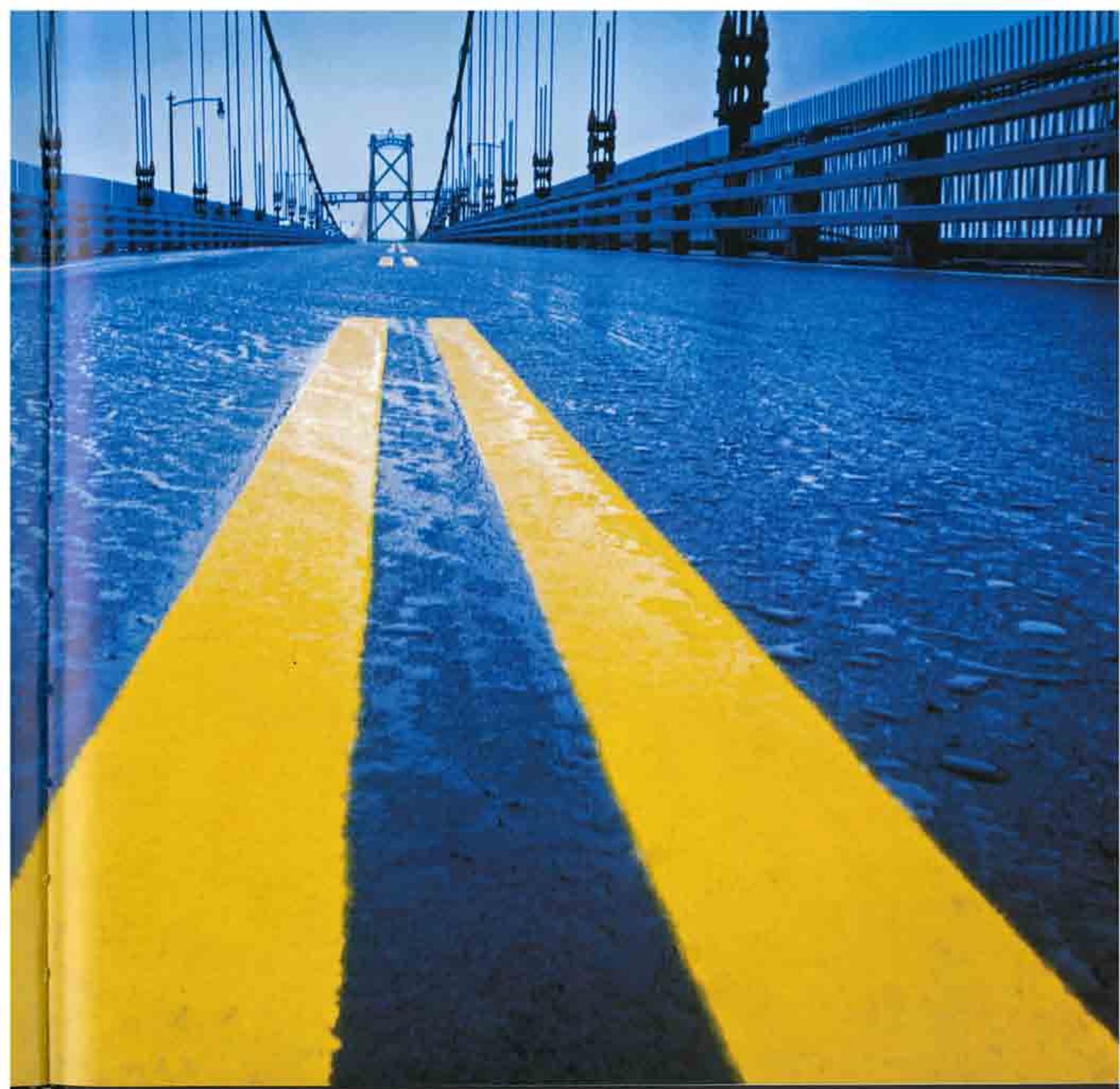


THE FOUNDATION LAYER of asphalt was applied at Cherubini Metal Works, located approximately 10 kilometres away in the community of Woodside. The final application of asphalt was applied after the sections were installed.

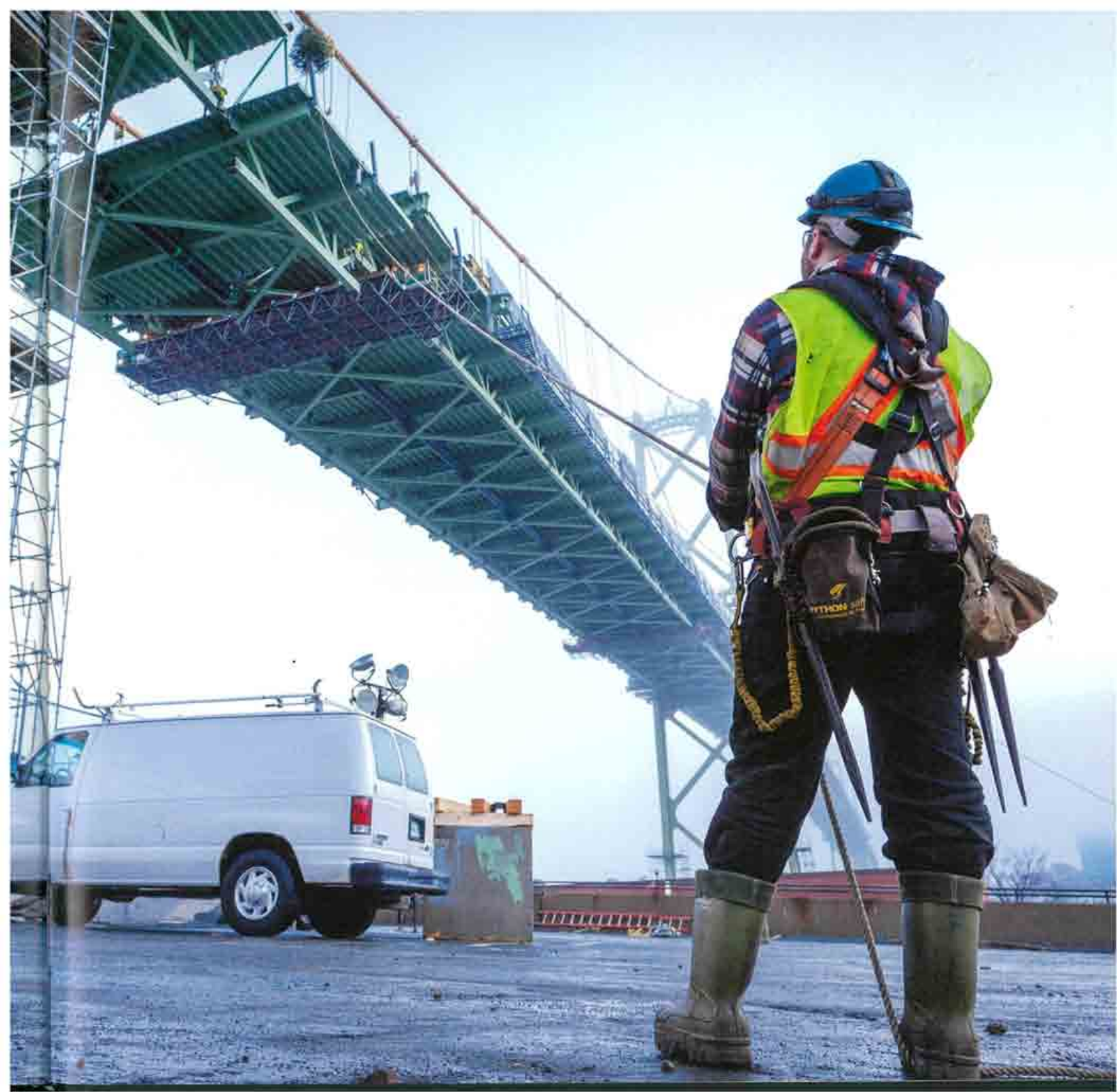
Epoxy asphalt was used on the Big Lift due to its enhanced life and thinner application, thus reducing the overall weight of the bridge deck.

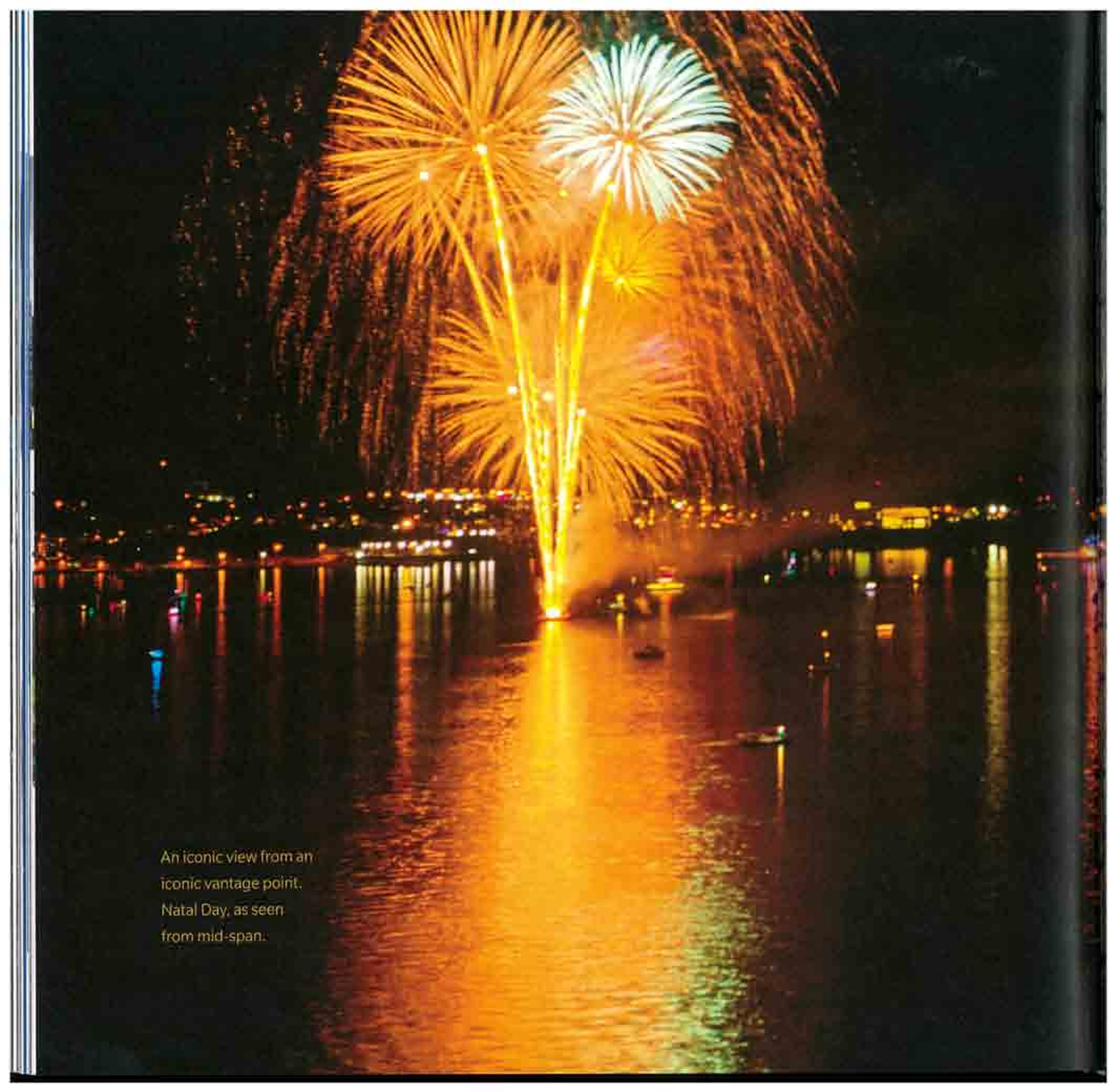
Halifax Harbour Bridges is the only known user of epoxy asphalt in Atlantic Canada. This is the same material and process that was used to resurface the San Francisco Bay Bridge in 2013.



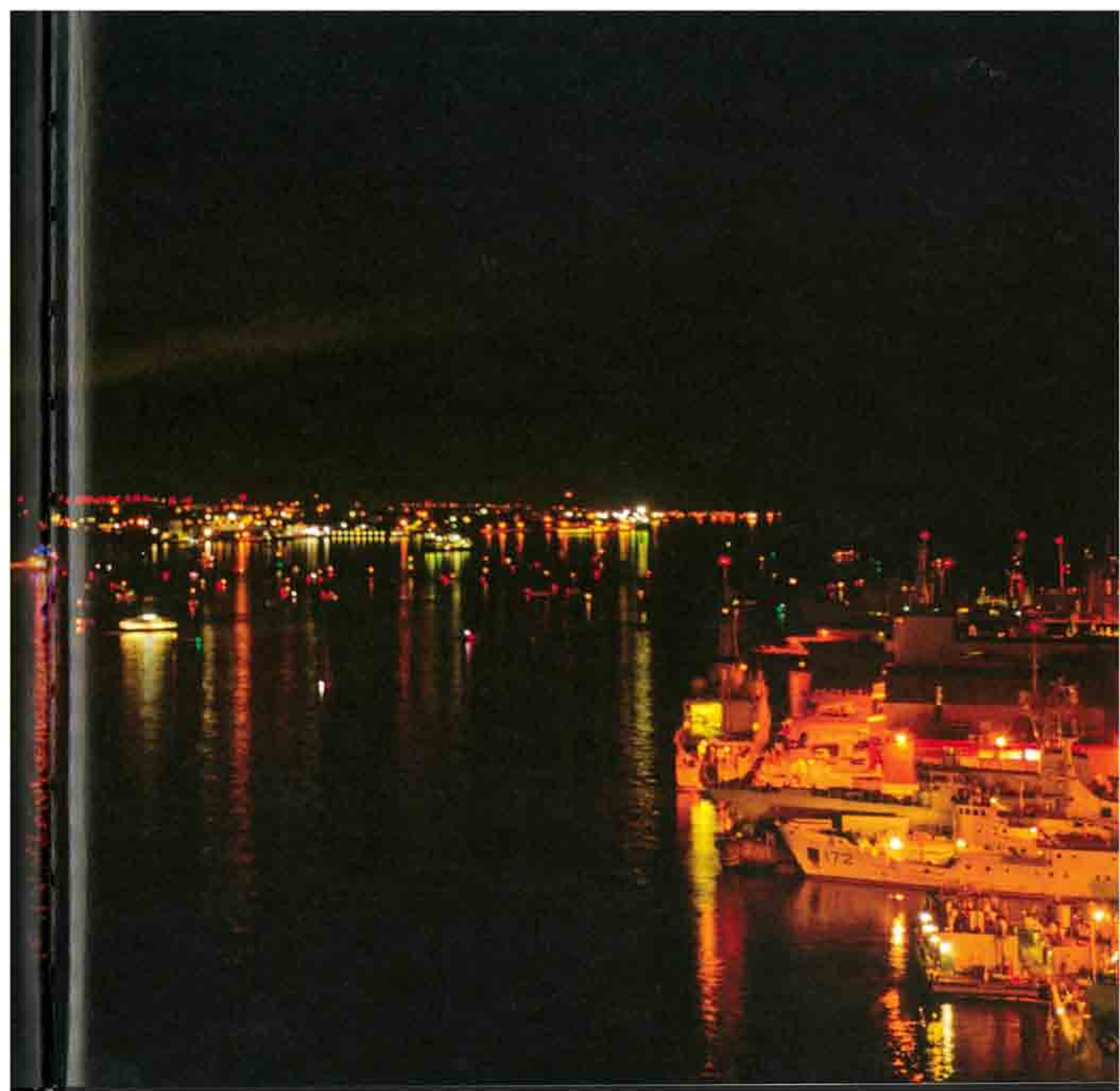








An iconic view from an
iconic vantage point.
Natal Day, as seen
from mid-span.



BIG LIFT PARTNERS

OUR SINCERE THANKS to our partners who worked with us to ensure the Macdonald Bridge remains safe for future generations. And thank you to our neighbours and our customers for your patience through this once-in-a-lifetime project. Special recognition goes to Halifax Transit, the Halifax Port Authority and the Department of National Defense for their collaboration and partnership over the last several years.

Air Liquide
All Canada Crane
Amman & Whitney
American Bridge Company Canada
Anixter
Atlantic Hardchrome Ltd.
Auto Locators
Axis Mobility Services
AW Leil Cranes & Equipment
Black & McDonald
Bradken Canada Manufactured
Products Ltd.
Brockman Engineering Inc.
Cahill Group
CBCL
CFM
Cherubini Metal Works Ltd.
COWI North America Ltd.
Cumberland Paving & Contracting Ltd.
Dartmouth Metals and Bottle Ltd.
Duron Atlantic Ltd.
D.S. Brown Company
The Dyson Corporation
Eagle Beach Contractors Ltd.
Eastern Fence

Finnoe Design LLC
Groupe Océan
Halifax Regional Municipality
Harbourside Engineering Consultants
Hazmasters Inc.
Industrial Safety World Inc.
Integrated Hydraulics & Industrial Services
Ironworkers Local 752
Irving Equipment Ltd.
JAMAC
Killick Group
Klohn Crippen Berger
L&A Metalworks
MacFarlands
MacGregor's Custom Machining Ltd.
Mageba Group
Marid Industries Ltd.
Marsh Canada Ltd.
McInnes Cooper
M&J Total Transport and Rigging
M & R Engineering Ltd.
Munters Corporation
On Guard Traffic Control
Optimum Controls Corporation
Pennine Control Systems Ltd.

Red-D-Arc
Risksmart
RKO Steel Ltd.
RMI Marine Ltd.
RWDI Air Inc.
Safway Services Canada Inc.
Sani Engineering Ltd.
Sancton Access Inc.
Sani Engineering Ltd.
Servant Dunbrack McKenzie &
MacDonald Ltd.
Singleton and Associates
Skarborn Engineering Ltd.
SNC - Lavalin
Stantec
TEAM Industrial Services
Trans Canada Coatings Consultants Ltd.
Top Construction Ltd.
United Rentals
Williams Form Engineering Corporation
WireCo WorldGroup
VSL International Ltd.
Zieman Engineering LLC



THE BIG LIFT showcases dozens of photographs from a collection of thousands made by Nova Scotian photographer Dale Wilson, while on assignment with Halifax Harbour Bridges.

A labour of love documenting an engineering marvel and industrial beauty, the photographer introduces us to the people who made it happen, and how they made it happen.

Dale Wilson has masterfully captured forever the lasting legacy of **THE BIG LIFT**.



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附錄三

Evolution of Asset Management at MTA Bridges and Tunnels

Evolution of Asset Management at MTA Bridges and Tunnels

Justine Tietjen P.E.

Deputy Chief Engineer, Program Operations and Asset Management
Engineering and Construction

87th Annual Meeting and Exhibition of IBTTA, September 16, 2019



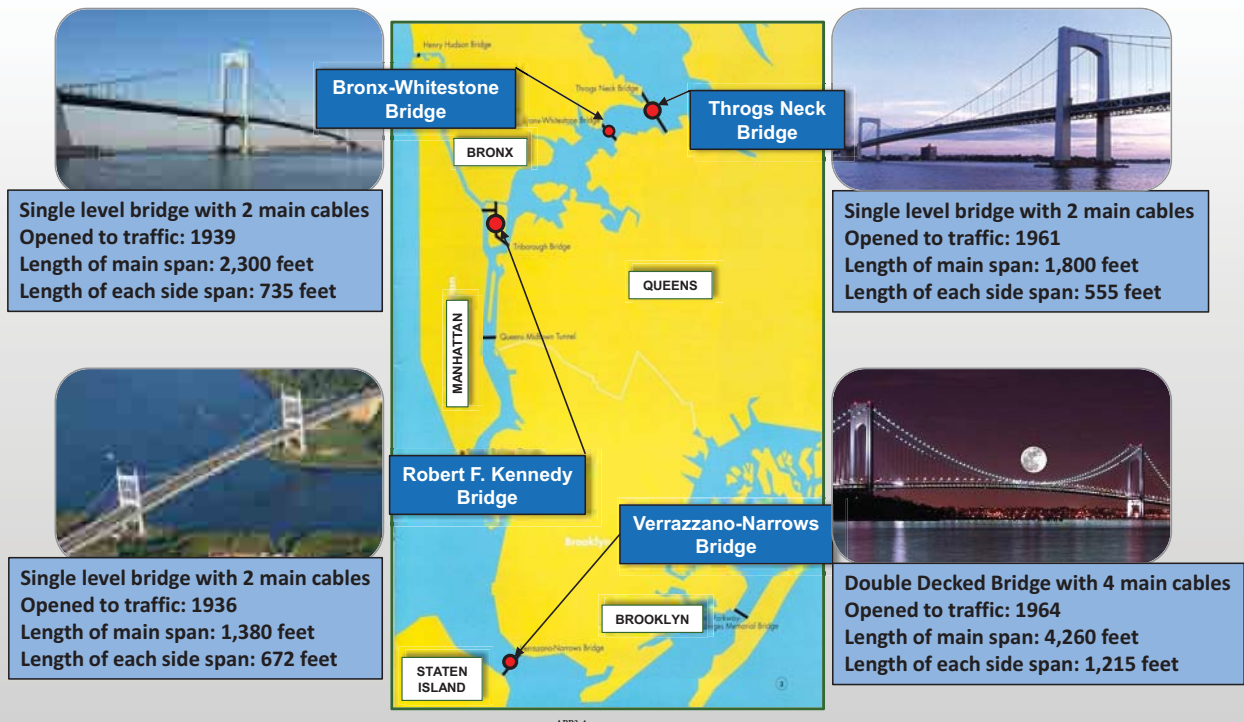
APP3-2

Overview

- Background on MTA Suspension Bridges
- Asset Management at B&T
- Master Planning for the Future
- Asset Management Program Strengths and Gaps

APP3-3

Facility Overview



Asset Management at MTA B&T

- Since the inception of its Capital Program in 1992, MTA B&T has maintained and improved its facilities via both Capital and Operating Investments

Maintenance and Capital Programs

- Bridge Preservation Program – contracted routine maintenance such as joint repair, spot painting, bridge and pier washing, cleaning of drainage systems, etc.
- Painting Program – ensures structural elements are protected from the elements
- Rolling 20-Year planning process for major structural rehabilitation, reconstruction and replacement



20-Year Master Plans / 5-Year Capital Program

- 20-Year Master Plans are based upon:
 - Asset Condition / Condition Trends
 - Structural Element Level Risk Analysis
 - A multi-hazard risk / resiliency review
 - Review for compliance with modern standards
 - Review of regional transportation needs
- 20-Year Plan is updated every 5 years, and a new detailed 5-Year Program is developed

APP3-6

Asset Conditions

- Asset Conditions are recorded as part of the Federally Mandated Biennial Inspection
- MTA B&T has recorded the condition of every single element on its structures since the inception of the Federal Bridge Inspection Program
 - Data includes non-structural as well as structural elements on the bridges, as well as off bridge elements such as retaining walls
 - Condition trends document either improvement or dis-improvement due to investment or lack thereof

APP3-7

Asset Conditions

- Special inspections are performed on critical elements that cannot be assessed visibly such as the main cables



APP3-8

Element Level Risk Assessment

- MTA B&T is performing an element level risk assessment on the structures to help prioritize investments across assets in a similar condition given funding constraints
- Elements are assessed for both vulnerability modes and criticality of failure
 - Vulnerability Modes**
 - Failure Mode
 - Likelihood of detection
 - Capacity over demand ratio
 - Exposure to dynamic loads and fatigues
 - Probability of damage or deterioration
 - Remaining service life
 - Criticality Scoring**
 - Operational impact
 - Hazard severity
 - Structural redundancy / fracture critical

Scoring results in a Risk Priority Number for each element

		Criticality Score				
Vulnerability Score		1	2	3	4	5
	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

APP3-9

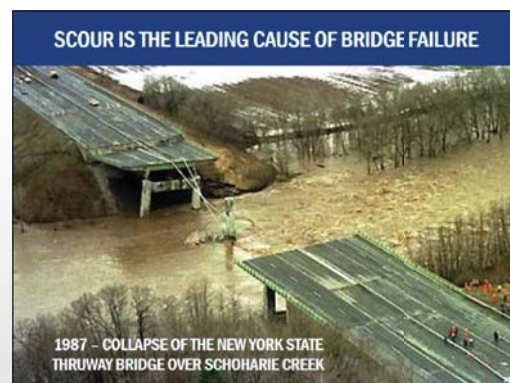
Structural Health Monitoring

- MTA B&T is embarking on a study to develop a strategic and integrated Weigh-In-Motion / Structural Health Monitoring Program for its bridges to enhance its Asset Management
- The goals of the program are as follows:
 - Provide greater situational awareness of structural conditions in real time to help with the development of inspection and repair strategies
 - Provide enhanced awareness of structural conditions during extreme events
 - Monitor vulnerable structural elements identified during element level risk assessments
 - Reduce inspection costs and provide supplemental inspection data
 - Determine load specific reactions of members at risk
 - Develop site specific live load design criteria for evaluation of structural members and for use during design of replacement structures

APP3-10

Risk / Resiliency Mitigation

- In addition to the element specific structural risks, bridges are subject to a variety of natural and man-made hazards including:
 - Seismic
 - Wind
 - Structural overloads from heavy trucks
 - Fire
 - Scour
 - Vessel Impacts



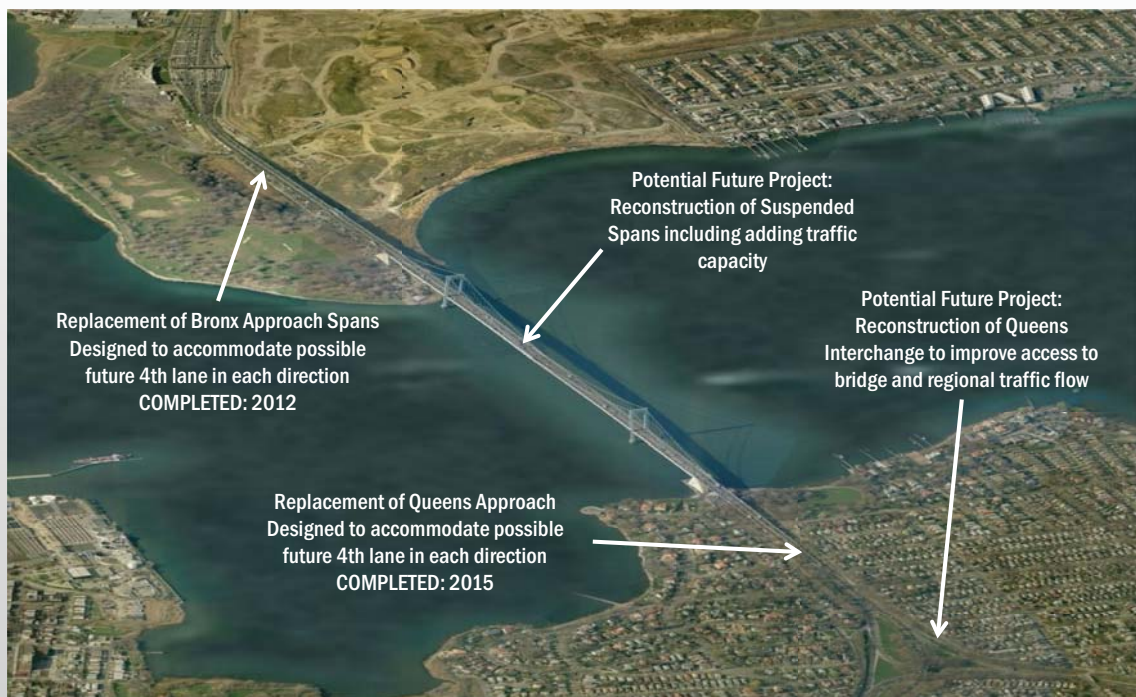
APP3-11

Regional Mobility Improvements / Structural Upgrades

- MTA B&T suspension bridges are critical links between communities and in the regional highway network
- 20-Year planning allows the Authority to plan not only to address deteriorating conditions in a timely manner, but also to make significant improvements to eliminate functionally obsolete structures and improve regional mobility
 - There are ongoing long term plans for major regional mobility improvements at each of the Authority's suspension bridges

APP3-12

Bronx-Whitestone Bridge Improvements and Future Planning Considerations



APP3-13

Throgs Neck Bridge Improvements and Future Planning Considerations



Verrazzano-Narrows Bridge Improvements and Future Planning Considerations



Robert F. Kennedy Bridge Improvements and Future Planning Considerations



APP3-16

Master Planning for the Future

- As discussed above, B&T Capital projects address multiple goals
 - State of Good Repair and extension of service life (dehumidification of cables, deck replacement, structural retrofits, etc.)
 - Resiliency (both structural and non-structural, electrical, communications, etc.)
 - Upgrades to current design standards
 - Upgrades to account for overweight vehicles
 - Upgrades to eliminate functional obsolescence
 - Other risk mitigation such as vessel impact, scour, security
 - Regional interoperability improvements and added traffic capacity
 - Aesthetics

APP3-17

Asset Management Program Strengths and Gaps

- Strengths: B&T has a robust informal Asset Management Program
 - Outstanding Inspection Program and documentation of asset conditions, age, and expected service life
 - Ongoing documentation of structural and other types of risk
 - Ongoing or recently completed master planning studies
 - Ongoing evaluation of technologies to improve data capture
- Gaps:
 - Formalized tracking and linking of maintenance expenditures to individual assets – under development
 - Central data warehouse linked to BIM tool for visualization of issues to erase project planning – under development

APP3-18

Questions?

APP3-19

附錄四

Risk and Asset Management

Risk and Asset Management

Barry Colford, PE, CEng., FICE.
Vice President, Complex Bridge Practice,
AECOM

APP4-2

Challenges

- We are now all expected to do more with less resources (funding and labor)
- The assets are aging
- Climate:
 - 1.5 degree rise since 1880
 - More intense storms
 - 100 year floods twice as frequent as 40 years ago
- Societal Changes
 - More stringent H&S requirements
 - More intense public scrutiny
 - More environmental requirements



APP4-3

Can we keep doing this?



APP4-4

Asset management

- Does not replace existing good practice, instead it provides the framework within which this practice may be more effectively implemented, managed and complemented by other processes
- It is not maintenance management
- Authorities should have asset management requirements common to all transport assets (e.g. roads, structures, tunnels, ports, airports and buildings)
- provides a systematic and holistic framework for the management of a group of assets to:
 - deliver specified Levels of Service
 - while minimizing whole life costs

Transportation Asset Management is a **strategic** and **systematic** process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their lifecycle. It focuses on **business** and **engineering** practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well defined objectives.

APP4-5

What do we get from Asset Management?

Improves

- Financial performance
- Economic performance

Fundamental Questions: Answer those questions that drive most of the expenditure decisions:

- Which capital projects to undertake, when, and why?
- What work should my operations and maintenance crews be doing, where, and why?
- When to Repair, Refurbish, and Replace

"Tell the story":

- For decision makers/public create a business case to drive investment in operations, maintenance, and capital spending.
- Paper / decision trail

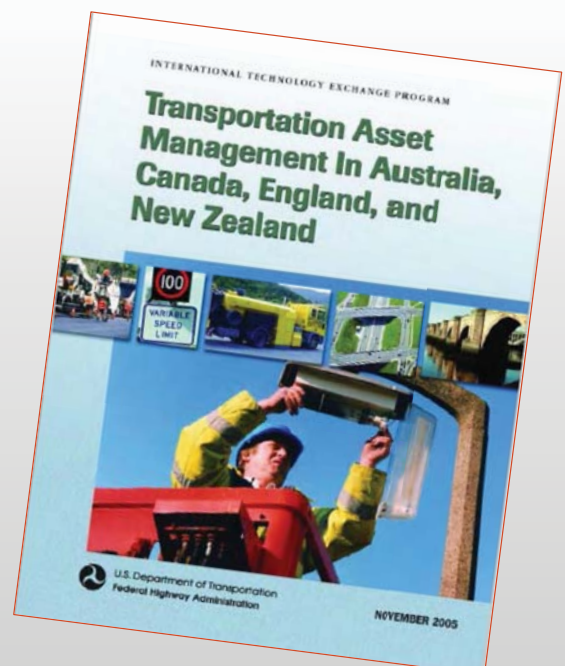
FHWA Require:

- Readily meet FHWA MAP 21 /FAST reporting requirements
- TAMP plans must be submitted and based on risk

FHWA Study of Asset Management

2005 Study of Asset Management in four countries:

- England
- New Zealand
- Australia
- Canada



England

In England, The Highways Agency (now Highways England) has a Structures Management Information System (SMIS), a repository of condition data for all structures on the national network.

- One of the most important drivers for asset management in England has been governmental directives on transport policy and accounting procedures. A tradition of managing road assets began in 1825 when Parliament stated that it was government's "duty to maintain" infrastructure built with public funds.
- The privatization of the road network in the UK over the past 25 years made a asset management the main tool in the management of the UK's roads and bridges. Key Performance Indicators, Risk Analysis and Whole Life Costing were required to measure performance and determine prioritization.



APP4-8

7

New Zealand

- New Zealand has been a world leader in many aspects of road network management
- The maintenance activities on the network have been privatized- meaning good information and effective management are essential
- In asset management, New Zealand has implemented innovative performance-based maintenance contracts, established a performance-oriented asset management decision making structure
- Risk management, key performance indicators and whole life costing are all used



APP4-9

8

Australia- New South Wales

- Management of the road network is outsourced
- The analysis procedures and prioritization schemes used depend on the type of asset program being considered.
- For network and road capacity expansion, benefit-cost analyses are used to justify investment.
- Infrastructure asset management projects are prioritized through a risk management process



APP4-10

9

Canada -Alberta

- Mid-1990s outsourcing to private companies.
- Systematically identifying deficiencies and allocating resources was an important part asset stewardship responsibilities.
- An asset management program based on risk was viewed as serving this function



APP4-11

10

FHWA study concluded

- All of the highway management programs the team studied in the three countries:
- Had privatized the road network
- Used asset management and the concept of risk for establishing investment priorities.
- The study concluded that:
- Most U.S. asset management experience does not have the same level of application.
- Risk concepts need to be incorporated more systematically into U.S. asset management efforts.

APP4-12

11

Risk Based Asset Management

- FHWA has now recognized that Risk is key to managing assets



U.S. Department of Transportation Federal Highway Administration		Memorandum
Subject: INFORMATION: Risk-Based Interval Determination for Routine Bridge Inspections	Date: June 8, 2018	
From: /Original signed by/ Joseph L. Hartmann, PhD, P.E. Director, Office of Bridges and Structures	In Reply Refer To: HIBS-30	
To: Division Administrators Federal Lands Highway Division Directors		
<p>The Moving Ahead for Progress in the 21st Century Act (MAP-21) (P.L. 112-141), was signed into law on July 6, 2012. As part of this enactment, Section 1111 amended Section 144 of Title 23 United States Code (U.S.C.) and directed the Federal Highway Administration to, "consider a risk-based approach to determining the frequency of bridge inspections."</p> <p>Section 650.311(a)(3) of the National Bridge Inspection Standards (NBIS) (23 CFR 650 subpart C) states, "Certain bridges may be inspected at greater than twenty-four month intervals, not to exceed forty-eight months, with written FHWA approval." This extended routine inspection interval has historically been accomplished by following Technical Advisory 5140.21 dated September 16, 1988 (http://www.fhwa.dot.gov/bridges/nbis/ta5140.21.pdf). To meet Section 1111 of MAP-21, the FHWA has developed risk-based, routine inspection interval guidance in the attachment that State transportation departments, Federal agencies, and tribal governments can use as an alternate approach to the current technical advisory.</p> <p>Additionally, 23 CFR 650.311(a)(2) states, "Certain bridges require inspection at less than twenty-four intervals." The attached risk-based, routine inspection interval guidance may also be used to satisfy this provision.</p> <p>When State transportation departments, Federal agencies, and tribal governments consider using this option, the Division Offices should review the submission then coordinate with the Office of Bridges and Structures for final approval.</p> <p>Please direct questions to John Thiel at (202) 366-8795 or e-mail at John.Thiel@dot.gov, or to Shay Burrows at (202) 366-4675 or e-mail at Shay.Burrows@dot.gov.</p> <p>cc: Directors of Field Services</p> <p>HIBS-30 Brian Kory, HIBS-10 Joe Kralik, HIBS-20</p>		

APP4-13

12

Defining and Quantifying Risk

Cause of Death	Probability of occurrence
Heart Attack	1 in 5
Hospital Infection	1 in 38
Car Accident	1 in 84
Bike Accident	1 in 4,919
Air Accident	1 in 5,051
Shark Attack*	1 in 60,453
Lightning	1 in 79,746
Train Crash	1 in 156,169

*Shark data represents number of attacks worldwide, not deaths.

APP4-14

13



APP4-15

14

Kutai Kartanegra Bridge



APP4-16

16



APP4-17

Management of Risk



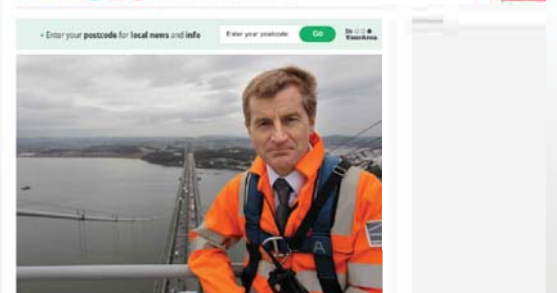
For Owners it is all about managing risk- but who owns the risk? Is it the Engineers in the Authority; the Executives or the Politicians?

APP4-18

This bridge cannot cope: Engineer raised alarm about the Forth Road crossing TEN MONTHS ago

CONFIDENTIAL papers show Chief Engineer Barry Colford identified problems with the bridge in a letter to the Scottish Government in 2018, warning that the bridge was not safe for vehicles weighing more than 150 tonnes until load-bearing beams were strengthened.

By Mark Adams
PUBLISHED 13:51, 15 SEP 2019



Risk Based Asset Management for Bridges

- We usually base all our bridge asset management on condition alone
- Each element is assigned a quantitative score based on the vulnerability and criticality of each element.
- The product of the criticality score and the vulnerability score is called the Risk Priority Number (RPN).
- The method provides the owner with a ranking of elements most at risk.
- This ranking can be used to determine the capital program and frequency of inspection for each component



APP4-19

Risk Analysis Theory

- Determine how critical each element of the bridge or tunnel is and examine how vulnerable each element is by using a number of metrics.
- In essence Criticality x Vulnerability is a way of calculating Risk.
- Risk = Likelihood x Consequence is **Vulnerability x Criticality**.
- Criticality x Vulnerability = Risk Priority Number (RPN). The higher the number the higher the risk.
- Once an RPN is assigned to a bridge or tunnel element then maintenance, capital planning and inspection can all be prioritized in a methodical way based on the risk to the Owner.

Vulnerability and Criticality

Vulnerability Metrics

- Failure Mode
- Likelihood of detection
- How hard is the component working and what is its condition (C/D ratio)
- Dynamic Load and Fatigue
- Probability of Damage or Deterioration

Criticality Metrics

- Operational Impacts
- Hazard Severity
- Structural Redundancy/Fracture Critical

Weighting of the Vulnerability and Criticality metrics can also be carried out. For the Vulnerability Metrics this will weight the importance of each individual metric. For the Criticality Metrics the three metrics can be weighted again to differentiate between individual metrics but also to differentiate between bridges.

Capital Program

- How do we determine which capital projects to prioritize if we have multiple assets?
- Ranking by priority using risk analysis techniques is used. The RPN values already established for each of the elements on the bridges are the building blocks to enable the prioritization of projects to be determined as shown in the example below:

Bridge	Capital Project	RPN
A	Suspender Replacement	20
B	Pin and Link Replacement	18
C	Main Cable Inspection	25
A	Main Cable Dehumidification	25
D	Finger Joint Replacement	18
D	Anchorage Dehumidification	22
B	Deck Repairs	15
C	Tower Painting	10

APP4-22

22

Inspection Frequencies

- Inspection frequency can be varied with risk of damage or failure.
- Beneficial in three ways:
 - Elements that are most at risk of failure are inspected more frequently
 - Resources and staff can be used more efficiently
- Increasing the inspection frequency of critical components provides more assurance of the long term structural integrity



APP4-23

23

PESTLE Analysis

- Structural and Operational Risks have been accounted for in prioritizing projects
- Owners Authority may wish to also look at all of the risks that can be included in a PESTLE (political, economic, social, technical, legal and environmental) analysis
- Would involve evaluating all these risks if each individual project was not carried out.
- Economic, political, social and legal issues are in many cases directly tied to operational risk.



APP4-24

24

Deterioration Curves

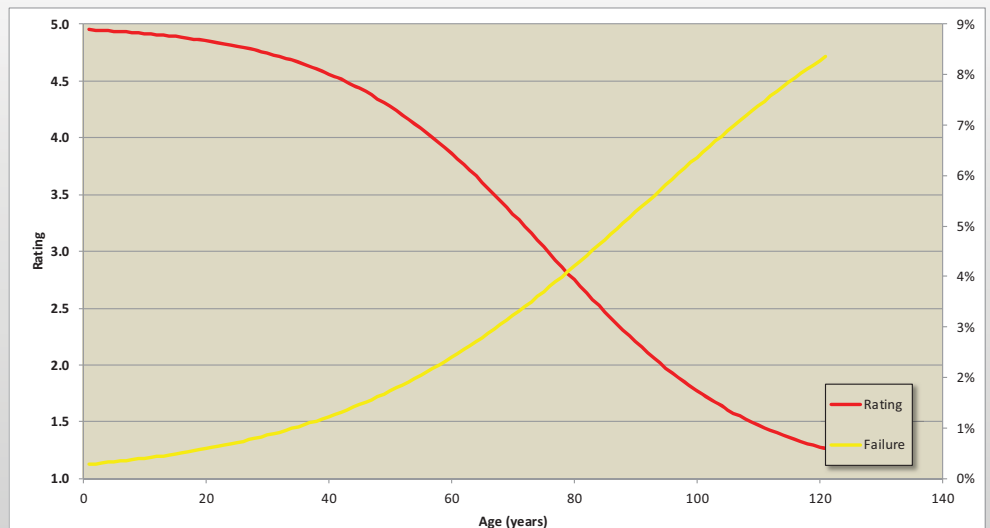
Example Calculation

14 <<User-selected Model No. from "Curves" Guideway, Track, Bridges

Decay Curve		AC Curve			Failure Curve			Years to 2.5	Revised Useful Life
Constant	Age	C0	C1	C2	C0	C1	C2		
4.3832	(0.0587)	0.4181	3.6229	(0.0399)	0.1097	3.6260	(0.0399)	83.3942	83.3942

Results

Age	Rating	AC	Failure
0	4.95	1.0875%	0.2844%
1	4.95	1.1306%	0.2957%
2	4.94	1.1752%	0.3074%
3	4.94	1.2216%	0.3195%
4	4.94	1.2698%	0.3321%
5	4.93	1.3198%	0.3452%
6	4.93	1.3717%	0.3588%
7	4.93	1.4256%	0.3729%
8	4.92	1.4816%	0.3876%
9	4.92	1.5396%	0.4027%
10	4.91	1.5998%	0.4185%
11	4.91	1.6623%	0.4349%
12	4.90	1.7271%	0.4518%
13	4.90	1.7943%	0.4694%
14	4.89	1.8641%	0.4877%
15	4.88	1.9364%	0.5066%
16	4.88	2.0113%	0.5262%
17	4.87	2.0890%	0.5466%
18	4.86	2.1696%	0.5676%
19	4.85	2.2531%	0.5895%
20	4.84	2.3396%	0.6121%
21	4.84	2.4292%	0.6356%
22	4.83	2.5220%	0.6599%
23	4.82	2.6182%	0.6851%
24	4.81	2.7177%	0.7111%
25	4.79	2.8208%	0.7381%
26	4.78	2.9275%	0.7661%
27	4.77	3.0379%	0.7950%
28	4.76	3.1521%	0.8249%
29	4.74	3.2703%	0.8558%
30	4.73	3.3925%	0.8878%

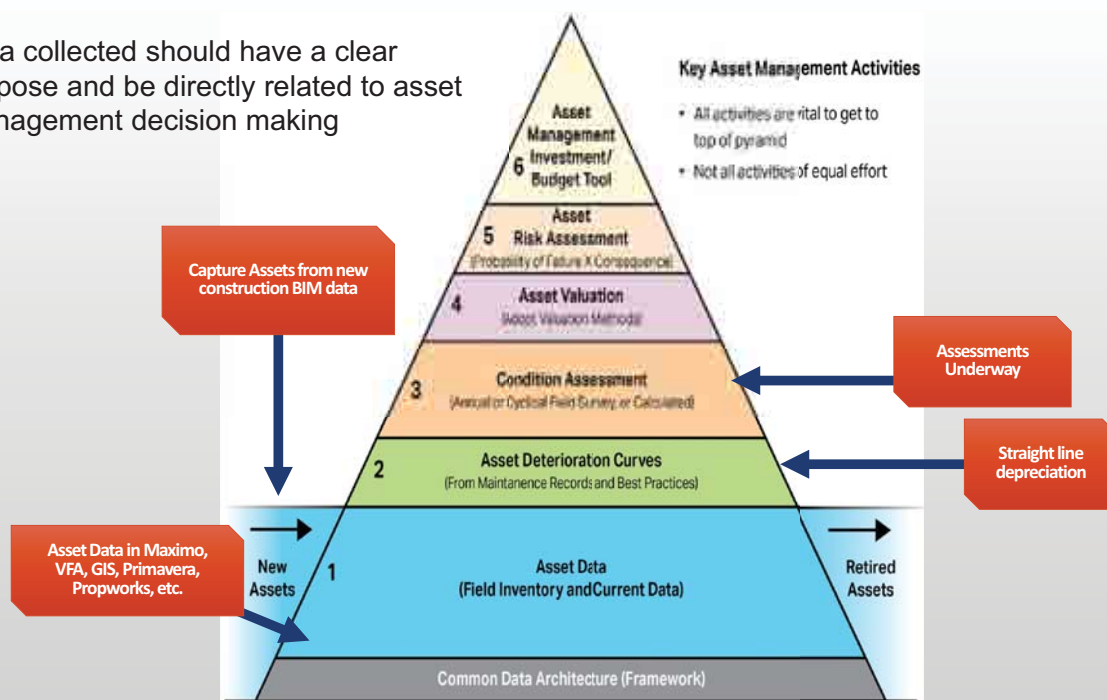


APP4-25

25

Asset Management Simplified Process

Data collected should have a clear purpose and be directly related to asset management decision making



APP4-26

26

Conclusions

Asset Management of bridges is changing and the rate change will increase especially with BIM.

Current methods of using Biennial Inspections and Special Inspections to identify Maintenance and Capital Programs may not be meeting needs

A methodology based on identifying risk will give owners assurance, over the Service Life of all their assets, of:

- Structural Integrity
- User Safety
- Operational Efficiency
- Best Value

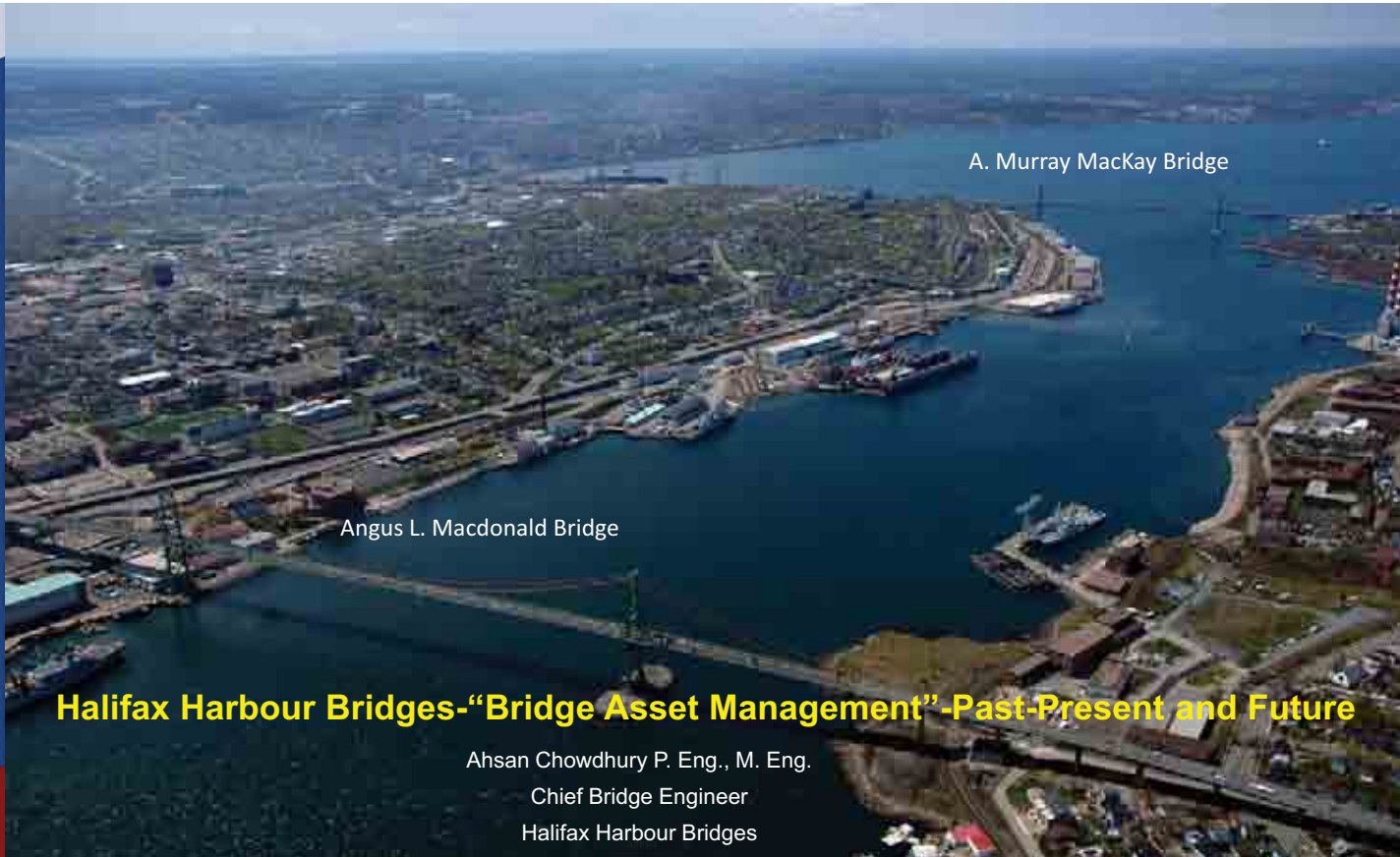


APP4-27

27

附錄五

Halifax Harbour Bridges-“Bridge Asset
Management”-Past-Present and Future

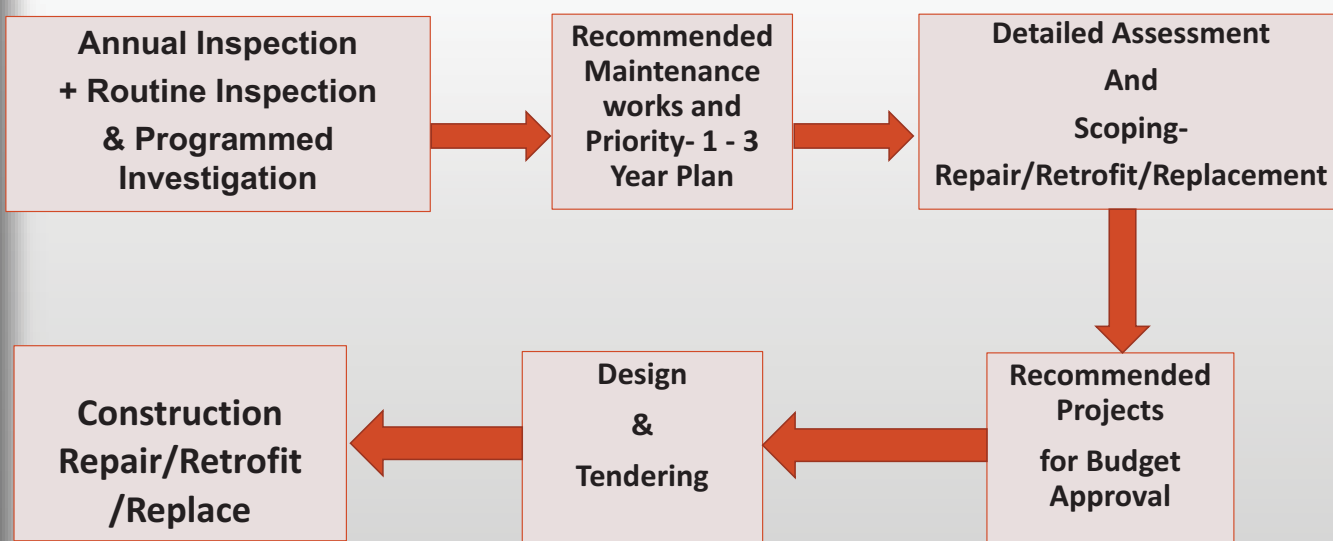


HHB Assets

- Two Long Span Suspension Bridges
- Toll Infrastructures
- 16 Ancillary Structures
- Approach roads
- Buildings



Current Model- Inspection-Evaluation- Maintenance



APP5-4

Report Card- Annual Inspection

Number ID	Element	Location	Maintenance Recommendation	Maintenance Type	Priority
2018-AMM-3	Bearings	HAb (free)	Continue to monitor the bearings.	Monitor Condition	1-3y
2018-AMM-5	Bearings	H2 (fixed)	Reposition longitudinal restraints prior to undertaking vertical bearing replacements in the future (if required).	Bearing Repair	7y+
2018-AMM-10	Bearings	D3 (fixed)	Continue to monitor the bearings.	Monitor Condition	1-3y
2018-AMM-12	Bearings	D5 (free)	Continue to monitor the bearings.	Monitor Condition	1-3y
2018-AMM-16	Bearings	DAb (free)	Continue to monitor the bearings.	Monitor Condition	1-3y
2018-AMM-17	Expansion Joints	HAb, HCB, DCB, DAb	Clean debris from joint.	Bridge Cleaning	< 1y
2018-AMM-18	Expansion Joints	D5	Repair or replace the expansion joint gland.	Expansion Joint Repair	< 1y
2018-AMM-20	Expansion Joints	DCB	Monitor gland on north side.	Expansion Joint Repair	< 1y
2018-AMM-21	Girder Span Access	HGS b/w Pier H1 and HCB	Clean and repair coatings at welded connections.	Minor Steel and Coating Repair	4-7y
2018-AMM-22	Girder Span Access	Pier D5	Fix the access doorways at Pier D5.	Access Maintenance	1-3y
2018-AMM-23	Girder Span Access	HGS/DGS	Consider modifying floor hatches to facilitate safe operation.	Access Maintenance	1-3y

APP5-5

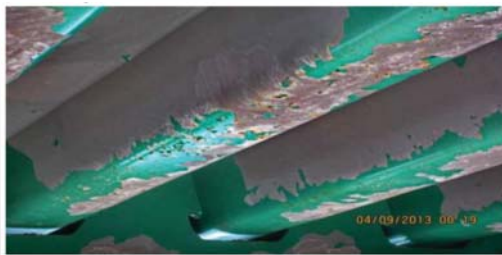
Investigation Report & Maintenance Status- Concrete Foundation

Pier No.	Priority	Depth of Concrete Removal, mm			
		North	East	South	West
W.Abutment	Medium	350	180	250	200
Bent H3	Low	200	200	200	200
Bent H2	Medium	330	300	200	200
Bent H1	High	250	250	250	330
West Cable Bent	Very low	-	-	-	-
West Main Pier	Very low	-	-	-	-
East Main Pier	Very low	-	-	-	-
East Cable Bent	Completed	-	-	-	-
Bent D1	Very low	-	-	-	-
Bent D2	Medium	300	280	160	300
Bent D3	Medium	250	300	200	185
Bent D4	Medium	240	300	280	250
Bent D5	High	180	250	290	300
Bent D6	Completed	-	-	-	-
Bent D7	Low	180	180	180	185
Bent D8	Medium	300	170	180	160
Bent D9	Completed	-	-	-	-
Bent D10	Completed	-	-	-	-
Bent D11	Completed	-	-	-	-
East Abutment	Low	200	200	200	200

Pier	Priority	Status
Halifax Abutment	Medium (3-5 years)	Complete 2017
H3	Low (5-10 years)	Complete 2017 (Seized Bearings)
H2	Medium (3-5 years)	Complete 2017
H1	High (1-3 years)	Complete 2014
HCB	Very Low (10-15 years)	2013 (Rock Anchor installed for Stability)
HMT	Very Low (10-15 years)	2024
DMT	Very Low (10-15 years)	Underwater Concrete Investigation 2019
DCB	High (1-3 years)	Complete 2012
D1	Very Low (10-15 years)	2024
D2	Medium (3-5 years)	2019 (construction)
D3	Medium (3-5 years)	2020
D4	Medium (3-5 years)	2020
D5	High (1-3 years)	Complete 2014
D6	High (1-3 years)	Complete 2016
D7	Low (5-10 years)	2022
D8	Medium (3-5 years)	2020
D9	Medium (3-5 years)	Complete 2013
D10	Medium (3-5 years)	Complete 2013
D11	Medium (3-5 years)	Complete 2013
Dartmouth Abutment	Low (5-10 years)	2022

APP5-6

Asset Conditions-Challenges & Issues



APP5-7

$\frac{D}{C} = \frac{\text{Demand}}{\text{Capacity}}$

Main Tower D/C = 0.75 -1.00



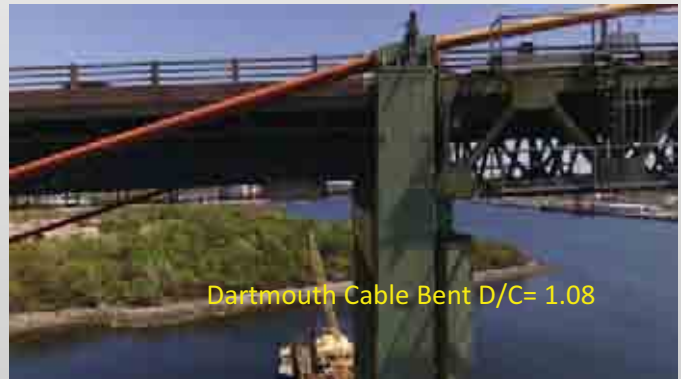
Main Cable D/C = 1.01
Factor of Safety= 2.31



Stiffening Truss D/C = 1.0



Dartmouth Cable Bent D/C= 1.08



APP5-8



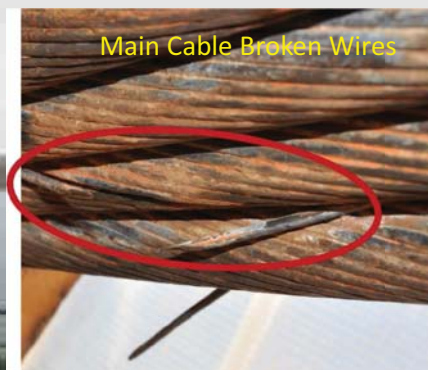
Deck Fatigue Life Issue



Wearing Surface



Concrete Foundation Restoration



Main Cable Broken Wires



Main Cable Bird Caging

APP5-9

Recent Development- Element Level Detailed Inspection

$$WADI = \frac{\sum_{i=1}^n LIF_i * MDI_i}{\sum_{i=1}^n LIF_i}$$

$$RPN = GIF * WADI$$

$$DI \text{ FOR 'CORROSION IN STEEL ELEMENTS'} = \frac{(A_1 * 1 + A_2 * 2 + A_3 * 3 + A_4 * 4)}{(A_1 + A_2 + A_3 + A_4)}$$

- GIF- Global Importance Factor
- DI- Defect Impact
- WADI- Weighted Average Defect Impact
- RPN- Risk Priority Number

Risk Vs Intervention

RPN	Timeframe for intervention
80 - 100	Immediate action required
75-80	Action suggested within one year. Monitor component
25-75	Action suggested within 2-5 years. Increase frequency of inspection
0-25	Continue regular inspection

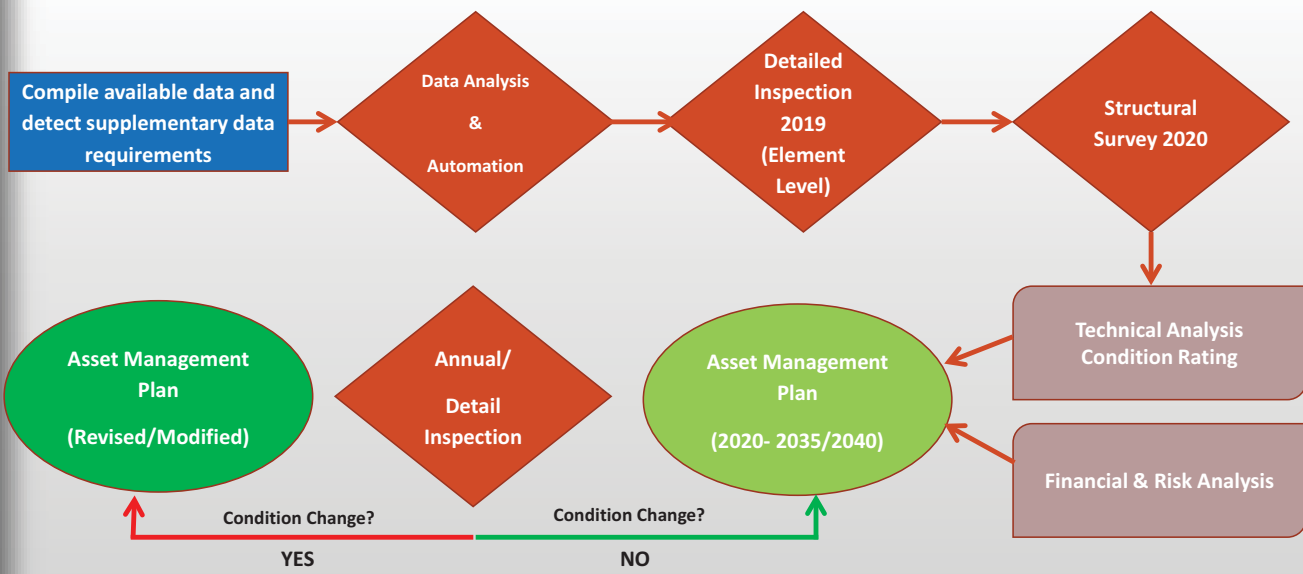
APP5-10

Deck (OSPD) Detail Inspection Results

Date (dd/mm/yyyy)	Segments Inspected	GIF	WADI	RPN	Timeframe for Intervention
03/06/2016	H1	20	1.38	27.60	Action suggested within 2-5 years. Increase frequency of inspection
28/06/2016	M4	20	1.28	25.60	Action suggested within 2-5 years. Increase frequency of inspection
24/05/2017	D12	20	1.55	31.06	Action suggested within 2-5 years. Increase frequency of inspection
24/05/2017	1/2 D13	20	2.23	44.62	Action suggested within 2-5 years. Increase frequency of inspection
28/06/2017	M1	20	1.04	20.80	Continue regular inspection
24/05/2017	1/2 M2	20	2.29	45.80	Action suggested within 2-5 years. Increase frequency of inspection
28/06/2017	1/2 M2	20	1.00	20.00	Continue regular inspection
24/05/2017	1/2 M3	20	1.60	32.10	Action suggested within 2-5 years. Increase frequency of inspection
11/07/2017	D14	20	1.03	20.51	Continue regular inspection
11/07/2017	1/2 D15	20	1.01	20.28	Continue regular inspection
21/08/2017	1/2 D15	20	1.08	21.63	Continue regular inspection
21/08/2017	1/2 D16	20	1.12	22.30	Continue regular inspection
30/08/2017	1/2 M22	20	1.04	20.79	Continue regular inspection
30/08/2017	M23	20	1.01	20.21	Continue regular inspection

APP5-11

Risk and Data Based Bridge Asset Management Plan:



APP5-12

Asset Management Model:



APP5-13

Bridge Information Model and Management System- BIMMS

The purpose of BIMMS is to develop and implement an automated bridge information and management system to visualize and manage the asset in efficient and cost-effective manner.

Users will have easy access to all relevant information (**inspection reports**, **drawing**, **photos**, **repair history**, **condition ratings**; **repair priority number with color coding** and **WO**) at their fingertips.

GIS based 3D Bridge Model:

<http://esrica->

atlantic.maps.arcgis.com/apps/webappviewer3d/index.html?id=8363ad2e38b64305b9714069d83983fc



APP5-14

Thank You!

Questions?

APP5-15

附錄六

Optimizing TCO Through Digital Asset Management, Data and New Technologies



APP6-2



APP6-3

AGENDA

- Brief presentation of Sund & Bælt Assets
- Results
- Total Cost of Ownership – TCO
- Digital Asset Management
- *New technologies*
- Conclusions & Perspectives

3
APP6-4

STOREBÆLT BRIDGES

Europe's largest bridge, world #3,
1624 m main span, 254 m pylons,
65 m passage height

17.5 km Highway, 18.5 km Railway,
State Guarantee Model

Approx 25 mill passengers per year,
> 25,000 vessels

Bridges, Tunnels, Roads &
Railways

APP6-5

DIGITAL STRATEGY

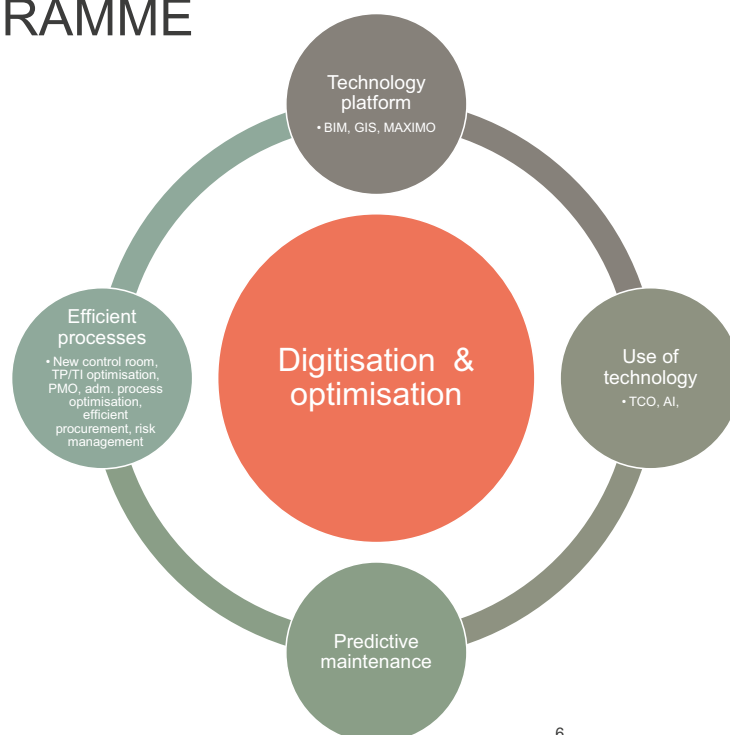
New technologies bring greater efficiency

- Ensure 2% annual productivity
- High quality standards & high accessibility/safety levels for our customers
- Ensure optimal TCO for new constructions
- Sharing knowledge through cooperation

Data from Drones, Sensors & Robots

- Increased Digitisation of our maintenance
- Big Data & Analytics, AI (Artificial Intelligence)
- New data sources; robots/drones/sensors
- Digital models: GIS, BIM, AR

OPTIMISATION AND DIGITISATION PROGRAMME



RESULTS

OPEX

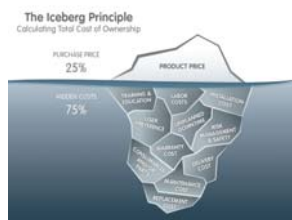
- Reduced maintenance & operation cost – target 10% in 5 years – more than on track
- Higher quality – prolonged lifetime & better asset conditions
- More knowledge from data & models

CAPEX

- Reduced renewal cost – budget index
- Better TCO in new projects with data models

TOTAL COST OF OWNERSHIP

Total Cost of Ownership (TCO) is a financial model intended to help owners determine the total cost of assets over their lifetime.



Optimising TCO in new projects



Typical types of TCO



TCO benchmark - By normalising data, TCO models from different operating models can be used to compare and transfer best-practice



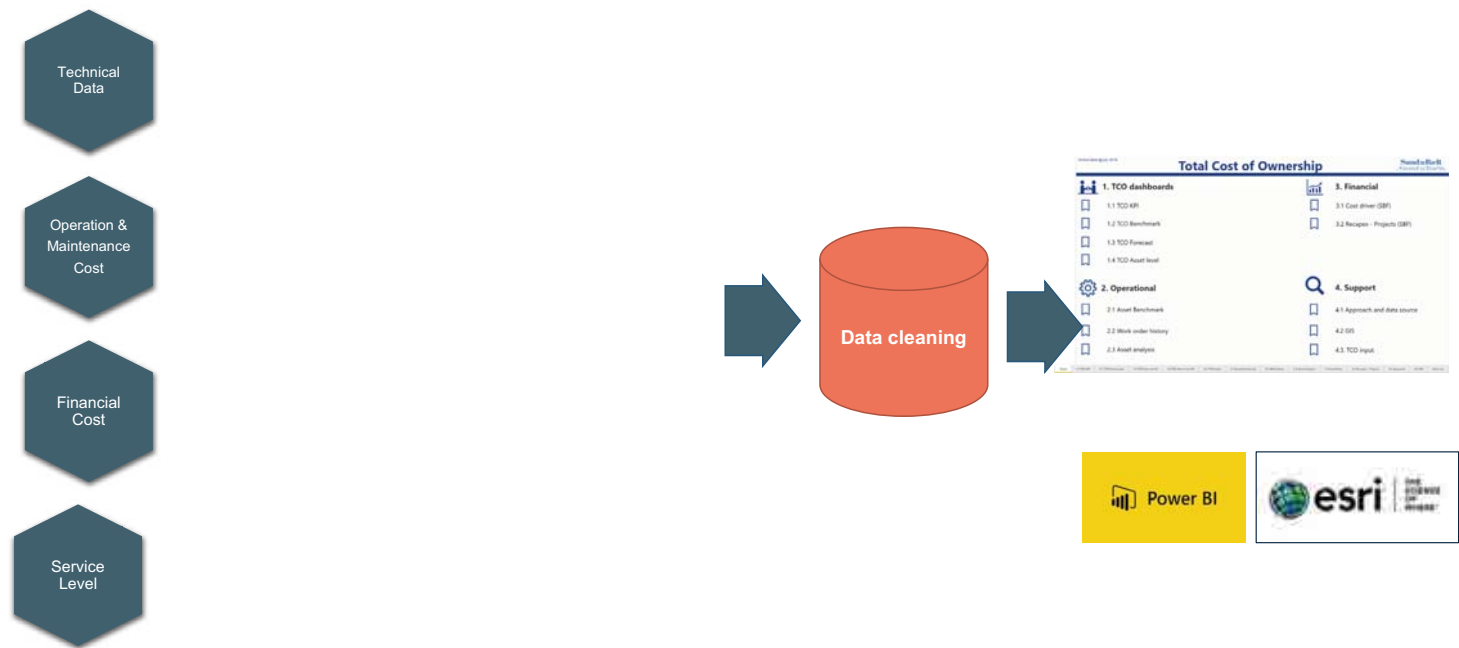
TCO model – Digital twin enables TCO simulations and optimisation by analysis and adjustment on high impact drivers and service levels



TCO at Asset level. All cost within Asset lifetime is calculated at Asset TCO.



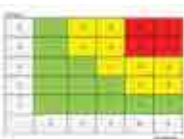
THE TCO ENGINE - DATA MODEL



9
APP6-10

THE TCO APPROACH IS NOT BREAKING NEWS...

The fundamental spirit of the organisation is to continuously strive for improvement

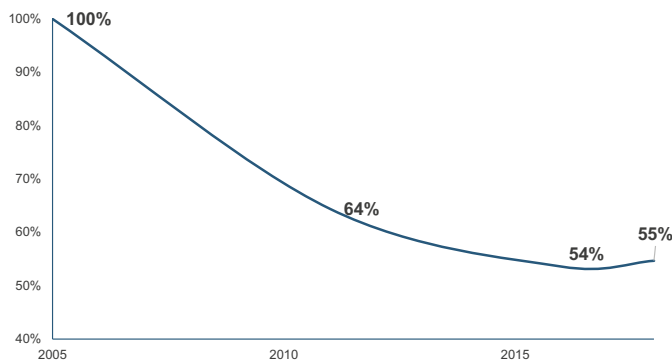


Investment in new technology to reduce operational cost and predict failures.



Fully implemented EAM and SCADA system capturing operational data and maintenance history.

The TCO approach on the Great Belt Link has **reduced the reinvestment budget to index 55%** compared with the planned budget in 2005



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APP6-11

TCO AS AN OPERATING TOOL



Before

Copious spreadsheets and long lists of unstructured data.

Work order history in note form means that failures can be described in endless ways.

e.g. one asset group 17,000 work orders

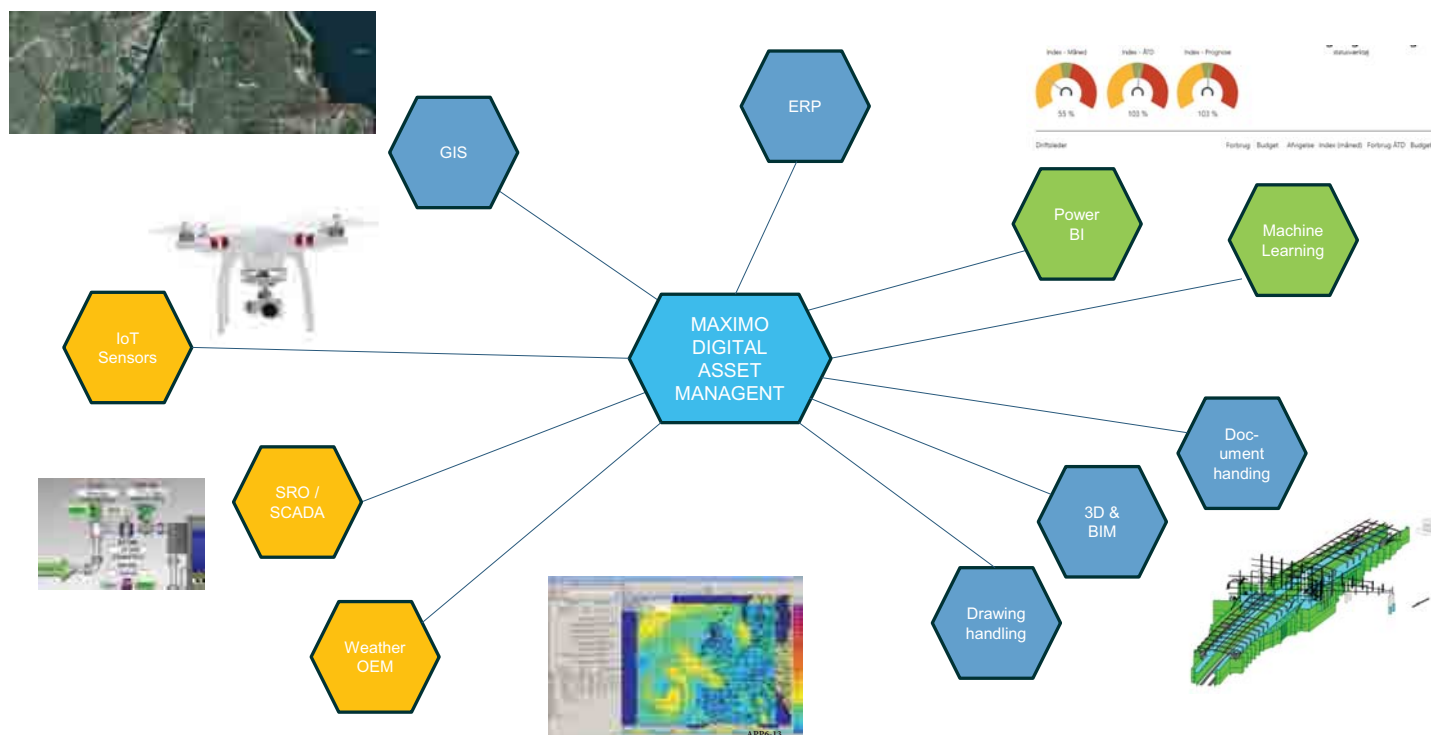
Tvangskinner (profillet): Løse bolte
Nordtunnel - L 634 IBO Koerledning - 2. HSP - Hakkkontakt (pkt. 4.2 i T138.04.90)
FORV - Koeling af E3-udstyr FCC024 (aerligt lovpligtigt eftersyn)
T138.02.54.81.28005M - Kontrolskema for eftersyn af D58 1994 drev
Kontroller fodre for brud- revner og fastgørelse
Skærvervogn FCCS 868-3 - Kontrol af bremseklovers slidtage
Kontrolkontakt 24/23 afbrydes med et stykke isolerende materiale.
Dato og tidspunkt:
Kontrolmærkat med initialer og dato for eftersyn påslæbes
Korner - L 564 - Spor 3 - km 109.703 - Maal C (i mm) - Koerledning
Maaling med tangenperimeter omkring tilfødsringer
K-ophæng: Korrekt symmetri paa V-hænger
TILSTAND - Udsiktning af en halv tungepart H/V
Spor 3- km 130.350
2. hovedspor - km 129.740
Sikkerhedsudhæng - er det defekt skal det udsiktes
Sprøge Tekniskbygning - VTS Tasterum
Stedbetjeningskontakt: Lampen udsiktes i tilfælde af defekt lamper
Funktionsrest af materiel den skal bruges til nattes arbejde.
Trækstænger efterses
Motor- 1.5 Filter-oliekløbing til koelblæser- centrifugerfilter - Kontroller og rens filter holder
Nylontandhjul: Adskilt/renset
Koerledning: koerletraaden hænger i fellet
AU.LS.VT.000042 Løvsæmningstavle VBA2
Bro ophæng: Corona

Now:

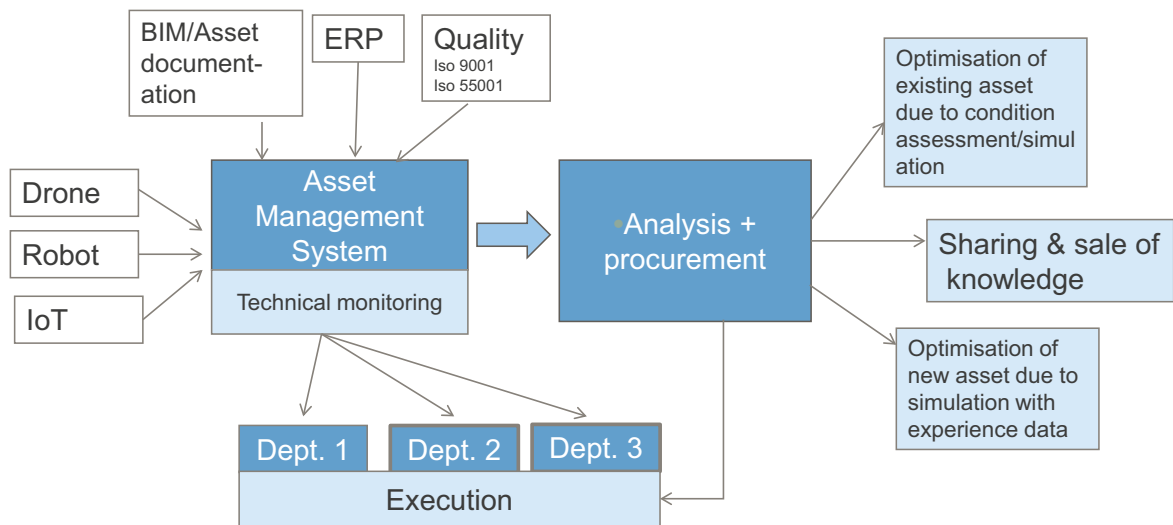
- Structured data by machine learning (NLP)
- Easy access to data through dynamic dashboards with integrated GIS maps
- Every operational manager can run cost drive analysis



MAXIMO AS PART OF OVERALL DIGITISATION

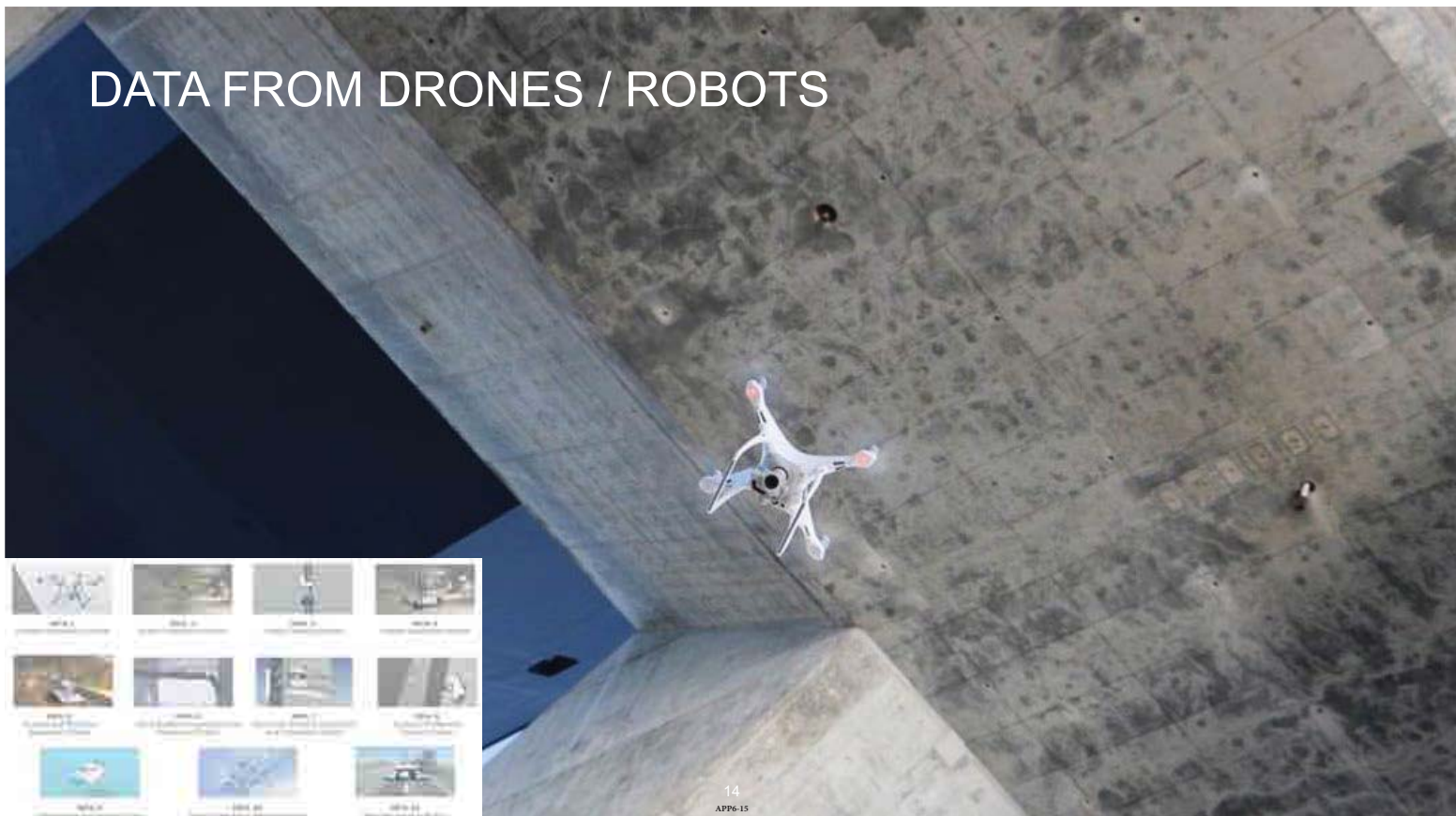


DIGITAL MAXIMO CONCEPT



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APP6-14

DATA FROM DRONES / ROBOTS

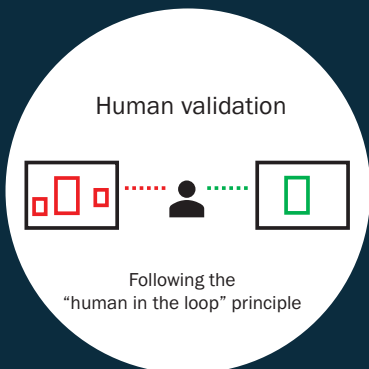


14
APP6-15

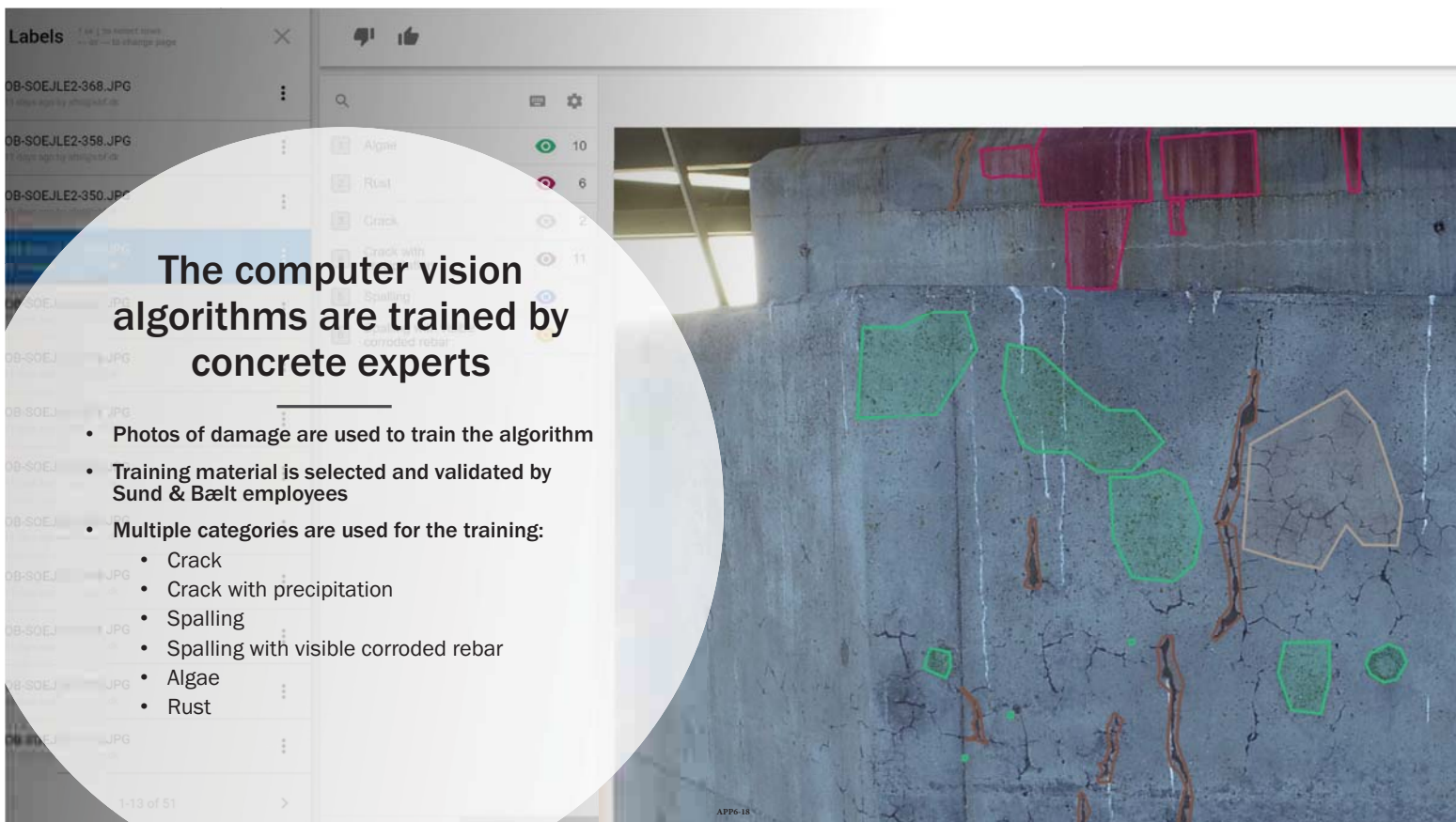
WHY? BEFORE AND NOW



15
APP6-16

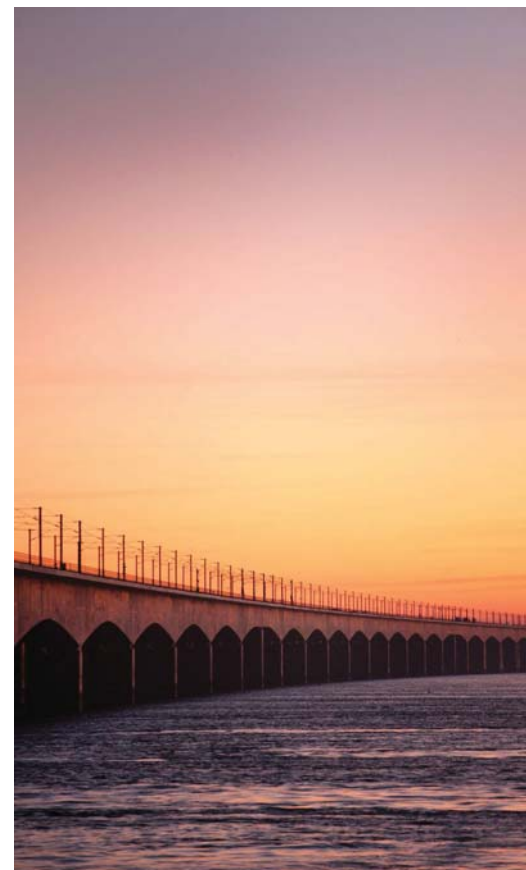


- Easily store thousands of images
- Reduce manual review time with automatic damage detection
- Spot trends in your growing dataset
- Export your data to your own systems



CONCLUSIONS & PERSPECTIVES

- Datadriven Asset Management improves the efficiency of operations and maintenance
- The Maximo AM system supports a long-term focus on maintenance, holistic approach to the management of risks and assists in accessing information / knowledge-sharing
- TCO focus contributes to a long lifetime, good condition, customer focus & reduced total costs
- Opportunities to gain much more detailed information about our assets are increasing with the rapid advance of technologies for collecting and analysing data
- We will have more data from sensors, robots & models
- Opportunities from AI/Machine Learning/ Cognitive Analysis in our Asset Management will increase
- Predictive maintenance will advance
- The sharing of knowledge and data will improve data models



THANK YOU – QUESTIONS ?

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