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香港物流協會

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冷鏈物流新興技術應用指南

Guidelines for the Application of Emerging Technologies in Cold Chain Logistics

此項目由香港物流協會主辦，並由香港特別行政區政府工業貿易署「工商機構支援基金」撥款資助。

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(項目編號 Project Reference: T21 004 004)

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(項目編號：T21 004 004)

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一. 序言

香港物流協會會長
袁美儀工程師

現代科技日新月異，營商環境瞬息萬變，如何應用先進科技提升效率並實現可持續發展，已成為本港物流業界的重要課題。在當今全球化的商業環境中，冷鏈物流管理扮演著確保產品品質和安全的關鍵角色。然而，在科技急速發展的時代，冷鏈物流管理更要求結合尖端科技應用於運輸規劃、倉存管理以及品質控制等範疇，才能提供高效、可靠的冷鏈物流服務。

為鞏固香港作為國際物流中心以及中國內地重要轉口港之一的地位，提升本港物流業在大灣區乃至全球市場的競爭力，香港物流協會在香港工業貿易署「工商機構支援基金」的資助下，實施「制定冷鏈物流管理體系之實務守則，以針對及協助物流業的長遠發展」項目，並委託香港品質保證局及香港貨品編碼協會作為項目的執行機構。此階段的「冷鏈物流新興技術應用指南」更著重於科技應用的指引，協助本港物流從業員由傳統運作模式轉型，以創新科技提高營運效率和管理水平。

我們期望香港物流業界能透過此守則獲取經驗，掌握物流發展的新趨勢，達到與時並進，繼而在國際物流市場中突出優勢，抓緊發展機遇。與此同時，亦期望物流同業同心協力，持續進步，提升香港物國際物流中心的地位。

二. 獻辭

運輸及物流局局長
林世雄, GBS, JP

《冷鏈物流新興技術應用指南》出版誌慶

睿智創見
遠圖新天

運輸及物流局局長林世雄

獻辭

立法會議員(航運交通界)
易志明議員, SBS, JP

繼兩年前出版《冷鏈物流管理體系實務守則》一書後，很高興香港物流協會再獲「工商機構支援基金」資助，推出《冷鏈物流新興技術應用指南》，作為業界在冷鏈物流管理方面的參考文獻。

隨著內地經濟高速發展，生活水平不斷地提高，人民對生鮮食品、保健藥物等商品的需求與日俱增；加上電子商貿的蓬勃發展，訂購貨物再沒有國界、彊界的限制。確保來自世界各地的貨品（特別是對環境溫度較為敏感的商品）經過長時間的運輸、儲存及配送，亦不會變質及損壞，是發展冷鏈物流的關鍵。在科技的迅速發展下，透過應用物聯網、大數據、人工智能這些新興科技，不但提升冷鏈物流的效率，還可進行遠端嚴格溫控，更精準地確保商品應有的品質。

《十四五規劃綱要》及《粵港澳大灣區的發展綱要》均明確支持香港作為國際航運物流中心，這本《冷鏈物流新興技術應用指南》能夠讓物流業界掌握新科技的發展，並應用在冷鏈物流的操作及管理，提升冷鏈物流的競爭力，促使業界把握物流發展的新機遇，鞏固香港物流樞紐的地位！

獻辭

香港品質保證局總裁
林寶興博士

隨著科技不斷進步，電子商貿和大灣區的快速發展，冷鏈物流業與其他行業一樣，引入創新技術已成為取得長遠成功的重要一環。誠然，香港作為國際物流中心，需要制定一套適用於本地的《冷鏈物流新興技術應用指南》，協助物流業優化管理及運作水平，在瞬息萬變的市場中掌握新機遇。香港品質保證局作為區內最具領導地位的合格評定機構及標準制定者之一，自1989年由香港政府成立至今，一直致力協助企業解決問題，提升核心能力和營運表現。本局除了提供專業的合格評定服務外，亦透過知識分享和技術轉移，推動企業持續進步，為社會帶來更大的福祉。

香港品質保證局去年很榮幸再次獲香港物流協會邀請，擔任「工商機構支援基金」項目——《冷鏈物流新興技術應用指南》的執行機構，協助制定及推廣《冷鏈物流新興技術應用指南》，推動業界建立有效的智能冷鏈物流管理系統或升級現有系統，鼓勵他們持續改進，優化管理及運作程序，把握發展機遇。本局技術團隊總結和分析了業界訪談調查所得，結合冷鏈物流的專業知識，將相關項目成果編制成這本報告書，供物流業及有興趣的公眾人士免費參考。

期望項目能推動香港冷鏈物流業應用更多嶄新科技，不斷提升水平，加強競爭優勢，促進業界整體的長遠發展；同時將冷鏈技術和科技普及化，打造智慧冷鏈物流新時代。

獻辭

香港貨品編碼協會總裁
林潔貽女士, MH, JP, FCILT, FHKIM

隨著新鮮食品電商盛行、消費者對產品品質要求提升，以及不同法規要求，冷鏈物流成為業界關注點。政府最近也發表了《現代物流發展行動綱領》，鼓勵業界與其他大灣區城市制訂高價值貨品(如冷鏈貨物)的物流服務管理準則及標準，《冷鏈物流新興技術應用指南》的發佈正合時宜。

作為提供國際物流及供應鏈標準且中立的機構，香港貨品編碼協會十分榮幸獲得香港物流協會邀請，擔任「工商機構支援基金」項目——《冷鏈物流新興技術應用指南》的執行機構。憑藉我們對不同行業流程的了解，以及對新興技術應用的專業知識，本會就不同應用場景，提供從基礎到進階、基於標準的科技及實踐建議，協助業界規劃出最適合的方案。

期待指引能成為實踐冷鏈物流的明燈，引領業界把握香港和大灣區機遇，推動香港物流業的可持續及高質量發展。

三. 項目背景及簡介

香港擁有資金和貨物自由交易及低税率的優勢，亦是一個重要的全球貿易中心。與其他行業一樣，隨著科技不斷進步，香港冷鏈物流業未來的成功將有賴於創新技術的驅動。因此，制定一套適用於本地的「冷鏈物流新興技術應用指南」有助於物流業在瞬息萬變的市場中抓住新機遇。

為了滿足業界、中小企及社會的需要，香港物流協會獲得工業貿易署「工商機構支援基金」的資助，推行本項目，以制定**「冷鏈物流管理體系」的新興技術應用指南**，以協助業界在擁抱機遇的同時，建立有效的智能冷鏈物流管理系統，或升級現有系統 ，達到持續改進，提升及優化其管理及運作程序。

四. 項目目的

利用新興及合適科技改善及提昇冷鏈營運的技術和流程

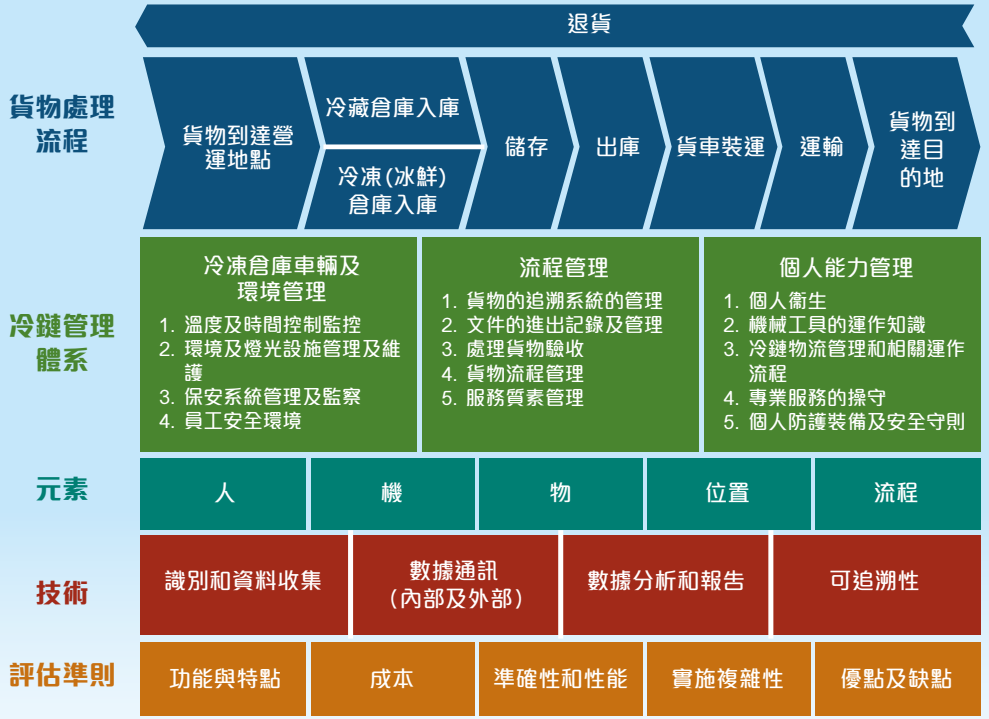
五. 項目內容

- 進行案例研究，以審閱之前所制定的建議冷鏈物流操作系統
- 舉辦與利益相關者的諮詢研討會
- 舉辦項目啟動和簡介會
- 舉辦項目宣傳活動（例如: 透過電子郵件行銷及電子報上的廣告）
- 制定「冷鏈物流管理體系」的新興技術應用指南
- 舉辦「新興技術在冷鏈物流業的應用」指南分享及指導工作坊
- 舉辦項目經驗分享會
- 編制及發佈項目成果及項目指南

A. 技術框架結構

框架由五個層面構成

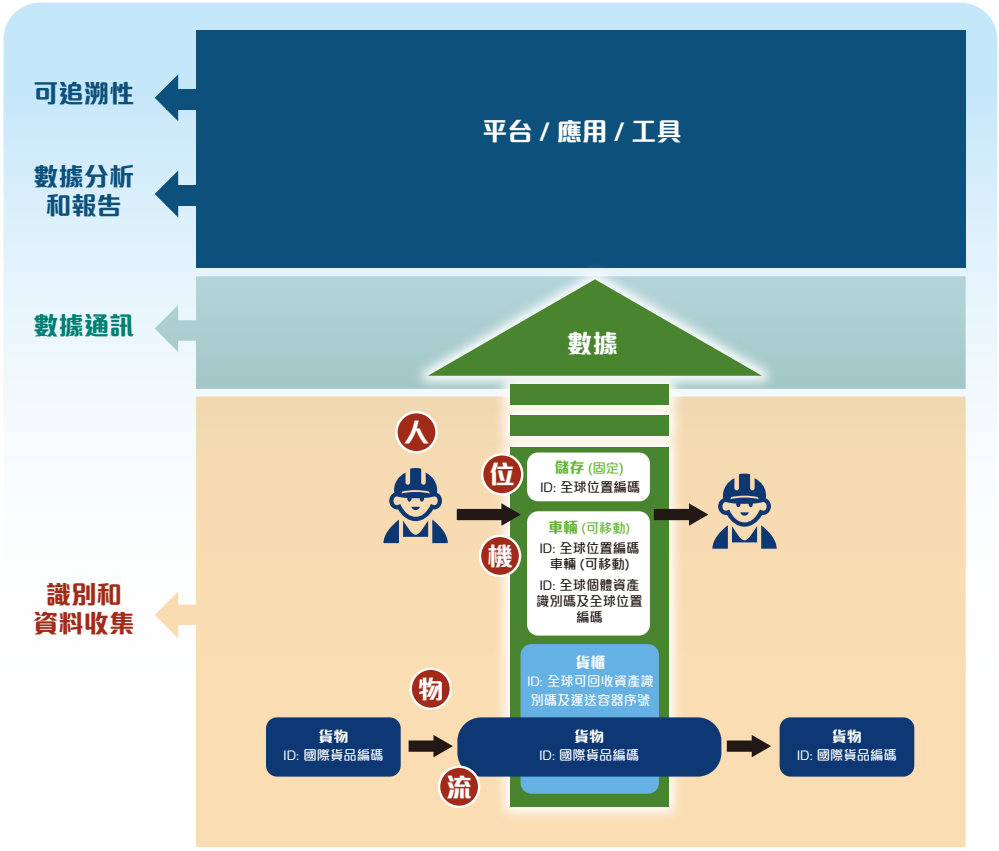
貨物處理流程 | 冷鏈管理體系 | 元素 | 技術 | 評估準則



B. 應用技術

包括四種應用技術：

識別和資料收集 | 數據通訊 | 數據分析和報告 | 可追溯性



C. 選用指南的關鍵設計

選擇指南旨在回應業界訪談時給予的意見。

- 設計原則應著重風險管理
  - 如何利用科技將風險降到最低
  - 例如：縮短冷鏈產品暴露在高溫環境下的時間
  - 尤其在最後一里送貨至最終目的地，冷鏈產品暴露在戶外或惡劣環境中，風險難於管理

- 其他重點範圍：
  - 節能方面（例如 ESG 的要求）
  - 設備預防性維護（如冷藏車及製冷設備）

- 其他營運挑戰：
  - 出庫發貨
  - 貼標
  - 入庫貨品和文件/電子郵件同步
  - 貨品追溯

D. 技術選擇原則

技術選擇原則基於市場上可用及最常見的技術。

- 了解操作場景
- 選擇合適（足夠）的技術
- 了解技術
  - 特點和功能
  - 準確度和性能
  - 成本（一次性成本、持續成本）
  - 實施的複雜性
  - 未來的擴展性

E. 技術清單

應用於物流的科技非常廣泛，以下簡單介紹數種常用或可用於各物流環節中的技術，而此等技術亦可應用在冷鏈物流管理中。

a. 識別和資料採取

條碼

- 條碼可以分成兩大種類，分別為一維條碼及二維條碼。
- 一維條碼：
  - 一維條碼也稱線性條碼，是目前常見的傳統條碼，由不同寬度的黑色與白色條紋組合而成，並按照特有的編碼規則來排列，每一組圖形識別碼裏都會帶著產品本身的資訊。
- 二維條碼：
  - 二維條碼又稱二維碼，使用黑白矩形圖案表示二進位的資料，每組條碼都記載著獨特的資訊。與一維條碼不同的是，二維碼不僅橫向儲存資料， 也可以縱向儲存，還具有定位點與容錯機制。
  - 容錯機制的優點是即使條碼有一點污漬或毀損，不需要掃描完整條碼也能順利地讀取條碼內的資料。

無線射頻辨識 (RFID)

- 無線射頻辨識最早是20世紀的軍事技術，用於區分空中軍機是我方或敵方，以避免誤擊。隨著技術的發展，無線射頻辨識的應用已廣泛出現在我們的日常生活中。
- 它是一種非接觸式自動識別系統，可以在無線射頻辨識標籤及卡片中讀取與寫入資料。
- 特徵與優勢：
  - ▸ 同時讀取多組標籤
  - ▸ 讀取距離遠
  - ▸ 可以穿透遮蔽物進行掃描
  - ▸ 污漬的表面讀取資料
- 目前，根據不同的頻率，無線射頻辨識標籤可以細分為低頻、高頻、超高頻及微波。
- 無線射頻辨識標籤會根據本身的供電方式，區分為被動式、半被動式及主動式三個種類。

溫度傳感器

- 溫度傳感器一般是指將溫度轉化為電子數據的電子元件。用於製作溫度傳感器的導電體，它的電阻會隨著溫度變化。

濕度傳感器

- 濕度傳感器一般是指將濕度轉化為電子數據的電子元件。濕度傳感器可感測，測量並報告空氣中的相對濕度。相對濕度是空氣中的實際水分與在該空氣溫度下可以保持的最高水分含量之比。

人面辨識

- 特指利用分析比較人臉視覺特徵資訊，來進行身份鑑別的電腦技術。
- 廣義的人面辨識包含構建人面辨識系統的一系列相關技術，包括人臉影像擷取、人臉定位、人面辨識預處理、身份確認及身份尋找等；而狹義的人面辨識特指通過人臉進行身份確認或者身份尋找的技術或系統。
- 人面辨識是一項熱門的電腦技術研究領域，它屬於生物特徵辨識技術，是對生物體（一般特指人類）本身的生物特徵來區分生物體個體。

b. 數據通訊 (內部及外部)

流動網絡 (2G/2.5G、3G/3.5G、4G/4.5G、5G)

- 絕大多數無線流動通訊網絡是數碼訊號制式的，除了可以進行語音通訊外，還可以收發短訊、MMS，以及透過轉接連上互聯網。
- 5G與4G的服務的分別
  - 5G的傳輸速度較4G快5至10倍，利用5G網絡於戶外透過無線上網亦可享受家居光纖寬頻服務相若的質素。當訊號良好時，現時4G的網絡時延大概約20至40多毫秒，而5G的時延更可低至約10至20多毫秒，比4G少一半。因此，5G比4G更適合用於直播和實時通訊，畫面「窒格」的情況會相對較少。

無線區域網路 (Wi-Fi)

- Wi-Fi 是一種無線網絡技術，讓電腦(筆記型電腦和桌上型電腦)、行動裝置(智慧型手機和穿戴式裝置)及其他設備(印表機和攝影機)能夠連線到網際網絡。此技術能讓上述等多種裝置相互交換資訊，建立一個網絡。網際網絡連線是透過無線路由器運作。

藍牙

- 藍牙技術是一種開放式無線數據和語音通訊信的全球規範。它建基於低成本的近距離無線連接的特殊技術，為固定和移動設備建立通訊環境。

c. 數據分析和報告

報告和視覺化工具

- 數據視覺化主要藉著圖形化法，清晰有效地傳達與溝通資訊。直觀地傳達關鍵的資訊與特徵，從而深入剖釋相當稀疏而又複雜的數據集。

互動式資料探索工具

- 資料探索是一種類似於初始資料分析的方法，資料分析師使用視覺探索而不是傳統的資料管理系統，來了解資料集的資料內容和特徵。這些特徵包括資料的大小或數量、資料的完整性、資料的準確性，以及資料元素或資料中的檔案/表格之間的潛在關係。

- 資料探索通常涉及自動化和手動活動。自動化活動包括資料剖析、資料視覺化或表格化報告，讓分析師初步了解資料及其關鍵特徵，再進行手動探索或過濾資料，以識別任何異常或模式。

- 資料探索亦可以指臨時查詢或資料視覺化，以識別可能隱藏在資料中的潛在關係和見解，而無需事先做出假設。

d. 可追溯性

溯源工具/平台

- 採用雲端技術的網絡服務及相容多種科技，包括無線射頻識別(RFID)、條碼、全球定位系統(GPS)及感測器等，為企業提供多種不同的解決方案，以即時獲取重要產品資訊，例如生產進度、存貨資料、送貨日程。

區塊鏈

- 區塊鏈技術是一種先進的資料庫機制，允許在企業網路中透明地共用資訊。區塊鏈資料庫將資料存儲在區塊中，而資料庫則一起連結到一個鏈條。在沒有網路共識的情況下，您不能刪除或修改鏈條。即使時間推移，資料仍然能保持一致，因此，您可以使用區塊鏈技術創建不可改變的分類帳，以便跟蹤訂單、付款、帳戶和其他交易。系統內置的機制可以阻止未經授權的交易條目，並確保這些交易的共用視圖的一致性。

e. 機器人與人工智慧

機器人

- 機器人學是一門跨學科的工程和科學分支，包括機械工程、電子工程、信息工程、計算機科學等。機器人學涉及機器人的設計、建造、操作和使用，以及用於控制、感覺反饋和信息處理的計算機系統。

◆ 機器人流程自動化 (RPA)

- 機器人流程自動化是一種軟體技術，可輕鬆構建、部署和管理軟體機器人，模擬人類與數碼系統和軟體進行交互的操作。就像人類一樣，軟體機器人可以理解屏幕上的內容，完成正確的按鍵操作、瀏覽系統、識別和提取數據、執行各種定義的操作。然而，軟體機器人可以比人更快、更一致地完成這些操作，而無需休息。
- 商業利益
  - 機器人流程自動化可優化工作流程，使組織更具彈性、反應更靈敏，進而提高盈利能力。它還可以通過消除工作日中的單調任務，提高員工滿意度、參與度和生產力。
  - 機器人流程自動化 (RPA) 是一種非侵入式的軟件技術，可以快速實現數碼轉型，並且非常適合為缺乏API、虛擬桌面基礎架構 (VDI) 或數據庫訪問的工作流程提供自動化方案。

◆ 自動導引車 (AGV)

- 自動導引車是一種可攜式機器人，它可以沿著地板上標記的線條或電線行走，或使用無線電波、視覺攝像頭、磁鐵或激光導航。它們通常用於工業應用中，以在大型工業建築物（例如工廠或倉庫）中運輸重物。自20世紀末以來，自動引導車的應用範圍已擴大。

◆ 自主機器人 (AMR)

- 由於AMR配備了攝像鏡頭和傳感器，如果它們在導航其環境時遇到意料之外的障礙物，例如掉落的箱子或人群，它們將使用避免碰撞等導航技術來減速、停止或重新規劃其路徑，繞過障礙物，然後繼續執行任務。

◆ 自動化存取系統 (AS/RS)

- 市場上的自動化存取系統技術以不同的速度處理不同數量、類型和速度的非托盤庫存，以滿足不同的吞吐量需求。ASRS還有許多其他替代名稱，包括動態存儲系統、高密度存儲和檢索系統及物到人揀選技術。

人工智能 (AI)

- 在計算機科學中，人工智能有時被稱為機器智能，是機器展示的智能，與人類和動物展示的自然智能相對。計算機科學將AI研究定義為「智能代理」的研究：任何感知其環境並採取行動，以最大化成功實現其目標的設備。俗稱「人工智能」一詞用於描述模仿人類與其他人類思維相關 「認知」功能的機器，例如「學習」和「解決問題」。

- 供應鏈優化的應用案例
  - ▸ 物流自動化
  - ▸ 倉庫自動化
  - ▸ 自動化質量檢查
  - ▸ 庫存優化
  - ▸ 區域特定預測
  - ▸ 改善供應商選擇
  - ▸ 綠色運輸物流

f. 現有冷鏈技術

保溫包裝

• 主動式

- 這些系統使用機械或電力系統，由能源來源驅動，結合製冷系統和恆溫控制，以維持適當的產品溫度。

• 被動式

- 被動式熱系統通常使用相變材料(PCM)，例如冰或乾冰。這些運輸系統是最基本和最具成本效益。
- 冷藏箱
- 物聯網（IoT）傳感器

• 混合式

- 混合式熱系統結合使用相變材料(PCM)和恆溫控制。這些系統通常使用PCMs作為能源來源，由恆溫控制調節以維持適當的產品溫度。

最後一里冷鏈交付技術

- 帶有溫度傳感器帶溫度感測器的隔熱袋或保溫袋

- 帶有溫度傳感器的冷鏈手推車

六. 解決方案選擇步驟

步驟 1

選擇目標物件及基本處理方法

產品 (詳見附錄 1)

- 庫存單位
- 批次/批號
- 序列化

保溫包裝 (詳見附錄 2)

- 主動式
- 被動式
- 混合式

儲存

- 固定位置
  - 冷藏室
  - 冷凍庫
  - 冷氣庫
- 可移動裝置
  - 冷藏貨櫃
  - 冷藏車
  - 自動導引車
  - 自主移動機器人

步驟 2

選擇識別和標籤技術 (詳見附錄 3)

- 條碼 (1D/2D)
- 無線射頻辨識 (RFID)

步驟 3

選擇感測器 (詳見附錄 4)

- 溫度
- 濕度

步驟 4

選擇通訊技術 (詳見附錄 5)

- 有線
- Wi-Fi (需要Wi-Fi 路由器+寬頻網絡，20m)
- 藍牙 (需要藍牙集線器+寬頻網絡，5m)
- 行動網路 (4G/5G) (需行動裝置/手機)

步驟 5

選擇應用程式/平台/工具 (詳見附錄 6)

七. 冷鏈營運之應用場景

	場景 1 貨物的追溯系統的管理	場景 2 冷凍車輛	場景 3 冷藏倉庫	場景 4 冷藏箱	場景 5 最後一里交付
對象	產品	車輛	固定冷凍儲存	容器	專案
追蹤	序列化	序列化	序列化	序列化	序列化
包裝	被動	不適用	不適用	被動	被動
標識和標籤	條碼與RFID	條碼與RFID	條碼與RFID	條碼與RFID	條碼與RFID
感測器	溫度	溫度	人臉辨識 保障員工安全穿戴式裝置	溫度	溫度
通訊	無線	無線	有線/無線	無線	無線
應用程式	溯源平台	車隊管理系統	倉庫管理系統	溯源平台	溯源平台

場景 1 - 貨物的追溯系統的管理

步驟 1

選擇對象

產品 (詳見附錄 1)

- 應為每件貨物貼上用作識別的貨物條碼/識別號/貨物批次號方便追蹤

包裝 (詳見附錄 2)

步驟 2

選擇標識和標籤技術

條碼與 RFID (詳見附錄 3)

步驟 3

選擇感測器

溫度 (詳見附錄 4)

感測器數量

步驟 4

選擇通訊技術 (詳見附錄 5)

步驟 5

選擇應用程式/平台/工具

貨物追溯平台 (詳見附件 6)

場景 2 - 冷凍車輛

步驟 1

選擇對象

車輛

步驟 2

選擇標識和標籤技術

條碼與 RFID (詳見附錄 3)

步驟 3

選擇感測器

溫度 (詳見附錄 4)

感測器數量：

- 每個溫區最少 1 個感測器
- 每個入口/出口最少 1 個感測器

步驟 4

選擇通訊技術 (詳見附錄 5)

步驟 5

選擇應用程式/平台/工具

倉庫管理系統 (詳見附件 6)

場景 3 - 冷藏倉庫

步驟 1

選擇對象

固定冷凍儲存

步驟 2

選擇標識和標籤技術

條碼與 RFID (詳見附錄 3)

步驟 3

選擇感測器

1. 溫度（-25°C -18°C）(詳見附錄 4)

感測器數量：

- 每個溫區最少 1 個感測器
- 每個入口/出口最少 1 個感測器

2.

人臉辨識保障員工安全

- 識別並記錄進出倉庫的人員

衡量特定員工可以在倉庫內停留的時間長短

3.

穿戴式裝置

- 監控員工狀況向員工和
- 管理層提供警報

步驟 4

選擇通訊技術 (詳見附錄 5)

步驟 5

選擇應用程式/平台/工具

產品追溯平台 (詳見附件 6)

場景 4 - 冷藏箱

步驟 1

選擇對象

容器 (被動包裝)

步驟 2

選擇標識和標籤技術

條碼與 RFID (詳見附錄 3)

步驟 3

選擇感測器

溫度 (詳見附錄 4)

感測器數量

步驟 4

選擇通訊技術 (詳見附錄 5)

步驟 5

選擇應用程式/平台/工具

產品追溯平台 (詳見附件 6)

場景 5 - 最後一里交付

步驟 1

選擇對象

產品 (詳見附錄 1)

防護包裝 (詳見附錄 2)

- 借助最後一里冷鏈交付技術

步驟 2

選擇標識和標籤技術

條碼與 RFID (詳見附錄 3)

步驟 3

選擇感測器

溫度 (詳見附錄 4)

感測器數量

步驟 4

選擇通訊技術 (詳見附錄 5)

步驟 5

選擇應用程式/平台/工具

產品追溯平台 (詳見附件 6)

八. 附錄

附錄 1 – 產品等級對照表

常用選項

產品等級	庫存單位	批次	序列化
ID	產品代碼	批次號	序號
主要應用范圍	- 訂購 - 補貨 - 庫存管理	- 批次級品質控制 - 產品召回	- 防偽 - 單品級品質控制 - 退貨管理
實施複雜性	低	中	高
實施成本	低	中	高

附錄 2 – 包裝對照表

常用選項

包裝	主動	被動	混合
功能與特點	主動熱系統不使用任何相變材料（PCM），例如水/冰或乾冰。這些系統使用由能源供電的機械或電力系統，並結合恒溫控制來維持適當的產品溫度。	被動熱系統通常使用相變材料（PCM），例如水/冰或乾冰。這些運輸系統是最基本且最具成本效益的。 例如冷箱	混合主動被動熱系統結合使用水/冰或乾冰等 PCM 和恒溫控制裝置。這些系統通常使用 PCM 作為能源，透過恒溫控制來調節以維持適當的產品溫度。
實施複雜性	中	低	中
實施成本	高	低	中

附錄3 – 產品等級對照表

常用選項

識別和標籤技術	條碼(1D/2D)	無線射頻辨識 (條碼+超高頻無線射頻辨識)
組成部分	• 條碼標籤印表機	• 條碼標籤和吊牌書寫印表機
	• 條碼掃碼機	• 條碼掃碼機
	• 電腦版軟件	• 被動無線射頻辨識 掃描器/讀取器
		• 電腦版軟件
功能與特點	• 識別物品	• 識別物品
	• 逐一掃描	• 被動無線射頻辨識自動掃描
優點與缺點	優點：成本低	優點：快速自動掃描大量物品
	缺點：輕鬆進行標誌線掃描和同一物品的雙重掃描	缺點：被動無線射頻辨識標籤成本較高，不適合金屬包裝物品
工作範圍和精準度	5-50公分 & 99.50%	20-500公分 & 99%
實施複雜性	低	中
實施成本	低	中

附錄4 – 感測器比較表

常用選項

	透過溫度資料記錄進行識別	溫度和濕度數據記錄		
組成部分	條碼+主動無線射頻辨識標籤平台	溫度數據記錄儀	有線溫濕度感測器	物聯網溫濕度感測器平台
	• 掃碼機 • 主動式無線射頻辨識標籤 • 雲端平台	• 掃碼機 • 無線電池輔助感測器 • 主動式無線射頻辨識標籤 • 電腦版軟件	• 有線感應器 • 電腦版軟件	• 無線電池輔助感測器 • 雲端平台
功能與特點	• 識別物品 • 透過固定閱讀器自動掃描 • 數據記錄 • 短訊/電子郵件警報 • 網路為基礎的儀表板	• 數據記錄 • 記錄	• 實時監控 • 短訊/電子郵件警報	• 數據記錄 • 遙控及實時監控 • 短訊/電子郵件警報 • 網路為基礎的儀表板
優點與缺點	優點：標籤可充電重複使用、自動掃描和資料擷取 缺點：有源RFID 標籤成本昂貴	優點：簡單快速的資料記錄設置，成本低廉 缺點：沒有即時監控和警報	優點：透過簡訊警報進行現場即時監控 缺點：安裝成本較高	優點：透過簡訊/電子郵件警報進行完全遠端即時監控 缺點：年費成本高，每年需更換電池
工作範圍和精準度	-30°C to +80°C @0.4°C, 0-100%RH	-20°C to +60°C @0.1°C, 10-90%RH @0.1%RH	-20°C to +60°C @0.1°C, 10-90%RH @0.1%RH	-30°C to +80°C @0.4°C, 0-100%RH @2%RH
實施複雜性	簡單	簡單	中	簡單
成本	高	低	中	高

附錄5 – 通訊技術對照表

常用選項

通訊科技	有線	Wi-Fi	藍牙	行動網路 4G/5G
組成部分	電纜	- 無線路由器 - 用於互聯網連接的寬頻網絡	- 藍牙集線器 - 用於互聯網連接的寬頻網絡	- 藍牙集線器 - 用於互聯網連接的寬頻網絡
功能與特點	有線	無線	無線	無線
優點與缺點	優點：可靠且高速 缺點：不靈活	優點：靈活 缺點：覆蓋範圍廣且需要硬體安裝	優點：靈活 缺點：通訊距離短(<20米)	優點：非常靈活且無需安裝硬件 缺點：需要服務提供者
工作範圍和精度	範圍長且非常可靠	50米及可靠	20米及不太可靠	範圍長且可靠
實施複雜性	高	中	低	低
實施成本	人工成本高	中	低	低

附錄6 – 應用程式/平台/工具比較表

常用選項

應用程式/平台/工具	雲端平台	現成的包裝	客製化軟件	試算表工具
客製化	有限	有限	高度可定制，以滿足特定的業務需求	取決於使用者知識
功能與特點	提供一系列標準特性和功能	提供一系列標準特性和功能	可以開發以包含特定的特性和功能	與特定軟件相比功能有限
可擴展性	高	可能會或可能不會提供可擴展性選項，具體取決於方案	可擴展以配合業務增長和不斷變化的需求	可擴展性有限
支援和更新	通常附帶供應商支援和定期更新	通常附帶供應商支援和定期更新	可以透過開發團隊的持續支援和進行客製化更新	沒有專門的支援或更新，取決於用戶知識
實施時間表	快速實施，因為它是一個即用型解決方案	快速實施，因為它是一個即用型解決方案	由於開發和定製過程，實施時間更長	立即使用，最短的實施時間
數據分析和報告	可以提供基本的報告和分析功能	可以提供基本的報告和分析功能	可進行客製化深入數據分析和報告	取決於使用者知識
整合能力	僅標準應用程式介面	僅標準應用程式介面	可與現有系統集成，實現無縫資料流	有限
使用者培訓	通常需要較少的使用者培訓，因為它遵循標準流程	通常需要較少的使用者培訓，因為它遵循標準流程	需要進行培訓以使用戶熟悉自訂工作流程	熟悉且常用的工具，只需最少的培訓
成本計算方法	透過訂閱	按時初始授權成本 + 實施諮詢費用 + 年度維護費用	按時初始授權成本 + 實施諮詢費用 + 年度維護費用	許可證費用
實施成本	低	中	高	非常低

九. 鳴謝

項目督導委員會成員

主席

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聲明

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本項目指南所述資料截至2024年2月為止。如有任何疑問，請向我們查詢。

Guidelines for the Application of Emerging Technologies in Cold Chain Logistics

This project is organised by the Hong Kong Logistics Association and funded by the "Trade and Industrial Organisation Support Fund" of the Trade and Industry Department, the HKSAR Government.

(Project Reference: T21 004 004)

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1. Project Background and Introduction

Hong Kong possesses the advantages of free movement of capital and goods, as well as low tax rates. It is also a crucial global trading centre. As technology continues to advance, the future success of the cold chain logistics industry in Hong Kong, like other sectors, relies on the drive of innovative technology. Therefore, the development of a set of "Guidelines for the Application of Emerging Technologies in Cold Chain Logistics" tailored to the local context becomes essential, enabling the logistics industry to seize new opportunities in a rapidly evolving market.

To address the needs of the industry, small and medium-sized enterprises, and the community, the Hong Kong Logistics Association has received funding from the Trade and Industry Institutions Support Fund of the Trade and Industry Department to implement this project. This project aims to formulate guidelines for application of emerging technologies in the **"Cold Chain Logistics Management System"**. This initiative not only assists the industry in seizing opportunities but also facilitates the establishment of an effective smart cold-chain logistics management system or upgrade existing ones. This aids the industry in achieving on-going enhancement, benefiting from an optimised managerial and operational procedures.

2. Project Objective

To enhance the cold chain logistics operations and processes by suggesting suitable emerging technologies

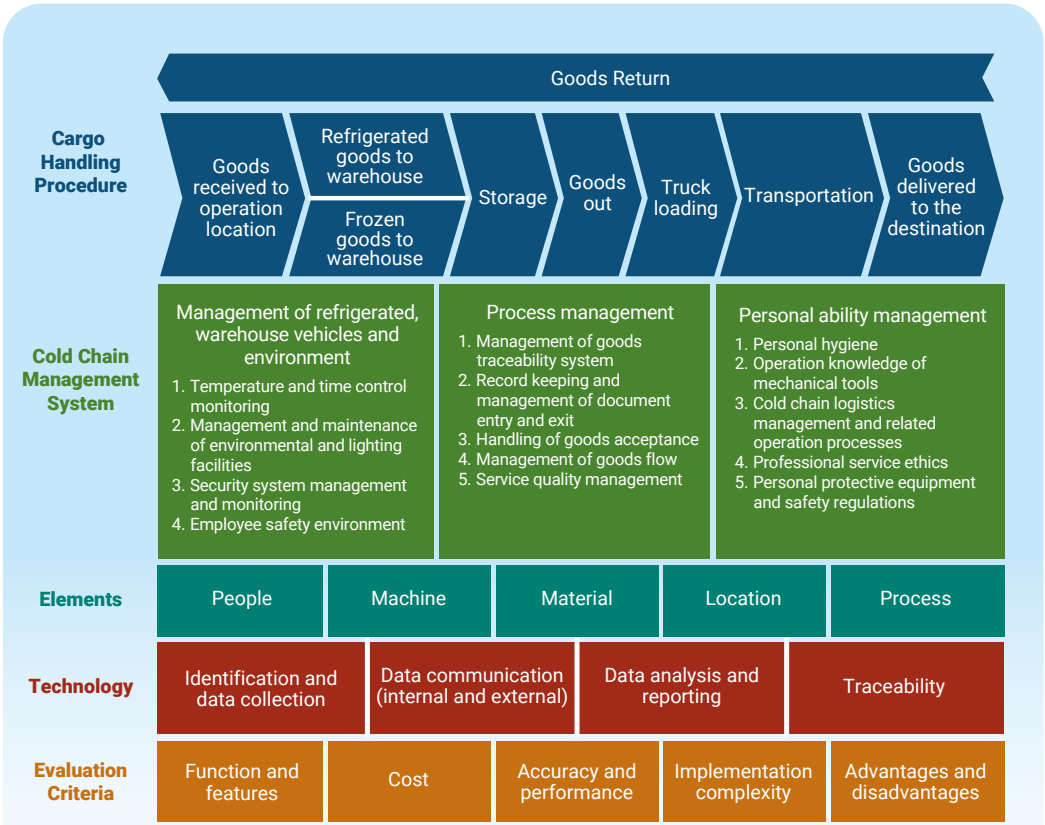
3. Project Details

- Conduct desktop research to review the suggested cold chain logistics operations formulated in the previous project
- Organize focus group consultation with stakeholders
- Organize kick-off and briefing seminar
- Conduct promotional activities for the project (such as eDM and advertisement on newsletter)
- Develop Guidelines for application of emerging technologies in cold chain logistics
- Organize the “Application of emerging technologies in cold chain logistics industry” Guideline of Practice Sharing and Guidance Workshops
- Conduct a pilot program experience sharing seminar
- Develop and publish project outcomes and project guideline

A. Technical Framework Structure

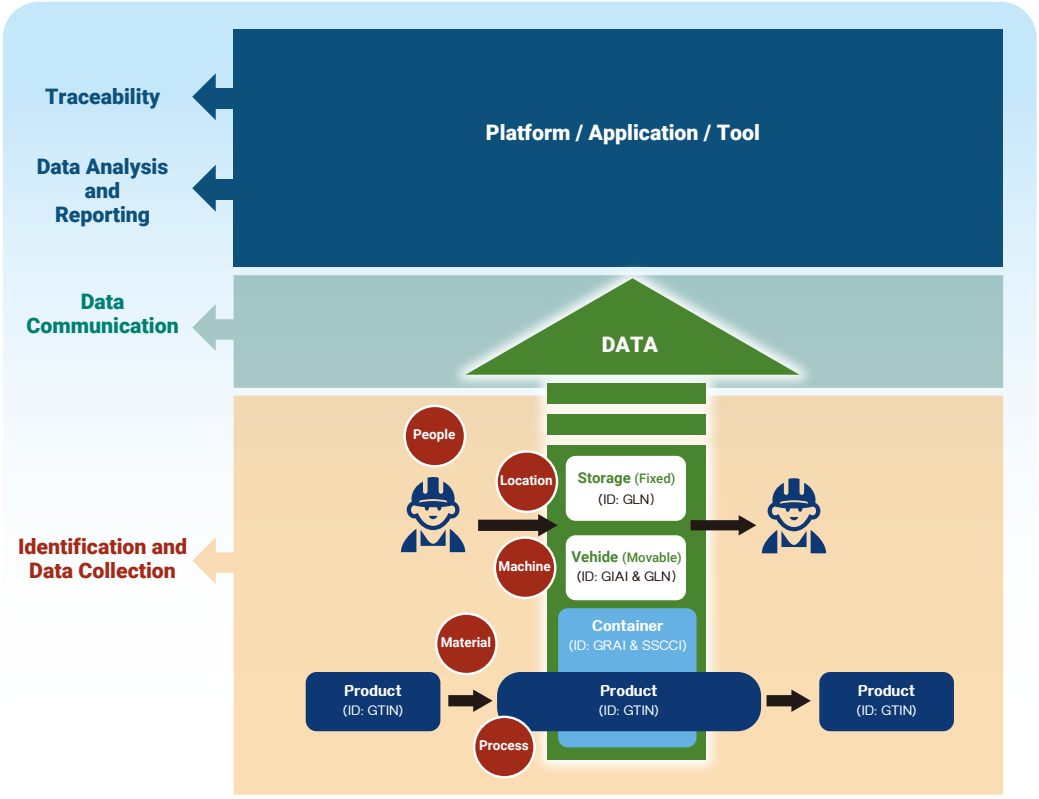
The framework consists of 5 layers:

Cargo Handling Procedure	Cold Chain Management System	Elements	Technology	Evaluation Criteria



B. Applied Technology

Identification and Data Collection | Data Communication | Data Analysis and Reporting | Traceability



C. Key Design of Selection Guide

The selection guide is designed to accommodate the key feedback from the industry consultations.

- The design principles should focus on risk management.
  - The use of technology to minimize risk.
  - Such as reducing the time that cold chain products are exposed to high temperatures.
  - Especially, for the last mile delivery, where cold chain products are exposed to outdoor or harsh environments, and risks are difficult to manage.
- Other key areas of focus include:
  - Energy conservation (ESG).
  - Equipment preventive maintenance (e.g., refrigerated trucks).
- Other operational challenges include:
  - Outbound shipments.
  - Labelling.
  - Synchronization of inbound goods and documents/emails.
  - Product traceability.

D. Principles of Technology Selection

The technology selection is based on the most common technologies that are available from the market.

- Understand operating scenarios
- Select the appropriate (sufficient) technology
- Understand the technology
  - Features and functions
  - Accuracy and performance
  - Costs (one-time costs, ongoing costs)
  - Implementation complexity
  - Future scalability

E. List of Technologies

a. Identification and Data Acquisition

- Barcodes can be divided into two types, namely 1D barcodes and 2D barcodes.
- 1D barcodes：
  - ▸ The one-dimensional barcode, also known as linear barcode, is a common traditional barcode composed of varying widths of black and white stripes. It is arranged according to unique coding rules, and each group of graphic identification codes carries information about the product itself.
- QR codes：
  - ▸ The two-dimensional barcodes, also referred to 2D barcodes, employ black and white rectangular patterns to represent binary data, with each set of barcodes recording unique information. In contrast to 1D barcodes, 2D codes can store data both horizontally and vertically, and QR codes also contain anchor points and fault-tolerant mechanisms.
  - ▸ The advantage of the fault-tolerant mechanism lies in its ability to enable smooth reading of data in the barcode, even if it is slightly stained or damaged, without requiring a full barcode scan.

Radio Frequency Identification (RFID)

- RFID originated as a military technology in the 20th century to distinguish between friendly and enemy aircraft, preventing accidental strikes. With technology advancement, RFID has become prevalent in our daily lives.
- It is a non-contact automatic identification system that can read and write data within RFID tags and cards.
- Features and benefits:
  - ► Simultaneously read multiple tags,
  - ► Extended reading distance,
  - ► Capable of scanning through obstructions,
  - ► Read through surface dirt.
- RFID tags are currently categorised based on different frequencies: Low Frequency, High Frequency, Ultra High Frequency and Microwave.
- RFID tags are classified into three types according to their power source: Passive, Battery-Assisted Passive, and Active.

Temperature Sensor

- A temperature sensor generally refers to an electronic component that converts temperature into electronic data. It is constructed with a conductive material in which resistance changes with temperature.

Humidity Sensor

- A humidity sensor generally refers to an electronic component that converts temperature into electronic data. A humidity sensor can sense, measure, and report the relative humidity in the air. Therefore, it can measure humidity and air temperature. Relative humidity is the ratio of actual moisture in the air to the maximum moisture content that can be maintained at that air temperature.

Facial Recognition

- Specifically refers to computer technology that uses visual feature information to analyse and compare human faces for identification purposes.
- Broadly speaking, facial recognition includes a series of related technologies for building facial recognition systems, including face image acquisition, face positioning, facial recognition preprocessing, identity verification, and identity search, etc.; while narrow facial recognition specifically refers to the technology or system that uses facial recognition for identity verification or identity search.
- Facial recognition is a popular research area in computer technology. It belongs to biometric recognition technology, which distinguishes individual organisms by their own biological characteristics (usually referring to humans).

b. Data Transmission (Internal and External)

Mobile Network (2G/2.5G, 3G/3.5G, 4G/4.5G, 5G)

- The majority of wireless mobile communication networks operate on digital signal formats, allowing not only voice calls, but also the exchange of text messages, MMS, and internet connectivity via data transfer.
- The difference between 5G and 4G services
  - 5G boasts a transmission speed 5 to 10 times faster than 4G, providing comparable quality for wireless internet in outdoor environments and home fiber broadband services. In areas with good signal, 4G networks typically exhibit latency of about 20 to 40 milliseconds, whereas 5G can achieve significantly lower latency, ranging from approximately 10 to 20 milliseconds—half that of 4G. Therefore, 5G is more suitable for live broadcasting and real-time communication, resulting in fewer instances of screen "stuttering."

Wireless Fidelity (Wi-Fi)

- Wi-Fi is a wireless network technology that facilitates the connection of computers (laptops and desktops), mobile devices (smartphones and wearable devices), and other devices (printers and cameras) to the Internet. This technology enables the seamless exchange of information among multiple devices, establishing a network. Internet connectivity is established through a wireless router.

Bluetooth

- Bluetooth technology is a global standard for open wireless data and voice communication. It is a special short-range wireless technology connection based on low-cost, which establishes a communication environment for fixed and mobile devices.

c. Data Analysis and Reporting

Reporting and Visualization Tools

- Data visualization primarily aims to convey information and communicate clearly and effectively through graphical means. To effectively communicate conceptual ideas, aesthetics and functionality must be harmonised, intuitively conveying key aspects and features. This approach enables a profound insight into sparse and complex data sets.

Interactive Data Exploration Tools

- Data exploration is a method similar to initial data analysis, where data analysts employ visual exploration rather than traditional data management systems to comprehend the content and features of data within the dataset. These features include the size or quantity of data, data integrity, data accuracy, and possible relationships between data elements and files/tables in the data.
- Data exploration typically involves a combination of automated and manual activities. Automated tasks encompass data parsing, data visualisation, or tabular reporting, enabling analysts to gain a preliminary understanding of the data and recognise its key features. Subsequently, manual drilling down or filtering of data is performed to identify anomalies or discern patterns.
- Data exploration can also refer to ad hoc queries or data visualisation to uncover potential relationships and insights hidden in the data without making assumptions beforehand.

d. Traceability

Traceability tools / platforms

- The adoption of cloud-based traceability platforms is compatible with multiple technologies, including wireless radio frequency identification (RFID), barcodes, global positioning system (GPS), and sensors, etc., to provide enterprises with a variety of solutions to instantly obtain important product information, such as production progress, inventory data, delivery schedule.

Blockchain

- Blockchain technology is an advanced database mechanism that enables transparent information sharing within an enterprise network. The blockchain database stores data in blocks, which are linked together in a chain. Data remains consistent over time as modifications or deletions are impossible without network consensus. Therefore, blockchain technology is employed to establish an immutable ledger for tracking orders, payments, accounts, and various transactions. The system's built-in mechanisms prevent unauthorised transaction entries, ensuring consistency in shared views of these transactions.

e. Robotics and Artificial Intelligence

Robotics

- Robotics is an interdisciplinary branch of engineering and science that encompasses mechanical engineering, electronic engineering, information engineering, computer science, and other domains. It involves the design, construction, operation, and use of robots, along with the development of computer systems for their control, sensory feedback, and information processing.

◆ Robotic process automation (RPA)

- Robotic process automation (RPA) is a software technology designed to simplify the creation, deployment, and management of software robots that emulate human actions when interacting with digital systems and software. Similar to humans, software robots can comprehend on-screen content, execute precise keystrokes, navigate systems, recognise and extract data, and perform various predefined actions. However, software robots can accomplish these tasks more rapidly and consistently than humans, without the need for breaks or pauses.

- Business Benefits

  - Robotic process automation streamlines workflows, and enhances organizational profitability, flexibility, and responsiveness. It also boosts employee satisfaction, engagement, and productivity by eliminating mundane tasks from their daily work routines.

  - RPA is non-invasive and can be swiftly implemented to expedite digital transformation. It is particularly well-suited for automating workflows that involve legacy systems lacking APIs, virtual desktop infrastructures (VDIs), or database access.

Automated Guided Vehicle (AGV)

- An AGV is a portable robot that follows marked lines or wires on the floor, or uses radio waves, vision cameras, magnets, or lasers for navigation. They are commonly used in industrial applications to transport heavy materials within a large industrial facility, such as a factory or warehouse. The application of automatic guided vehicle broadened during the late 20th century.

Autonomous Mobile Robot (AMR)

- An AMR is a type of robot capable of autonomously understanding and navigating its environment. AMRs utilise a sophisticated array of sensors, artificial intelligence, machine learning, and computing for path planning to interpret and move through their surroundings without being tethered to wired power sources.

- Since AMRs are equipped with cameras and sensors, encountering unexpected obstacles in their environments, such as a fallen box or a crowd of people, triggers navigation technique like collision avoidance. This allows them to slow, stop, or re-route their path around the object before resuming their assigned tasks.

◆ Automated Storage and Retrieval Systems (AS/RS)

- The AS/RS technologies on the market can manage diverse volumes, types and velocities of non-palletised inventory at variable speeds, adapting to fluctuating throughput demands.

- ASRS is also known by various alternative names including dynamic storage systems, high density storage and retrieval systems and goods-to-person picking technology.

Artificial Intelligence (AI)

- In computer science, artificial intelligence (AI), sometimes referred to as machine intelligence, is intelligence exhibited by machines, contrasting with the natural intelligence displayed by humans and animals. AI research in computer science is defined as the exploration of "intelligent agents": devices capable of perceiving their environment and taking actions to maximise the likelihood of successfully achieving their goals. Colloquially, the term "artificial intelligence" is used to describe machines that mimic "cognitive" functions associated with human minds, such as "learning" and "problem solving".

- Use cases for supply chain optimisation
  - Logistics automation
  - Warehouse automation
  - Automated quality checks
  - Inventory optimisation
  - Region-specific
  - Improved supplier selection
  - Greener transport logistics

f. Existing Cold Chain Technologies

Thermal Protective Packaging

• Active

- Active thermal systems do not involve the use of phase change materials (PCM) such as water, ice or dry ice. Instead, these systems utilise mechanical or electric systems powered by an energy source, combined with thermostatic control to maintain appropriate temperatures for products.

• Passive

- Passive thermal systems commonly employ phase change materials (PCM) like water, ice or dry ice. These shipping systems are the most basic and cost effective.
- E.g. Cold box
- With IOT sensors

• Hybrid

- Hybrid thermal systems use a combination of PCMs and thermostatic controls. These systems typically use PCMs as a source of energy, which is regulated by thermostatic control to maintain proper product temperatures.

Last Mile Cold Chain Delivery Technologies

- Insulated or thermal bags with temperature sensors

- Insulated trolleys with temperature sensors

4. Solution Selection Steps

Step 1

Select Target Object and handling methods

Product (Refer to Appendix 1 for details.)

- SKU (Stock Keeping Unit)
- Batch/Lot
- Serialised

Thermal Protective Package (Refer to Appendix 2 for details.)

- Active
- Passive
- Hybrid

Storage

- Fixed Location
  - Cold Room
  - Freezer
  - Chiller
- Movable Equipment
  - Refrigerated Container
  - Refrigerated Truck
  - AGV
  - AMR

Step 2

Select Identification and Labeling Technology

(Refer to Appendix 3 for details.)

- Barcode (1D/2D)
- RFID

Step 3

Select Sensor (Refer to Appendix 4 for details.)

- Temperature
- Humidity

Step 4

Select Communication Technology

(Refer to Appendix 5 for details.)

- Wired
- Wifi (Requires Wifi Router + Broadband Network, 20m)
- Bluetooth (Requires Bluetooth Hub + Broadband Network, 5m)
- Mobile Network (4G/5G) (Requires Mobile Device/Phone)

Step 5

Select Application/Platforms/Tools

(Refer to Appendix 6 for details.)

5. Application Scenarios in Cold Chain Operations

	Scenario 1 Management of Goods Traceability System	Scenario 2 Refrigerated Vehicles	Scenario 3 Cold Warehouse	Scenario 4 Cold Box	Scenario 5 Last Mile Delivery
Object	Product	Vehicle	Fixed Storage	Container	Project
Traceability	Serialized	Serialized	Serialized	Serialized	Serialized
Packaging	Passive	N/A	N/A	Passive	Passive
ID & Label	Barcode vs RFID	Barcode vs RFID	Barcode vs RFID	Barcode vs RFID	Barcode vs RFID
Sensor	Temperature	Temperature	Temperature Face Recognition Wearable Device	Temperature	Temperature
Communication	Wireless	Wireless	Wire/Wireless	Wireless	Wireless
Application	Traceability Platform	Fleet Management System	Warehouse Management System	Traceability Platform	Traceability Platform

Scenario 1 – Management of Goods Traceability System

Step 1

Select Object

Product (Refer to Appendix 1 for details.)

- Each piece of goods should be labeled with a cargo barcode/identification number/goods batch number for identification purposes to facilitate tracking.

Packaging (Refer to Appendix 2 for details.)

Step 2

Select Identification and Labeling Technology

Barcode vs RFID (Refer to Appendix 3 for details.)

Step 3

Select Sensor

Temperature (Refer to Appendix 4 for details.)

Quantity of Sensor

Step 4

Select Communication Technology

(Refer to Appendix 5 for details.)

Step 5

Select Application/Platforms/Tools

Product Traceability Platform (Refer to Appendix 6 for details.)

Scenario 2 – Refrigerated Vehicles

Step 1

Select Object

Vehicle

Step 2

Select Identification and Labeling Technology

Barcode vs RFID (Refer to Appendix 3 for details)

Step 3

Select Sensor

Temperature (Refer to Appendix 4 for details)

Quantity of Sensor:

- At least 1 sensor for each temperature zone
- At least 1 sensor for each door
- Additional Features: Record utilisation for preventative maintenance

Step 4

Select Communication Technology

(Refer to Appendix 5 for details.)

Step 5

Select Application/Platforms/Tools

Fleet Management System (Refer to Appendix 6 for details)

Scenario 3 – Cold Warehouse

Step 1

Select Object

Fixed Frozen Storage

Step 2

Select Identification and Labeling Technology

Barcode vs RFID (Refer to Appendix 3 for details)

Step 3

Select Sensor

Temperature (-25°C -18°C) (Refer to Appendix 4 for details)

1. **Quantity of Sensor:**
   - At least 1 sensor for each temperature zone
   - At least 1 sensor for each entrance / exit

2. 

   Face Recognition for Safety
   - Identify and record the staffs in/out the storage

   Measure how long of a specific staff can be stayed inside the storage

3.

Wearable Device

- Monitor the staff situation
- Provide alert to staff and management

Step 4 Select Communication Technology

(Refer to Appendix 5 for details.)

Step 5 Select Application/Platforms/Tools

Warehouse Management System (Refer to Appendix 6 for details)

Scenario 4 – Cold Box

Step 1

Select Object

Container (Passive Packaging)

Step 2

Select Identification and Labeling Technology

Barcode vs RFID (Refer to Appendix 3 for details)

Step 3

Select Sensor

Temperature (Refer to Appendix 4 for details)

Quantity of Sensor

Step 4

Select Communication Technology

(Refer to Appendix 5 for details.)

Step 5

Select Application/Platforms/Tools

Product Traceability Platform (Refer to Appendix 6 for details)

Scenario 5 – Last Mile Delivery

Step 1

Select Object

Product (Refer to Appendix 1 for details.)

Thermal Protective Packaging (Refer to Appendix 2 for details.)

- With Last Mile Cold Chain Delivery Technologies

Step 2

Select Identification and Labeling Technology

Barcode vs RFID (Refer to Appendix 3 for details)

Step 3

Select Sensor

Temperature (Refer to Appendix 4 for details)

Quantity of Sensor

Step 4

Select Communication Technology

(Refer to Appendix 5 for details.)

Step 5

Select Application/Platforms/Tools

Product Traceability Platform (Refer to Appendix 6 for details)

6. Appendix

Appendix 1 – Product Level Comparison Table

Commonly used options

Product Level	SKU	Batch/Lot	Serialized
ID	Product Code	Batch Number/ Lot Number	Serial Number
Key Application	- Ordering - Replenishment - Inventory Management	- Ordering - Replenishment - Inventory Management	- Anti-counterfeiting - Item Level Quality Control - Return Management
Implementation Complexity	Low	Medium	High
Implementation Cost	Low	Medium	High

Appendix 2 – Packaging Comparison Table

Commonly used options

Packaging	Active	Passive	Hybrid
Functionality & Feature	Active thermal systems do not use any phase change materials (PCM) such as water/ice or dry ice. These systems use mechanical or electric systems powered by an energy source, combined by thermostatic control to maintain proper product temperatures.	Passive thermal systems commonly use phase change materials (PCM) such as water/ice or dry ice. These shipping systems are the most basic and cost effective, e.g. Cold Box.	Hybrid thermal systems use a combination of PCMs such as water/ice or dry ice and thermostatic controls. These systems typically use PCMs as a source of energy, which is regulated by thermostatic control to maintain proper product temperatures.
Implementation Complexity	Medum	Low	Medium
Implementation Cost	High	Low	Medium

Appendix 3 – Identification and Labeling Technology Comparison Table

Commonly used options

Identification and Labeling Technology	Barcode	RFID (Barcode + Passive UHF RFID)
Components	• Barcode Label Printer	• Barcode Label and Tag Writing Printer
	• Barcode Scanner	• Barcode Scanner
	• Software for PC	• Passive RFID Scanner/Reader
		• Software for PC
Functionality & Feature	• Identify the items	• Identify the items
	• Scanning one-by-one	• Scanning automatically by Passive RFID gateway
Pros & Cons	Pros: Low Cost	Pros: Fast and automatic scanning in huge amount of items
	Cons: Line-of-sign scanning and Double scan of same item easily	Cons: Higher cost on Passive RFID label tag, not suitable for metallic packaging items
Operating Range & Accuracy	5-50cm & 99.50%	20-500cm & 99%
Implementation Complexity	Low	Medium
Cost	Low	Medium

Appendix 4 – Sensor Comparison Table

Commonly used options

	Identification with Temperature Data Logging	Temperature and Humidity Data Logging		
Identification and Labeling Technology	Barcode + Active RFID Tag Platform	Temperature Data Logger	Wired Temperature & Humidity Sensor	IoT Temperature & Humidity Sensor Platform
	• Barcode Scanner • Active RFID Tag • Cloud Platform	• Wireless Battery-assisted Sensors • Software for PC	• Wired Sensors • Software for PC	• Wireless Battery-assiste Sensors • Cloud Platform
Functionality & Feature	• Identify the items • Scanning automatically by Fixed Reader • Data Logging • SMS/Email Alert • Web-based Dashboard	• Data Logging • Reporting	• Real-time Monitoring • SMS/Email Alert	• Data Logging • Remote & Real-time Monitoring • SMS/Email Alert • Web-based Dashboard
Pros & Cons	Pros & Cons Pros: Tag can be recharged to reuse, scanning and data capturing automatically Cons: Expensive cost on Active RFID Tag	Pros: Simple & Fast Setup for Data Logging with Low Cost Cons: No Real-time Monitoring and Alert	Pros: Real-time Monitoring at Site with SMS Alert Cons: Higher Cost for Installation	Pros: Fully Remote and Real-time Monitoring with SMS/Email Alert Cons: High Cost for Annual Subscription Fee, need to replace battery yearly
Operating Range & Accuracy	-30°C to +80°C @0.4°C, 0-100%RH	-20°C to +60°C @0.1°C, 10-90%RH @0.1%RH	-20°C to +60°C @0.1°C, 10-90%RH @0.1%RH	-30°C to +80°C @0.4°C, 0-100%RH @2%RH
Implementation Complexity	Easy	Easy	Medium	Easy
Cost	High	Low	Medium	High

Appendix 5 – Communication Technology Comparison Table

Commonly used options

Communication Technology	Wired	Wifi	Bluetooth	Mobile Netowrk 4G/5G
Components	Cable	- Wifi Router - Broadband Network for internet connection	- Bluetooth Hub - Broadband Network for Internet connection	- Mobile Device/Phone - Mobile Network
Functionality & Feature	Wireless	Wireless	Wireless	Wireless
Pros & Cons	Pros: Reliable & High Speed Cons: Not flexible	Pros: Flexible Cons: Coverage & Require hardware installation	Pros: Flexible Cons: Short communcation distance (<20m)	Pros: Very Flexible & No hardware installion Cons: Require service provider
Operating Range & Accuracy	Long & Very Reliable	50m & Reliable	20m & Not very reliable	Long & Reliable
Implementation Complexity	High	Medium	Low	Low
Implementation Cost	High Labour Cost	Medium	Low	Low

Appendix 6 – Application/Platforms/Tools Comparison Table

Commonly used options

Application/Platforms/ Tools	Cloud Platform	Off-the-Shelf Package	Tailor-Made Software	Spreadsheet Tool
Customization	Limited	Limited	Highly customizable to meet specific business requirements	Dependent on user knowledge
Functionality & Feature	Offers a range of standard features and functions	Offers a range of standard features and functions	Can be developed to include specific features and functions	Limited functionality compared to specific software
Scalability	High	May or may not offer scalability options depending on the package	Scalable to accommodate business growth and evolving needs	Limited scalability
Support and Updates	Generally comes with vendor support and regular updates	Generally comes with vendor support and regular updates	Can be tailored with ongoing support and updates from the development team	No dedicated support or updates, dependent on user knowledge
Implementation Timeline	Quick implementation as it is a ready-to-use solution	Quick implementation as it is a ready-to-use solution	Longer implementation time due to development and customization process	Immediate use, minimal implementation time
Data Analysis and Reporting	May offer basic reporting and analysis capabilities	May offer basic reporting and analysis capabilities	Can be tailored for in-depth data analysis and reporting	Dependent on user knowledge

Application/Platforms/ Tools	Cloud Platform	Off-the-Shelf Package	Tailor-Made Software	Spreadsheet Tool
Integration Capabilities	Standard API Only	Standard API Only	Can be integrated with existing systems for seamless data flow	Limited
User Training	Generally requires less user training as it follows standard processes	Generally requires less user training as it follows standard processes	Training required to familiarize users with custom workflows	Familiar and commonly used tool, minimal training needed
Costing Method	by Subscription	On-time Initial License Cost + Implementation Consultancy Cost + Annual Maintenance Cost	On-time Initial Development Cost + Ongoing Enhancement Cost + Annual Maintenance Cost	License Cost
Implementation Cost	Low	Medium	High	Very low

7. Acknowledgments

Project Steering Committee

Chairlady

- **Ir. Elsa Yuen** President of Hong Kong Logistics Association

Members

- **Mr. Alex Koo** Chief Executive Officer of AOC Freight Express Holdings Ltd.
- **Mr. Stephen Chan** Managing Director of Power Hub Ltd.
- **Mr. Henny Loh** General Manager of Angliss Hong Kong Food Service Ltd.
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- The Hong Kong Association of Freight Forwarding & Logistics
- The Hong Kong Shippers' Council
- Hong Kong Sea Transport & Logistics Association
- The Institute of Purchasing & Supply of Hong Kong
- Logistics and Supply Chain MultiTech R&D Centre

List of Organisations Consulted

Logistics and Logistics Related Associations (in alphabetical order)

- The Chamber of Hong Kong Logistics Industry
- Hong Kong Sea Transport & Logistics Association
- The Hong Kong Institution of Engineers

Enterprises with in-house Cold Chain Service Providers and Cold Chain Service Providers (in alphabetical order)

- Angliss Hong Kong Food Service Limited
- Chevalier AOC Freight Express Holdings Limited
- CK One Limited
- ETAK Logistics Limited
- HAVI Logistics Services (Hong Kong) Limited
- Kerry Logistics Network Limited
- PARKnSHOP (HK) Limited
- Sun Fat Heung Food Products Limited
- Tai Hing Worldwide Development Limited
- TAHUHU Cold Chain Logistics
- Yamato Logistics (HK) Limited
- Yuhu Group (Hong Kong) Investment Holdings Limited

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Statement

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