出國報告(出國類別：開會)

戰車模擬器性能提昇案暨系統連網整合之關鍵技術研討出國報告

服務機關：國防部軍備局中山科學研究院第一研究所
姓名職稱：中校技正 盧南華，聘用技士 林世鴻
派赴國家：美國
出國時間：101 年 12 月 02 日至 101 年 12 月 08 日
報告日期：102 年 01 月 08 日

目　　　　次

戰車模擬器性能提昇案暨系統連網整合之關鍵技術研討出國報告

壹、 目的

　　本院執行陸軍委製「戰車模擬器性能提升案暨系統連網整合」專案，依委協議書律定，已如期完成戰車射擊模擬器功能測試，並陸續完成系統後續交運、測試工作，以滿足使用單位之操作訓練需求，惟後續戰車模擬器之系統整合、連網及營級演訓部份，尚有多項技術尚需突破、更新；為提升全系統最終整合、連網及產品品質，實有必要參考國外模擬先進廠商相關系統整合、連網及視效投影、繪圖等模擬技術，以提高戰車模擬器之逼真度及整體聯合演訓能力。

　　此次出國因時程緊迫，在美國當地僅停留不到四天，故僅聯繫拜訪美國佛羅里達州奧蘭多附近三家模擬器先進廠商，依序拜訪具世界投影器領導地位之 Christie Digital Systems 公司、ETC Simulations 模擬器製造公司及圖像使用者介面先驅 DiSTI Corporation 公司，針對其模擬訓練系統與開發工具之產品資訊及核心技術能量予以瞭解，進行技術開會研討，並就戰車模擬器場景編輯、HLA 連網、智慧型目標物設計、營級戰術聯合演訓等關鍵技術進行研討交流，同時就各公司相關產品功能瞭解與應用，俾提升本院研製戰車模擬器及與兵棋系統(如 JCATS)間 HLA 聯網架構設計等關鍵技術資料蒐集及經驗交流。

　　此次出國另一項收穫，即在參觀 Christie Digital Systems 公司時，該公司引介我們造訪另一家位於奧蘭多之配合廠商: Intelligent Decision 公司，該公司為現今當紅，美國陸軍用來訓練單兵戰鬥人員整合戰術作戰之 DSTS(Dismounted Soldier Training System)系統主合約商，Intelligent Decision 公司讓每位士兵佩戴一組頭戴式顯示器和 3 組姿態感測器，槍身槍口部位也會安裝一感測器來偵測槍枝瞄準位置，讓準心和眼點的方向可以分離，更真實的模擬步兵作戰時的情況，士兵的移動是透過一組位於槍身的搖桿來完成控制，並利用一組手部感測器，作為手部姿態的偵測(旋轉)，作開門等需要手部動作的任務，這種單兵訓練，其實可以用來整合至戰車模擬器上，作為本組後續合成化戰場或聯合演訓規劃建置之借鏡參考。

貳、 過程

　　此次美國公差出國計畫之實際行程如表 1.所示，前後出國公差天數為七天，而實際停留美國拜訪廠商天數實則只有四天，全程均於佛州奧蘭多附近進行相關參訪、開會行程，因時程緊迫，僅拜訪四家佛羅里達州奧蘭多附近模擬器先進廠商，相關參訪研討內容綜整於下述章節中。

表 1.赴美公差工作計畫表

日　　期	星　期	公差地點	工　　作　　項　　目	備　　考
101.12.02	日		台北搭機至洛杉磯。	
101.12.03	一	美國 佛州 奧蘭多	早上班機抵奧蘭多，完成住宿安置及參訪資料與研討議題整備後，下午赴 Christie Digital Systems 公司，針對其模擬器相關產品資訊及核心技術能量開會研討。	
101.12.04	二	美國 佛州 奧蘭多	赴 ETC Simulations 公司，針對其模擬訓練系統相關產品資訊及關鍵技術能量開會研討。	
101.12.05	三	美國 佛州 奧蘭多	赴 DiSTI Corporation 公司，就其模擬訓練系統開發工具之產品資訊與關鍵技術能量予以瞭解，並進行技術研討及開會交流。	

日　　期	星　期	公差地點	工　　作　　項　　目	備　　考
101.12.06	四	美國佛州奧蘭多	至 Intelligent Decision 公司，針對其 DSTS(Dismounted Soldier Training System) 單兵戰鬥人員整合戰術作戰系統相關產品資訊及核心技術能量開會研討，下午 15:30 即離開該公司，直接起程前往機場搭機飛往洛杉磯轉機返國。	
101.12.07	五		搭機返台。	
101.12.08	六		搭機返台。	

以下僅就拜訪之四家廠商分別作描述，依序分別為 ETC 公司、DiSTI 公司、Christie 公司及 Intelligent Decisions 公司:

一、　ETC 公司

ETC(Environmental Tectonics Corporation)這家公司早在民國 90 年間，就曾參與當年國軍人體離心機性能提升及空軍水下逃生模擬器報價評估，雖然最後因報價過高未得標在國內建造模擬器，但綜觀該公司所生產之產品，與本組非常類似，品質、專業程度都是令人敬佩，本次出國公差特別鎖定該公司，以了解其產品特質、公司營運狀況、管理手法等，以為本組參考借鏡，或未來合作、競爭之依據；另有一點在此特別提出，該公司對於商業機密這一塊真是保密到家，不但不准帶相機進公司，就連碰觸其滑鼠、鍵盤都不行，隨行人員更是緊迫盯人，任何參訪人員要求，都得請示長官奉核，做的真是滴水不漏，此舉真值得本院借鏡。

此次拜訪，ETC Simulation 公司主要由軍方及政府解決方案部門(Military and Government Solutions)Robert Lee 先生，重大公共建設解決方案部門(Critical

Infrastructure Solutions)John Alexandrovich 先生，及對策解決方案部門(Response Solutions)Edwin Shakarian 先生負責接待，ETC 公司於 1969 年創立至今，目前產品已遍佈全球 80 幾個國家，模擬領域包括航空醫學訓練器(AeroMedical Training)、體操訓練器(Gymnastics Training)、人體離心機(High-G Training)、一般航空模擬器(General Aviation)、直昇機模擬器(Helicopter Training)、缺氧訓練器(hypoxia Training)、維修訓練器(Maintenance Training)、戰術飛行模擬(Tactical Flight Solution)、空間迷向訓練器(Spatial Disorientation & Situational Awareness Training)及水下逃生訓練器(Water Survival Training)，其實 ETC 這家模擬器製造公司的產品非常多樣，且都是依顧客需求量身訂製的(Customer Design)，在此僅針對與本組比較有相關或值得學習、具未來性之模擬器作介紹概述如后。

（一） 空間迷向及環境辨識訓練器(Spatial Disorientation Training & Situational Awareness Training)

圖 2.1-1 ETC 公司空間迷向機

圖 2.1-2 ETC 公司環境辨識儀
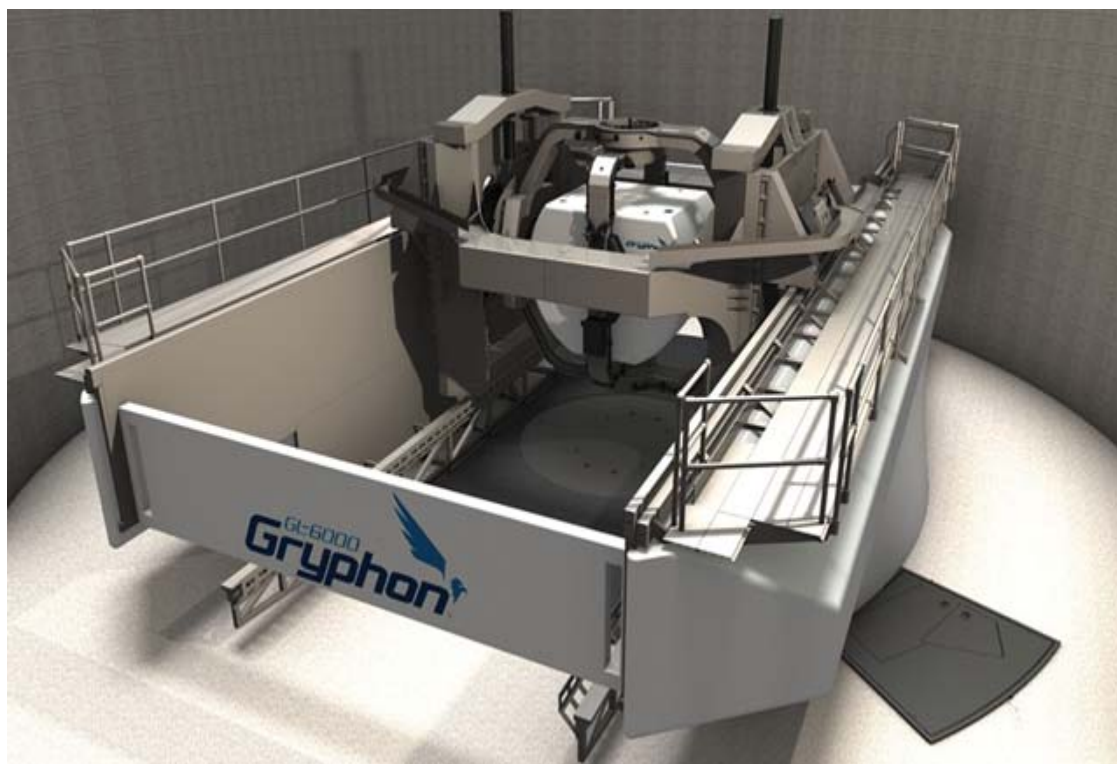
　　ETC 公司生產一系列具動感平台之空間迷向及環境辨識訓練器(Spatial Disorientation & Situational Awareness Training)，跟本組交給國軍之航空生理訓練裝備雷同，飛行學員在一封閉式萊艙內，經由仿真之視效場景及飛行座艙，可模擬固定翼戰機、雙座運輸機及雙座直昇機之空間迷向功能，透過氣動式六軸動感平台提供有如親臨實境般之感受，ETC 公司強調其所設計之空間迷向機是絕對客製化(Customer Design)，視效場景不但可依客戶需求，提供大到水平 220 度、垂直 65 度，小到水平 120 度、垂直 90 度投影器投射之視野，飛行座艙也可設計為可抽換式(Reconfigurable)座艙，以提供各類不同機型進行訓練。

（二） 水下逃生訓練器(Water Survival Training)

圖 2.1-3 ETC 公司水下逃生訓練器

水下逃生訓練器之危險性頗高，除了逃生座艙之特殊設計外，亦需搭配廠房、水池、造浪、吊掛系統、水下潛水裝備及潛水救生人員訓練等，就本組目前專業及經驗而言，執行此項訓練模擬器之建造與維護，確實有相當難度。

（三） 維修訓練器(Maintenance Training)

圖 2.1-4 ETC 公司維修模擬器

維修訓練器這個領域本組尚未有相關產品產出，以前維修訓練器結合實際線上裝備，困難度確實頗高，現今因電腦及繪圖功能一躍千里，許多以前無法完成或呈現之功能皆能一一克服，電子技令亦能自動鏈結至維修訓練器上作為說明及解釋，本組未來亦可朝此一方向努力。

（四）　人體離心機(High G Training)

圖 2.1-5 ETC 公司人體離心機

　　ETC 公司生產之人體離心機之動力系統採電力控制，與國軍航空生理訓練中心由法國得標生產製造之離心機利用油壓系統驅動不同，在後續系統維護與清潔方面有相當大助益，雖然國內離心機在 97 年間已進行一次性能提升，但宥於經費不足且工程浩大，僅提升電腦、生理裝備、相關線路及相關軟體，液壓動力系統依然沿用，本組在人體離心機這一領域亦尚未涉足，但本組亦有空間迷向機製造經驗，未來若要跨足此領域，難度應不高，但在安全互鎖機制方面應多考量、注意。

（五） 彈射座椅模擬器(Ejection Seat Simulator)

圖 2.1-6 ETC 公司彈射座椅模擬器

　　ETC 公司所設計之彈射座椅模擬器原則上跟本組交給國軍之航空生理訓練裝備雷同，只是設計上他在彈射軌道旁另安排一下降扶梯，萬一座椅發生卡在半空中無法順利下滑時，飛行學員可藉此梯自行爬下，此套裝備原則上可模擬到 10 G 之彈射力道，利用空壓機彈射缸原理，配合相關安全互鎖控制機制，可依客戶需求模擬各種機型戰機之座椅彈射訓練功能，飛行學員得依各項正確之操作程序始能完成彈射模擬。

（六） ADMS 緊急應變處理訓練系統(Advanced Disaster Management Simulator)

　　ADMS 緊急應變處理訓練系統乃 ETC 公司最新開發之一套專門訓練指揮體系應變處理能力之軟體模擬系統，利用逼真的視效影像場景搭配智慧型目標物及音效系統，可模擬機場緊急應變處理(Airport Management)、醫療處理訓練(Medical training)、火警應變處理訓練(Fire Training)、警察處理應變訓練(Police Training)、緊急應變處理訓練(Emergency Training)及自然災害處理應變訓練(Natural Disaster Training)，且具場景編輯和訓後歸詢能力。

此套系統除提供仿真實景街道/建物之 3D 模型，背景環境尚包括農地、荒涼空曠地、港口、機場、商業區、工業區、火車站等，各種意外事故可選擇設定不同之情境及危險程度，以交通事故為例，可選擇車輛種類、每部車內之人數、起始之損害程度、漏油情況及起火程度等，例如裝載阿摩尼亞的貨車翻覆，阿摩尼亞揮發氣體造成人體呼吸不適，設定火災之位置與類型及可能造成之濃煙影響等；模擬處置方式之資源與真實世界之功能相似，例如消防車之水管必需接上水車或路邊消防栓後才可實施灑水灌救動作，救火期間會設定路障管制交通但會引發其他道路交通阻塞等。

警察人員訓練包括建築物封鎖保全及盤查可疑份子、建立警戒範圍及設置封鎖線、規劃安全路線以接送 VIP 人物至特定地點、練習與歹徒高速飛車追逐、策略性設置路障、面對暴動之計畫與準備等；當事故處置指揮官面對緊急狀況、災難或意外事故時，需要學習如何指揮、管制、協調及聯繫各相關單位人員與資源，緊急應變處理訓練系統提供一些評分規則以判斷指揮官之處置是否妥當，如救出人數或減緩傷害程度、組織及部署資源在一個安全且有效率的模式、練習處理大批人群集會事件、工作任務之策略協調、動態風險評估、符合標準作業程序、幫助作業之順暢推動、事前做大規劃之演習、建立更好的效能、測試及驗證災難決策計畫等。

以下就此套系統提供之部份訓練功能加以描述：

1. 機場緊急應變處理(Airport Management)

圖 2.1-7 ETC 公司機場緊急應變處理

　　失事頻率低，但傷亡人數慘重之空難意外事故，需要迅速、熟練及定位準確地明確
處理，ADMS 系統可提供給機場指揮人員作為在高壓力、環境變遷迅速之環境下，學習如
何應變及指揮機場保安、救火人員迅速、明確地進行人員安全撤離等善後工作。

　　從飛機漏油至爆炸，利用宛如實境之視效影像、火焰、煙霧、日夜間、雨天及具人
工智慧之車輛、人員模擬，ADMS 系統可利用編輯器自行設計所有可能發生之場景，包括
模擬一般載客用客機、貨機、固定翼戰機或直升機，亦提供恐怖分子、劫機等各式鎮暴、
反恐演練場景，每輛車子(ADMS-DRIV)、每部消防車(ADMS-ARFF)都有自己的操控螢
幕，在指揮體系(ADMS-COMMAND)之指揮之下，去從事救難、滅火及救人等緊急應變
處置。

2. 火警應變處理訓練(Fire Training)

圖 2.1-8 ETC 公司火警應變處理訓練

　　火警應變處理訓練系統(Fire Training)，可訓練消防單位如何指揮消防人員、車輛派遣等各式模擬，包括滅火程序、人員搜救、隔離、通風、水柱拉管等操演訓練，ADMS系統可利用編輯器自行設計所有可能發生之場景，例如建築物內外火警現場、倒塌之建築物火警、加油站火警、船、飛機、火車上之火警、核災、電力公司、森林大火等各式各樣情境模擬，透過有如親臨現場之實境視效模擬，訓練消防工作者如何在最短時間內，從容而不受傷的完成滅火任務。

3. 警察處理應變訓練(Police Training)

圖 2.1-9 ETC 公司警察處理應變訓練

　　ETC 公司這套 ADMS 系統，提供一套專門訓練警察，甚至鎮暴警察及執法人員在處理各種生死攸關案件中之標準程序，利用編輯器自行設計所有可能發生之場景，可模擬車禍現場處理、街頭暴動、恐怖分子攻擊、人質劫持、運鈔車劫持、火警處理管制、生化武器攻擊事件處置及各種相關緊急聯合操演訓練，利用此套系統模擬，訓練警察及執法人員在遇到各種可難發生之緊急事件上，能事先獲得訓練之機會，以免在實際生活遇到相同情況，產生不知所措或領導統御等問題。

二、 DiSTI 公司

　　DiSTI 公司創建於 1994 年，應該算是一家蠻新的軟體公司，該公司雖然不大，但卻以提供客戶人機介面圖像整合技術聞名，此次拜訪主要由全球銷售及支援部門主管(Director of Global Sales & Support)Christopher P. Giordano，及全球市場部門主管(Director of Global Marketing)Scott Ariotti 負責接待；首先就 DiSTI 公司做一簡介，目前主要產品在於圖像互動技術部份提供人機介面(HMI，Human Machine Interface)開發，而在維護訓練系統相關技術研發部份居全球領先地位。

DiSTI 公司在先進圖像使用者介面技術部份有重要的創新技術，在工業界配合客戶需求，提供高便利性及高效能的圖像處理解決方案，在模擬訓練系統部份，亦提供飛行座艙及車輛儀表面板嵌入式應用軟體，讓使用者能得到圖像動態快速反應。

　　DiSTI 公司同時提供客戶專業的服務，當客戶有系統維護操作訓練之需求時，該公司可製作仿真之模擬件，而在外觀上及功能上都與真實件相似，提供客戶以更便宜的經費及更快速的方法達到相同的裝備訓練成效，並可降低實體裝備的操作需求，以減少實體裝備的耗損；該公司在對客戶服務的基本要求為：使客戶滿意即是 DiSTI 公司成功的基石，DiSTI 公司提供之產品或服務，都要求最好的品質、超凡的價值、有限的經費、及嚴苛的功能要求。

DiSTI 公司目前主要的產品簡要說明如下：

(一)、GL Studio：

　　可讓程式設計師或系統開發者建構並整合高親和性的人機介面圖像，2D 及 3D 模型模擬及完整的互動控制功能，提升模擬系統之仿真度與複雜度，以有助於學習成效及增強記憶力。此軟體的優點有：

　　1.提供全壽期服務之軟體工具。

　　2.可快速產生合乎需求且令人驚嘆之模型。

　　3.滿足在訓練及教學上的需求。

　　4.可以很容易完成測試、確認及驗證。

　　5.可配合安裝在桌上型電腦、網路伺服器或是嵌入式系統中。

圖 2.2-1 DiSTI 公司人機介面圖像

GL Studio 是一套物件導向(Object-Oriented)介面的設計軟體工具，其中又包含 Data Director、Map Toolkit 及 Approach Plate Toolkit，利用 Data Director 將所有資料來源無縫整合，使用 Map Toolkit 產生動態地圖顯示，再配合 Approach Plate Toolkit 與 Approach Procedure Charts 互動以製作出 GL Studio 物件。

GL Studio 可應用的層面包括：

1.航太產業：可快速開發互動式及物件導向的圖像顯示，以提供建立模型、測試及人因工程之研究。

2.汽車產業：可將產業設計圖像無縫轉換為嵌入式可互動之儀表圖像，以滿足產品全壽期之支援。

3.模擬及訓練產業：開發 2D 或 3D 仿真圖像，以提供模擬訓練時，飛行載具座艙或車輛儀表、控制面板及多功能顯示器等所需圖像。

GL Studio 為配合不同之作業環境及客戶功能需求，共支援四種版本分別說明如下：

1.GL Studio：最基本功能之版本，主要提供最基本及最常用的圖像功能，讓使用者在桌

上型電腦作業環境下，開發建置互動式圖像人機介面功能。

2.GL Studio DT(Desk-Top)：加強桌上型人機介面圖像功能，增加執行碼產生器選擇設定及網路資料連結等功能。

3.GL Studio ES(Embedded System)：提供嵌入式系統(Embedded System)作業環境開發功能，以配合在嵌入式系統下，仍有最大的資料存取與圖像處理之效能。

4.GL Studio Premium：GL Studio 系統中最高功能等級，綜整 GL Studio DT 及 GL Studio ES 之所有功能，提供最佳效能之解決方案。

　　GL Studio 最近又增加了 Lumen 功能，以確保 GL Studio 可以持續滿足未來十年客戶各種介面開發之需求，其功能及特色在使客戶開發結果不受作業系統或硬體平台之限制，其主要特色說明如下：

1.支援 DirectX：擴展座艙儀表顯示與 DirectX 相容之相關操作環境，如 Havok Vision Engine、MetaVR 及 Prepar3D 等。

2.多點觸控(Multi-Touch)：提供座艙可同時互動觸控之點數近乎沒有限制，使用者可以利用系統資料庫中常用的控制動作，或是由使用者自行訂定。

3.支援多工執行緒(Multi-Thread)及多核心(Multi-Core)：藉由現在多核心 CPU 電腦架構，Lumen 可依使用者在增加更多核心處理器時，自動擴充調整分配工作以提升系統效能。

4.先進字型功能：提升字體顯示層次，讓使用者可依字體輪廓作任意的字型變化，例如字型陰影可設定火熱或柔和，或是由使用者自行設定不同的效果。

5.僅需第一次編譯建置：使用 LUA 產生之結果，可直接使用在已建置完成之系統中，不需再重新編譯原有程式。

　　Map Toolkit 提供使用者開發即時動態地圖顯示功能，此軟體具有整併多種地理圖資影像格式及使用者自訂顯示符號，以多圖層方式結合為單一即時之 2D 顯示畫面，其支援現有常見多種地理圖資影像格式，並允許使用者可以很容易再行自訂之地理圖資影像格式；此軟體功能可運用在模擬器多功能顯示器上，以結合地面資訊與導航或武器符號

(如 GPS 導航、小牛飛彈追蹤等)。

圖 2.2-2 DiSTI 公司 Map Toolkit 即時動態地圖顯示

　　Map Toolkit 系統預設提供的符號包括 40 種標準航空導航符號、全方位 360 度或四分之一方位 90 度 HSI 符號，以及 MIL STD 2525B(兵棋系統所定義符號)4 種聯合演訓符號、12 種部隊層級符號與 113 種作戰單元符號，另外使用者也可利用 GL Studio 工具自行設計定義特定符號；該軟體同時提供 DTED 高度資料整合地形圖資並可即時處理地形陰影顯示、最多至 16 層次不同顏色等高線顯示相對本機高度、依據目標機位置/高度及本機視角方向自動計算處理目標機在地表之投射陰影等功能。

圖 2.2-3 DiSTI 公司標準航空導航符號顯示

(二)、飛行載具座艙及車輛儀表開發服務：

　　「DiSTI」本身就是虛擬儀表開發的同義字，因 DiSTI 公司提供協助客戶設計開發所需之儀表顯示，以滿足客戶之應用目標，該公司以 C++或 Java 語言提供預先編譯的軟體及介面操作文件資料，讓客戶可自行整併到自己的軟體架構中，同時提供相關軟體原始碼，允許客戶後續可自行維護與修改軟體內容；虛擬儀表可應用在許多模擬器或訓練系統中，例如：

　　1.快速建置虛擬的原型以提供測試驗證。

　　2.桌上簡易型、部份功能型及全功能型之訓練器。

　　3.教官操控台。

4.同步顯示面板。

5.電腦輔助教學。

圖 2.2-4 DiSTI 公司飛行載具座艙儀表顯示

相關應用案例：

1.Nissan 汽車作為車輛控制面板之原型設計：在汽車音響實體尚未大量製造生產前，測試及驗證控制邏輯系統功能。

2.AAI 公司 T-25 戰機，製作電戰訓練模擬器(SECT，Simulator Electronics Combat Training)：提供電戰部門(Electronics Combat Officer)設計時可以快速重組相關系統模組，以滿足最終使用需求功能。

3.DiSTI 公司提供飛行訓練學校三種變換座艙儀表應用：包括 CH-47 直昇機、UH-60 直昇機及 OH-58 直昇機模擬器，以一個單一 2D/3D 顯示螢幕及整合控制介面，飛行時以 2D 及 3D 顯示座艙儀表，訓後回顧時則提供飛行軌跡線及相關圖像。

此相關功能設計構想對於未來陸軍所需之戰術訓練系統架構規劃可提供參考。

(三)、Replic8：

　　Replic8 目的使客戶在不需要撰寫程式方式下，很輕鬆就產生電子技令等級 3 或 4 的虛擬訓練文件內容，該軟體簡化技令文件製作過程，提供 out-of-the-box 的 3D 課程架構設計概念，讓使用者很容易就可建構教學管理系統、網頁畫面、或是桌上型電腦單機操作環境，由傳統個別頁面教學方式轉換成互動頁面教學，以增加學習記憶力、縮短學習時間、並與學員間產生互動關係。
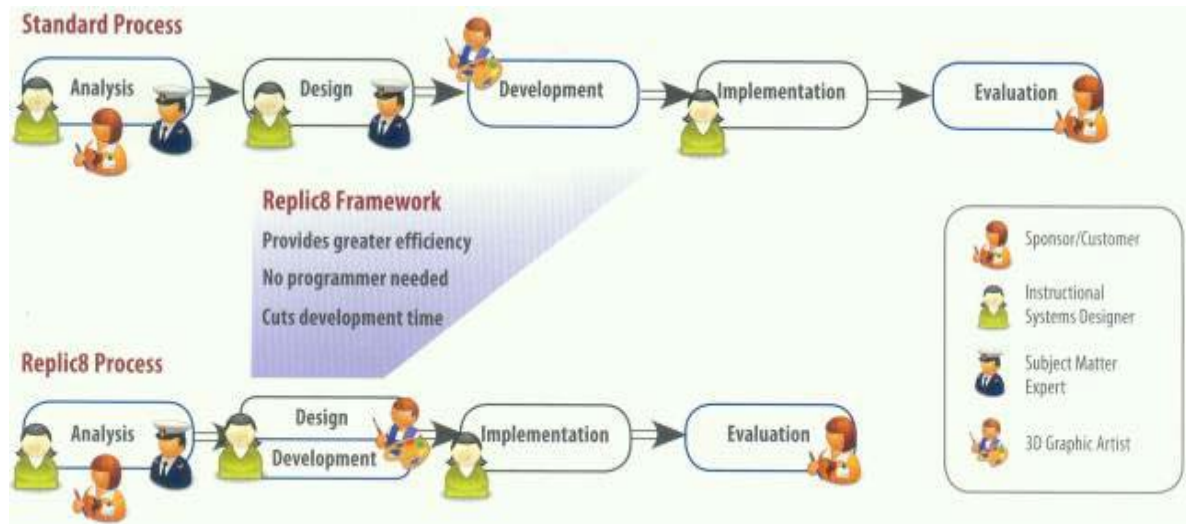
圖 2.2-5 DiSTI 公司 Replic8 電子技令工具
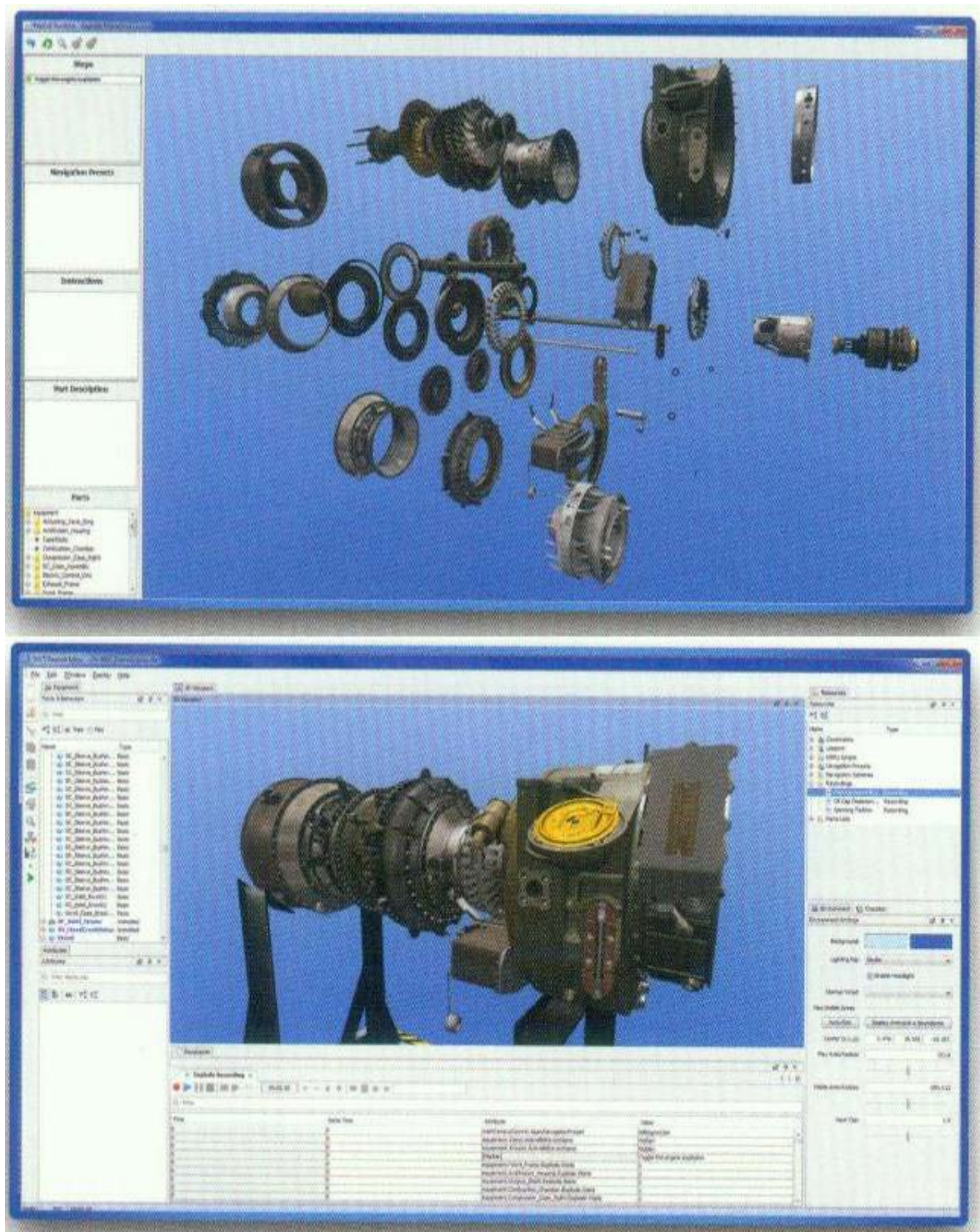
Replic8 是藉由目前常見的 3Ds MAX 操作畫面，在使用者利用 3Ds MAX 工具產生 3D

模型之外觀、如何拆解及如何作動製作後，軟體自動輸出該模型之幾何形狀、材質、及

3D 動畫等資料，並可讓使用者預覽確認其輸出結果是否正確；在 Replic8 編輯器中使用

者係依據實作設計(Design by Doing)之概念逐步建立教學課程，使用者僅需依序逐步記錄所需執行之步驟，另可特別標註部份燈光照明、特別零組件標示、及使用工具拆解或組裝等，後續軟體即可依此設計步驟程序轉換為未來學員訓練的互動教學課程。

圖 2.2-6 DiSTI 公司 Replic8 互動教學流程

(四)、虛擬維護訓練系統之設計服務：

　　DiSTI 公司同時亦提供客戶虛擬維護訓練系統之設計服務，虛擬維護訓練系統通常包括模擬訓練之軟體邏輯、電腦硬體設備、顯示裝備及 3D 虛擬環境，提供使用者或教官互動之人機操作介面；虛擬維護訓練系統又大致分為下列兩個層級：

　　1.局部工作層級：此層級設計主要目的，在於特定區域之維護訓練而非全系統，即將所需訓練之分系統特別拆解出來獨立訓練與驗證，DiSTI 局部工作層級虛擬環境服務部門提供不同之訓練操作介面，如桌上型電腦、網頁及筆電等。

圖 2.2-7 DiSTI 公司虛擬維護訓練系統

2.全載台層級：此層級則包含到全載台整體相關零組件，提供訓練學員不僅可模擬執

　　行傳統組件拆換程序外，還可執行問題檢測程序，以及學習全載台操作之原理。

　　DiSTI 公司目前在模擬器及訓練系統虛擬環境開發已經有很完備之制度與程序，以

下是 DiSTI 公司成為全球頂尖虛擬維護訓練系統技術開發之主要因素：

　　1.特有的工作流程方式能有效地於短時間內產生所需結果。

　　2.已有實際驗證績效，沒有技術上之風險。

　　3.軟體自動化程度高，可以最少的時間及工作達成目標。

　　4.虛擬維護訓練系統設計時即考量到最佳化之執行效能。

　　5.提供 3D 使用者人機介面，可縮短學習曲線。

　　相關應用案例：

1.　奧克拉荷馬州 HEMTT M9784A 戰車虛擬操作訓練系統：由奧克拉荷馬州防衛部門

　　訓練中心委託開發局部工作層級之虛擬操作訓練系統，目的在訓練學員如何操作

　　完成替戰車加油及卸油之程序，系統要求可在 2 天時間內完成 300 張 PowerPoint

投影片資料更新需求，每次則提供學員 4 小時的操作訓練課程，所有使用過的學
員及教官都對系統操作容易及訓練成效感到滿意。

圖 2.2-8 DiSTI 公司 M9784A 戰車虛擬操作訓練系統
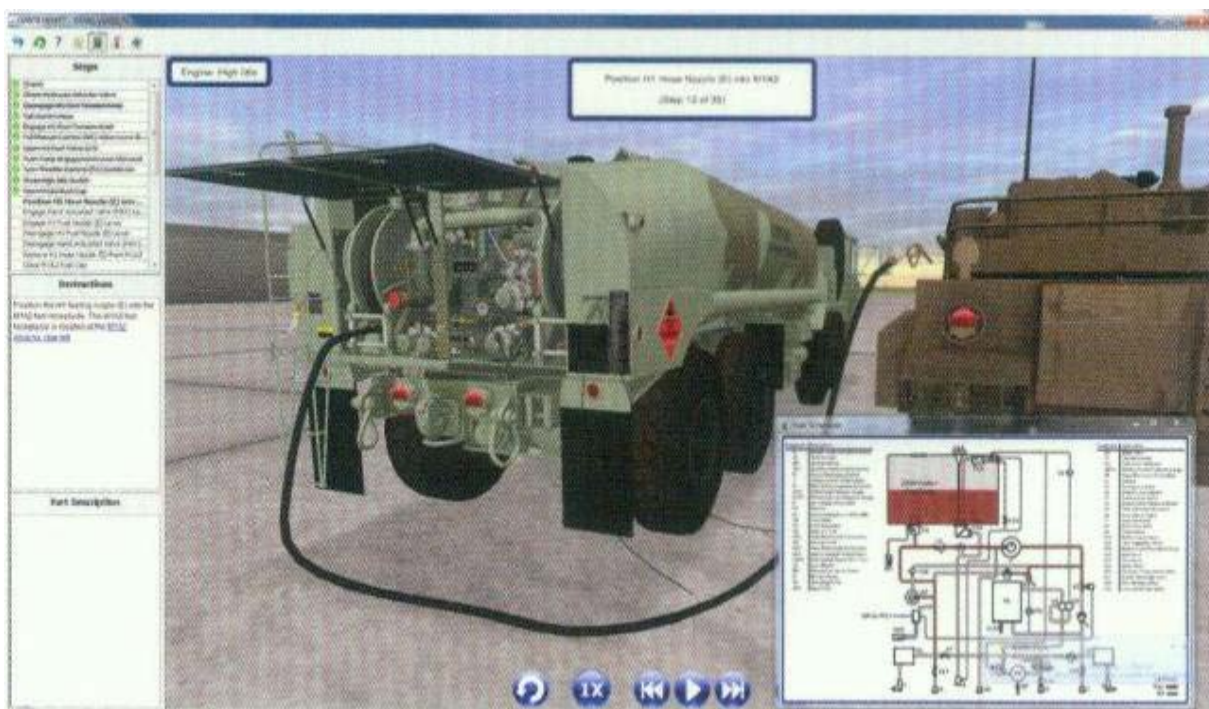
2.F/A-18 大黃蜂戰機全載台層級整合型視效環境維護訓練系統(IVEMT，Integrated
  Visual Environment Maintenance Trainer)：以戰機模擬維護訓練系統(SAMT，
  Simulated Aircraft Maintenance Trainer)架構為主，提供即時互動式戰機各部
  位細部圖解之電腦輔助設計(CAD，Computer Aided Design)資料。

圖 2.2-9 DiSTI 公司 F/A-18 大黃蜂戰機全載台層級整合型視效環境維護訓練系統

3.海軍直昇機降落船艦減震訓練系統(LCAC，Landing Craft Air Cushion)第 4 級/
第 5 級電子技令及載台：DiSTI 公司提供活動式載台設計，經由高階電子技令操作
及活動性設計，使海軍得到仿真之訓練成效並節省訓練經費。

圖 2.2-10 DiSTI 公司海軍直昇機降落船艦減震訓練系統

目前世界各國模擬器訓練均走向合成化戰場之整合潮流，在合成化戰場整合技術中
各系統間 3D 視效與 2D 圖台之資料庫整合則扮演相當重要的角色，為了容易管理及統一
資料來源，目前比較流行之軟體工具即為 TerraSim，該軟體可將基本圖資以流程圖設計

方式，依使用者需要產出可適用於目前主要之軟體系統環境中，讓使用者僅需維護單一之資料來源，當資料更新後將重新執行各應用軟體系統環境轉檔作業，如此可保證圖台資料之一致性，其主要功能說明如下：

(一)、TerraTools：完整地形地圖之解決方案：

提供最先進之城市資料庫產生器，輸出 Havok Vision Engine 及 Havok Game Middleware，TerraTools 之設計理念在於設計時即建立關聯性，而非傳統僅在輸出格式轉換時才建立關聯性，因此可自動產生遊戲環境之視效圖像處理引擎軟體，提供兵推式模擬訓練系統使用(如 OneSAF、JointSAF、JCATS 等)，TerraTools 輸出之 3D 地形資料庫無論在視效模擬以及兵推式模擬訓練系統半自動武力(SAF，Semi-Automated Forces)之應用上均令人驚嘆。

圖 2.2-11 完整地形地圖之解決方案

Havok 為世界級 3D 視效圖像系統，而且在物理行為及人工智慧行為方面，Havok 視效圖像處理引擎軟體已被驗證為高階中介軟體，可支援高階 3D 遊戲及客戶特定需求之訓練環境。

TerraTools 依據使用者之原始空間地形資料，編譯成高效能的 TSG(Tiled Scene Graph)格式，輸出提供組合 Havok 視效圖像處理引擎軟體使用，視效資料庫中元件自動支援大範圍空間資料換頁功能，產生之結果可以在 TerraSim Vision Viewer 瀏覽器中預覽，或是載入到 Havok vForge 中編輯，或是直接應用在使用者訓練系統中自行開發之視效處理引擎軟體上使用。

TerraTools 使用基本城市原始資料，利用 Urban Detail 工具可自動賦予建築物之外

觀、產生人行道、行人斑馬線、停車格等，即可產生密集複雜之城市區塊；使用者也可利用現存之遊戲模型資料建置出複雜的 3D 城市環境模型，Havok 視效圖像處理引擎軟體之輸出格式可以滿足常見之遊戲軟體(如 COLLADA、3Ds Max、OpenSceneGraph、OpenFlight 等)中使用。

MASA SWORD 是一種兵推式模擬系統，提供自動控制單元及可客製化的行為模式，系統可支援至最多數千個模擬單元；TerraTools 亦提供自動產生 SWORD 系統環境之單元物件，支援即時視效及兵推圖像顯示包括 VR-Vantage、VR-Forces，以及遊戲軟體如 VBS2 等，TerraTools 輸出之 3D 地形資料庫可支援大多數商用或軍事上使用的模擬訓練系統。
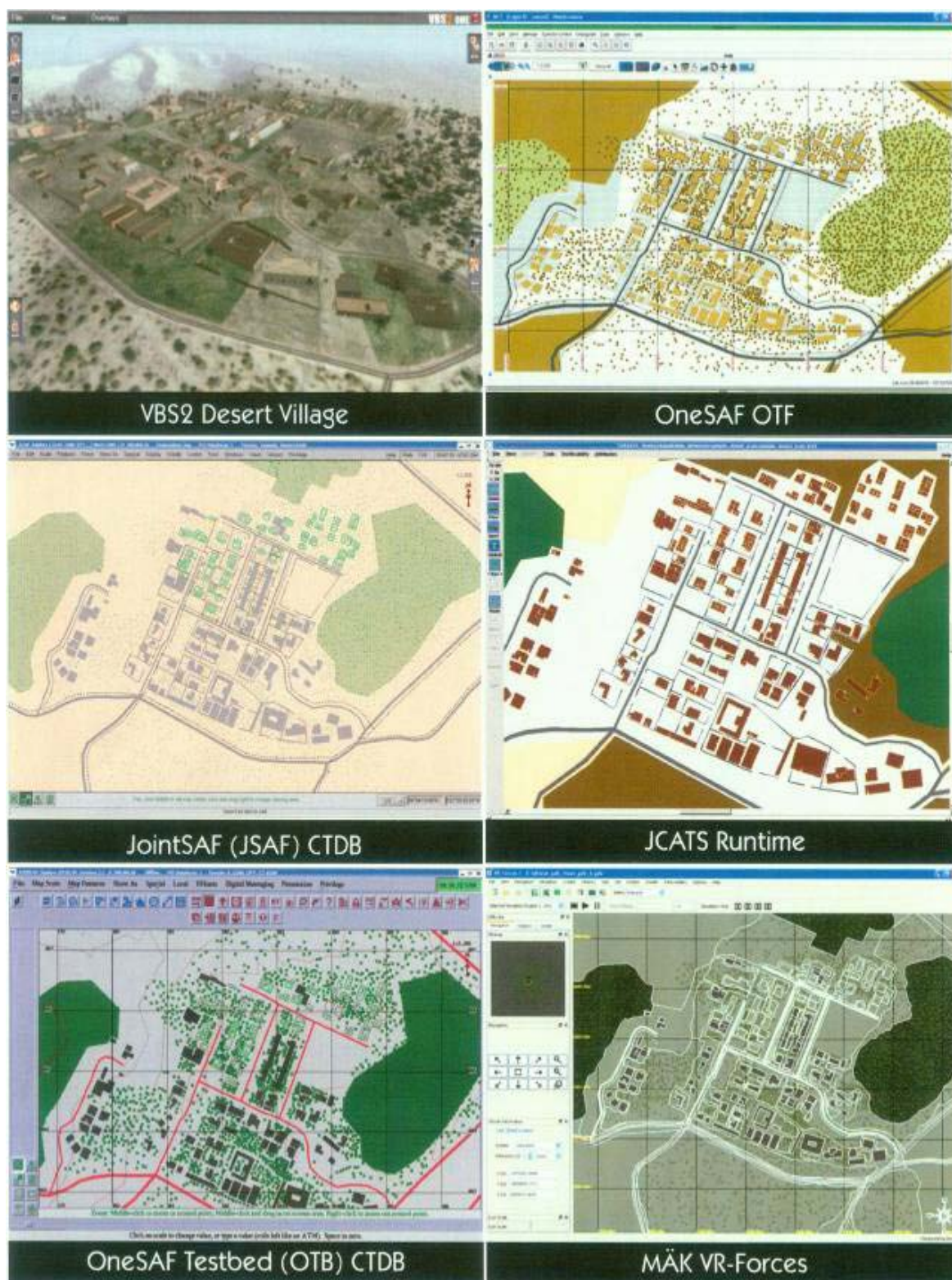
圖 2.2-12 MASA SWORD 兵推式模擬系統

Terrastan 2D view in SWORD Terrain Generation Tool
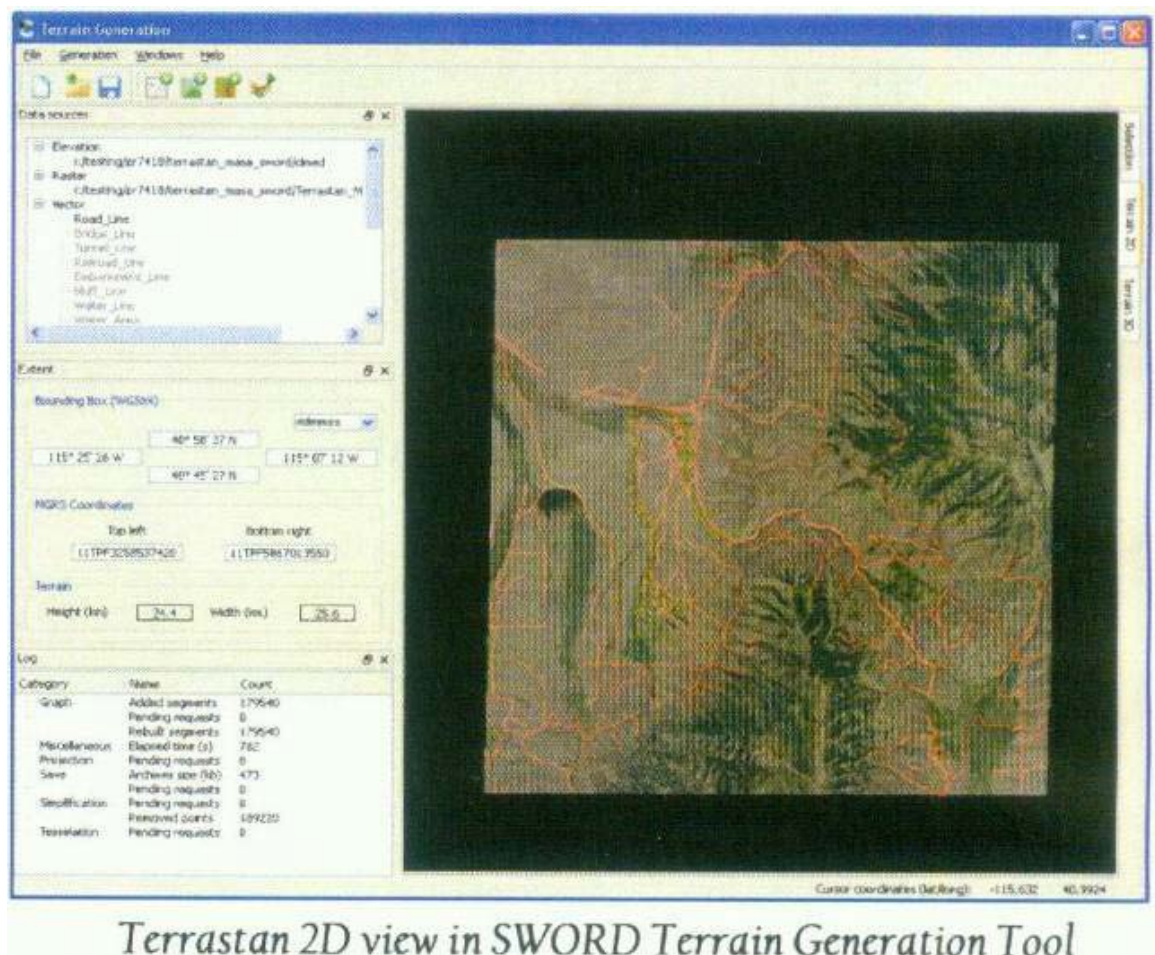
TerraTools 能經由詳細地理圖資以多圖層方式準確呈現模擬環境，以支援訓練任務之即時模擬演練，從標準地理圖資來源及 3D 模型建構出 WORD 完整功能之模擬訓練環

境，同時 TerraTools 輸出之模組可以加到兵推式訓練系統中，以提供多層級之軍事操演及其他即時聯合演訓需求。

TerraTools SWORD 依據國際 SWORD 地形圖資研討會資料，產生地形結構檔案以支援所有需要的元件及圖層，TerraTools 提供處理、格式化、整合、調校等功能建構出大量的向量原始圖層資料，輸出時針對原始資料自動賦予 SWORD 所需的屬性資料，TerraTools 利用先進的 ITIN(Integrated Triangulated Irregular Network)地表模型，整合多層地表高度模型資料以呈現一完整之地表圖資影像；下圖即為 TerraTools 產出一塊 25 公里 X25 公里平方之 SWORD 地形結構檔案資料，此資料庫由高解析度地形、道路網、叢林、排水道或河道、地表材質說明資料、村鎮等所組合建構而成。

TerraTools 的輸出格式在兵推模擬系統部份包括 OneSAF、JointSAF、JCATS、VR-Forces 等，在模擬器系統視效圖像格式部份包括 OpenSceneGraph、OpenFlight、VR-Vantage、X-Plane 等，在遊戲系統部份包括 VBS2、SteelBeasts、Havok Vision 等。

圖 2.2-13 TerraToolsSWORD 地形結構檔案資料

VBS2 Desert Village

OneSAF OTF

JointSAF (JSAF) CTDB

JCATS Runtime

OneSAF Testbed (OTB) CTDB

MÄK VR-Forces

(二)、DEMTools：

　　支援一個低價、整併、提升、及控制修改數位高度模型(DEM，Digital Elevation Models)
資料，以產生 GIS 原始資料，提供使用者可以很容易地利用工作流程方式來設計，並

可讓使用者可以快速地同時處理多組原始高度模型資料及向量資料；其主要功能特色如下：

1. 直覺的使用者圖形操作介面。

2. 可接受多數常用的資料來源格式，如 DTED、GeoTIFE、GridASCII、GridFloat、USGS DEM、及 Shapefile 等。

3. 提供 6 個先進的 DEM 操作工具以轉換使用者之高度資料。

4. 內建向量資料編輯及屬性設定功能。

5. DEM 顯示管理工具用來特別標註特定 DEM 屬性。

6. 可產生多數常用的資料輸出格式，如 GeoTIFE、GridASCII、GridFloat、及 Shapefile 等。

7. 整合提供求助系統工具及線上技術支援功能。

圖 2.2-14 數位高度模型
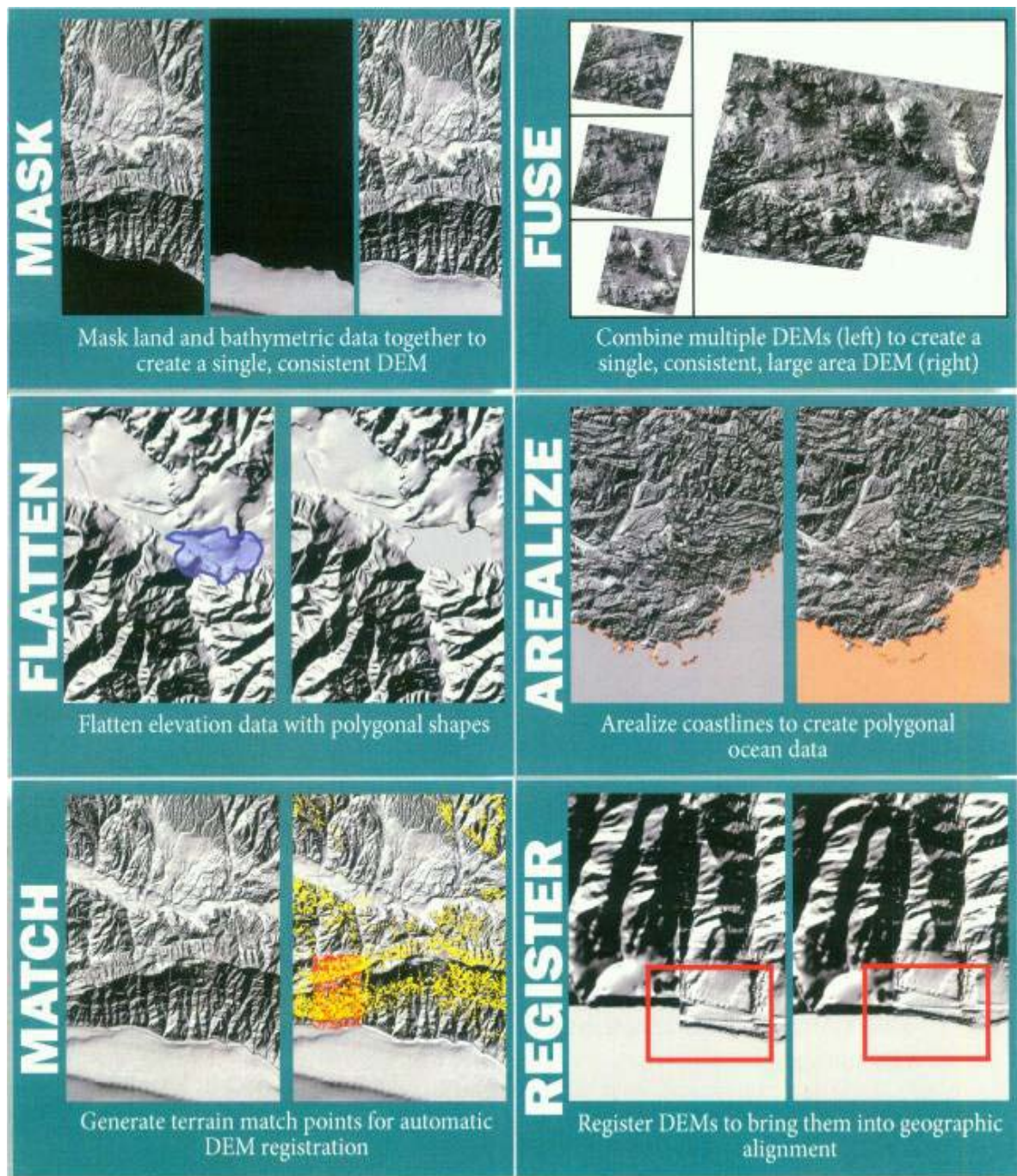
(三)、MaterialMAP：

　　支援一個低價、由影像資料產生地表材質地圖之工具，這些地表材質用來當執行模擬

　　訓練時，提供元件運動、設定路線、即時視效顯示及感測裝置之顯示等應用；其主要

　　功能特色如下：

　　1.可接受多數常用的資料來源格式，如 ECW、GeoTIFE、JPEG、及 PNG 等。

　　2.支援不同等級顏色及頻譜影像顯示功能。

3. 可自行設定建置顏色及頻譜影像等級屬性以提供新影像使用。

4. 提供自行設定等級規則，並可快速地檢視設定等級之視效影像結果。

5. 可記錄所有測試結果，從中挑選出最佳之等級影像顯示結果。

6. 可產生多數常用的資料輸出格式，如 ESRI Shapefile、GeoTIFE、PNG、及 JPEG 等。

7. 可產生材質地圖資料供多數常用的兵推式模擬訓練系統(如 OneSAF OTF、JointSAF CTDB 等)，及遊戲系統(如 VBS2、Steel Beasts、Havok Vision Engine 等)使用。

圖 2.2-15 地表材質地圖資料
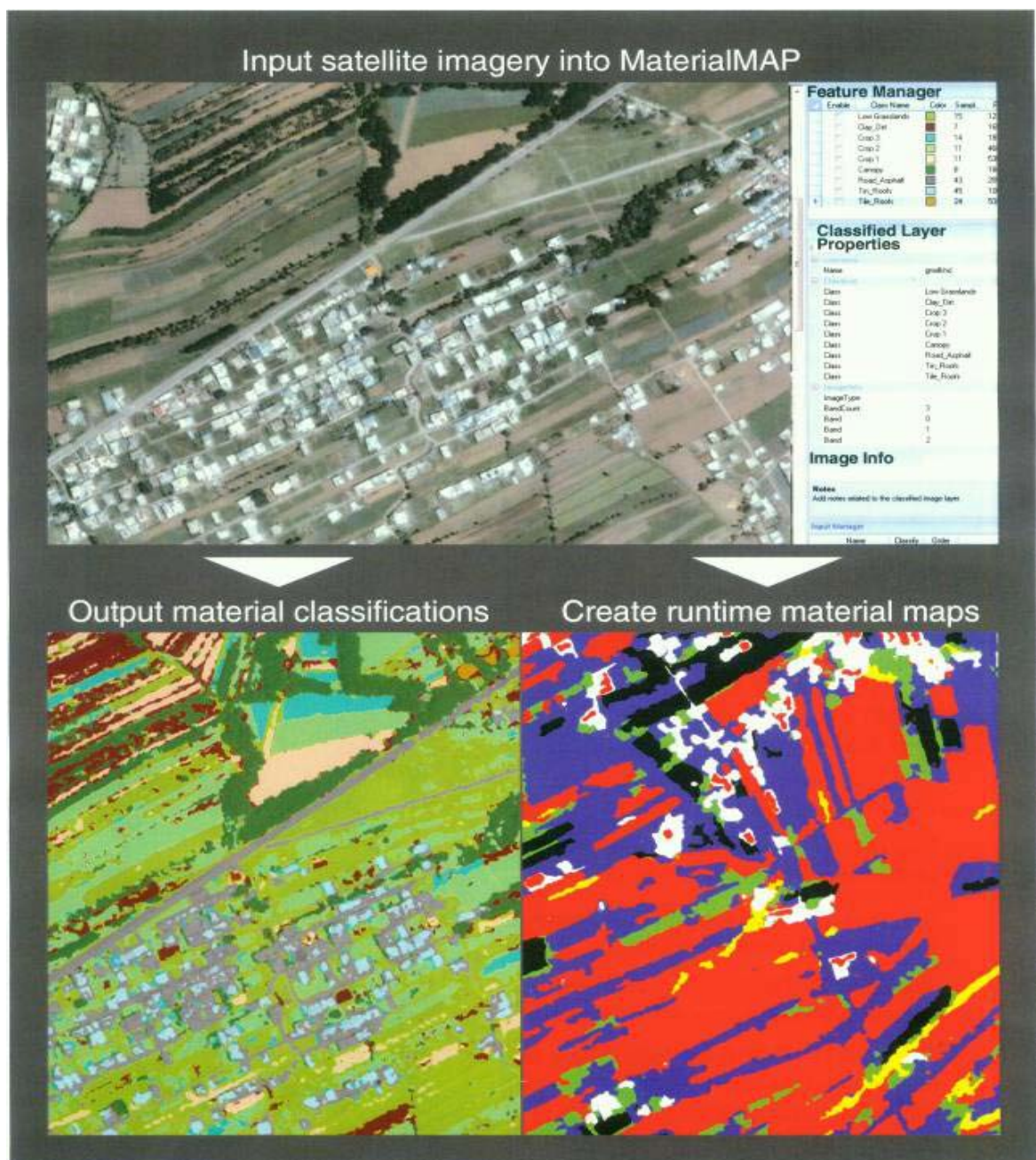
目前世界各公司之系統發趨勢也慢慢走向垂直整合，從最基本的 2D 平面顯示，到 3D 顯示的視效資料庫，再進而擴展到以網路伺服器/使用端之分散式架構；以 VT MAK 公司為例，其依續推出一系列相關之產品說明如下：

(一)、VR-Forces：

VR-Forces 提供一個功能強大且具彈性之戰場想定產生模擬環境軟體，支援戰術指揮官指管訓練、威脅目標物產生與操控、智慧行為模式測試驗證及電腦合成武力(CGF, Computer Generated Forces)等功能；電腦合成武力提供圖形化人機使用者介面，讓使用者只要用點選方式即可很容易地設定戰場想定中合成武力之起始位置、行進路線與轉折點、賦予任務或計畫等，系統初始顯示畫面為 2D 之平面戰術地圖，當使用戰場想定編輯功能時則切換到 3D 畫面，以精確地設定合成武力之起始位置與高度，選擇 XR 模式則會顯示完整戰場想定之畫面，以確認最後設定結果。

圖 2.2-16 電腦合成武力圖形化人機介面
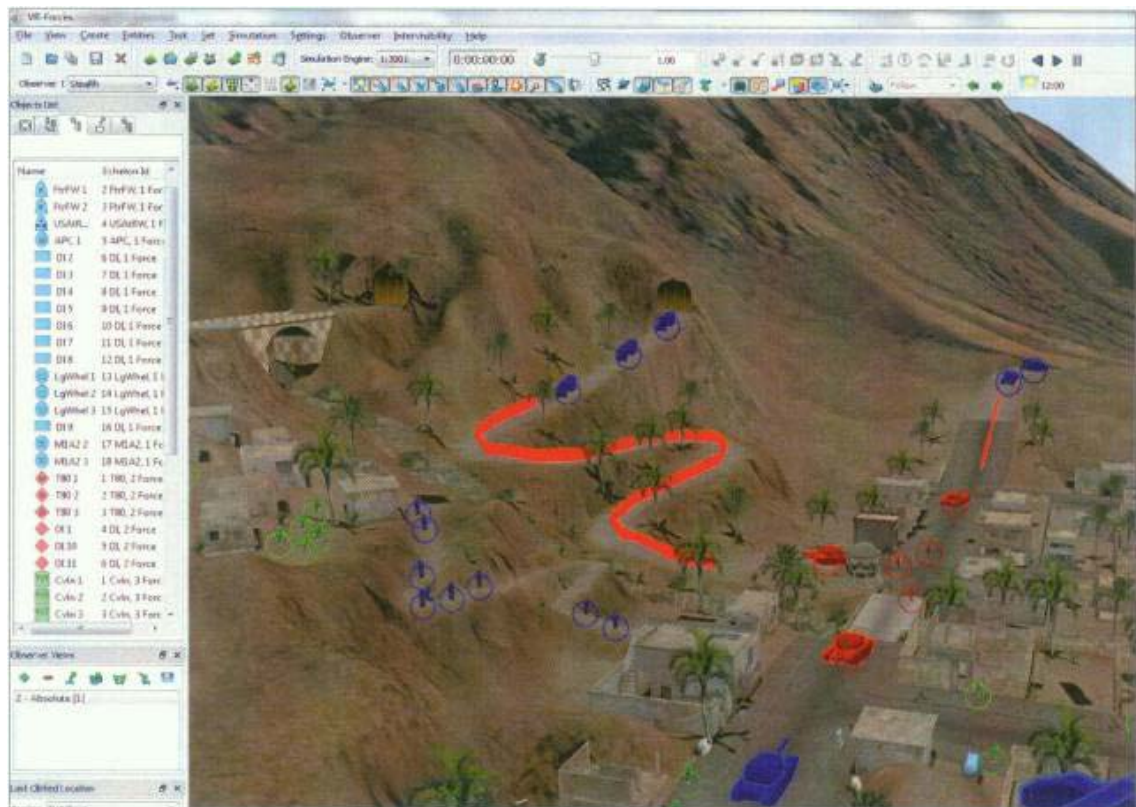
VR-Forces 系統模擬之模型包括許多戰場元件及武器系統，在戰場想定執行模擬訓練時，車輛及人員元件會依著地形起伏、沿著道路、護衛陪同、繞過障礙物運動、藉由模擬無線電機制通訊聯繫、偵測並攻擊敵方武力、最後並計算戰損結果，合成武力運動模式則可設定到單兵個別運動或是部隊集體運動模式。

VR-Forces 系統提供 GUI 元件編輯使用介面，可編輯車輛動力模式、感測裝置性能、及武器影響範圍等，VR-Forces 系統為一個分散式系統架構，可以將多個各自處理的模擬軟體系統組成一個大範圍的聯合演訓環境。

VR-Forces 系統除了已經提供強大的 CGF 環境外，仍支援功能強大的發展工具增加自訂之 CGF，允許使用者利用 VR-Forces 提供之模擬引擎與 GUI 介面開發，或是以 C++ API 將 VR-Forces 的功能整合至使用者自行開發系統中；系統允許使用者新增、替換、或修改 VR-Forces 提供之模擬引擎中之車輛動力模式、行為模式及戰術作為、戰損評估計算模式、感測裝置、反制武器裝備、及武器等，遠端控制 API 則支援使用者經由網路執行遠端控制 VR-Forces 模擬引擎。

VR-Forces 系統適合於大型演訓架構，支援 DIS(Distributed Interactive Simulation)及 HLA(High Level Architecture)聯網通訊協定，並提供大量文件以做為操作使用者、建模操作與系統開發設計運用，甚至在必要情況下使用者需直接處理 VR-Forces 模擬引擎核心時，也可獲得 MAK 公司之支援與服務，而系統也會依據國際間新的規範、地形格式資料及聯網標準格式隨時更新相關功能。

圖 2.2-17 VR-Forces GUI 元件編輯使用介面
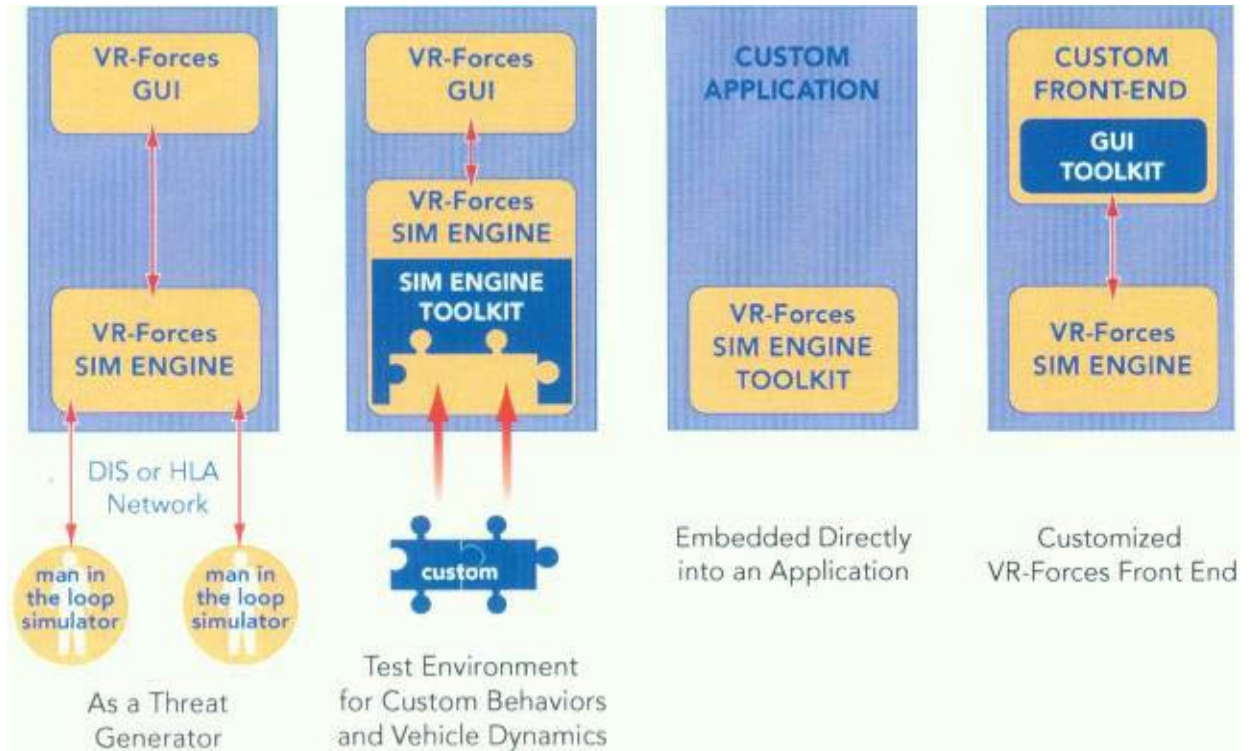

(二)、VR-Vantage Stealth：

VR-Vantage Stealth 系統支援戰場視效顯示工具以呈現 3D 戰場想定，依據 DIS 或 HLA

虛擬訓練環境資料提供使用者大範圍之戰場資訊，可同時以 2D 及 3D 方式檢視視效影

像，這些資料包括：

1.尾隨特效：當跟隨在特定移動元件之後，例如地面車輛後之塵土、人員之足跡、船

　艦後之波浪等。

2.敵軍攻擊者或目標物：以不同圖形顯示敵軍與友軍。

3.記錄運動軌跡：可以圖像顯示每個元件之行進路徑。

4.元件標示：在元件旁顯示相關資訊。

5.感測裝置強度：顯示元件感測裝置電磁波發射角度及範圍。

6.元件高度顯示。

VR-Vantage Stealth 系統可以由 VR-Forces 呈現戰術圖像如運動轉折點、行進路線

及運動範圍等，Picture-in-Picture Inset View 功能可以讓使用者選擇任一車輛所

看到之視角範圍，也可設定模擬監視器在戰場任何位置、任何觀看角度及拉近/拉遠
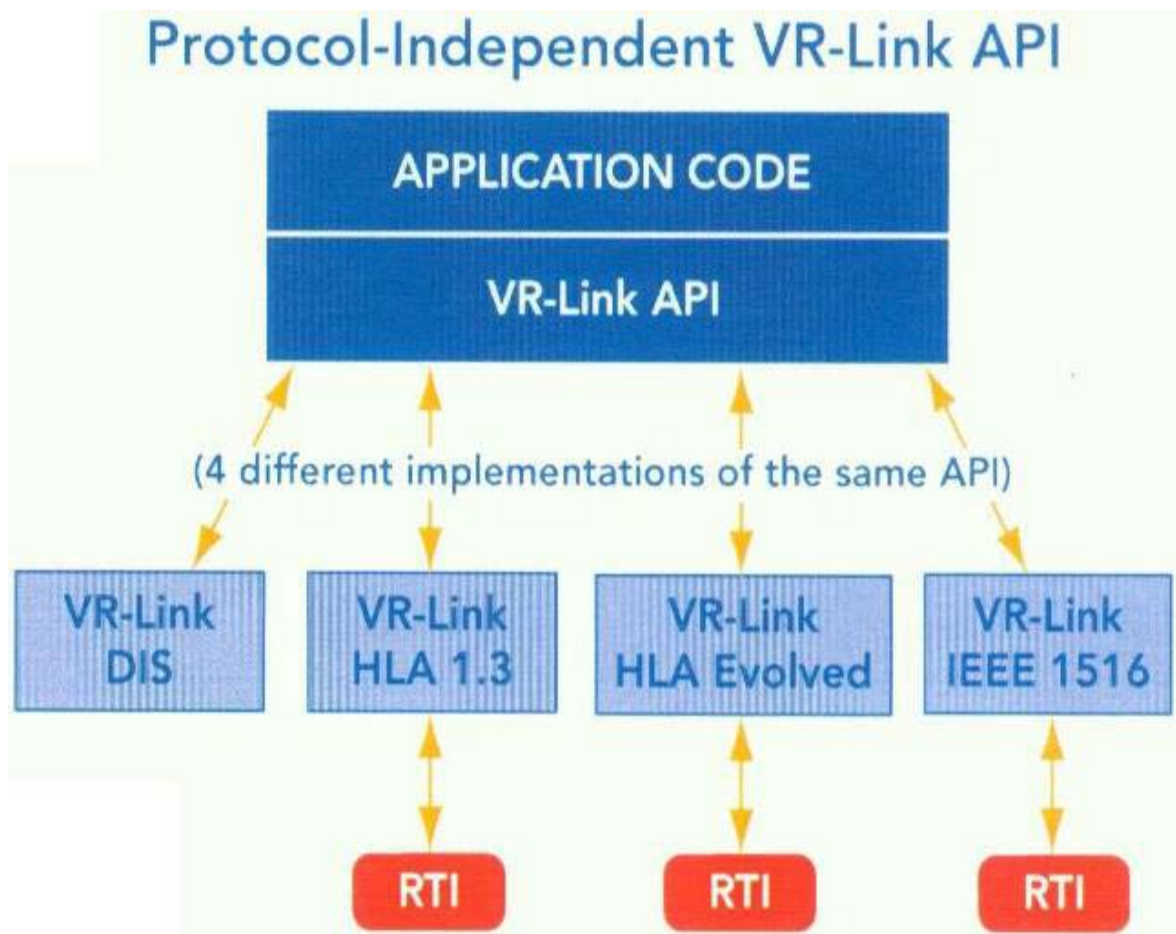
等功能，在 3D 戰場視效場景中亦可設定 2D 戰場平面顯示圖以瞭解目前所在位置。

圖 2.2-18 VR-Vantage Stealth 系統支援戰場視效顯示
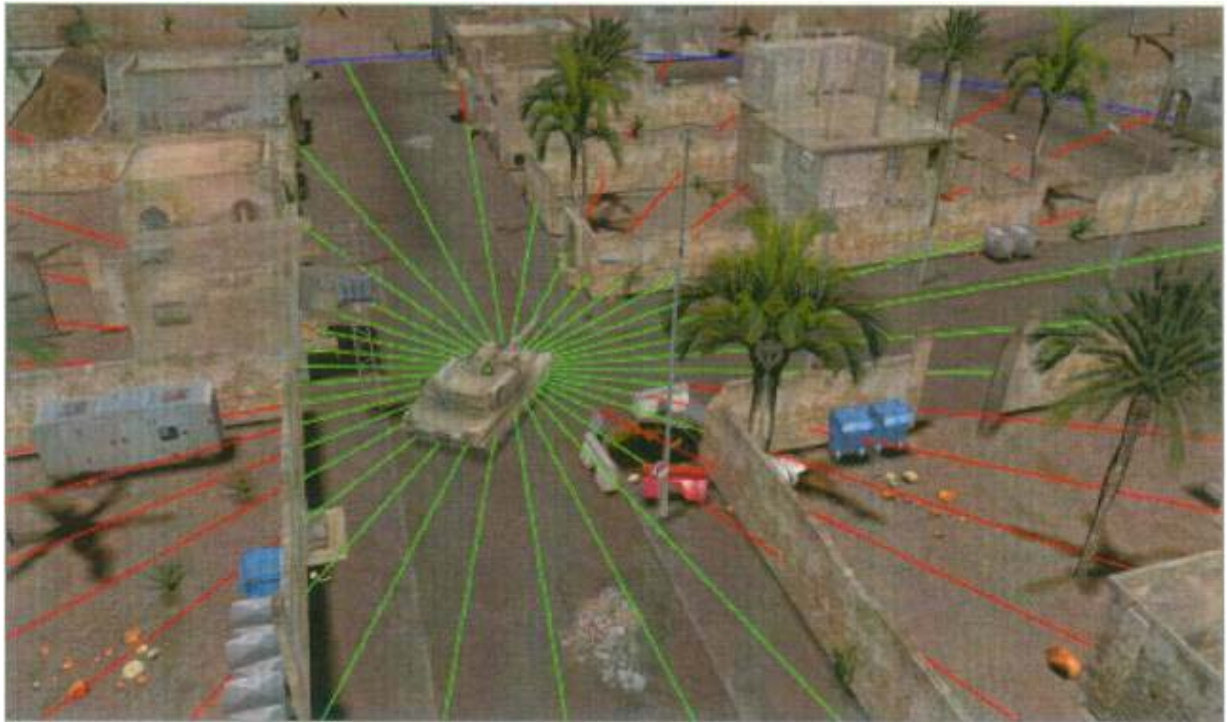
(三)、VR-Link：

　　　利用 VR-Link Networking Toolkit 可以透過 IEEE 標準的 HLA 高階聯網架構或是 DIS 分散式互動模擬，快速且容易地將模擬器與虛擬訓練系統連結起來，VR-Link 提供容易使用之設計操作介面及強大的程式碼產生器，藉以降低系統開發風險、投資經費、及開發時間；使用 VR-Link API 開發之應用軟體，可以與 DIS、HLA 1.3 版本、IEEE 1516-2000 版本、HLA Evolved 版本等相容。

圖 2.2-19 VR-Link 通訊協定

　　VR-Link 最上層與通訊協定無關之 API 用來設定目前模擬系統元件與物件之狀態，任何需傳給其他應用軟體資料則透過 HLA RTI 或是 DIS 網路工具自動轉換對應格式，而在接收資料部份，對於遠端物之狀態(如死傷狀況、出發位置、同步訊號轉換、要求屬性資料及過濾訊息等)都交由 VR-Link 來處理，而使用者如有需要仍可直接控制存取比較底層之資訊。

　　雖然 VR-Link API 在分散式模擬架構中轉換大部份共用資訊，使用者仍需要 VR-Link 支援自行定義 FOM 的內容，VR-Link 編碼產生器接收到任何 HLA FOM，如果不是標準 RPR FOM 格式時則會自動擴充該 FOM 格式，這些軟體工具支援微軟 Visual C++或是 UNIX Makefiles 之原始程式碼與標題定義檔，經由編譯後則擴充加入到 VR-Link 中，VR-Link 編碼產生器可支援 HLA-1.3-Style OMT 檔案格式及 IEEE-1516-Style XML-Based FOMs 格式。

(四)、MAK WebLVC Server：

MAK 看到模式模擬與模擬器整合在一起聯合演訓之未來發展趨勢，MAK WebLVC Server 希望能將實兵(Live)、模擬器系統(Virtual)、及兵推式訓練系統(Constructive)之聯合演訓可以整合在網路上，主要包括下列要件：

1.WebLVC 通訊協定：針對模擬器通訊資料或是實兵資料建立 Consensus-Based 開放式標準，以做為伺服器及使用端間應用軟體資料傳送之依據。

2.MAK WebLVC Server：透過 WebLVC 通訊協定連結 Web-Based 間 DIS/HLA 虛擬戰場之環境架構，MAK WebLVC Server 扮演重要關鍵角色。

3.MAK WebLVC Testbed：提供使用者線上環境下測試自行開發之應用軟體。

4.MAK WebLVC Components：堆砌建構整個系統架構之 MAK Web 應用軟體，使用者可依其需要自行設計其網路應用軟體。

5.MAK Web Apps：提供有用的模擬及視效圖像軟體工具，可以在桌上型電腦瀏覽器上執行，或是在筆電及手機等攜帶型裝置中執行。

圖 2.2-20 MAK WebLVC 架構
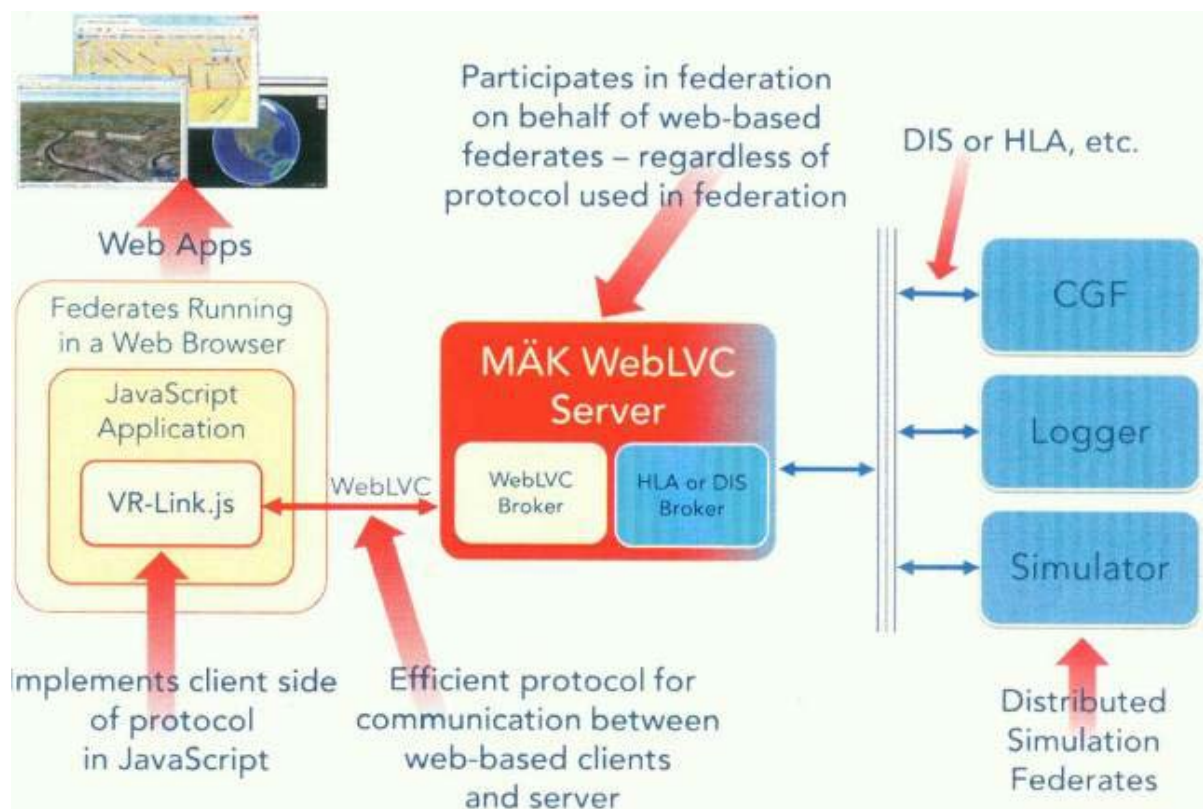
三、 Christie Digital 公司

　　Christie Digital Systems 公司主要由亞太主管(Director Asia-Pacific Immersive Solution)Barry Lewinen，及新加坡地區銷售經理(Regional Sales Manager) 羅文湘(Daniel Loh)負責接待。Christie Digital Systems 公司主要在世界各地提供高品質之投影顯示系統與提出滿足各不同領域需求(如商務、教學、訓練等)之視覺解決方案，包括先進模擬系統之視效投影、科學領域研究經由 3D 呈現、最新藝術領域之呈現、及好萊塢影片電影之播放等。

圖 2.3-1 Christie 公司雙影像輸入投影器
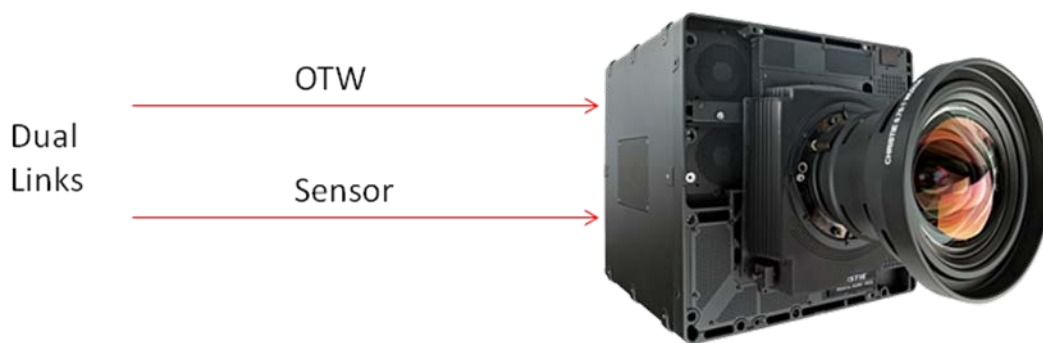
　　Christie Digital Systems 公司前年底即推出一款可同時兩組視效影像訊號輸入之 LED 投影器(請參考圖 2.3-1)，機型為 Christie Matrix StIM WU，此型投影器一推出後，即獲得多家模擬器公司之青睞，如美國波音公司在此機型一推出後，立即應用在其最新型 AH-64 阿帕契戰鬥直升機模擬器上，此款模擬器亦預計於今年交運至中華民國陸軍，由本組負責後續維修相關保修事宜；美商 J.F Taylor 公司對陸軍直升機模擬器進行性能提升，其投影系統亦採用此機型，為利用其具備雙視效影像訊號輸入之優點，可同時將 OTW(Out of Window)影像及 IR Sensor 影像輸入至投影器，飛行學員目視飛行時，一般眼睛只能看見可見光 OTW 影像，看不到 IR 影像，但只要戴真實飛機上之夜視頭盔，即可於視效螢幕上看到仿真之 IR 視效場景，此型投影器專門設計給一般視效影像及紅外線影像共用(請參考圖 2.3-2)，只要在系統設計中動態切換模式即可控制兩者影像之變換，而不需要如傳統需以兩部投影機才可達成此功能，這對於需同時提供白晝與夜間配戴夜

視鏡操作訓練(如戰車、甲車、直昇機等)之模擬器，可減少系統架構之複雜度，亦可減少投資成本，且此機型之照明(Illumination)設備為 LED 設計，平均壽命為 50,000 小時，故根本沒有未來燈泡備料問題，也就是說投影器裝備採購後，沒有以前燈泡壽命 2,000 小時即需更換之問題，另一項值得稱讚的優點，乃其 LED 光源設計，非常適用於具動感平台上耐震之訓練，一般燈泡型投影器常因平台劇烈搖晃而熄滅，造成視效投影突然中斷，得需等投影機關機數分鐘後再重新啟動，才能繼續執行模擬機訓練；但此款 LED 投影器有一共通性缺點，就是亮度及解析度不足，造成同一面投影螢幕，需更多台投影機去投影，才能呈現同樣的品質。

圖 2.3-2 正常雙 IG 影像輸入方式
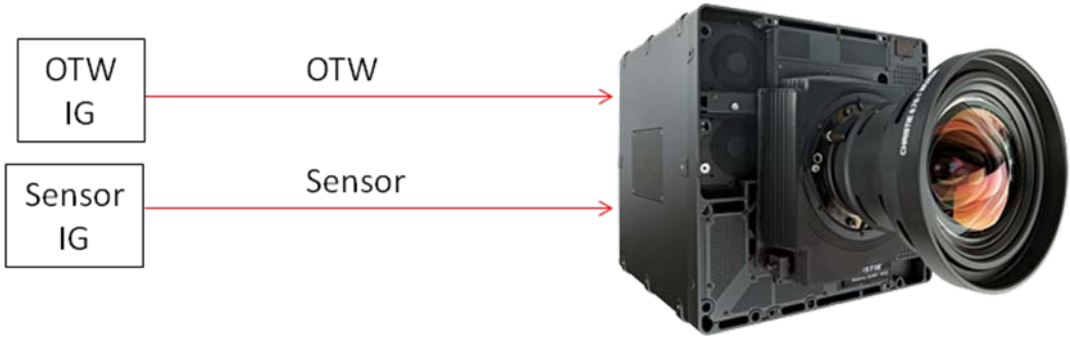
因此款投影機推出後廣受好評，去年底 Christie 又推出此型最新款之投影機型 Christie Matrix StIM WQ，同樣為 LED 光源投射、雙視效影像訊號輸入，但針對亮度及解析度不足的部份，此新款投影器作了大幅改善，但相對地投影器大小及重量亦稍微變大了(規格請參考圖 2.3-3)。

圖 2.3-3 Christie 公司 Matrix StIM Specification 比較表

| Christie Matrix	StIM WQ	StIM WU
LED Lifecycle:	50,000(Hrs)	50,000(Hrs)
Luminous Flux:	800(Lumens)	600(Lumens)
Resolution :	2560*1600	1920*1200
Dimension :	440*400*406(mm)	220*467*287(mm)
Weight (No Lens):	40(kg)	32(kg)

有些公司為節省成本開銷，僅利用一部 IG 同時處理 OTW 及 IR Sensor 之視效資料庫資料(請參考圖 2.3-4)，此種方法亦是可行，只是飛行學員或教官需額外自行於教官台切換訓練場景，而不是隨時戴上夜視頭盔就可進行夜間訓練。

<div align="center">圖 2.3-4 單 IG 影像輸入方式</div>

　　配合目前最流行之 3D 風潮，也可將兩組輸入訊號分別代表兩個操作人員不同之視眼點，當操作人員配戴主動式 3D 眼鏡時，鏡框上設計切換開關即可變換不同之視眼點；例如戰車射擊模擬器中車長及射手、直昇機前後座(駕駛及武器空電操作人員) (請參考圖 2.3-5)或左右座(正駕駛及副駕駛)之不同視眼角度，即可提供不同視眼點之 3D 立體影像，可提升訓練之成效。

圖 2.3-5 解決不同視眼點投影器解決方案
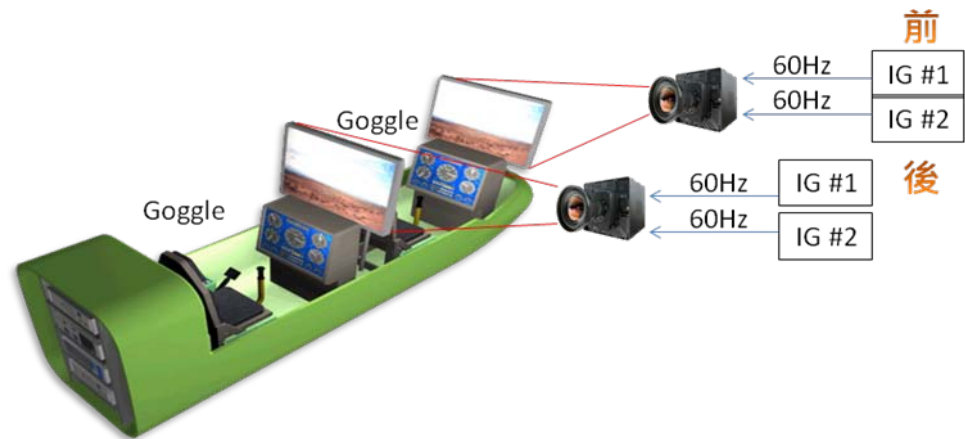
    Christie 公司亦提出另一解決視效影像左右橫移時所產生之殘影問題解決方案，我們知道殘影產生之理由為視效電腦因處理大量視效資料庫影像，故無法提高其更新運算頻率，故通常視效電腦之運算頻率大都只訂在 60Hz，若利用 Christie 公司新推出之 LED 雙視效影像訊號輸入投影器，透過兩部相差 1~2Hz 之 60Hz OTW IG 輸入視效影像，就能徹底解決一向被人詬病之視效殘影問題(請參考圖 2.3-6)。

圖 2.3-6 解決視效殘影問題投影器解決方案
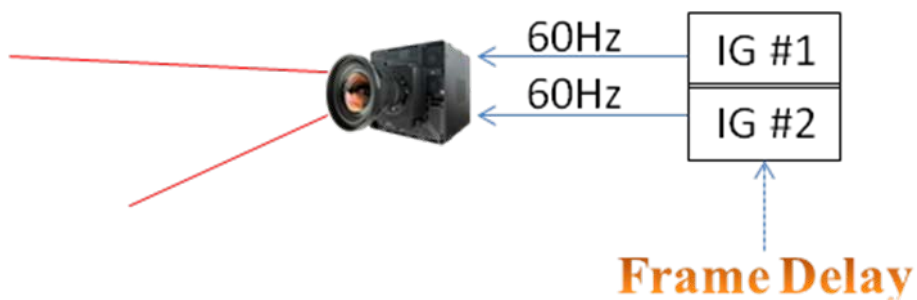
    另外 Christie Digital Systems 公司目前也與美國陸軍研究所(ARL，Army Research Laboratory)合作，以 3D 虛擬實境系統技術營造出模擬之戰場環境；由 ARL 戰術環境模擬部門(Tactical Environment Simulation Facility)Fakespace System Inc.公司負責

研製之 RAVE II 系統,其中包含兩套模擬系統:敵情環境模擬系統(Hostile Environment Simulation)及沉浸式環境模擬系統(Immersive Environment Simulation), 訓練人員站在一個全方位的跑步機上,依訓練人員之跑動使人沉浸在虛擬的敵方地形及戰場環境中。

四、 Intelligent Decisions 公司

此次有幸造訪美國陸軍用來訓練單兵戰鬥人員整合戰術作戰之 DSTS(Dismounted Soldier Training System)系統主合約商 Intelligent Decision 公司,雖非既定之行程安排,但卻受益良多,因該公司所設計之 3D 系統不僅造價低廉,且未來可整合至本組自行開發之陸軍戰甲車、多武器射擊模擬器上,並與美軍 JCATS 系統串連,創造後續規劃陸軍合成化戰場或聯合演訓系統雛型。

DSTS 系統由 VBS2 提供虛擬戰場模擬,可同時讓 9 位士兵在 40X40Ft 的空間內進行戰術訓練,若搭配 VBS2 電腦產生之虛擬兵力,其演訓規模亦可達到排、連級以上軍事行動演練,整套模擬器可以在 4 個小時內安裝完畢。基於硬體需求低、空間需求小和安裝迅速的特性,所以可隨時機動的將裝備送往第一線所需的受訓單位進行訓練任務,而不需每個單位都要一個固定場地放置設備,如此可大幅降低裝備的維護人力與空間的需求。DSTS 可以讓部隊在執行真實任務之前,快速取得模擬裝備,依照任務所需特性預先進行模擬訓練,藉此增加對任務的熟悉度。

圖 2.4-1 DSTS(Dismounted Soldier Training System)單兵戰鬥人員整合戰術系統

每位士兵佩戴一組頭戴式顯示器和 3 組姿態感測器，如圖 2.4-2 所示，姿態感測器能偵測士兵目前的身體姿態和眼點的方位，透過頭戴式顯示器會依照眼點方位呈現適當場景，士兵的身體姿態也會同步反應到場景的人物模型之中，槍身槍口部位也會安裝一感測器來偵測槍枝瞄準位置，讓準心和眼點的方向可以分離，更真實的模擬步兵作戰時的情況，士兵的移動是透過一組位於槍身的搖桿來完成控制，本次展覽的設備又增加了兩組手部的感測器，作為手部姿態的偵測(旋轉)，作開門等需要手部動作的任務。

圖 2.4-2 DSTS 單兵戰鬥人員感測器安裝示意圖

　　值得一提的是，應用於 DSTS 系統上之 VBS2(Virtual BattleSpace 2)虛擬戰場平台，該軟體係由 Bohemia Interactive 公司配合美國陸軍 GFT(Games for Training)計畫發展出來的，除提供 3D 視效顯示及互動運作之虛擬戰場環境模擬平台外，亦提供相關發展套件或編輯工具，可依任務需要任意編輯各種地形圖資及 3D 模型，並可執行各項任務場景編輯、即時修改、CGF(Computer Generating Forces)智慧型目標物模擬及訓後迴放評估等功能，其本身亦提供 DIS/HLA(High Level Architecture)介面可與其他模擬器串連，達到未來合成化戰場之整合性需求。

　　VBS2 為一開放式的平台架構，提供許多開發工具幫助協力廠商基於此平台上來開發相關模擬應用，透過各種應用的開發，藉以達成虛擬戰場內各式任務的需求，VBS2 本身雖俱備 AI(Artificial Intelligence)運算功能，但當模擬大型的任務時，所需模擬的 AI 物件數量將相當龐大，為降低運算負載，則可透過搭配其他的 CGF 電腦來協助運算，例如 DI-GUY 公司開發了 Lifeform Server 來控制 VBS2 場景中非真實人員操作的各式物件，提供 AI 物件各種高擬真的行為動作，並且可以和 VBS2 本身的物件進行各類事件的互動，如出現槍聲事件後，Lifeform Server 的人員會產生掩蔽或尖叫等反應，維妙維肖的逼真場景，真的令人拍案叫絕。

VBS2 模擬軟體因價格低廉，因應市場需求，目前最新版本已來到 2.0 版，在相關應用之協力廠商相繼開發出搭配產品後，個人認為以下幾種應用，可列入本組未來開發版圖內：

1.戰傷模擬系統：透過 VBS2 提供的介面取得人員的受傷部位和狀態，然後提供操作介面對受傷人員進行醫療協助，如量測脈博、呼吸觀察和給藥救治等，如無法救治，也可安排醫療後送等相關工作，完成治療後，受傷人員可以繼續加入戰鬥，讓模擬演訓成為連續型的戰鬥任務，並且訓練醫護人員處於砲火威脅下進行醫療行為，同時隊友須考量醫療人員位置而進行掩護等，確實反映出真正的戰場情況。

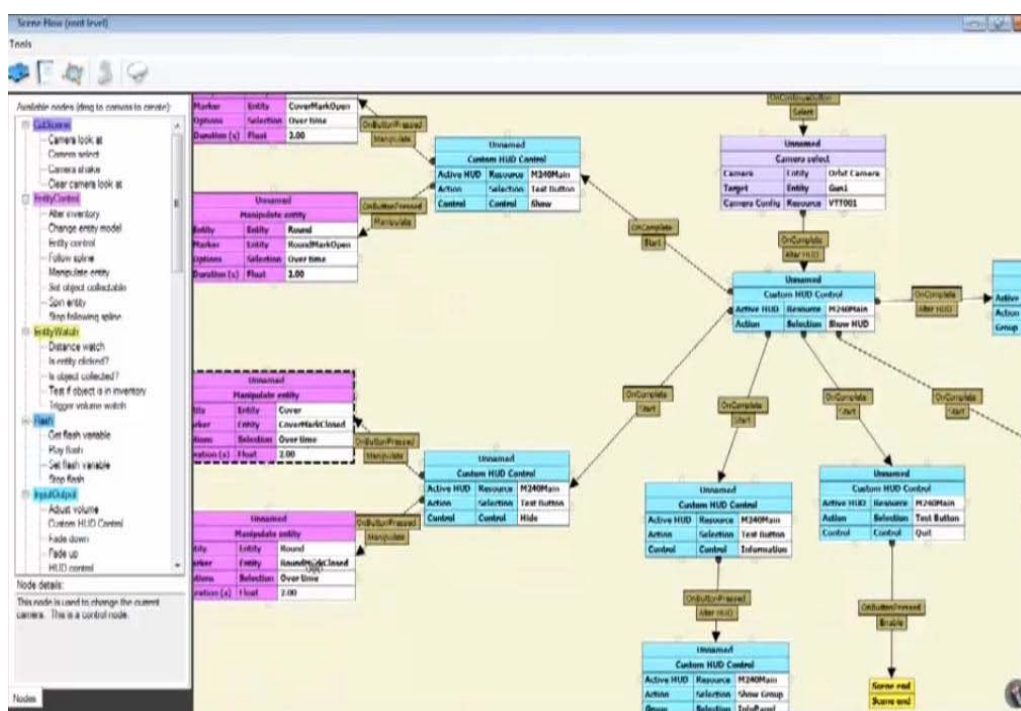圖 2.4-3：戰傷模擬系統

2.維修模擬系統：利用 VBS2 低成本、3D 繪圖功能及互動式架構，可快速又容易地開發出適合各軍種使用之維修模擬器，教材開發人員不需具備程式設計能力，透過流程化設計界面，開發人員只需將拖拉方式將所需的動作結點依照訓練流程加入，建立訓練邏輯流程圖，即可快速完成訓練教材，大幅簡化教材開發時間，搭配快速佈署到不同設備的特色，提升傳達訓練任務的時效性。

圖 2.4-4: 維修模擬系統

圖 2.4-5: 訓練邏輯流程圖

3.城鎮戰模擬系統：利用成熟之 DSTS 系統為基礎，整合包括砲兵、裝甲車、攻擊直升機
和步兵的聯合訓練，想定執行順序為砲兵火力支援，裝甲車進入城鎮，步兵下車搜索，
然後攻擊直升機進行空中掃蕩、最後運輸直升機執行空運任務，空中並配置 UAV 對戰場
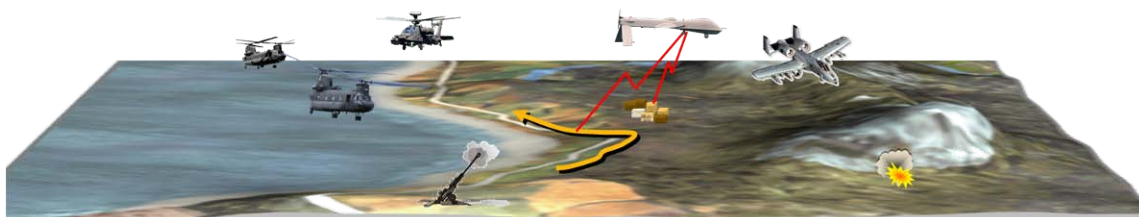環境監控。甚至本組心理抗壓模擬器一般人詬病價格太高，亦可改採 DSTS 系統模式來模

擬，以降低成本。

圖 2.4-6: 城鎮戰模擬系統

4.聯合演訓: 由於 VBS2 可快速且大量的模擬各式載具與操作人員，所以可以滿足過去使用全功能模擬器執行模擬訓練上，在武器載具種類與數量上不足的缺點，並且可以非常容易和既有的全功能模擬系統或兵棋系統進行整合訓練。系統並可與 JCATS 等模擬系統串連，讓 VBS2 主要負責 3D 戰場顯示、3D 戰場觀測、武器特效與人員操作系統，JCATS 負責全域的戰場狀態顯示(2D)、我軍的武力追蹤、空軍單位模擬、產生或觸發其他系統事件和敵軍單位模擬。

圖 2.4-7: 聯合演訓

參、 心得

由本次與相關模擬器廠商開會研討後，可以發現目前國際間均朝向合成化戰場之遠景而努力，有些公司是以縱向垂直整合系統之目標而發展(如 DiSTI、MAK 公司等)，目的在開發一整套全方位系統，包括 2D 平面圖像顯示、3D 視效場景顯示、及網路分散式連網架構等，期使能涵蓋所有範疇，提供客戶一完整之解決方案。

另外有一些公司則是以橫向水平整合之目標而發展(如 ETC、TerraSim、Lockheed Martine 公司等)，目的在將其他公司之產品(如實兵之 MILES 系統、兵推式之 JCATS 系統、模擬器系統、遊戲之 VBS2 系統等)，連結整合成一套共用運作之模擬訓練環境，以滿足客戶聯合演訓之需求。

目前本院已陸續為三軍建置相當數量之模擬器，在縱向垂直整合部份已累積相當經驗，但仍借鏡國外之經驗再將 2D 平面圖像及 3D 視效場景，以共同資料來源轉換格式方式，以達到共同圖台之目的；而未來主要應將著重在橫向水平整合之技術開發，尤其是國軍仍存在許多經由軍售管道所獲得之國外系統，如何為國軍後續模擬訓練產品之需求評估、技術開發及部置運用訂定統一之規範或標準，則是對於推動後續國軍合成化戰場 LVCG 領域之技術發展與整合之一大挑戰。

綜觀本次出國，應可獲得以下成果：

1. 了解並學習目前國外模擬器產業推動 LVCG 之進度及成果，以為本組未來推動國內三軍模擬器、實兵及戰管中心 LVCG、兵棋系統及合成化戰場之借鏡。

2. 藉由本次出國，了解目前模擬器產業在 DIS/HLA 聯網、智慧型目標物設計及場景編輯系統等方向開發之成果及技術門檻，以為本組後續相關訓模技術規劃發展之參考。

3. 藉由了解支援模擬產業之下游廠商優良產品，可提升本組模擬技術及品質，並突破相關開發上的瓶頸及新領域，俾利整合工作之遂行。

4. 將遊戲技術運用於訓模產業(GFT，Game For Training)係美軍近年來推動之方向，且本院未來即將改制，便宜、低單價之遊戲模擬產業，本組目前並無結合遊戲技術與訓模技術應用之相關產品或發展技術，參考國外模擬器在此領域之技術及趨勢，並結合至本組

戰車模擬上之整合，亦是此次出國之重大成果表現。

肆、 建議事項

　　經過此次出國與國外模擬器相關產業廠商觀摩討論發現，國外模擬器廠商及相關支援開發廠商研發新產品速度驚人，本院改制在即，加上國防預算逐年縮減，建議本組應朝低單價、自我開發(如力感系統、動感平台)方向努力，開創自我品牌附加價值，產品才有競爭力。

　　綜整本組產品與國外模擬器比較，目前在品質及技術層面上雖屬並駕齊驅，但同仁不應以此為滿足，應持續加強瞭解國際訓模市場發展趨勢，進而提升本院於模擬產業之技術能量，以免原地踏步，自我感覺良好而不向前走，終將悖離模擬主趨勢，而無法與國外模擬器整合，建議上級單位能持續支持本組參與國際訓模產業相關展覽(如美國 I/ITSEC 及歐洲 ITEC)及與相關技術領域廠商進行交流研討，俾掌握與蒐集訓練模擬器最新技術與發展趨勢，進而提升本院訓模產品自製之廣度、深度與競爭力。

　　綜整建議事項包括：

1. 在技勤、醫療戰傷、3D 單兵戰鬥人員戰術作戰及 LVCG 整合等，本組可擴展此方面領域。

2. 朝向低單價、自我開發(如力感系統、動感平台)方向努力，開創自我品牌附加價值，以降低採購成本。

3. 多參與國際訓模產業相關展覽，有助於本院發展。

4. 能多參與國際相關模擬技術領域廠商交流研討，除可獲得轉型後商機，更有助掌握市場動態。

附件一、ETC 公司型錄資料

THE WST SYSTEM CAN BE PURCHASED AS A SUITE OF TRAINERS OR AS INDIVIDUAL TRAINING ELEMENTS.

Helicopter Rescue Hoist Trainer (HRHT)

The HRHT is a hoist mechanism that simulates the hoisting of a trainee into the rescue helicopter. The HRHT main platform is 10 feet high and supports the hoist mechanism and the rotor downwash sprayers. The instructor uses a remote control to operate the winch that drives the hoist mechanism from this platform. The instructor controls the activation, speed and direction of the winch.

Underwater Escape Survival Trainer (UEST)

The UEST simulates a rapidly sinking inverted aircraft where trainers can learn underwater escape procedures. A variety of aircraft from within the customer's inventory can be simulated including fixed and rotary wing variants. All exits and windows are correctly sized for the aircraft being simulated. The UEST provides aircrew the opportunity to train using different cabin exit points under day and night conditions.

Parachute Drop Disentanglement Trainer (PDDT)

The PDDT supports aircrew practicing disentanglement from the shroud lines and canopy of their parachute in the event that the parachute lands on top of them in the water. After successful disentanglement, the trainee swims away from the parachute and enters a one-man life raft, which is secured by a rope to the pool edge.

Parachute Drag Trainer (PDT)

The PDT is used for aircrews to practice righting, self-stabilization and parachute release skills when being dragged by a wind-blown parachute upon water entry. ETC's PDT consists of a tower, cable run, and a wall support. The PDT provides realistic, variable drag speed for different wind conditions.

ZERO/ZERO
EJECTION SEAT SIMULATOR

ETC Ejection Seat Simulators *SAVE LIVES!*

AIRCREW TRAINING SYSTEMS

ADVANCED AIRCRAFT TRAINING DEVICE (AATD)

ADVANCED AIRCRAFT TRAINING DEVICE (AATD)

The Advanced Aircraft Training Device (AATD) is a multi-purpose flight training device with a real world visual system, and a flight model and instrument display that simulates the performance and flight characteristics of a single engine aircraft. It combines the capability to support training in Basic Flight (VFR), Instrument Flight (IFR), Spatial Disorientation, Upset Recovery, Unusual Attitude and Mishap Prevention Training.

OPERATIONAL COCKPIT SWITCHES (GENERIC OR AIRCRAFT SPECIFIC)

Individual Instrument Failures Center Control Stick with Aileron and Elevator Trim	Rudder Pedals	Fuel Boost Pump
Pitot Heat Switch	Ignition Switch	Power Control Lever	Navigation Lights	Landing Lights	Taxi Light	Avionics Master Switch
Multifunction Display	Flaps Lever

Certifiable to FAA, JAA Training Device Levels
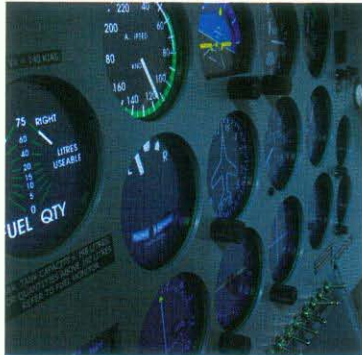
TRAINING CAPABILITIES

Preflight Procedures	Instrument Crosscheck	Straight and Level Flight	Unusual Attitude Recoveries	Stalls	Spin	Recovery
Visual Glide Path Control	Cross Wind Landings	Wind Shear and Turbulence Procedures	Fuel System Failure
Takeoff Procedures	Turns (Normal and Steep)	Landing Procedures and Techniques (round-out and flare)
System Failures	Navigation Equipment Malfunctions	Engine Failure	Landing Emergencies	Individual Instrument Failures

FULL INSTRUMENT NAVIGATION TRAINING SYSTEM

| Instrument Procedures and Cross Checks | Navigation via VOR, VOR/DME, and ADF systems | GPS (Optional) |
| Instrument Approaches (VOR, ADF,ILS and Localizer) | Cross-country flying in VFR, IFR and Night Flight conditions |

FEATURES

Geotypical Visual Database

The flight takes place over a computer-generated, textured, three-dimensional geotypical visual database of the customer's choosing and includes airport facilities, such as building structures, taxi-ways, and properly marked and correctly oriented runways with controllable approach lighting, topographical features and cultural features.

Full Meteorology Menu

The AATD has a full meteorology menu. The instructor can vary time of day, visibility, cloud type, cloud tops and bottoms, cloud slope, rain, thunder and lightning. Clouds can be adjusted for density and visibility, to simulate the base, middle or tops up to 45,000 ft. Additionally, the instructor can select various levels of wind turbulence, wind direction, wind speed and wind shear.

Realistic Aircraft Sounds

The AATD generates realistic aircraft sounds, including the engine, propeller, flaps and landing gear, in addition to information from the Tower and ARTCC (Air Route Traffic Control Center).

CCTV Recording System

The Flight Trainer Station records and displays the ground track, the ILS flight path, heading airspeed and glide path. Airport latitude, longitude, navigation aids are shown on the flight path recorder display monitor. This can be subsequently printed on a supplied printer.

附件二、DiSTI 公司型錄資料

Imagery, Objects and Icons

The DiSTI Map Toolkit offers the flexibility to combine the components necessary to produce high quality mapping applications. Below is a sample anatomy.

Data Visibility
- CADRG
- DNC
- GeoTIFF
- AIF
- AIF
- MAP DATA

Color Control
- White
- Yellow
- Green
- Red
- White
- OVRLAY CLR

Map Orientation
- North Track
- Track Up
- Track Up
- ORIENTATION

Zoom Control
- 500 nm
- 200 nm
- 50 nm
- 25 nm
- 10 nm
- 5 nm
- 1 nm
- 5 nm
- ZOOM LEVEL

Symbology Control
TOGGLE SYMBOLOGY ON/OFF SYMBOLOGY COLOR:
ALL OFF ALL ON SYMBOLOGY

Layer Control Visibility
DECLUTTER INSTRUMENTS
HDG SPD P/R ALT MSN CLK ETA EST NAV COM ALL OFF ALL ON DECLUTTER

Overlay Visibility
TOGGLE OVERLAYS ON/OFF
WHTR STRT WTR ALL OFF ALL ON OVERLAY

DiSTI

Virtual Maintenance Training
Professional Services

DiSTI is recognized as the industry leader in enabling virtual maintenance training through the rapid development of high fidelity virtual representations and environments.

Virtual Maintenance Training

Virtual Environments

The anatomy of a Virtual Maintenance Trainer typically consists of simulation software logic, computer hardware and displays, and a 3D virtual environment that serves as the interactive front end for the students and instructors. DiSTI is the recognized leader in the simulation and training industry in the production of virtual environments. DiSTI's virtual environments are found in the maintenance training devices that demand the highest level of fidelity and accuracy.

Part Task Level

The primary purpose of a Part Task Level maintenance trainer is to teach specific procedures without requiring the development of the entire system. It only encapsulates a part or portion of the overall training needed for certification. The Part Task Level Virtual Environments that are created by DiSTI's services organization maximize student interactive and spatial awareness in a form factor that is accessible via a variety of delivery mechanisms: desktop, web, or mobile.

Platform Level

The Platform Level maintenance trainer delivers a comprehensive training device that works as a complete system. The entire virtual environment functions as a cohesive system, exactly as the real-world device does. Not only can the student perform traditional remove and replace procedures, but they can also perform troubleshooting operations and learn theory of operation. DiSTI's virtual environments are configured with thousands of properties required by the training devices simulation engine to deliver accurate input/ response events during training.

DiSTI Virtual Environment Development

DiSTI's virtual environments are the recognized gold standard in the simulation and training industry. The following are reasons why DiSTI's technology yields the best virtual maintenance trainers:

» A patent-pending workflow that delivers effective on-time results

» Proven no risk technology

» Software automation that minimizes development time and effort

» Optimized runtime that is uniquely designed for maintenance training

» Copyrighted 3D user interface that minimizes user learning curve

F-35 JSF Virtual Maintenance Trainer developed by DiSTI

Why Choose Virtual Maintenance Training?

With the advent of sophisticated gaming technology and graphics, the modern trainee is accustomed to using computer technology for training. DiSTI's virtual maintenance trainers and their innovative training capabilities leverage these benefits:

» Reduces time required for hands-on training

» Lowers training device lifecycle costs

» Increases student throughput

» Increases accessibility to the training materials

» Serves as a powerful instructor aid

» Enables team training

CH-47 Virtual Maintenance Trainer developed by DiSTI

Stories of Success

Oskosh HEMTT Fuel Transfer Trainer: Part Task

The Product Training Center of Oshkosh Defense selected DiSTI to develop the HEMTT M978A4 Tanker Virtual Task Trainer. The goal of the training device is to teach students the procedures necessary to operate the vehicles' fueling and defueling capabilities. This trainer allowed the center to replace a 2-day, 300 slide PowerPoint lesson, with a virtual application that achieved the training objectives in a single 4-hour training session. Students and instructors are very complimentary of the application's ease of use and effectiveness.
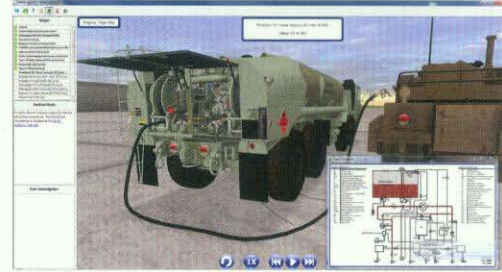
Platform Level Virtual Surrogates: the F-18 IVEMT

Built on the foundation of the F/A-18 Simulated Aircraft Maintenance Trainer (SAMT), the F-18 Super Hornet Integrated Visual Environment Maintenance Trainer (IVEMT) is a platform level maintenance trainer providing enhanced interactivity and detailed real-time aircraft schematics through the use of CAD data.

Level 4 and 5 Courseware for Navy's LCAC

Built for the U.S. Navy, DiSTI developed a blended learning system with 200 hours of SCORM conformant courseware for the Landing Craft Air Cushion (LCAC) vehicle. DiSTI's solution resulted in unprecedented training realism and significant cost savings through courseware and simulation portability.

Replic8 ™

Where Vision **Meets Reality** ™

Easily Create Virtual Training Content in Minutes

Create stunning interactive level 3 and 4 courseware assets with Replic8 and without writing code. Replic8 simplifies the process by providing an out-of-the-box 3D lesson framework that integrates easily into any extensible learning management system, web page, or desktop environment. Upgrade from the traditional page-turning learning to an interactive training experience that increases knowledge retention, shortens training schedules and engages the student.

Working Without Programming

Replic8 starts with conventional 3ds Max models that are typically used to produce movies or photographs for courseware assets. As a 3ds Max plug-in, the Replic8 Exporter then exports the model's geometry, materials, and animations for use in the Replic8 Editor.

In the Replic8 Editor, the user creates lessons with the Design by Doing concept. The user records the steps to perform a series of actions. These recordings become the basis of playback and interactive lessons for the student. All of this is accomplished without any programming.

Standard Process

Analysis → Design → Development → Implementation → Evaluation

Replic8 Framework

Provides greater efficiency

No programmer needed

Cuts development time

Replic8 Process

Analysis → Design / Development → Implementation → Evaluation
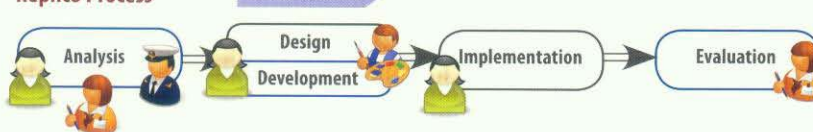
- Sponsor/Customer
- Instructional Systems Designer
- Subject Matter Expert
- 3D Graphic Artist

Process Workflow:

1. Build with 3ds Max:

Build 3D interactive content in 3ds Max with the assurance that all essential textures, materials and animations will be imported correctly into your lesson. Use 3ds Max to create how your model looks, how it comes apart and how it moves. Then use the Replic8 Exporter to publish a Replic8 Equipment file. Replic8 supports version 2010, 2011, 2012, 2013, and both 32-bit and 64-bit 3ds Max.

2. Preview 3D Content:

Preview and validate your 3D Replic8 Equipment File with the Replic8 Equipment Previewer to ensure all equipment geometry, hierarchy and animations exported from 3ds Max are correct. Cut down on development time by verifying your content before starting lesson creation.

3. Design by Doing:

Use the Replic8 Editor to quickly create interactive training content with the intuitive 3D Design by Doing workflow. Load the Replic8 Equipment file and design each procedure the student will perform. Instead of writing code, record the workflow and the Editor will generate all the necessary scripting for the lesson steps. The Editor's advanced features include part highlighting, part identifiers, and tool-tip pop-ups without programming.

4. Learn and Engage:

Deploy engaging training material and improve learning retention by allowing students to do procedures, instead of just watching them. Whether it's as simple as changing a light bulb or as complex as a full engine tear down, Replic8 makes training more effective by increasing student involvement, safety, and throughput. Deploy stand-alone or in a web browser by using Java on Windows, Linux, or OS X systems.

GL Studio® GL
Toolkit

Aerospace

Simulation & Training

Automotive

Interface with Reality™

Build high fidelity graphics and fully interactive controls into software products with this award winning suite of powerful tools. GL studio enhances the level of realism and sophistication of any development effort.

DiSTi

Cockpit & Dashboard Instruments

Professional Services

DiSTI's name is synonymous with virtual instrumentation development and our services organization is here to assist in the creation of instrumentation to meet your design and application objectives.

Cockpit & Dashboard Instruments

DiSTI's name is synonymous with virtual instrumentation development and our services organization is here to assist in the creation of instrumentation to meet your design and application objectives.

Virtual Instrumentation:

DiSTI produces virtual instrumentation to meet your design specifications and application objectives. Virtual instrumentation is used to facilitate a variety of simulation and training devices, including:

» Rapid virtual prototypes
» Desktop, part-task, and full mission trainers
» Instructor operator stations
» Repeater panels
» Instructor training aids

Delivery Details:

DiSTI delivers pre-compiled software builds in either C++ or Java, along with an Interface Control Doument, allowing semless integration with your software project. DiSTI also delivers all related project source, allowing you to maintain and update deliver content.
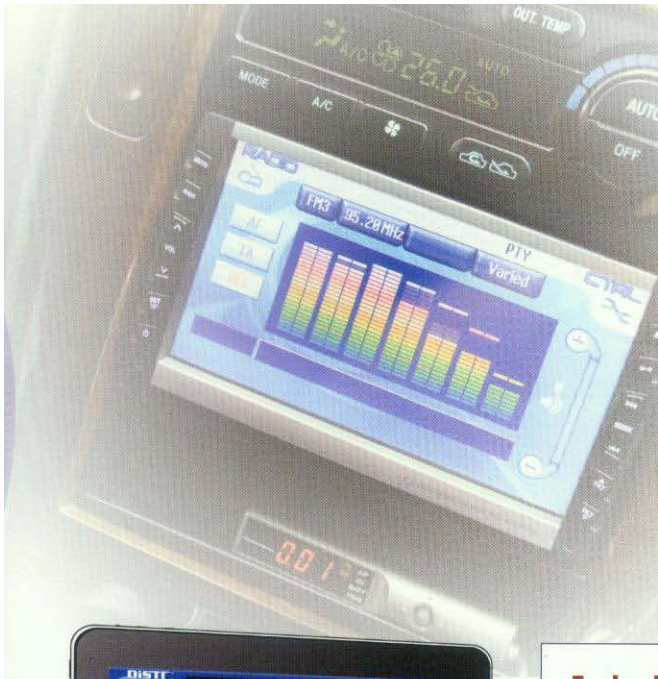
The DiSTI Advantage:

DiSTI's services organization is an industry leader in the development of virtual cockpits, instrumentation and infotainment displays. Our highly skilled staff includes engineers, 3D modelers, and graphics artists capable of meeting any project objectives. Whether you just need assistance in a particular area to subsidize your existing workforce, or a turn-key delivery, we can help.

Embedded Development:

If you are ready to get your applications embedded, DiSTI's services team can take you there. With GL Studio ES and app publishing experience for smart devices, DiSTI is poised to give you the market advantage of today's mobile and embedded device capabilities. Consider your iOS, Android, or embedded Linux application development challanges solved.

Variations:

DiSTI's tools and services have been utilized in the production of a variety of 2D and 3D virtual instrumentation content including:

» Aircraft cockpit instrumentation - analog and electronic
» Vehicle dashboards
» Gunner stations / reticles
» Ship consoles

The DiSTI Map Toolkit is a plug-in for GL Studio that allows developers to create real-time moving map displays for their desktop applications.

DiSTI Map™

Toolkit

Develop Moving Maps with Ease

The DiSTI Map Toolkit is a plug-in for the GL Studio editor that allows the development of real-time moving map display applications. The toolkit provides the capability to combine multiple geo-referenced map imagery formats and user-defined symbology across multiple layers to produce a single real-time 2D map view. Numerous map imagery formats are supported and new formats are easily added using a plug-in reader architecture.

Map Data Formats

» Extendable architecture supports multiple map formats and symbology:
- DTED
- GeoTIFF
- CADRG
- DNC
- AIF (JPEG, PNG, TIFF, ETC.)
- GL Studio Objects

» Seamlessly add Paths and Waypoints

The DiSTI Map Toolkit provides the features and functionality to mimic any existing map interface or create a new whole new look:

» Simple integration into GL Studio projects
» Hardware supported map rendering
» Pan, rotate, and zoom capability
» Auto-resolution based on Altitude

» Out-of-the-box or user-defined symbology
» Visibility culling of symbology
» Pre-cache map data
» Dynamic paging of map imagery

— Map Toolkit Process Flow —

Symbology

Overlays

Map Assets

**Imagery**

DiSTI Map Toolkit in GL S
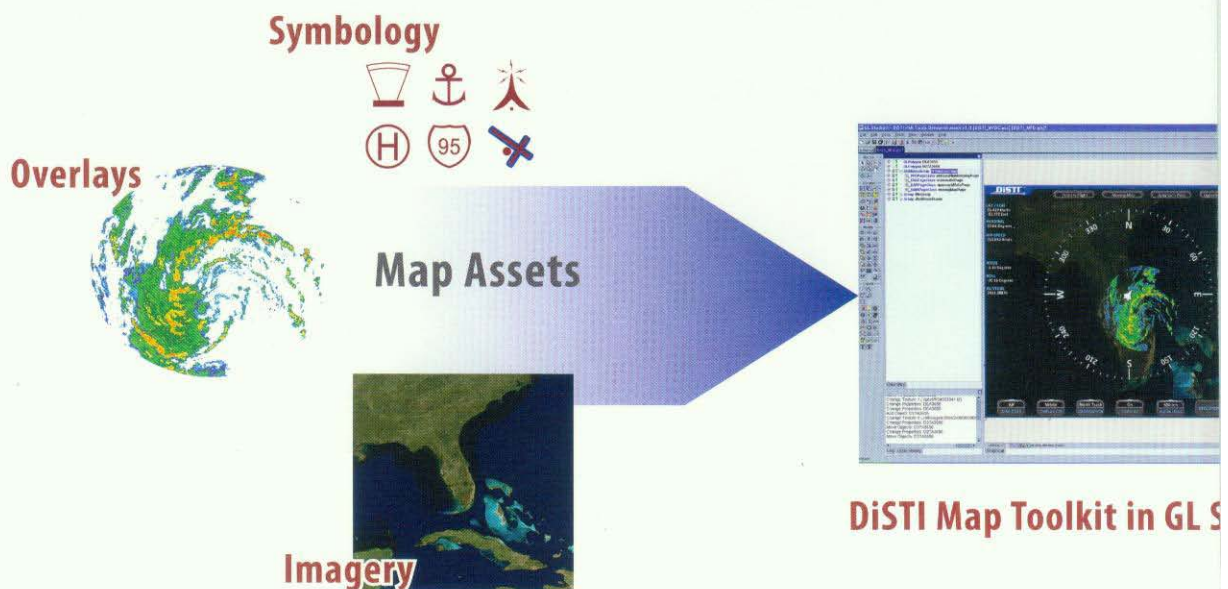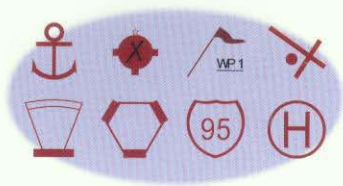
Symbology

This toolkit provides a quick and easy interface to overlay user-defined symbology, which can be created from GL Studio objects. Symbology includes 40 standard aviation symbols with full HSI and quarter HSI. It also includes the MILSTD 2525 B with 4 affiliations, 12 echelons and 113 unit symbols.
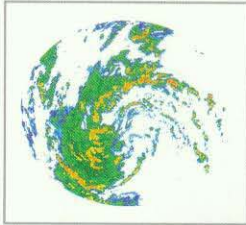
DiSTI Arbitrary Image Format

DiSTI created a standard method for inserting geo-referenced map imagery layers from any standard image file format supported by GL Studio. The Arbitrary Image Format utilizes an XML schema to define sets of geo-referenced images to be used as map imagery layers. This feature allows developers to expand how they utilize the toolkit to portray data from disparate resources in a single display.
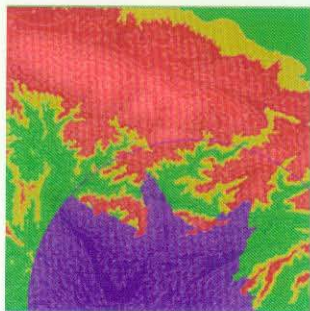
Elevation Data

The all new support for DTED elevation data allows users to integrate the following capabilities:

» Terrain map with runtime controllable "moonscape" shading
» Up to 16 elevation bands with configurable colors based on height of band relative to ownship altitude
» Threat rings with line-of-sight shading based on location and height of threat above terrain
» Contour lines with configurable color, line thickness, smoothing, and spacing
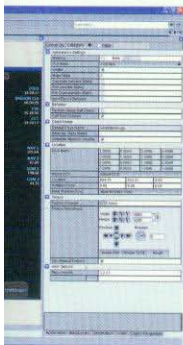
...udio Editor

DiSTI Map Toolkit in User Application

附件三、Christie 公司型錄資料

> The Visdec Electronic Decision Theater at the Huazhong University of Science and Technology (HUST), Wuhan, China is a digital "think tank", as well as the largest advanced visualization display in China.

People and experience

It's our experience and our people that make Christie world-class.

Christie is a pioneer in 3D stereoscopic DLP technology, a true innovator in visual environments. As your partner in 3D/visualization and simulation, our world-class sales engineers, solution architects, project managers, design and mechanical engineers and integration experts work together to deliver the most advanced, functional and intuitive display solutions. Our sales engineers provide recommendations for the most cost-effective, functional and usable system to meet your needs.

Solution architects – The solution architect leads the technical development from proposal through to final installation and acceptance. This involves leading the design team in the application of display technology so that it best meets your requirements.

Project management – Christie's certified project managers oversee the details of the entire installation to ensure it remains on budget and without worry for a seamless transition from concept to completion and customer operation.

Application engineers – From the initial site survey to final installation, Christie's expert field application engineers will ensure that your system is installed and integrated quickly and efficiently, and is 100% operational.

Training – You and your staff will receive training and support for your new system.

Global service and support – Technical support - with offices all over the world, we provide a customer-centric approach to providing technical support services.

Christie at a glance

A world leader in visual solutions for world-class organizations.

Christie is a global visual technologies company offering diverse visual display solutions for business, entertainment, and industry. With expertise in film projection since 1929 and professional projection systems since 1979, we've established a reputation as the world's single source manufacturer of variety of display technologies and solutions for cinema, large audience environments, control rooms, business presentations, training facilities, 3D and virtual reality, simulation, education, media and government.

As a market leader, Christie has installed over 100,000 projection solutions worldwide. Whatever the application, our solutions are purpose-built to meet unique projection requirements, encompassing image processing to the visual display to managing the content. And we back our solutions with industry-leading service and support ensuring complete customer satisfaction.

Experienced – Founded in 1929, more than 80 years in the display industry
Innovative – Over 30 "firsts" and many more patents
Capable – 1500 staff in 16 countries, with expertise in all disciplines
Reliable – World class ISO 9001/14001 manufacturing facilities
Holistic – Recognized with the inaugural Green AV award in 2010
Stable – Part of a $1.5B company with balanced portfolio

Our Customers

- Airbus Industries
- Ball Aerospace & Technologies Corp.
- Boeing
- BP Aberdeen
- BP Gulf of Mexico
- Canadian Maritime Helicopter Program (CMHP)
- Carlton University
- Caterpillar
- China Petroleum and Chemical (Petrochemical) Corporation
- CSC
- Discovery World "HIVE"
- Fisheries & Marine Institute of Memorial University of Newfoundland
- Flight Safety International
- HMS Collingwood (UK)
- Intuitive Surgical, Inc.
- Lockheed Martin
- Marathon Oil
- NASA Goddard Space Center
- National Museum of Maritime Biology and Aquarium (Taiwan, China)
- Nexen
- Pennsylvania State University
- RAF (Royal Air Force) Leuchars (UK)
- RAF Shawbury
- Royal Saudi Air Force
- Scripps Institute for Oceanography
- SimJET Training Systems
- South Australian Virtual Reality Centre (SAVRC)
- US Air Education and Training Command (AETC)
- US Air Force
- US Air National Guard
- US Army
- Weil Cornell Medical College

6

Christie's integrated visual display solutions

Christie offers full support for our customers no matter the level of engagement required. We'll consult with you, determine project scope and feasibility, and move into system design with a focus on your critical success factors, no matter what scale your project requires. Supported by experience, technology leadership and innovation, Christie follows with ISO certified project management practices that see you through to design, installation, integration and complete training and support.

Christie's broad support services meets our customers' expectations for functional, continuous, reliable system performance. With the best technology delivered in a fully integrated solution, coupled with a choice of service coverage programs or a la carte preventive maintenance and emergency field service options, Christie provides complete piece of mind for your investment.
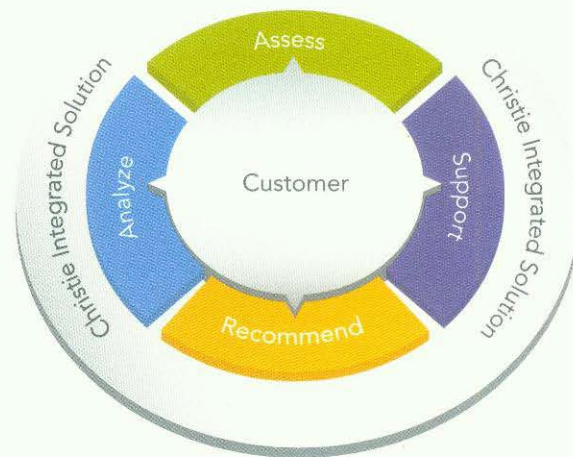
Consulting

What do you need your system to do for you? In our pre-sales consultations, we work with you to assess any workflow requirements and system considerations. We work with architects to integrate our display solutions into your facility designs. Using needs analysis and user case studies, we help you interact successfully with your existing systems. Our team of factory-trained Field Application Engineers can also provide a site survey to evaluate your current system and site prior to installation and identify possible issues.

Feasibility studies

Once the scope of the project is agreed upon, we provide recommendations for the most cost-effective, functional system to meet your specific needs – whether it's a standardized package for quick, simple deployment or a completely customized solution.

System design

Diverse applications can create a variety of challenges. We provide high-performance "real world" visual display solutions: our 3D/advanced visualization and simulation products meet the most demanding specifications, including factors such as geometry, image blending and warping, resolution, color and brightness uniformity, immersion, stereoscopy and interactivity.

Critical success factors

We'll work with you to establish the key performance metrics such as resolution, brightness and contrast within the design to set as performance parameters and ensure your complete satisfaction.

Vendor selection criteria

Using the defined Critical Success Factors, Christie identifies key success criteria for components within the system (including screen, software, tracking and computer hardware). This helps your organization to make educated decisions during vendor selection, guaranteeing your satisfaction with our world class visual display solution.

Project management

With an ISO9001 certified custom project process, our project managers oversee the finite details of your visual display solution efficiently, on-budget and without worry for a seamless transition from concept to completion and customer operation. We coordinate design, procurement, factory testing, shipping and installation so the process runs smoothly and is all-encompassing.

Design
Factoring in the needs analysis study, we take the design from concept to reality. Working in collaboration with the customer, architects and mechanical engineers, we fully define space requirements, HVAC and electrical requirements and any other facility issues that may create challenges. No one likes surprises – and since our customers are well apprised of their facility and process implications, we incorporate milestones in the process to accommodate a comparison and contrast of the current design to the solution. We follow up with a critical design review to align the pre-production design with the project goal and the impact on the facility, ensuring that the design is in line with the project goals and the facility impact every step of the way.

Factory integration testing
Once released to production, projects are regularly staged in our factory. This allows for integration testing, which reduces risk during installation, as well as any unforeseen delays in the field, ensuring installation occurs in a timely fashion.

Factory preview/FAT
Customers have the option to purchase a factory preview or a Factory Acceptance Test (FAT). In the factory preview, customers are invited to visit the factory to view what has been staged. The FAT is based on specific test procedures that are developed in conjunction with the customer to demonstrate the critical performance requirements have been achieved.

Christie service and support coverage packages

Services	Service coverage packages			
	Basic	Extended	Premium	Custom
Regular and extended hours for technical phone support (8 a.m. to 8 p.m. EST)	•			Build a tailored support program to address your unique situation and needs
24/7 coverage hours for technical phone support		•	•	
Preventive maintenance field services	•	•	•	
Discount for additional labor services	•	•	•	
Firmware updates	•	•	•	
Emergency field service		•	•	
Management of Returned Merchandise Authorization (RMA) equipment directly with the manufacturer		•	•	
Critical inventory logistics for spare parts			•	
Remote network monitoring			•	
Training – access to Christie's researchable knowledge database and online training tool			•	
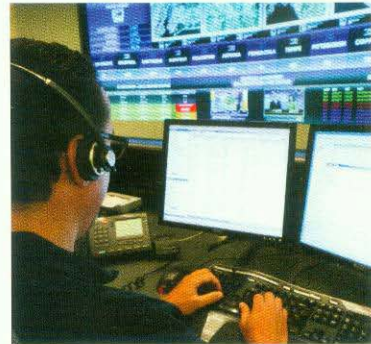
▲ Christie Network Operations Center

Installation

From initial site survey to final installation, our expert application engineers provide you with complete confidence that your system will be installed and integrated quickly, efficiently and will be 100% operational. Our team will meet the truck on site, unload and physically install the equipment, perform any configuration changes necessary to integrate it with Owner Furnished Equipment and fine-tune the system to ensure it performs optimally. At the conclusion of the installation, we will hold a training session to educate your users on how to operate the system.

Training and support services

Christie training and support helps ensure you and your staff hit the ground running. If an issue arises during operation our support network is available to resolve it quickly and return your system to a fully operational state. Our preventive maintenance services maintain and adjust your system throughout its useful life to keep it running at optimal performance.

Christie service and support

Our commitment to you – to deliver continuous, reliable product performance and minimal downtime – begins the moment you start doing business with us. A commitment that is built on a solid foundation of service and support programs.

These programs provide

System design – we'll help you develop the perfect visual display

Project management – let our experts manage your display's installation

Phone and on-site service – we're available for phone support and we'll come to you, if you need hands-on service

Remote monitoring – our 24/7 remote system monitoring lets us keep an eye on your projection system and keep it running

A spare parts program – so you always have the parts you need

To ensure your system runs smoothly, Christie offers the following services:

A la carte service offerings

| |
|---|
| Preventive maintenance field service |
| Mirror adjustment |
| Filter cleaning |
| Image alignment |
| Color balance of all sources |
| Lamp change completed as required |
| Filter replacement completed at lamp change |
| Hardware, software and firmware updates if applicable |
| End-user training |
| Emergency field service |
| Response time is based on priority as assigned by you, the customer |

The Christie Network Operations Center

Offering a national US-based service network, our Christie Network Operations Center (NOC) has a 24/7 service desk for technical support, and provides remote monitoring services that track, update and manage display systems to keep them running. By remote monitoring your projection system, we can detect and handle potential challenges before you're ever aware of them and before they can affect your projection system.

Critical inventory logistics (CIL)

The critical inventory logistics (CIL) network ensures that the right parts are in the right place at the right time. It is comprised of over 50 forward-stocking locations and a central-stocking location where critical spare parts are strategically deployed to allow optimal positioning and access 24/7/365. The CIL network is managed and executed in conjunction with the FedEx Supply Chain Solutions via an automated and engineered process.

2
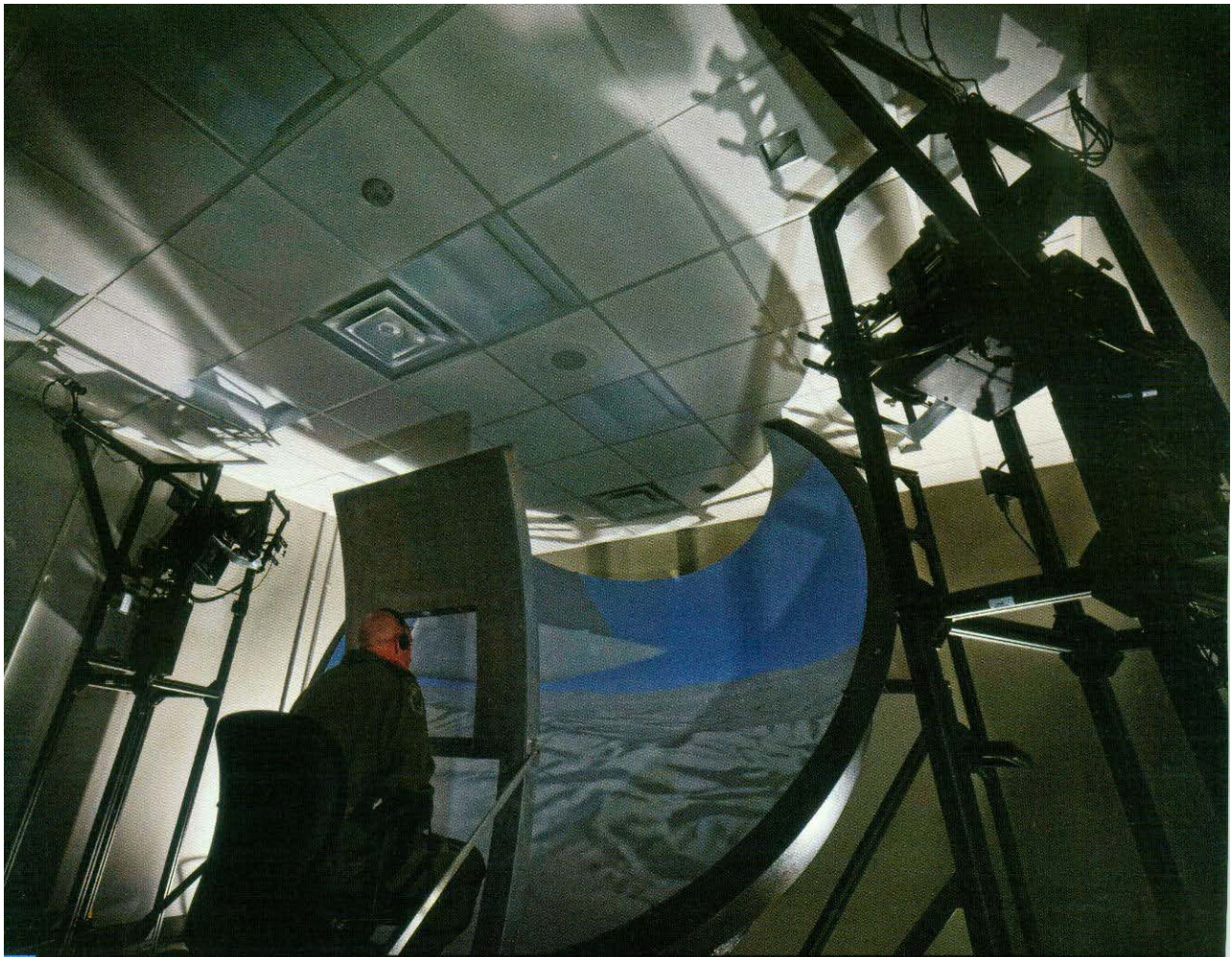
Visual display solutions for simulation and visualization

Aerospace
Defense
Design and architecture
Education and training
Energy
Government and infrastructure
Museums and entertainment
Sciences and biotechnology
Transportation

CHRISTIE®

Christie integrated display solutions

Christie® is the display solution expert who solves customer problems through our optimal use of technology for simulation and visualization markets. We understand the big picture. We understand the complexities and challenges of integrating display technology into your visual system needs. Whether a headtracked immersive CAVE™ environment with high resolution datasets, or a spherical screen creating an out-the-window view, factors such as geometry, image blending and warping, resolution, color, brightness uniformity, latency and frame rates – are integral considerations.

We leverage our exceptional products, knowledge and team experience to provide you with a complete integrated solution that's reliable, effective and sustainable and that accurately addresses your requirements for high performance, high resolution visual display systems.

We listen and evaluate your needs and goals to solve specific application challenges. Christie has the innovative technologies, engineering strength and integration expertise to offer completely customized solutions and turnkey visual display options.

Our solutions minimize your initial investment and the lifetime costs of your integrated display system. We work with you to deliver the most functionally advanced and intuitive display solution. Whether you are an integrator looking for a visual display partner, or an end user with demanding project specifications, Christie delivers application-specific solutions.

Customized solutions that answer your needs

Christie's ISO certified project management practices see you through the design, installation, integration and complete training and support of your project requirements. Christie's experienced team will integrate and install the system and fully train your employees and provide you with ongoing support.

Leading-edge technology plus world-class system integration expertise

The complexity of today's simulation and visualization applications poses a variety of display and image challenges. Christie's integrated display solutions can produce images of any size or resolution and meet almost any requirement. As one of the industry's leading technology providers, Christie has identified the technological problems that our customers face and we've developed innovative visual display solutions to resolve these issues.

Our integrated display solutions can be either customized or come as a standard preconfigured system. Create your solution from our:

| 1-chip or 3-chip DLP projection technology |
| Lamp or solid-state illumination |
| Motion tracking and interactivity |
| Real-time 3D display graphics |
| Infrared NVG capabilities |
| Anti-smear functionality |

Industry-leading service and support includes service offerings such as:

| Next day parts delivery |
| Repair and replacement |
| 24/7 remote monitoring of your display and connected devices |
| Reporting |
| Software upgrades |
| Troubleshooting and training |

▲ JiaoTong University - Shanghai, China, features a 1x3 curved screen, 2.5 meters tall by 8 meters wide that displays a blended, seamless image with a 90-degree field of view.

| Integrated display solutions |
| Service and support – from concept to reality |
| Completely customized solutions AND standard turnkey visual displays |
| World-renowned, proven technology – Christie Matrix and Christie Mirage DLP®-based projection platforms |
| Christie Twist™ – Industry-standard warping and blending technology |
| System integration tools – Christie AutoCal™, Christie Advanced Color™, Christie MotoBlend™ |

2

Markets served

Within simulation and visualization, Christie designs, integrates and installs visual display solutions for:

Aerospace
Defense
Design and architecture
Education and training
Energy
Government and infrastructure
Museums and entertainment
Sciences and biotechnology
Transportation

Whatever the application, our solutions are purpose-built to meet your unique projection requirements, and backed by industry-leading service and support ensuring complete customer satisfaction.

3-chip DLP projection

Christie delivers stunning, long-lasting image quality with unsurpassed DLP technology for a large array of high-performance, high resolution projection and display applications. With better color control, Christie delivers a smoother, cleaner, seamless digital picture. Our image quality is an industry benchmark.

▼ The U.S. Naval Academy (USNA), Annapolis, Maryland. The U.S. Naval Academy chose 14 Christie DS+6K-M projectors with Christie Twist and Christie AutoCal software to build two state-of-the-art ship simulators for their cadets.

The best performing illumination

Our Xenon-based 3-chip DLP projectors deliver superior image quality and color matching across multiple projectors for extremely bright, color rich, uniform images – whether you're using multiple projectors on a single screen or on multiple-screen displays. Our Mercury-based 3-chip DLP projectors share many of the same qualities, but offer quieter projector operation and an overall lower cost of ownership. Discharge lamps are very efficient at converting electrical power into light and can operate at a low power. These lamps have a long expected lamp life. The one-two punch of higher efficiency and longer life means these lamps have a low operating cost.

1-chip DLP LED illumination

With Christie's single chip DLP LED illumination platform, we provide high resolution, pixel density and reliability, and continuous system calibration in a cost-effective flexible platform that offers 2D/3D capability or, NVG stimulation. Utilizing solid-state LED illumination, provides precise, lifelike, vibrant colors and consistent performance over its lifecycle.

◄ Jenn Norton's Tesseract exhibit -
a CAFKA collaboration in the
Christie Hive at the Communitech
Hub, Kitchener, Ontario.
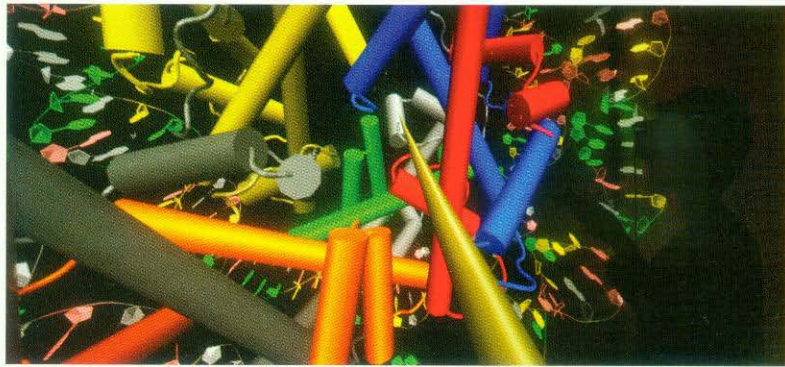
▶ Christie's 3D immersive
technology at Weill Cornell
Medical College, New York, NY,
enables visionary breakthroughs
in biomedical research.

Christie system integration tools

Christie offers system integration tools
as part of our complete display solution
package. Customizable, reliable and
efficient integration tools that meet even
the most demanding key visual environment
requirements, Christie system integration
tools include:

Christie AutoCal
Christie AutoCal automatically calibrates
virtually any arrayed projection display, from
flat to cylindrical to spherical, and adjusts it to
its optimized viewing configuration. Christie
AutoCal offers reduced location resource
requirements and increased customer
independence in terms of maintaining
multiprojector displays.

Christie MotoBlend
Christie MotoBlend ensures your dark scene
content (such as night time training
applications) is evenly maintained across
the entire display, without any residual light
distractions or artifacts sometimes found in
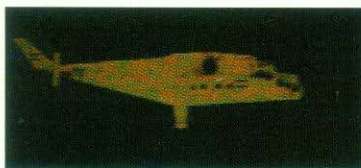other multiprojector displays.

Christie AccuFrame
Developed specifically to address the
simulation market, Christie AccuFrame™
enables the customer to reduce perceptible
image smearing due to image retention
and eye motion. Fully adjustable to support
various frame rates and environments, the
unique advanced electronics in all Matrix
Series projectors come standard with
AccuFrame to accurately display high
speed simulation content for the most
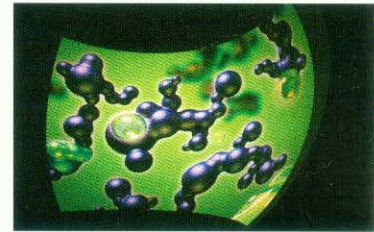true-to-life displays.

Christie Twist
Christie Twist is a powerful tool that maps
pixels to any projection surface with
proper geometry and perfect pixel to pixel
alignment. Christie Twist provides the
enhanced warping and expert blending
required for arrayed projectors to operate
as a single, uniform display – in both
visualization and simulation applications.

▲ Defence Research and Development Canada
and the Canadian Forces Aerospace Warfare
Centre have partnered to advance training
methods for the Royal Canadian Air Force.
Recently they improved their state-of-the-art
Hercules Observer Trainer (HOT) by adding two
Christie Matrix StIM™ projectors.

▶ Christie Edgeless Graphics Geometry (EGG) -
16 megapixel, 240-degree field of view display
featuring Christie AutoCal, Christie Matrix StIM
and Christie Twist.

▲ Expert advanced warping and blending through
Christie Twist.

▲ With Christie AccuFrame.
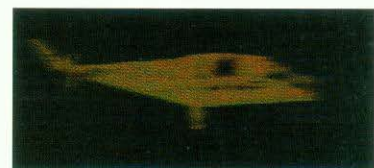
▲ Without Christie AccuFrame.

◄ The first-of-its-kind 360-degree simulated ride was featured at the LOTTE Pavilion at Expo 2012 Yeosu Korea. Sixteen Christie WU12K-M WUXGA 3-chip DLP projectors display visuals for "A World Full of Pleasures", featuring a virtual hot-air balloon ride in the pavilion's miniature amusement park.

Evolution of Christie

Christie has a rich history in the cinema industry and is credited for introducing digital projection technologies that set the stage for the contemporary movie theaters. In 1999, Christie acquired Electrohome Projection Systems, an international manufacturer of commercial projection systems.

Christie's broad range of technologies include DLP Cinema® projectors, LCD and DLP projectors, rear screen projection modules, video walls, and cutting edge projection technologies for 3D, virtual reality and simulation.

Christie has always chosen to develop products and solutions that are purpose-built for the application they serve.

Today, Christie is the only single-source provider of high performance digital projectors and visual solutions in North America and one of only a handful in the world. As a global market leader, Christie has installed over 100,000 projection display solutions in cinema, large audience environments, control rooms, business presentations, training facilities, 3D and virtual reality, simulation, education and media and government.

Why choose Christie?

More than 80 years of experience provides a lot of insight. Christie's decades-long partnership with technology display and light source leaders has resulted in the most reliable projectors in the industry, giving Christie a long history of innovation and technology leadership in the world of projection and display solutions.

Environmental leadership

We recognize our responsibility to control impacts to the environment from our business activities, products and services. We are fully committed to environmental solutions for current and future generations and to meet or exceed applicable environmental laws, regulations and organizational objectives. As an industry leader, we are committed to prevention of pollution and continual improvement through the implementation of our environmental management system.

Where will you find Christie?

Drawing on worldwide experience with Fortune 1000 companies, Christie delivers high-quality, reliable solutions and unprecedented levels of customer service and support for both simulation and visualization customers worldwide. With Christie the possibilities are as limitless as your imagination.

With design facilities spanning three continents and sales and support offices across the United States, Canada, Brazil, United Kingdom, France, Spain, Italy, Hungary, Germany, China, Singapore, Japan, United Arab Emirates, India and Korea, Christie is well-positioned to respond to any challenge.

◄ The Full Flight Simulation system at Royal Naval Air Station (RNAS) Culdrose, Cornwall, England, where training facilities for the RN Sea King helicopter are based, recently underwent a visual system technology upgrade to Christie's new Matrix StIM – an advanced LED-based DLP projection system.

5