Next Generation Emergency Management Common Operating Picture Software/Systems (COPSS)

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I. INTRODUCTION

In the state-of-the-art Command Center at the Applied Science Foundation for Homeland Security (ASFH) in the 90,000 sq. ft. Morrelly Homeland Security Center (MHSC) in Bethpage, NY, VCORE Solutions LLC ("Virtual Command Operations & Response Environments") has integrated, demonstrated, tested, deployed, and is operating powerful Emergency Management Common Operating Picture Software/Systems (EM/COPSS). With support from both New York State and U.S. Department of Homeland Security Science & Technology Directorate (DHS S&T) funding, this Regional COPSS demonstrates in an operational environment the next generation of emergency management situational awareness, command & control, and information sharing in a natural, easy to use and understand four-dimensional (4D) common operating picture.

This Regional COPSS is based on patented fourDscape® software technology, developed over the past decade by Long Island, NY-based Balfour Technologies. This powerful fourDscape augmented virtual reality technology has been effectively applied to local and regional emergency management operations and can be deployed nationally to deliver comprehensive situational awareness in support of safety, security and emergency preparedness, prevention, mitigation, response and recovery operations at all levels.

A fourDscape browser/server based COPSS is designed as an open, multi-layered service/resource oriented networked architecture (SOA/ROA, i.e. “cloud”) capable of (1) integrating and managing a multitude of disparate data sources of all types (including live and static data feeds); (2) interoperability with numerous other vendors information systems, COPs, information sharing frameworks, notification and alerting systems, analytics, etc.; and (3) sharing and passing information and comprehensive, timely situational awareness between first responders at the incident site, incident commanders, and emergency managers and decision makers at local, regional and national emergency operations centers across the country. And consistent with the recent Presidential Policy Directive on National Preparedness (PPD-8), this fourDscape COPSS capabilities and framework represents currently operational technology that can achieve an integrated, layered, and all-of-Nation [capabilities-based] preparedness approach that optimizes the use of available resources.

Next Generation COPSS such as fourDscape need to be open and scalable to facilitate global information sharing; deliver information in an easy-to-understand augmented virtual reality common operating picture; be easy-to-use walk-up technology with a full complement of embedded training/simulation capability; provide for effective information assurance; and be compliant and effective in executing national preparedness goals. All this can and will be achieved by next generation COPSS.

Keywords: common operating picture; fourDscape; virtual reality; telepresence; situational awareness; emergency response
makers at local, regional and national emergency operations centers across the country. And consistent with the recent Presidential Policy Directive on National Preparedness (PPD-8) [1], this fourDscape-based COPSS capabilities and framework represents currently operational technology that can achieve an integrated, layered, and all-of-Nation [capabilities-based] preparedness approach that optimizes the use of available resources.

II. FUNCTIONAL CAPABILITIES ANALYSIS

In [2] it was reported that there exists a critical gap in the Federal Emergency Management Agency’s (FEMA) ability to develop comprehensive situational awareness and share reliable information with all its strategic partners. There is a call for a comprehensive Crisis Management System as a near-term stop-gap measure, but an effective long term solution would benefit greatly from a next generation COPSS.

The primary mission of an effective COPSS is the development of Shared Situational Awareness (SSA) from all available assets (data sources from sensors, other disparate systems, decision support models, etc.), presented to the user (operator, manager, decision maker, responder, etc.) in a natural, interactive, easy to understand Common and/or user-defined Operating Picture, delivered where and when it is needed. To achieve this effectively requires a number of crucial functional capabilities that, as an operational example, a fourDscape-based COPSS can provide:

A. Open, Layered Architectural Approach

Over the past decade, fourDscape technology has been developed to provide a unique COPSS in an open, layered, and networked architecture framework (see Fig. 1). This layered architecture seamlessly integrates many disparate Resources, Analytics, Objects, and DataBases, fed into Engines, Portals, Servers and Browsers. Raw data is transformed from information into actionable knowledge and comprehensive situational awareness as the geospatial-temporal data flows up the layers and presented interactively to the user in a 4D augmented virtual reality fourDscape browser. The functionality of these eight layers is as follows:

(Layer 1) – 4D Resources: the interfaces to many disparate live, raw sensor/data feeds, such as video surveillance, tracking, environmental sensors, etc. Layer 1 is the lowest, most basic level in this open, service-, or more precisely, resource- oriented networked architecture;

(Layer 2) – 4D Analytics: here 3rd party analytic algorithms (ex: video analytics) can be applied to the raw sensor feeds to create intelligent meta-data associated with each live or recorded/archived sensor feed;

(Layer 3) – 4D Engines: can perform value added geocoding, time stamping, trans-coding, resource discovery, archiving, 4D database query/searching, etc. before transmitting data to higher layers;

(Layer 4) – 4D Objects: analytics meta-data can be processed here, fused with other sensor-sourced meta-data and pattern-matched (using 3rd party integrated algorithms), etc. to identify real-world dynamic objects from raw data sources to be infused into the augmented virtual reality 4D portal/scene providing valuable object ID/location/type/intent/etc. information to the user;

(Layer 5) – 4D Portal Engine: the back-end of the 4D servers, coordinating the flow of all dynamic information and sensor/data feeds into the 4D portals, which will be served to the user;

(Layer 6) – 4D Portals: combining both pre-positioned static datasets, such as terrain, base ground imagery, GIS datasets, etc., and all the dynamic geospatial-temporal data feeds and dynamic models into a powerful 4D portal, creating the augmented live virtual reality of buildings, campuses, localities, regions, nations and globes;

(Layer 7) – 4D Servers: serves 4D portals over local networks and/or the global internet to 4D browsers, and shares portal data with other servers as needed;

(Layer 8) – 4D Browsers: the custom user GUI, delivering powerful situational awareness to all levels of users on desktops, laptops, handhelds, command center walls, immersive curved dome augmented virtual reality environments, etc. 4D browsers display a natural, realistic, interactive augmented 4D virtual reality scene to the user, providing a powerful “telespresent” type of command and control environment right in the browser (see Figs. 2-5). From a user perspective, it is this “virtual presence” nature in a comprehensive real-time augmented virtual reality browser that is a defining feature of the next generation COPSS, although other critical technological features are necessary to

Figure 1. 8-layer architecture generates actionable information.
enable this experience. An open, layered, networked service/resource-oriented architecture like fourDscape is just the first technology step.

Figure 2. A realistic Virtual Reality interactive scene in a 4D browser.

Figure 3. Augmented Virtual Reality in an interactive 4D browser.

Figure 4. Tracking security assets and surveillance in an urban environment.

Figure 5. Virtual Reality telepresence inside building structures.

These eight layers/components operate as a networked, distributed architecture, similar to what today is commonly called “cloud” computing, using a variety of network protocols. For example, Layer 1 Resources can be configured as remote sensor feeds over the internet, communicating as a RESTful network resource, or a web service, using standard HTTP protocol, XML payloads, etc. The same applies for remote browsers, servers and engines. This creates a powerful network “cloud” of resources and services that, as data flows up the layered system and is transformed from independent information into cohesive knowledge, results in the delivery of Shared Situational “telepresence”-like Awareness for users at all levels and command locations.

B. Interoperability: Extensive 3rd Party Integration Capability

With fourDscape's open, layered, networked architecture, it is inherently designed for rapid integration with other systems and deployment in “system of systems” integrated frameworks (peer-to-peer, layered, master-slave, client-server, etc.). This is important, as next generation COPSS must leverage (per PPD-8) all available resources already deployed. Third party vendor system integrations preferably take place at the network interface level, i.e. integrated as part of the layered, networked “cloud” of assets, but can and have also been done at the SDK/API software level as well.

To exemplify and reinforce this important COPSS capability, we can look at how fourDscape has successfully leveraged its open, layered, networked architecture and integrated with numerous third party vendor sensor/systems, including the following extensive list: numerous IP/USB/website cameras, including Axis, Sony, Panasonic, Samsung, Mobotix, Verint, and including Siemens IPSP panoramic camera system and video analytics; GPS NMEA tracking devices; various environmental sensors, including MIT/Lincoln Labs chemical sensors with false alarm analysis/trending graphs and threshold level alerts for numerous chemicals, and mobile chemical sensors deployed at the Rose Bowl Parade; Wide-area persistent surveillance video (ITT system); Regional Geographical Information System (GIS) repositories/layers/formats (including
shapefiles); Breaking News Network (BNN) alerts geospecific to each region of interest; NOAA time-lapse weather overlay/models (similar to dynamic plume and other environmental models for decision support), buoy reports, etc.; Power outages; Airport delays; Bus tracks/paths/stops; Web mapping/feature services (WMS/WFS); SQLite embedded databases (DBs), PostgreSQL DBs, Microsoft SQL DBs, Microsoft Excel datasets; Semi-automated Standard Operating Procedures (SOPs), with steps/sequences cataloged, retrieved from SQL databases, and executed; 3D models/images from Pictometry & Fugro EarthData Oblique Imagery warehouses, PLW ModelWorks City Models, and dozens of common 2D/3D image/model formats; textured terrain meshes; 3D physics models such as Open Dynamics Engine (ODE); Smart Integration Manager Ontologically Networked Framework (SIMON, developed by SRI International); Unified Incident Command and Decision Support (UICDS, developed by SAIC for DHS, now includes Integrated Public Alert and Warning System (IPAWS) feeds; OnSSI Video Management System; VidSys Video Management System; Milestone Video Management System; Verint IP Video System; Vicon Video Management System; SteelBox Video Management/Recording/Playback System; Siemens APOGEE Building Management System using industry standard BACnet protocol; ShotSpotter Gunshot Locator System; ImmersiMap 360degree video walkthroughs and ingress/egress path determination; Qtags GuestAssist personal assistance request system (i.e. for stadium crowds); GPSit personnel/vehicle tracking system; Silent Passenger personnel/vehicle tracking system; Sentel BrainBox Sensor Management System; ScaleableDisplay EasyScene dome projection management system; Transportation Simulation System (TRANSIMS) traffic/evacuation modeling/simulation system; Mission Critical (M.C.) Access Building Information Model/Repository System including SOPs and other critical facility information, such as notification lists, building employee lists, 360degree video/image inventory, floor plans, fire suppression, gas & electric utilities, etc.; SRI Aware/MobileMesh network connectivity; GlobeComm Satellite backhaul connectivity; 3G/4G and mobile video cell network connectivity; and local WiFi Hotspot network connectivity.

This seemingly exhaustive list is just the beginning, clearly demonstrating the critical need for a COPSS framework that supports open, rapid integration of the enormous quantity and diversity of existing and future information resources.

C. Integration with Alert/Notification Systems

Integration with third party local, regional and national alert/notification systems is just as critical, and is straightforward with an open, layered, networked COPSS architecture. A next generation COPSS needs to share messages, alerts and warnings not just with emergency responders, but with the entire community to coordinate an effective emergency mitigation and response. A fourDscape-based COPSS also has a number of embedded native alert/notification functionality, including: receiving alerts from sensors and remote command centers, using the Emergency Data Exchange Language / Common Alerting Protocol (EDXL/CAP) Standard; Embedded Short Message Service (SMS) client to send text alerts over cell network to identified phones; Embedded Multimedia Messaging Service (MMS) capability to send live video streams to smartphones; Embedded email client/server to send/receive email notifications/alerts; Semi-automated Standard Operating Procedures (SOPs) that automatically send out multiple alert notifications (text, email) on a single mouse click; Use of 3rd party softphone technology for voice communication; and sending/receiving/playing of audio.wav files for audible canned messages and alerts. These are all important means of disseminating information for any next generation COPSS.

D. Comprehensive Situation Awareness

The next generation COPSS creates a powerful Augmented Virtual Reality (AVR) telepresence for every user. It delivers comprehensive situational awareness in a natural, realistic, interactive real-world experience, as if you were there. With a fourDscape-based COPSS, integrating the full complement of all available live geospatial-temporal data/sensor feeds together with all available static 3D GIS data/imagery and 3D/dynamic models, users can independently move and interact with the 4D virtual reality scene in real-time to remotely evaluate the known situation inside, outside, underground, locally or regionally (i.e. from ANY aspect) as it occurs. This creates powerful situational awareness for all levels of users. See Fig. 6 for a sample screenshot of an AVR environment simulating activity at a national airport, for example, which can be effectively applied to preparedness training, operations, security, emergency management and response, decision support, after action review, etc. at all levels.

![Figure 6. Airport Operations in an Augmented Virtual Reality COPSS](image)

E. Scalability

The next generation COPSS architecture must be designed to facilitate the communication of information, raw data, and/or actionable intelligence where and when it is needed. That requires real-time Global Information Sharing capability, both “vertically” to all levels of responders, managers and decision
makers, and “horizontally” to other local, regional and/or national command center operations supporting the emergency response. Fig. 7 graphically describe what this entails, and how a fourDscape-based COPSS achieves it.

![Figure 7. All levels of Information Sharing possible in a Regional COPSS](image)

Here you can see that there is bi-directional shared situation awareness (SSA) information flowing to/from responders at the incident site (using a variety of wireless handheld devices, including smartphones), incident commanders at mobile command posts (here shown as mobile “tailgatER” units (the “ER” is capitalized for Emergency Response - a fourDscape-based mobile common operating picture deployable in almost any vehicle), emergency managers and decision makers at emergency operations command centers, and between local/regional supporting command centers. Responders on-site can send live sensor data/video back to a mobile tailgatER incident command post, which in turn shares these data feeds back to the local/regional command center. And commanders, managers, and decision makers in command centers can send critically identified data/video (that it may have received from other responders, mobile tailgaterRs or other command center camera assets) directly to incident commanders using tailgatERs and responders handheld devices. For example, if a command center manager or incident commander recognizes a video feed that is time-critical to first responders on-site, by a simple drag-n-drop operation in the fourDscape COPSS browser they can immediately send that live video feed directly to the responders iPhones. This is powerful information sharing - situational awareness delivered where and when it is needed.

Next generation COPSS also need to share information globally. A fourDscape-based COPSS 4D Portal can also encompass the entire globe in 4D, where the user in a fourDscape browser can spin around the globe and hop from one locality to another, flying down to each Area of Interest (AOI) to analyze the available live sensor/data resources and 3D/4D models (i.e. the “augmented virtual reality”). Many AOIs of all sizes, locations, and resolutions can be supported, and alerts can be configured to automatically take the user to the appropriate location where the emergency/alert is taking place to instantly access the live sensors/models in a COPSS AVR visual scene.

F. Training

For operators, users, managers, and decision makers, next generation COPSS must be easy to use and understand at all levels. A fourDscape-based COPSS 4D browser is “walk-up” technology – in just a few minutes of guided usage any competent individual can be operating the natural, realistic virtual reality graphical interface and deriving valuable situational awareness. It is also important to understand that fourDscape technology is natively designed to support full real-time man-in-the-loop virtual reality simulation capability. Called “Embedded Training”, live sensor/data feeds can be replaced with simulated/recorded feeds depicting an emergency scenario, where emergency responders and managers can train using the same COPSS that they use live every day, making tabletop preparedness exercises much more effective. Simulated embedded training is a critical component of next generation COPSS. Enhanced training frequency and quality can minimize diminishing skills between training sessions that need to remain ever sharp when called upon to execute effectively under stress – lives may depend on it.

G. Information Assurance (IA)

Data security is of utmost importance, especially public network traffic, to prevent sensitive data feeds from being stolen, modified, or spoofed. For Information Assurance, the fourDscape-based COPSS has currently integrated Secure Socket Layer (SSL) encrypted transmissions, HTTP request authorization, and can readily implement other techniques for IA such as MD5 digest, OAuth, etc. For next generation COPSS to remain effective, the information they provide must be reliable, secure, and authenticated.

H. Certification & Compliance

There are a number of high-level certifications and compliance to standards that next generation COPSS must address, such as:

DHS SAFETY Act – provides liability protection to providers and users of qualified anti-terrorism technologies (QATT). Full details can be found in [3]. fourDscape has completed the pre-application process and is currently in process of submitting its completed full QATT certification application for expedited approval;

HSPD-5 National Incident Management System (NIMS) – full details can be found in [4]. A fourDscape-based COPSS is well aligned to support certain aspects of NIMS and Incident Command (ICS), such as scope of control, logistics, intelligence, etc. The fourDscape browser has used Homeland
Security Working Group symbology, but its design is flexible to incorporate other desired symbology sets as needed;

PPD-8 National Preparedness – aimed at achieving an integrated, layered, and all-of-Nation (all levels of government, the private and nonprofit sectors, and individual citizens) preparedness approach that optimizes the use of available resources. Full details can be found in [1]. The fourDscape-based COPSS approach and architecture is very closely aligned with this presidential directive – it is a layered and integrated network/cloud architecture that scales from private assets to local to regional to national scope, utilizes all available resources (new and already deployed sensor/data systems) from any and all sectors of society, even all the way down to an individual’s smartphone. The future of emergency preparedness and response lies with every individual (i.e. “all-of-Nation”); next generation COPSS must be capable of engaging with every resource and asset in the Nation.

I. Platforms

Next generation COPSS must be very flexible and configurable for a wide range of platforms and operating systems. fourDscape-based COPSS includes full immersive dome, touchscreen wall, desktop, laptop, handheld, and remote browser platforms. fourDscape software has been developed as a platform independent system with no specific platform dependencies (ex: Microsoft.NET), and as such is inherently designed to be compiled and deployed on most MSWindows (XP and beyond), Linux (fourDscape’s original environment), or Mac platforms. Next generation COPSS will also require a diverse and effective network communications infrastructure, which can include a combination of high-speed terrestrial internet, local 100MB/GB LAN, WiFi, mesh, 3G/4G cell, satellite, etc.

III. CONCLUSIONS

fourDscape-based COPSS has been utilized on a wide variety of projects, including recent/ongoing fourDscape EM/COPSS work with SRI International and the Port of Tampa FL, U.S. Air Force Research Laboratory, Nassau County NY Police Department, DHS S&T, the ASFHS, and embedded/simulated training for NASA Ames & the National Aviation Technology Center at Dowling College in Shirley NY.

This is just the tip of the iceberg. There is much more work to be done to integrate and deploy next generation AVR (like fourDscape) EM/COPSS where it can make an impact on the CONOPS and effectiveness of every security and emergency management, preparedness, mitigation, response and recovery operation, organization and agency. In [5] a national roll-out plan is presented that can begin this process of bringing powerful next generation emergency management COPSS technology to the forefront and make a substantial impact on the effectiveness of our nation’s future emergency preparedness and management operations.

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REFERENCES


BIOGRAPHY

Robert E. Balfour (BS’77, MS’80, PhD’99) is a Computer Scientist and Chief Technology Officer at VCORE Solutions LLC, a Resident Research Partner at the Morrelly Homeland Security Center in Bethpage, NY. An expert computer software/systems engineer and consultant for most of his career, over the past decade he has been issued multiple U.S. Patents for the invention of the 4D Browser, which forms the basis of VCORE’s current fourDscape® technology. Dr. Balfour has been instrumental in the development of fourDscape software, which has won multiple Long Island Software Awards (LISAs) and has also been recognized with the national Tibbetts Award from the SBA for outstanding contribution to a successful Small Business Innovation Research (SBIR) Program. Currently, Dr. Balfour continues his innovation at VCORE, applying fourDscape software technology to important homeland security applications.