Chemical and Radiation Sensors on Long Beach Fireboats
Evaluation of Plans for Data Collection, Real-Time Data Display, and Storage

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The Port of Long Beach is purchasing two new fireboats, which will have onboard three sensors for detecting hazardous chemicals and radiation. The sensors chosen are:

RAID® M100 ion mobility spectrometer for detecting chemical warfare agents and toxic industrial chemicals,

Dräger® X-am 7000 multi-gas detector for detecting methane (CH_4), isobutane (C_4H_{10}), oxygen (O_2), hydrogen sulfide (H_2S), and ammonia (NH_3),

FLIR® identiFINDER for detecting radiation sources and identifying the isotope emitting the radiation.

Each of these sensors can be hand-held. Previously, a firefighter would be required to periodically pick up the sensor and radio its readings along with the location of the sensor to some person outside the danger area, who would then relay that information to the other firefighters, as needed. The person reading the screen on the sensor could be in a hazmat suit, which made reading the sensor display difficult. For its new fireboats, the Port of Long Beach has specified that the three sensors on board for detecting hazardous chemicals and radiation should automatically transmit their readings and location to a manned computer outside the danger area, probably below the bridge. Firefighters will be able to do their job without looking at meters, but knowing that someone else is. The Port of Long Beach selected Safe Environment Engineering to implement the automatic transfer of meter readings to a computer near the ship's bridge. The Aerospace Corporation was selected to evaluate Safe Environment Engineering's hardware, software, and procedures for doing this. This report gives the results of that evaluation.

David Lamensdorf, CEO/President of Safe Environment Engineering, visited Aerospace on January 21 and 22, 2015. On the first day, Lamensdorf showed us (George Scherer and Karl Westberg) the Safe Environment Engineering hardware and software that will be used on the Long Beach fireboat and trained us in its use. On the second day, we evaluated that hardware and software and their suitability for use on a fireboat.

Figures 1 through 3 are photographs showing the equipment Lamensdorf brought with him and set up in our lab. Figures 4 through 6 are computer screen captures showing real time sensor readings and the location of each sensor. The information on the screen is updated at the same rate as the readout on the sensor is updated. The captions on Figures 1 through 6 describe a likely way the Safe Environment Engineering hardware and software would be deployed on the Long Beach fireboats.

Attached to each sensor is a "Life-line Interoperable Network Communicator" (LINC), which wirelessly transmits data sent to it by the sensor. Each sensor must be connected to a LINC. Different sensors output data in different ways; there are many different standards in use. The RAID and FLIR sensors output their data as RS-232 signals, the Dräger sensor outputs its data as an optical infrared signal. Other sensors on the market output their data as 4-20 mA analog signals, or digital signals employing the Internet protocol (TCP/IP) or the USB communications protocol. Lamensdorf emphasized that should Long Beach decide to use different sensors with different output signals, the LINC would be able to read those signals (although we would assume that there might be exceptions or new protocols in the future that would require the LINC to be modified in some way).

Regardless of the sensor, the LINC to which it is attached will always output a Wi-Fi signal. The information in the Wi-Fi signal from each LINC must somehow be transmitted to the computer near the fireboat's bridge and displayed in real time on the computer's screen. As discussed in the caption of Figure 1, the first step in the procedure for doing this is that a "Life-line Gateway" receives the Wi-Fi signals from every LINC and sends the information in those signals by one or more methods to the computer. The Gateway will most likely send the information to a secure remote server via a cell phone connection. The onboard computer would access this server and the information on it via the Internet. It would seem to us that variations in this procedure might possibly advantageous; one example being that if the Gateway should be installed permanently at one location on the boat, it might be advantageous to have a wired connection from it to an external antenna for a better cell phone connection. Or it might be advantageous to have the server that receives the information transmitted by the Gateway be on the fireboat, in which case a Wi-Fi transmission to that server might be desirable.

Lamensdorf did not definitely commit himself to any scheme for transferring the sensor data received by the Gateway to the local computer under the fireboat's bridge. This approach is advantageous because it leaves open the option of choosing the most suitable way for the fireboat application. Lamensdorf said, "It is my job to make it work, and I will do that." In our opinion, he has the flexibility and the tools and the equipment to make it work, which is installing a robust data collection, display, and storage system that meets the needs of the Long Beach Fire Department.

We evaluated all the specifications of the Life-line system that might possibly be applicable to its installation on the Long Beach fireboats. This evaluation is summarized in Tables 1a and 1b. Our conclusions are

(1) The Life-line system meets its specifications.

(2) Its installation and checkout needs to be done by an expert, namely, David Lamensdorf and his company, Safe Environment Engineering.

(3) The persons who will likely be at the computer viewing in real time the sensor readings need to be trained. The training should be supplemented by a specially prepared instruction manual that includes all the information needed to use the Life-line software and to interpret the screen displays. The manual should not include information that is not directly applicable to the installed system and its intended use. We think that with training and a well-written manual, the Long Beach firefighters will find using the Life-line system to be easy and straightforward.

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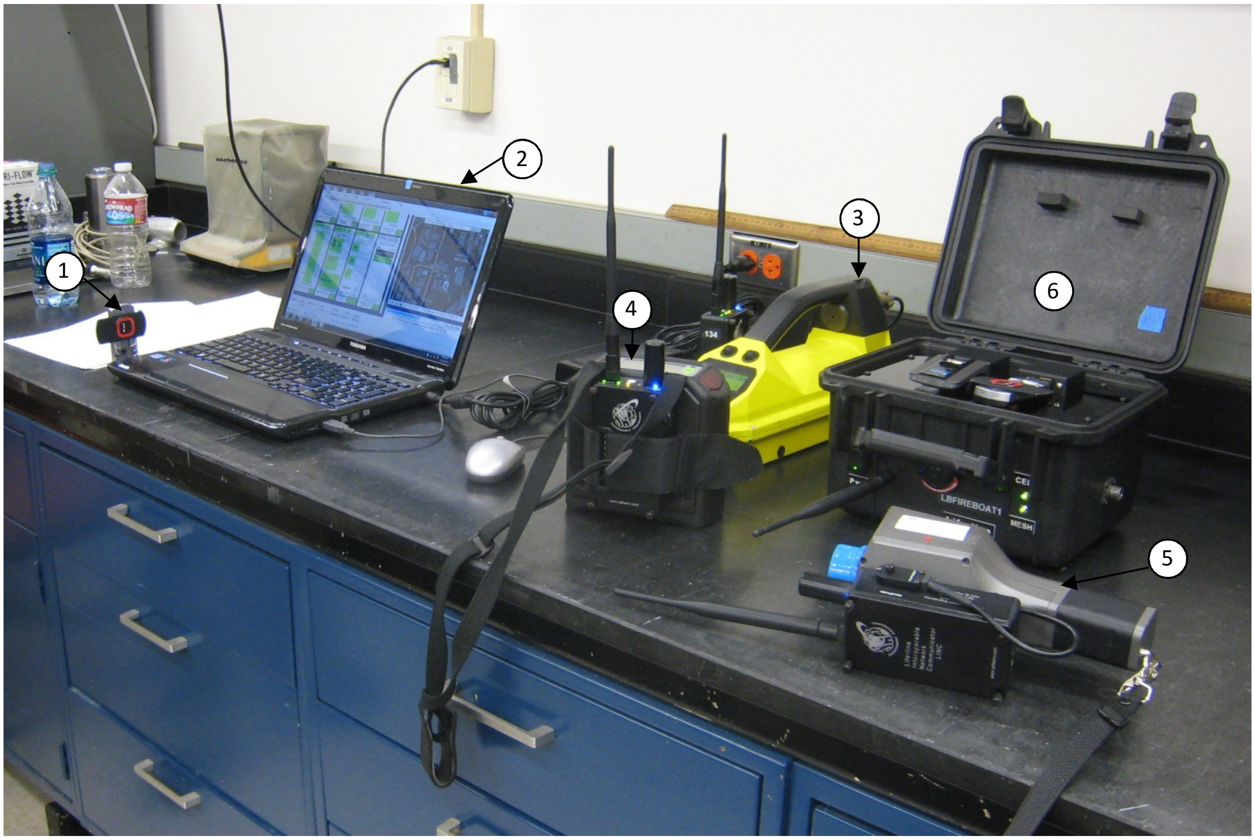

Figure 1. This is a photo of the test set-up. A Verizon 4G LTE cell card (1) was attached to a laptop (2), enabling the laptop to access the Internet wirelessly. The laptop used Life-line® software to read and display the output from three instruments, namely, a RAID® M100 ion mobility spectrometer (3) for detecting chemical warfare agents and toxic industrial chemicals, a Dräger® X-am 7000 multi-gas detector (4), and an ICX® (now FLIR®) identiFINDER (5) for detecting radiation sources and identifying the isotope emitting the radiation. Each of these instruments was connected a "Life-line Interoperable Network Communicator" (LINC), which wirelessly transmitted the data outputted from the instrument to the "Life-line Gateway" (6). The Life-line Gateway could be set to transmit the data received from the LINCs directly to the laptop, or preferably, when a cell phone connection is available, the Life-line Gateway could be set to transmit data to a remote server via the cell phone connection. The laptop would then access the remote server on which the data are stored via the Internet.

Figure 2. This photo shows the “Life-line Interoperable Network Communicator” (LINC) connected to the ion mobility spectrometer (IMS). The IMS outputs data as an RS-232 electrical signal. LINC receives the data and sends it to the Life-line Gateway. Communication between the IMS and LINC is initiated by handshaking. See Figure 3 for a close-up view of the lights on the LINC and their meanings.

Figure 3. This photo shows the LINC connected to the Dräger® X-am 7000 multi-gas detector. The Dräger outputs its data via an infrared optical signal to the LINC, and the LINC transmits the data to the Life-line Gateway. Communication between the Dräger and LINC requires handshaking. As discussed in Figure 1, the Life-line Gateway sends the data it receives from the LINCs to a laptop. The steady green light on the LINC labeled "Data" indicates that the data from the Dräger are successfully getting to the laptop. The steady green light labeled "WLAN" (Wireless Local Area Network") indicates that communication to the Gateway is wireless. The orange light indicates that the LINC is powered on; the blue light, that it is receiving a GPS signal. If the battery were low, the light labeled "Batt" would be red.

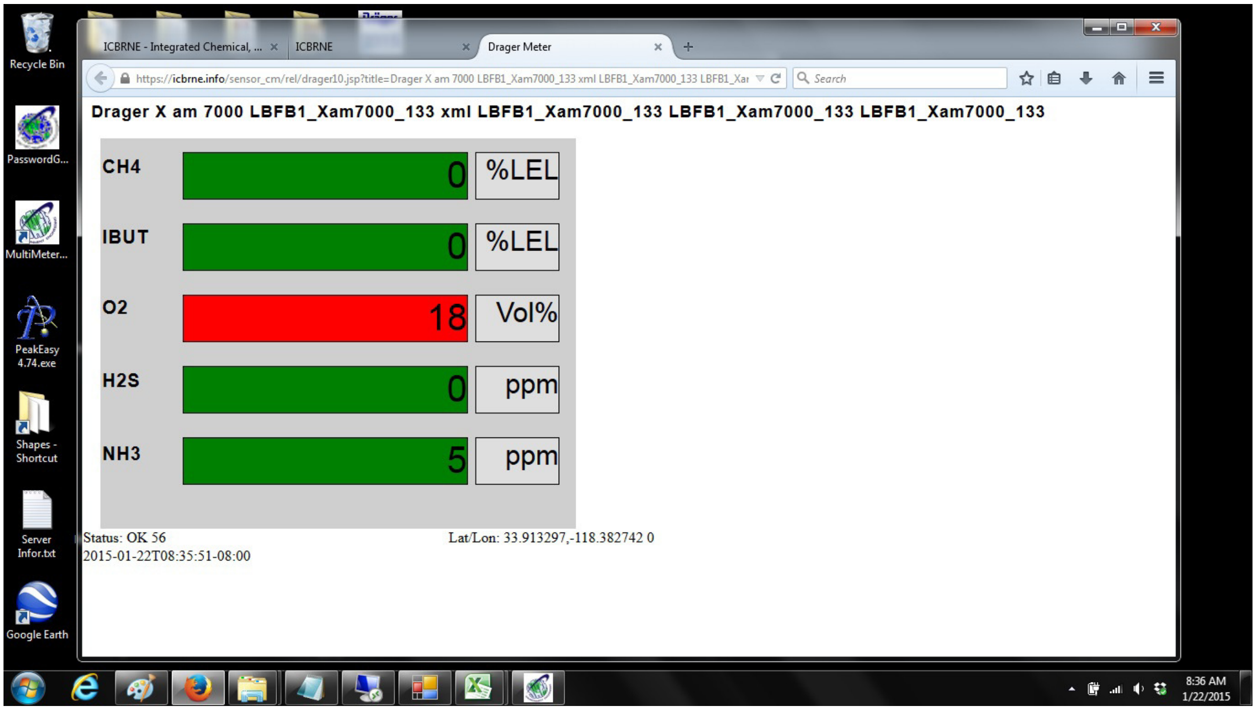

Figure 4. The laptop shown in Figure 1 used Life-line software to receive and display the data outputted from the three instruments shown in that Figure. The data received by the laptop can be displayed in several different ways. Double clicking on the onscreen Dräger icon results in the display shown in this screen capture. The display has the same format and would contain the same information as the display on the Dräger X-am 7000 multi-gas detector itself, as can be verified by comparing this display with that on the Dräger shown in Figure 3. In the laptop display, the window containing the measured percent oxygen has a red background, indicating that the oxygen level is too low. If the measured amount of methane, isobutane, hydrogen sulfide, or ammonia had been too high, the background of the windows displaying the out-of-limit amounts would have also been red.

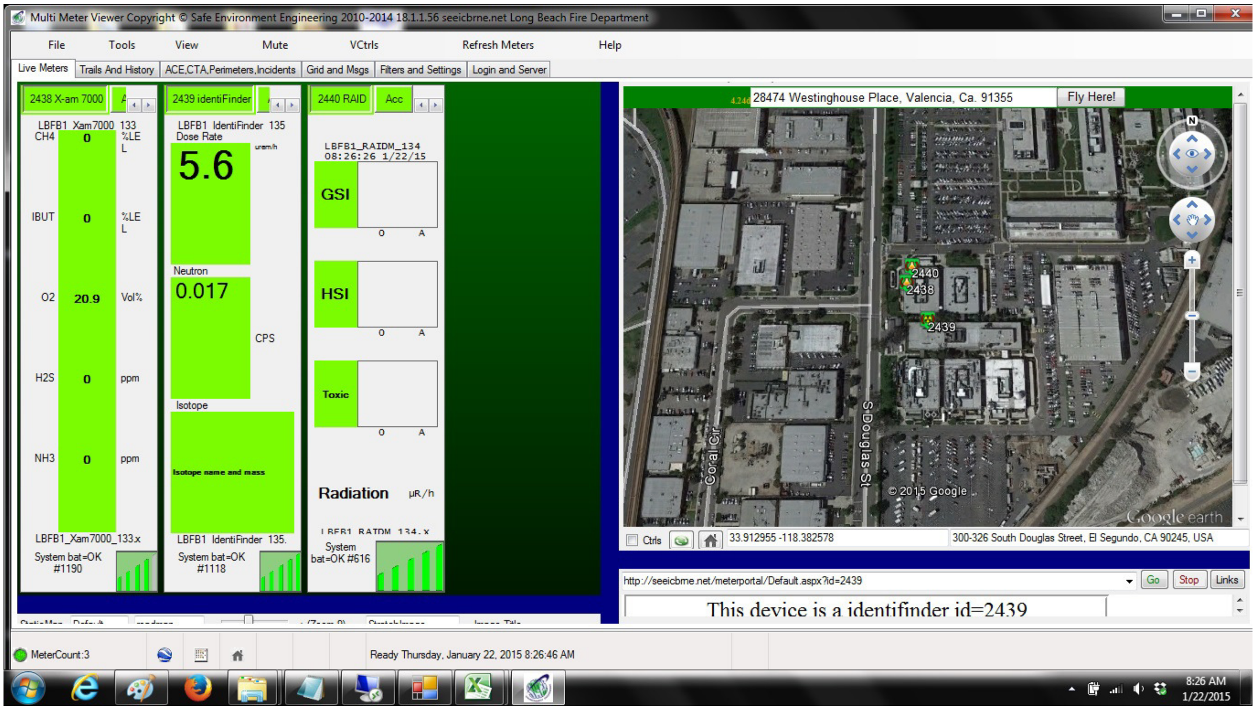

Figure 5. In this screen capture the outputs of all three instruments are displayed along with a Google Earth photo showing where each instrument was located. The location of each instrument was determined by the GPS in the LINC attached to it. The Google Earth photo was retrieved by the remote server that received sensor data from the Gateway.

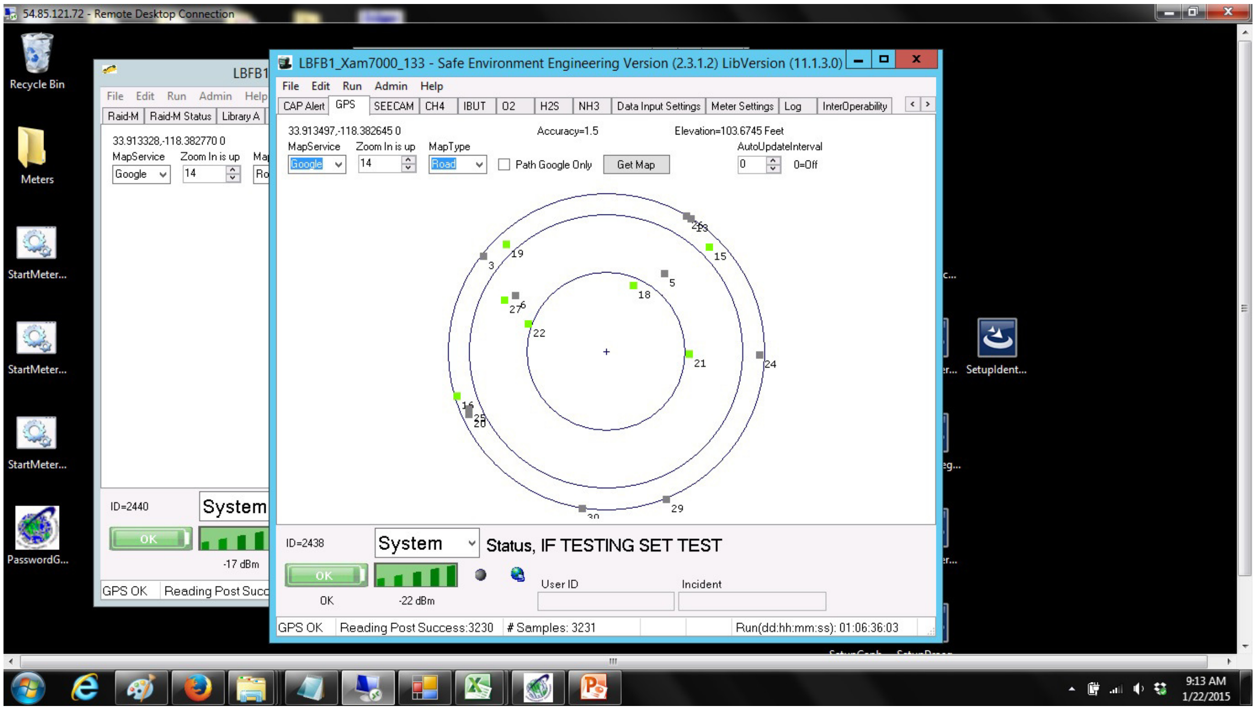

Figure 6. This screen capture gives the GPS coordinates of the Dräger X-am 7000 multi-gas detector, its elevation above the GPS ellipsoid, and the accuracy to which the coordinates were determined (1.5 m in this case). Also shown is a map of the satellites (gray and green boxes) used in determining the location of the Dräger.

Spec#	Description	Validation Method	Status	Comments
1.1	*Overview*			
a	Real-time actionable information in the form of remote real-time instrument console displays	Demo	Verified	
b	Geographically delineated information	Demo	Verified	
1.2	*First Responders*			
a	Remote real-time data from a safe location	Demo	Verified	
b	Color-coded schema and audible alarms	Demo	Verified	
c	User adjustable thresholds and alarms	Demo	Verified	
d	CAP messages -- Manual	Demo	Verified	
e	CAP messages -- automatic	Demo	Verified	
1.3	*Subject Matter Experts*			
a	Remote real-time data with additional detail	Demo	Verified	
b	Closely resembling the numerical display of the instrument	Demo	Verified	
c	Filter and limit display of meters	Demo	Verified	
d	Downloadable software from the web	Demo	Verified	
e	Tools must have been proven in large-scale regional exercises and interoperability trials	Vendor Doc		
1.4	*Emergency Management and command operations*			
a	Remote real-time data with additional detail	Demo	Verified	
b	Closely resembling the numerical display of the instrument	Demo	Verified	
c	Filter and limit display of meters	Demo	Verified	
d	Downloadable software from the web	Demo	Verified	
e	Tools must have been proven in large-scale regional exercises and interoperability trials	Vendor doc		
2	*Information System Architecture*			
2.1	*General Network Data Security Policy Reauirement*			
a	All subsystems and appliances shall be protected by means of a configurable administration account including user identification and password.	Demo	Verified	
2.2	*Encryption standars compatibility policy requirement*			
a	802.11i compliance, with WPA2 AES 128-bit encryption	Vendor doc	Verified	WLNN-xx-DP551 Series spec sheet
2.3	*Standard Data Telecommunication Protocol Policy Requirement*			
a	System shall be capable of using OASIS Common Alerting Protocol version 1.1 (CAP)	Vendor doc	Verified	National Incident Management System (NIMS) Supporting Technology Evaluation Program (STEP) Report

Table 1a. Requirements Verification Matrix. This table lists the system requirements from the "Long Beach Fire Boat CBRN System Functional Requirement Specification" document, together with the verification method used and the verification status. The applicable verification methods are: Inspection, Demo, and Vendor Doc. "Inspection" means that the requirement was verified by visual inspection of the hardware. "Demo" means that the requirement was verified by observing the system performance during a demonstration at The Aerospace Corporation laboratories. "Vendor Doc" means the requirement was verified based on documentation supplied by the vendor. The rest of the table is continued on the next page in Table 1b.

Spec#	Description	Validation Method	Status	Comments
2.4	*Third-Party Applications and Systems Data Sharing Policy Requirement*			
a	System shall be capable of sharing CAP data with third party software	Demo	Verified	
2.5	*Wireless Interoperability*			
a	Use standard wireless data transport protocols	Vendor Doc	Verified	WLNN-xx-DP551 Series spec sheet
2.6	*Geographic Information Systems*			
a	System shall have a GIS subsystem	Inspection	Verified	
b	System shall include provisions for one or more GIS systems for use on mobile devices	Demo	Verified	
2.7	*Data Repository and System Logs*			
a	500 GB storage of message traffic	Vendor Doc	Verified	
3	*System Apparatus & Infrastructures*			
3.1	*Mobile Transmission Appliances*			
a	Proven in large scale regional exercises and interoperability trials	Vendor doc		
b	Minimum of 50 units must now be in continuous service with variety of meters	Vendor doc		
3.1.1	*User Interface and Operation*			
a	Momentary on/off switch with timer. No other HMI required to use	Demo	Verified	
b	Provide visual indicators of operational status, network connectivity, low battery condition and GPS acquisition	Inspection	Verified	
3.1.2	*Meter interface options*			
a	Mobile wireless transmission appliances shall have multiple interfaces for use with new and legacy sensors	Demo	Verified	
3.1.3	*Wireless Network Requirement Specification*			
a	Each MTA shall include a removable/replaceable gain antenna with SMA connector	inspection	Verified	
b	Nominal Indoor/outdoor ranges shall be 150/300 feet	Demo	Verified	
3.1.4	*GPS Receiver Requirement Specification*			
a	20 channels, 36 second cold start acquisition, etc.	Vendor doc	Verified	WLNN-xx-DP551 Series spec sheet
3.1.5	*Power Source and Sustained Operation Requirement Specification*			
a	At least 10 hours continuous operation on battery	Vendor doc	Verified	Vendor guarantees 16 hours

Table 1b. Requirements Verification Matrix. (continued)