The INACHUS Project

Establishing a framework to improve urban search-and-rescue operations

Earthquakes and other disasters place great demands on urban search-and-rescue (USaR) crews. Besides dealing with countless human tragedies, USaR crews must rapidly assess structures, set priorities for operations, and complete dangerous rescues—all while coordinating their efforts with other first responders. In January 2015, a 4-year project was initiated to help USaR crews meet these and other demands. The nearly 14-million-euro project, titled "Technological and Methodological Solutions for Integrated Wide Area Situation Awareness and Survivor Localization to Support Search and Rescue Teams (INACHUS)," involves 20 partners from nine European Union (EU) member-states and two associated countries. It is partially funded by the European Commission. Technologies developed under the INACHUS project include:

- Systems that use mobile phone signals to estimate the number of victims and data from electromagnetic, visible light, and chemical sensors to locate them;
- A snake robot mechanism capable of penetrating inside rubble to accurately locate and communicate with trapped victims;
- Decision-and-planning modules for advanced casualty and damage estimation based on airborne and ground-based laser-scanning and imaging data; and
- Simulation tools for estimating the locations of survival spaces and identifying the location of survivors after a structural collapse.

The first field test of the project was held in June 2016 and was focused on victim localization tools. The second field test was held in May 2017 and was dedicated to tests of wide area assessment tools and collapse modeling tools. The third field test was held in April 2018 and was the first demonstration of the integrated INACHUS tools. The project's final field test, to be held in October 2018 in southern France, will demonstrate the fully integrated INACHUS system.

First Field Test

The first INACHUS field test—a pilot demonstration of individual victim localization solutions in realistic conditions—was held in Ågesta, Sweden. This test focused on the INACHUS snake robot. In brief, the robot integrates a video camera and light, an infrared camera, an electronic chemical nose, a doppler radar, and a communication system. It also includes a seismic and acoustic sensor to detect and locate noises from victims as well as a mobile phone detector to help locate mobile devices hidden in rubble.

An early version of the project's Emergency Support System/Common Operational Picture (ESS/COP) was also demonstrated. The ESS is designed to allow data to be shared instantly and used by various levels of command to improve situational awareness and response coordination. The COP is an interface that shows sectors and corresponding activity within sectors, three-dimensional (3-D) point clouds, and simulation models. USaR teams will use ESS/COP to digitally complete the forms required of teams involved in large-scale response missions (by the International Search and Rescue Advisory Group [INSARAG]). Teams will also use the system to share data in real time with the different authorities and agencies involved in the management of a crisis, through the aid of summaries and analytics visualized on a dashboard for understanding of mission progress. The first field test was attended by 11 end users, and it was considered a success.

Second Field Test

The second field test, held in Lyon, France, demonstrated the project's wide area surveillance solutions and collapse modeling tools to an audience of USaR operations specialists and structural engineers from Sweden, Belgium, the Netherlands, and France. In collaboration with CARDEM (**www.cardem.fr/fr**) demolition company, INACHUS partners identified a building in Saint-Fons, France, and created a scenario for its collapse that mimicked earthquake conditions.

One of the goals of this test was to demonstrate that INACHUS technological solutions could help USaR professionals improve their situational awareness. These tools included systems for generating 3-D models of a target building to:

- Aid in damage assessment;
- Identify the location of potential voids;
- Assess the stability of the structure; and
- Aid in determining possible rescue paths.

Fig. 1: INACHUS tools applied during the second field test included: (a) a UAV with a laser scanner; (b) a ground-based laser scanner; and (c) a UAV with a digital optical camera *(photos courtesy of INACHUS project)*

Fig. 2: The third field test was the first demonstration of the integrated INACHUS system. The technologies included a robot equipped with sensors and communication systems *(photo courtesy of INACHUS project)*

In the field test, crews had the opportunity to observe the imagery and 3-D models created by the INACHUS tools. Two unmanned aerial vehicle (UAV) flights—one with a laser scanner and another with an optical camera—took place over the collapsed building (the same setup could be readily applied for wide area surveillance of an entire affected area following an earthquake). Data was also collected from a ground-based laser scanner. The three data sets were then combined, and each served to highlight unique features of the collapsed building.

The visualization tools are designed to help USaR teams develop a clear understanding of a rubble pile, qualify the stability of a structure, and set priorities for intervention zones. During the field test, participants were also able to view the INACHUS tools that simulate a building collapse caused from an earthquake or explosion. Applied Science International Europe SRL (ASI), an INACHUS partner, created a predemolition 3-D model of the target building based on precise measurements taken from a site visit. The known variables of the explosion provided by the demolition company were applied within the INACHUS tools, which led to a model that roughly matched the actual rubble pile. This tool is expected to aid USaR teams in finding possible survivable spaces within a collapsed structure when applying the phenomenon variables in the INACHUS simulation tools.

After a visual investigation of a building, USaR teams could evaluate whether the pile of rubble and its voids corresponded with the INACHUS models and simulation results. End users who participated in the event agreed that the system could aid in decisions related to victim localization and structural integrity during USaR missions. The ESS/COP system was demonstrated once again at the final stage of the second field test.

Third Field Test

Fifteen USaR professionals from Sweden, the Netherlands, the United Kingdom, and the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA) gathered on April 20, 2018, at Training Base Weeze in Weeze, Germany, to attend the penultimate INACHUS field test. The event was the first demonstration of the integrated INACHUS system, as well as an opportunity to collect end user feedback.

COP/ESS software

Participants assumed roles at various levels of coordination when using the INACHUS COP/ESS software for visualization of response progress, damage in the affected area, 3-D models, or photos. They followed a scenario and completed specific tasks and saw how the tools could improve on the current pen-and-paper information sharing. They were able to immediately visualize their results on a large screen in the training event command center.

Robot

INACHUS partners also demonstrated victim localization

tools in a complex rubble pile, where volunteers were hidden. End users were given the opportunity to operate the robot. They used the infrared camera and radar in its head to find a victim, and they used the robot's speaker and microphone to communicate with the victim. End users noted that the interface was easy to use and interpret, including the sensor data and camera views.

Vibration detection

The INACHUS seismic system was used to develop a "heat map" of vibrations produced by victims inside a rubble pile. Using multiple, highly vibration-sensitive sensors placed across the site, the system can detect and locate very weak signals. The key to success is that the system continually learns to detect signals that differ from background noise. During the field test, the system detected signals such as knocking, shouting, tapping, and scraping. Very loud background noise, generated by a power generator placed on top of the rubble, did not affect the ability to detect and locate the simulated victim. End users were very impressed by the efficiency of the system and agreed that it is a significant step forward compared to tools currently in use.

Electronic nose

The INACHUS electronic nose is a chemical sensor that is able to measure gas concentrations in the air of confined spaces. The nose can detect human presence based mainly on the composition of exhaled breath. It can also detect hazards typically encountered during confined space entry, such as toxic and combustible atmospheres or an atmosphere that can cause asphyxiation. During the demonstration, the sensor was able to indicate the presence of a hidden survivor by revealing changes in the composition of the air in a void. Hazards were also demonstrated using sample vials, gas canisters, or actual hazardous conditions.

Surface radar

The purpose of the INACHUS surface radar is to detect and locate subtle movements in the rubble, such as a victim moving or breathing. Detecting movement through rubble is generally very challenging, and the performance of radar systems varies significantly depending on the materials and structure of the rubble pile. Nevertheless, during the pilot demonstration, the INACHUS surface radar was able to detect slight movements through thick concrete. The end users found the tool easy to use and the interface simple to understand. However, the distance between the sensor and the movement at the site was limited and did not reflect the full potential of using radar for motion detection.

Communication network

INACHUS is also developing a reliable, autonomous, and secure communication network. This will be essential to USaR operations where existing communications means are overloaded or not functioning. The INACHUS network can be used to share digitized INSARAG forms (completed in the ESS) and other data from the field in real time. Furthermore, it will allow for communication between the base of operations and the worksite, which end users state is a widespread problem in real missions.

INACHUS Partners

- Institute of Communication and Computer Systems (ICCS), http://i-sense.iccs.ntua.gr
- EXODUS S.A. (EXUS), www.exodussa.gr
- Totalförsvarets Forskningsinstitut (FOI), www.foi.se
- Crisisplan B.V. (CBV), www.crisisplan.nl
- Office National D'etudes Et De Recherches Aerospatiales (ONERA), www.onera.fr
- IK4-TEKNIKER (TEK), www.tekniker.es
- Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut (EMI), www.emi.fraunhofer.de
- Cinside AB (CINSIDE), www.cinside.se
- Applied Science International Europe SRL (ASI), www.appliedscienceint.com
- DIGINEXT (DXT), www.diginext.fr
- Laurea University of Applied Sciences (LUAS), www.laurea.fi
- Entente Pour la Foret Méditerranéenne (EPLFM), www.entente-valabre.com
- Specialistisch bijstandsteam (USAR.nl), www.usar.nl
- Stiftelsen SINTEF (SINTEF), www.sintef.no
- University of Twente, Department of Earth Systems Analysis, Faculty of Geo-Information Science and Earth Observation (ITC), www.utwente.nl
- Schüßler-Plan Ingenieurgesellschaft MBH, ScPl, www.schuessler-plan.de
- Södertörns brandförsvarsförbund (SBFF), www.sbff.se
- TELINT RTD Consultancy Services Ltd.
- BYTE COMPUTER S.A. (BYTE), www.byte.gr
- Micro2Gen (M2G), http://micro2gen.com

Final Event

The final event for the INACHUS project will be held on October 16, 2018, at the Amphithéâtre Gilbert PAURIOL Centre Euro-Méditerranéen de Simulation des Risques, Valabre, France. Attendees can learn about the fully integrated INACHUS system and watch demonstrations of the very promising INACHUS tools such as the seismic sensors, the radar systems, and the electronic nose. The event will also provide opportunities to network with the project's partners and invited stakeholders. Participation is free of charge. For more information about the INACHUS project and the final field test, visit **www.inachus.eu**.

Selected for reader interest by the editors.