Science for Diplomats at EC-86

Innovation

and

the Chemical Weapons Convention:

The Scientific Advisory Board's Report on Emerging Technologies

Tuesday, 10 October 2017

Ooms Room 13:30-14:45

Light Lunch Available At 13:00

OPCW | OPCW 1997-2017 YEARS

Dr Christopher M. Timperley (Chair of OPCW SAB)

03-05 | **JULY - 2017**
RIO DE JANEIRO - BRAZIL

INTERNATIONAL WORKSHOP ON INNOVATIVE TECHNOLOGIES FOR CHEMICAL SECURITY

Science for Peace

#ScienceforPeace

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS
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Introduction

Workshop was third in a series to inform SAB's report on developments in S&T to the Fourth Review Conference

It explored the potential of new technologies to enhance capabilities necessary for the implementation of CWC

The content was based on findings that arose through the report of the SAB's Temporary Working Group on Verification

The workshop opened with several addresses, from Dr Mark Cesa (IUPAC Past President), Dr Jonathan Forman (OPCW Science Policy Advisor), and our generous Brazilian hosts

The Brazilian Academy of Sciences

Professor Luiz Davidovich

President of the Brazilian Academy of Sciences

Academy established in 1916 - it is the primary academy of sciences in Brazil

Famous collaborators :

1925 Albert Einstein

1926 Marie Curie

The Brazilian Chemical Society

Aldo José Gorgatti Zarbin

President of the Brazilian Chemical Society

Founded in 1977 and the leading chemical society in Brazil and one of the largest scientific societies in South America with over 4000 members

Devoted to the development and growth of the Brazilian chemical community, the dissemination of chemical knowledge, and the responsible application of chemistry

Mission matches OPCW's principle of peaceful and rational uses of chemistry

Workshop themes

Emerging technologies and implementation of the CWC

- Contingency operations: challenges for OPCW inspectors
- Aerial platforms as a tool for supporting OPCW inspectors

Collecting data in remote and dangerous environments

- Unmanned airborne mass spectrometers for harsh environments
- Unmanned aerial vehicle equipped with various chemical sensors
- Modular robotic toolbox for chemical investigation support
- Marine environmental sample processing system

Contingency operations and challenges for OPCW inspectors

Starting with the 2013 UN-led mission to the Syrian Arab Republic, the TS has undertaken non-routine inspection, verification and technical assistance activities in Syria, Libya and Iraq

These contingency operations have required investigations, analysis, and fact-finding, with collection and evaluation of oral, material, and digital evidence of the use of toxic chemicals

Contingency operations and challenges for OPCW inspectors

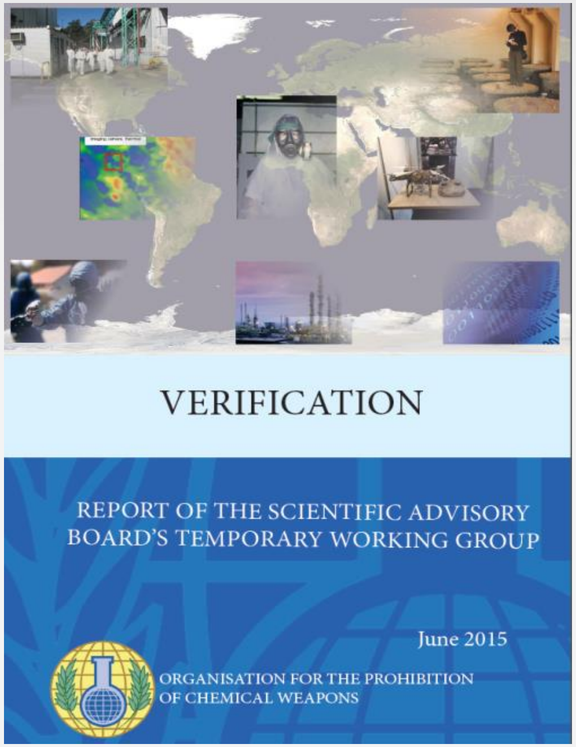
Non-routine situations in which these operations have occurred are insightful for consideration of new technologies with potential to enhance capabilities available to inspectors

Ms Katarina Grolmusova (Analytical Chemist, OPCW Inspectorate) reviewed the major differences between routine inspections & contingency operations involving OPCW inspectors

Some challenges of conducting non-routine missions

Non-technical: custom/transportation regulations (e.g. dangerous goods) can delay arrival of, or prohibit access, to certain equipment, and short-notice deployment

Technical: Access to investigation sites is time-limited; harsh environmental conditions; requirement for chain-of-custody, care required while obtaining and shipping samples; evidence needs authenticating, and requires expertise extending beyond chemical analysis

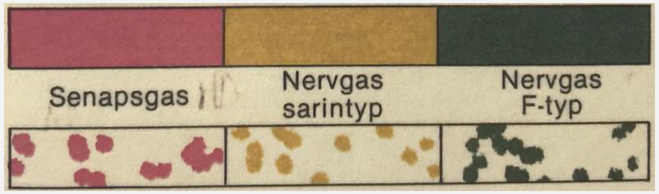


Enabling technologies that might be of value to inspectors

Useful on-site analysis tools were suggested to be those that provide preliminary detection (indicative tests) to guide where to collect samples for sending for off-site analysis

Examples of tools that are currently available to inspectors are CALID paper (colorimetric test) and hand-held detectors such as the LCD 3.3

Demonstration: CALID paper changes colour on contact with a chemical – the audience to test this and report the result



Point detection systems are used by inspectors

A single response by a detector (or CALID paper colour change) is only an indicator of the presence of a Schedule 1 chemical agent

False positives can occur, e.g. CALID colour change by a simulant

Aerial platforms as a member of the sampling team

Mr Guy Valente (Senior Project Officer, OPCW APB) discussed the advantages of unmanned aerial vehicles (UAVs) to support chemical emergency response operations:

- Scene documentation
- Safety support
- Sample planning
- Sample documentation

These technologies could provide a solution for States Parties seeking a chemical forensics and evidence management capability

Scene documentation

Safety support

Team on the ground employing 'hand signal' communication to UAV pilot in the cold zone

Raised fist indicates *"Something found"*

Pointing instructs the pilot to *"check there"*

UAV-assisted approach allows real-time observation in toxic environments from beyond the danger zone (improved safety)

Sample planning

Pilot may more closely examine an area

Pilot can communicate *"stop" or "go"* via LEDs on the drone to the team on the ground

Information recorded by the drone (evidence)

Team Leader and Safety Officer maintain radio and video contact with reconnaissance unit – upon return of this unit, the full team review the footage and develop a sampling plan

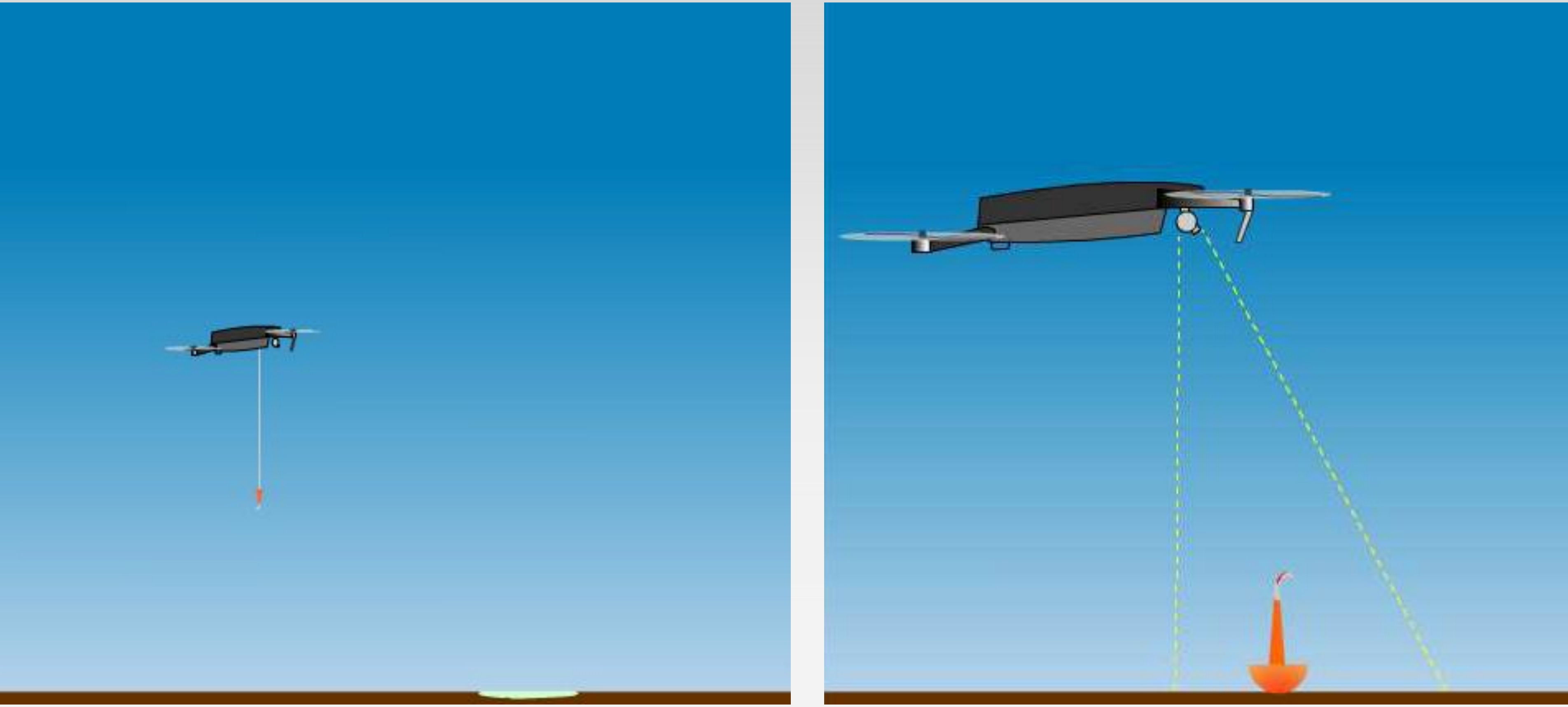
Sample documentation

Collation with wearable camera footage (Go-Pro™) creates a record of the scene taken from 200 m and at eye-level

Samples followed from their location scene all the way to the transport container

Sample chain-of-custody is thus ensured from the “hot zone”

Sampling and detection by UAV



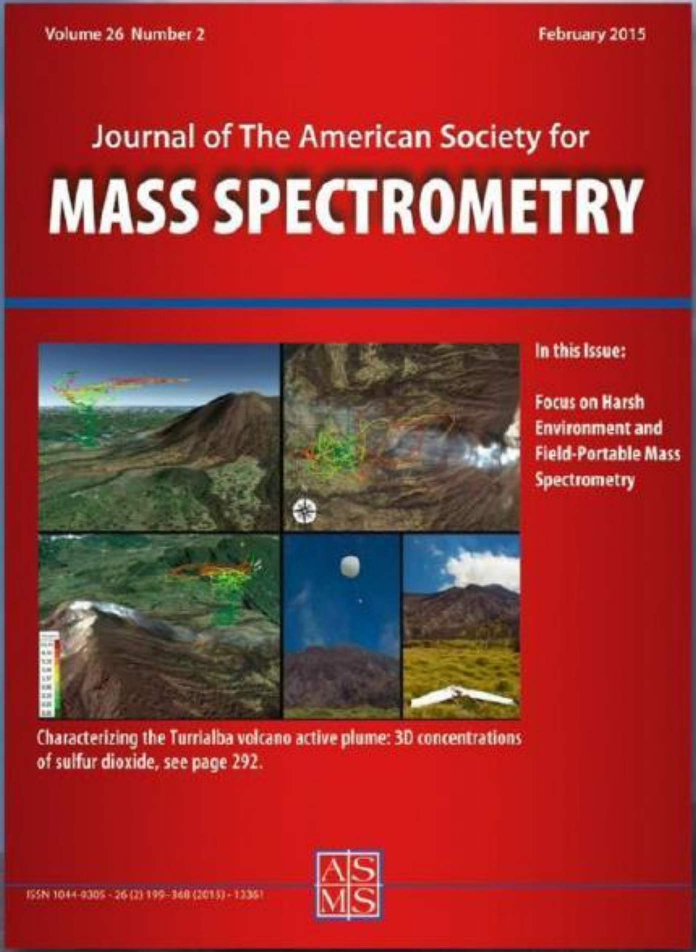
Demonstration of remote sampling: UAV immerses a piece of indicator paper into a "chemical spill" to result in a colour change

UAV with CBRN detection capability

Dr Marcel van der Schans (TNO, NL) presented research at TNO to allow measurements to be taken by a UAV in areas problematic for investigators to access (chemical-contaminated sites)

Research underway to equip the UAV with a gas sampling system which can be activated by an on-board generic detection system (need to locate away from downwash from the rotor blades)

Volcanic plume sampling and analysis achieved by UAV



FOCUS: HARSH ENVIRONMENT AND FIELD PORTABLE MASS SPECTROMETRY: RESEARCH ARTICLE

Unmanned Aerial Mass Spectrometer Systems for In-Situ Volcanic Plume Analysis

Jorge Andres Diaz,[1] David Pieri,[2] Kenneth Wright,[3] Paul Sorensen,[4] Robert Kline-Shoder,[4] C Richard Arkin,[5] Matthew Fladeland,[6] Geoff Bland,[7] Maria Fabrizia Buongiorno,[8] Carlos Ramirez,[9] Ernesto Corrales,[1] Alfredo Alan,[1] Oscar Alegria,[1] David Diaz,[1] Justin Linick[2]

[1]Physics School, GasLab, CICANUM, Universidad de Costa Rica, San José, Costa Rica
[2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
[3]INFICON Inc., East Syracuse, NY, USA
[4]CREARE LLC., Hanover, NH, USA
[5]Engineering Services Contract, Kennedy Space Center, Cape Canaveral, FL, USA
[6]National Aeronautics and Space Administration (NASA), Ames Research Center, Mountain View, CA, USA
[7]National Aeronautics and Space Administration (NASA), Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, VA, USA
[8]Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy
[9]Escuela Centroamericana de Geología, Centro de Investigaciones en Ciencias Geológicas, Red Sismológica Nacional (RSN), Universidad de Costa Rica, San José, Costa Rica

Abstract. Technology advances in the field of small, unmanned aerial vehicles and their integration with a variety of sensor packages and instruments, such as miniature mass spectrometers, have enhanced the possibilities and applications of what are now called unmanned aerial systems (UAS). With such technology, in situ and proximal remote sensing measurements of volcanic plumes are now possible without risking the lives of scientists and personnel in charge of close monitoring of volcanic activity. These methods provide unprecedented, and otherwise unobtainable, data very close in space and time to eruptions, to better understand the role of gas volatiles in magma and subsequent eruption products. Small mass spectrometers, together with the world's smallest turbomolecular pump, have being integrated into NASA and University of Costa Rica UAS platforms to be field-tested for in situ volcanic plume analysis, and in support of the calibration and validation of satellite-based remote sensing data. These new UAS-MS systems are combined with existing UAS flight-tested payloads and assets, such as temperature, pressure, relative humidity, SO_2, H_2S, CO_2, GPS sensors, on-board data storage, and telemetry. Such payloads are capable of generating real time 3D concentration maps of the Turrialba volcano active plume in Costa Rica, while remote sensing data are simultaneously collected from the ASTER and OMI space-borne instruments for comparison. The primary goal is to improve the understanding of the chemical and physical properties of emissions for mitigation of local volcanic hazards, for the validation of species detection and abundance of [illegible] based on remote sensing, and to validate transport models.

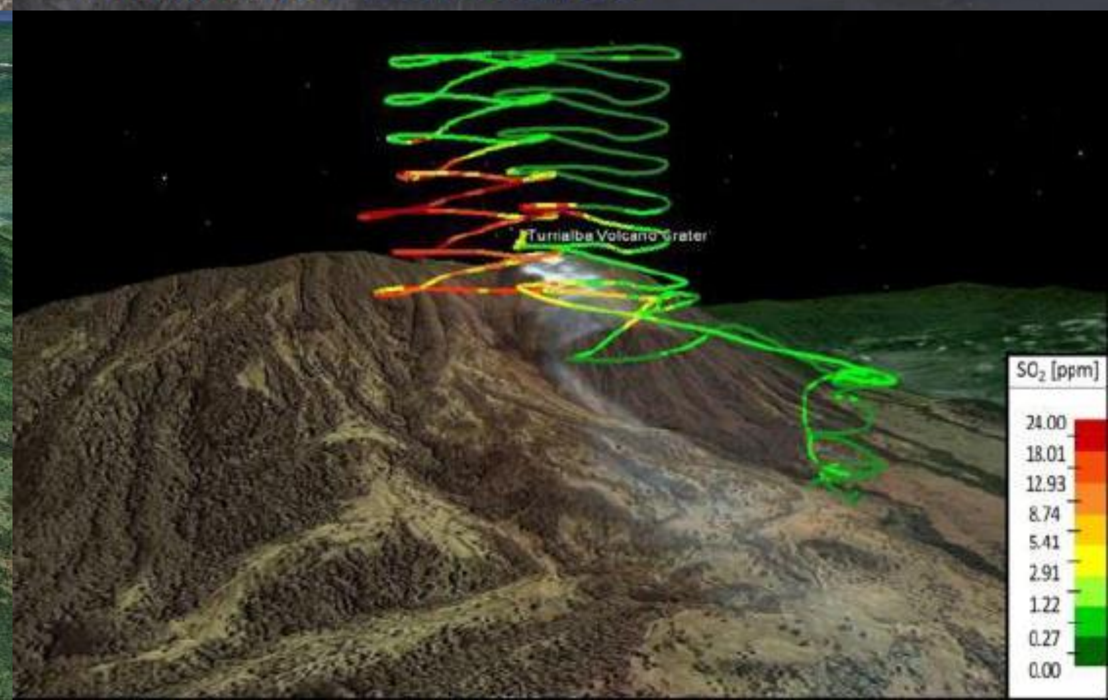
Keywords: Miniature mass spectrometer, In-situ gas analysis, Harsh environment, Unmanned aerial system, Validation and calibration, Remote sensing comparison, Volcanic plume analysis, Volcano monitoring, Airborne instrumentation, Volcanic emissions analysis

Artículo seleccionado como portada de la revista internacional *Journal of The American Society for Mass Spectrometry*
Edición especial de espectrometría de masas portátil de campo para ambientes peligrosos.

ISSN 1044-0305, Volúmen 26, Número 2, Febrero 2015

GASLAB CICANUM-UCR · Universidad de Costa Rica · JPL Jet Propulsion Laboratory · NASA · INFICON · Creare · Kennedy Space Center · Ames · Goddard Space Flight Center · INGV · RSN UCR-ICE

Ways to collect toxic gas samples and make measurements



Several sensors give more reliable results than a single sensor

MULTISENSOR SYSTEMS AND PATTERN RECOGNITION

Leader: Cristhian Manuel Durán A, Ph. D.
Founded: 2005

Universidad De Pamplona, Columbia

Research areas:

1. Industrial Automation
2. Data acquisition systems
3. Pattern Recognition and Artifitial Intelligence. Smart control.
4. Multisensor Systems

Control

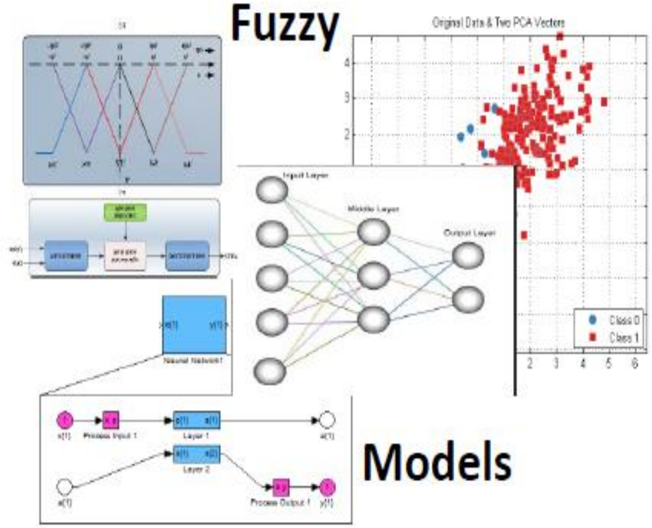
Ind Automation

OnChip (ANN)

DSP

DAQ and Embeeded System

Fuzzy

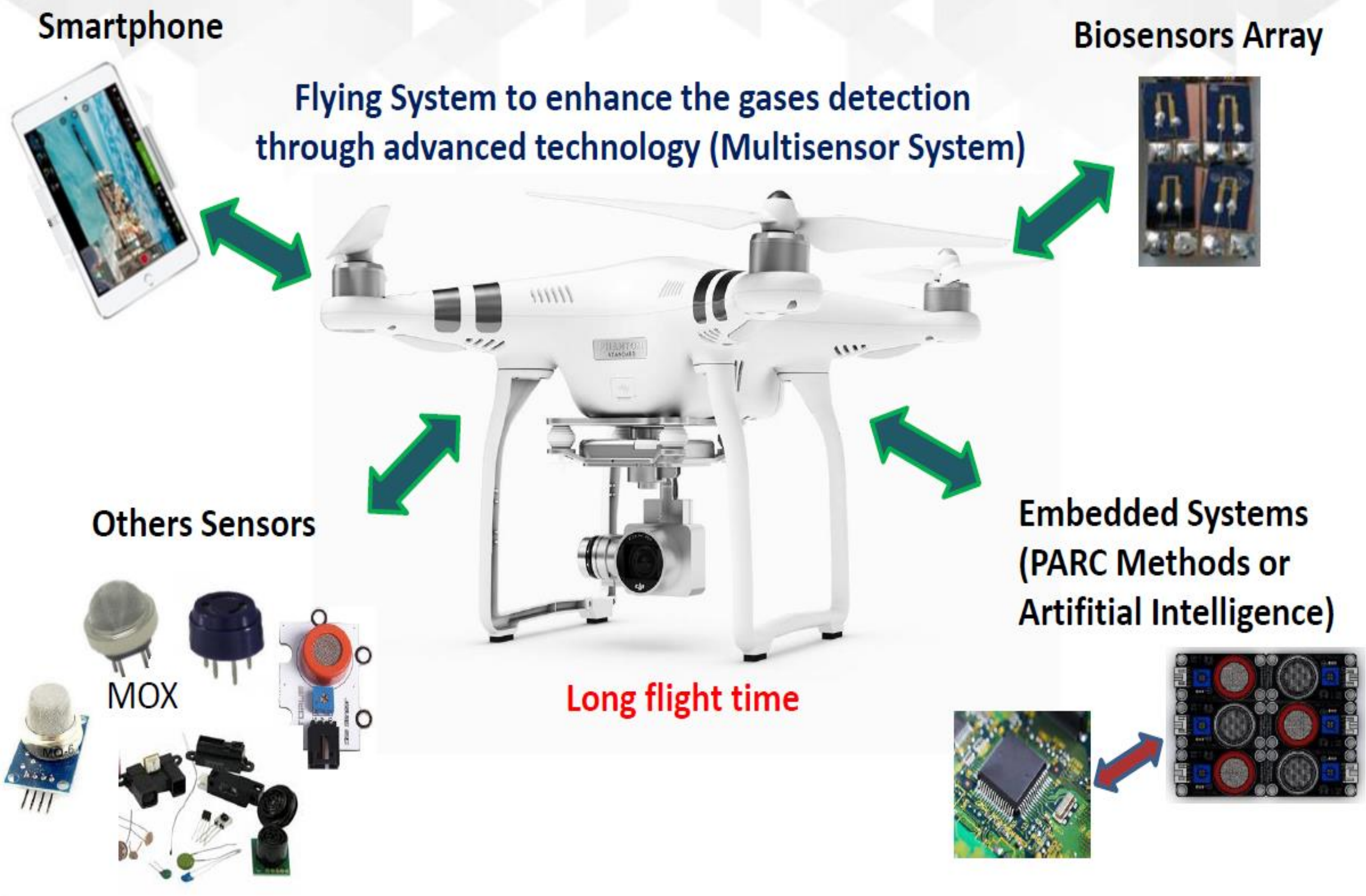


Models

- MOX Gas sensor
- Electrochemical Analysis

Multisensor System E-nose, E-tongue

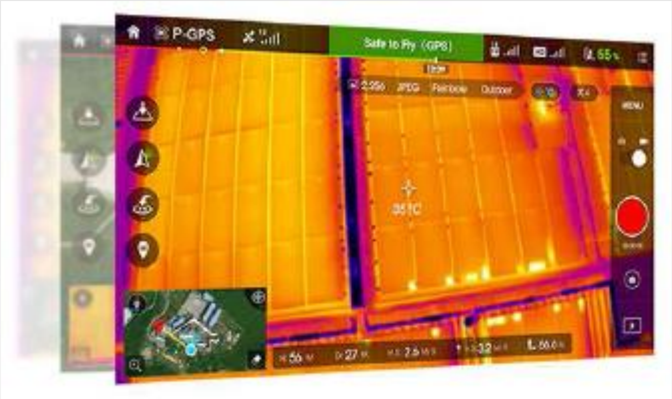
Sensor systems that might equip a UAV



UAVs in implementation of the CWC

Advantages can be foreseen for UAVs in the context of implementation of the CWC, especially for investigations:

- Pre-entry reconnaissance
- Scene documentation
- Entry route mapping
- Safety over-flight
- Recording sampling activities
- No need for wearable cameras
- On-board chemical detection/analysis
- Use as a flying sample transport container



Robotic land platforms for chemical investigations

Industrial Research Institute
for Automation & Measurements
PIAP

Poland

Grzegorz Kowalski

MODULAR ROBOTIC TOOLBOX FOR COUNTER-CBRN SUPPORT

Robot toolbox for chemical investigations

Talon

PackBot

Cobra

NBCmax

Equipment that can be added to land platforms

Liquid sampler

Environmental swab

Forensic set

Ground sampler

SPME adsorber

Air filter

Sample collection and processing of water

Dr Jim Birch (Monterey Bay Aquarium Research Institute, USA) described the use of unmanned systems for sample collection and processing of ocean water

Environmental Sample Processor (ESP) uses DNA probe and protein arrays to assess in near real-time the presence and abundance of specific marine organisms, their genes and/or metabolites (toxins)

On-board analytical methods can be used to track some marine toxins in seawater

Recognising biochemical change

‘If plants could talk’

- Remote sensing of terrestrial ecosystems
- Technologies being adopted for precision agriculture
- Optical sensors for the detection of chemical changes in plants

Large-scale environmental monitoring

- Data fusion: satellites and dispersion models (Al-Mishraq sulfur fire)

Chemical sensing

- Targeted catalytic degradation of organophosphates: pursuing sensors

Monitoring chemical change on the ground

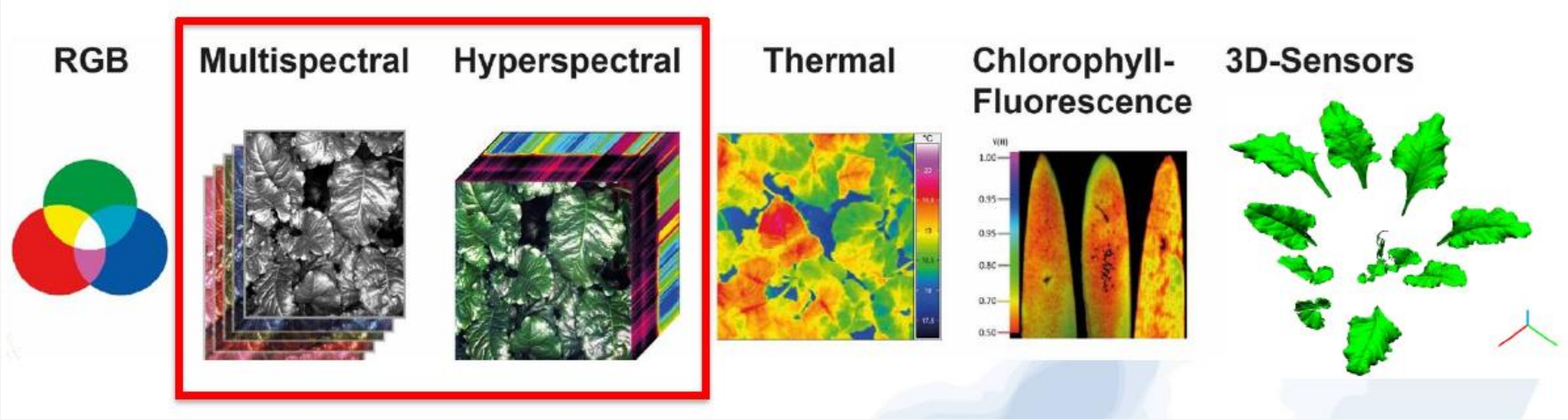
Dr Greg McCarty (US Department of Agriculture) provided introductory material summarising capabilities that have been developed for sensing of terrestrial ecosystems

Advances in space-based sensor technologies are now capable of producing datasets of high spectral resolution

Monitoring chemical change in plants

Dr Ricardo Inamasu (Embrapa Labex, Brazil) reported on the various sensors that are used for precision agriculture

Dr Matheus Kuska (University of Bonn, Germany) reviewed optical sensors for detecting chemical change in plants



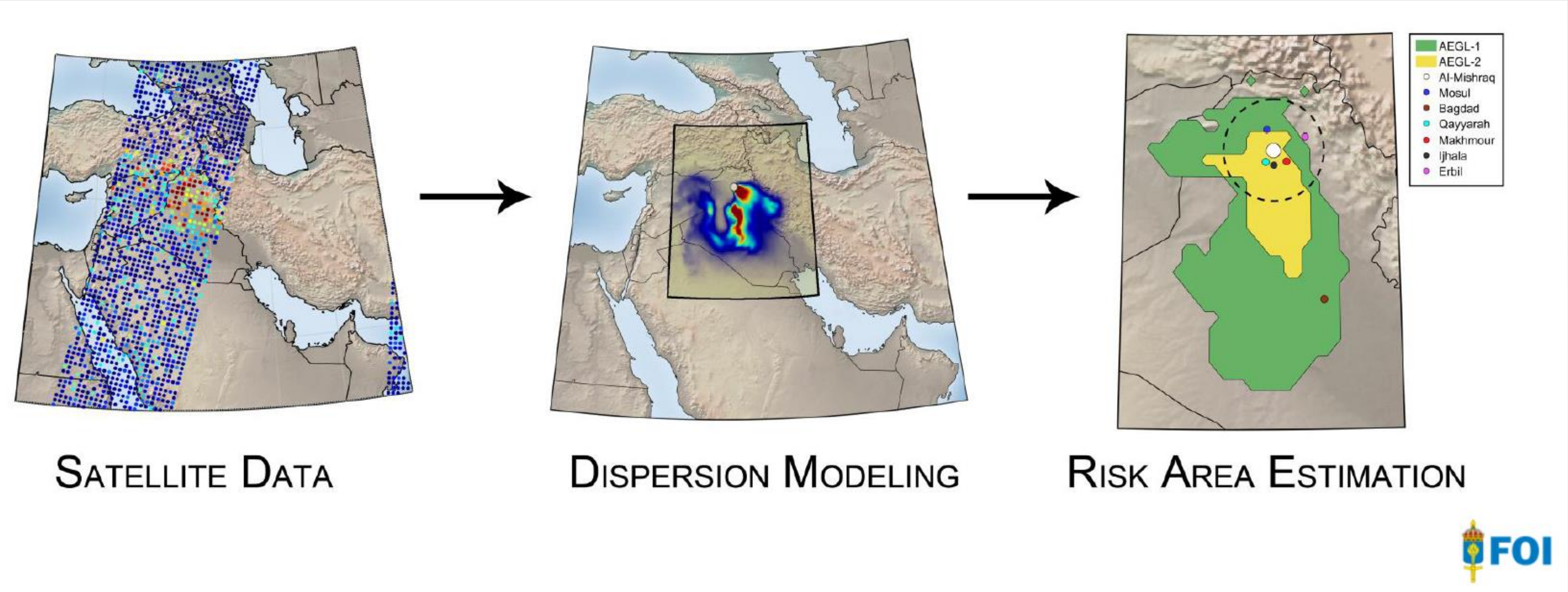
Data fusion: the 2016 Al-Mishraq sulfur plant fire

A stockpile of sulfur was located at the sulfur plant Al-Mishraq in Northern Iraq, close to Mosel

As the battle of Mosel intensified, Daesh (ISIS) ignited Al-Mishraq causing an extensive fire and a massive release of sulfur dioxide

Dr Oscar Björnham (FOI, Sweden) described the development of computer methods he used to model the sulfur dioxide plume

Computer model of the Al-Mishraq sulfur plant fire



The study demonstrated the potential for combining satellite measurements with numerical models to acquire new insight into chemical release events, both by increasing the accuracy of already available data and by providing new information

Sensors for toxic organophosphorus chemicals

GROUP OF CATALYSIS AND KINETICS

www.quimica.ufpr.br/elisaorth

GRUPO DE CATÁLISE E CINÉTICA UFPR

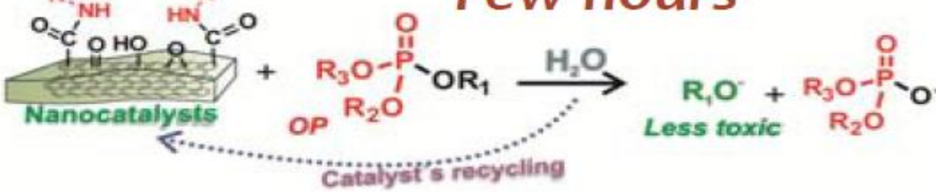
- Began 2012
- Concluded: 2 PhD, 3 Ms; > 9 UG;
- Ongoing: 4 PhD, 4 Ms, 4 UG

- Tailored catalysts (bio/nano)
- Rational material engineering
- Detoxification; Sensing
- Artificial enzymes ....

NANOCATALYSTS

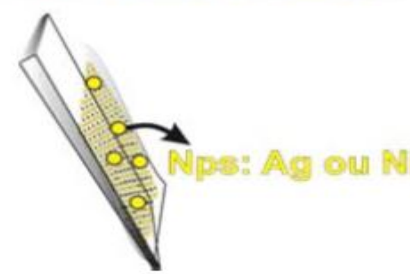
✓Degradation

Few hours



Stocks
Eminent threats

✓Sensor ?



The OPCW inspector of the future

The future?

Wearable technologies and point-of-care devices

- Flexible electronics and electrochemical devices
- Wearable technology: existing and emerging capabilities

Digital health

- What you can learn from your Smartwatch
- Smart data collection and focusing data analysis

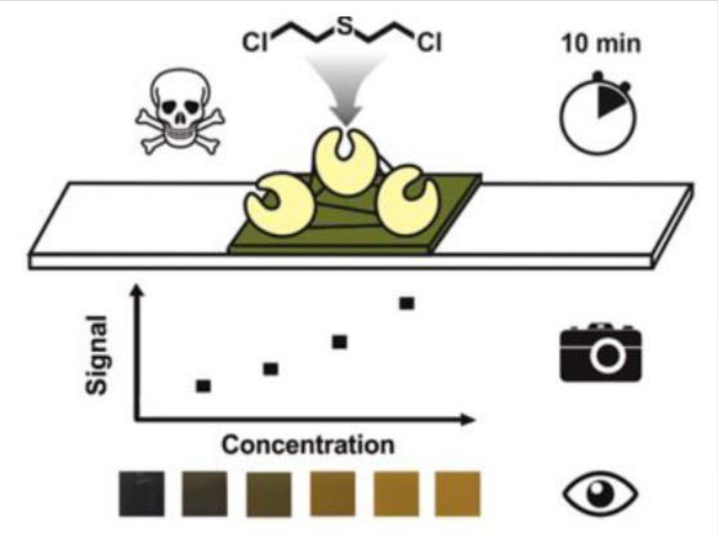
Foldable and wearable paper-based electronics

Professor Murilo Santhiago (Brazilian Nanotechnology National Laboratory) described his work on paper-based functional electronic chemical sensors

The sensors can be tailored to detect toxic chemicals – research into low-cost systems is valuable for developing components suitable for manufacture of wearable chemical sensors

Wearable technology for sensing chemical warfare agents

Dr Richard Ozanich (Pacific Northwest National Laboratory, USA) described existing and emerging wearable sensors for detecting chemical and biological warfare agents, including the use of some array detectors



His review included both inward (self monitoring) and outward (environmental) sensors

Sampling and analysis for diplomats

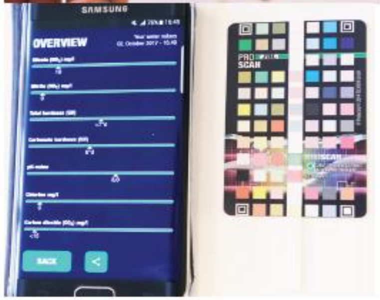
Science for Diplomats EC-86

Tea Analysis

1. Open the “JBL Pro Scan” app

2. Immerse color pads of the test strip completely into the sample for 2-3 seconds

3. Place the analysis strip on its side and drain the excess water on a wipe



4. Open the app, select “Quicks-can”, then select “water”, and select start

5. Position the analysis strip onto the ColorCard, wait 60 seconds (app will count down), hover the phone over the strip/card and let it take the reading

6. Compare results to the values on the other side of this card and identify the sample

OPCW 1997-2017 OPCW YEARS

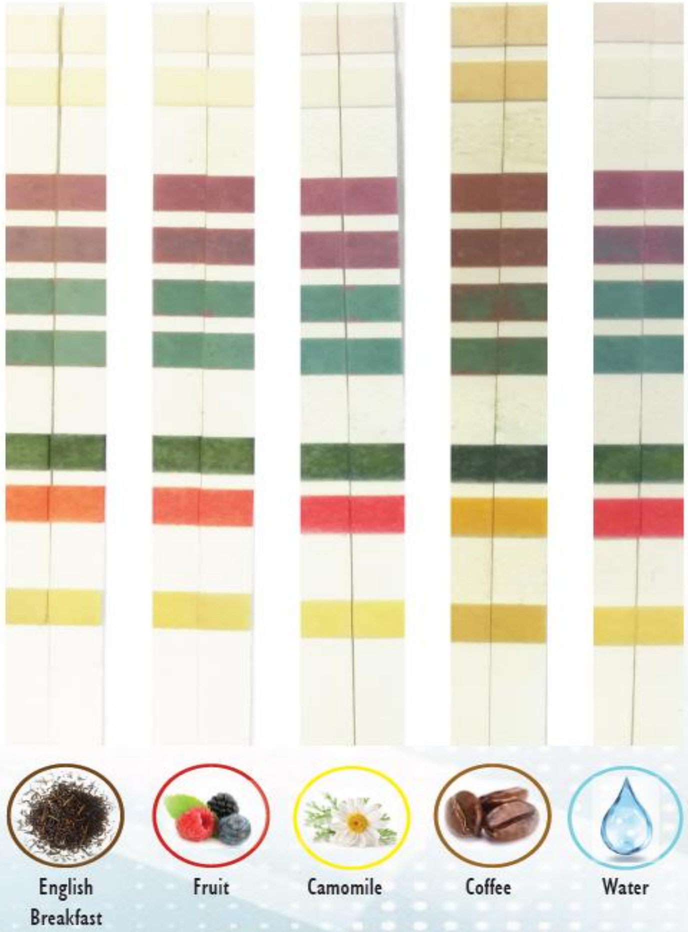
Sampling and analysis for diplomats

Tea Test Samples Reference

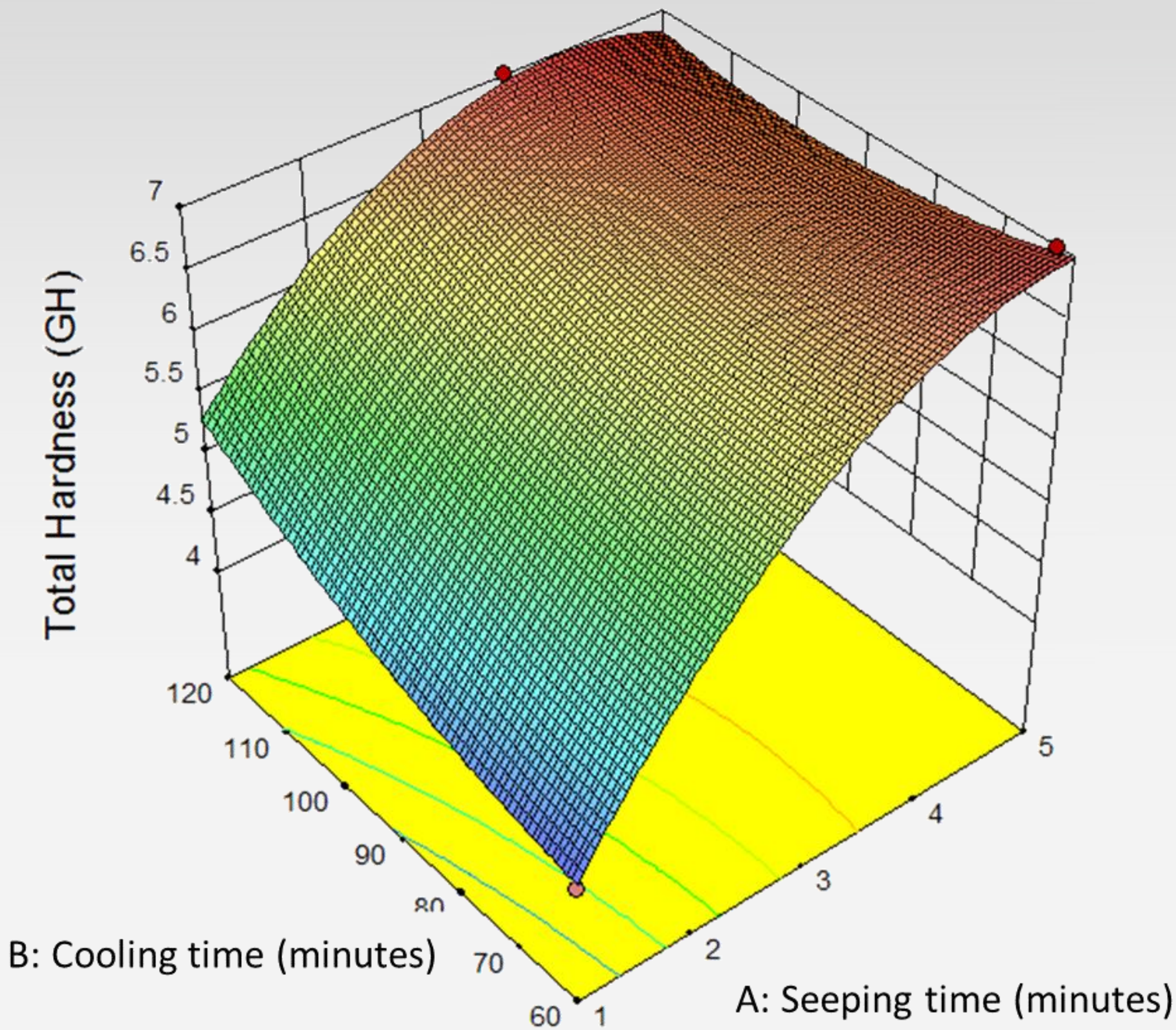
Tea	English Breakfast	Fruits	Camomile	Coffee	Water
Nitrate	0-10	10	10	18	25
Nitrite	0	0	0	0	0
Total Hardness	4-7	4-7	7	7	7
Carbonate Hardness	6-8	6-10	8-10	10	10
pH-value	6-7	6.8-7	7.2-7.4	6.4	7.8
Chlorine	0	0	0	0	0
Carbon Dioxide	20-30	15-35	15	35	15

Results

Tea Sample #	1	2	3	4	5
Nitrate					
Nitrite					
Total Hardness					
Carbonate Hardness					
pH-value					
Chlorine					
Carbon Dioxide					
Type of Tea					



Sampling and analysis for diplomats



Digital health

what you can learn from your smartwatch

Xiao Li
Michael Snyder
Stanford University, USA

Wearable technologies to track health are available

Wearable technologies as monitors of human health

Basis Peak

MOVES

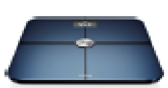
Scanadu Scout

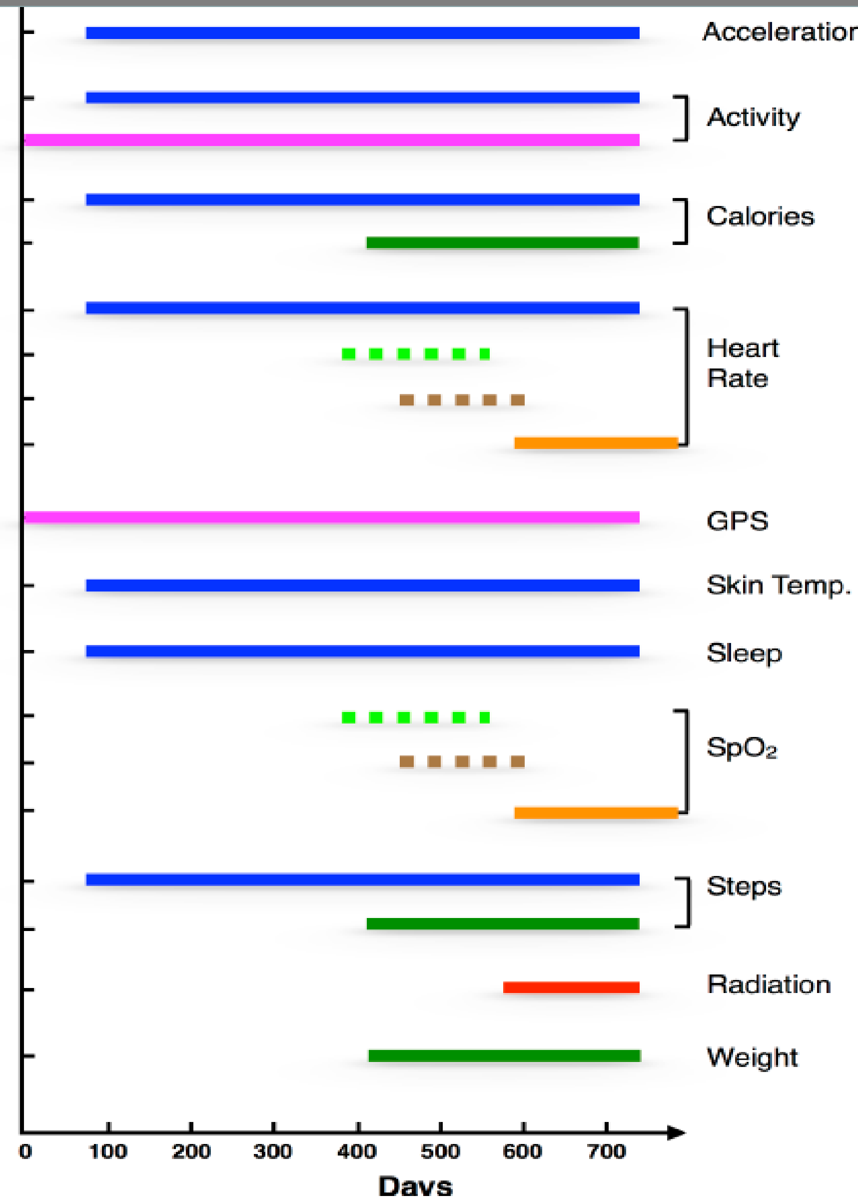
iHealth oximeter

Masimo oximeter

Radtarge Radiation

Withthings Smart Scale





Smart data collection & harnessing artificial intelligence

Mr George Harris (Chief Technology Officer, Basil Leaf Technologies, USA) discussed the use of Smart Data for health monitoring and diagnosis (e.g. DxTER™ prizewinning medical system)

Smart Data uses artificial intelligence (AI) systems that can be packaged into transportable systems (e.g. smart phones, tablets, or watches) – these can provide accurate data analysis at the point of collection: data and analyses can be shared at a later time

Other workshop themes

International monitoring

- Monitoring networks tracking chemical changes in marine waters

- Remote sensing and open-source research for non-proliferation

Computer aided engineering tools in CWC implementation

Monitoring chemical changes in the marine environment

Monitoring Networks tracking biogeochemical changes in coastal and maritime environments from Argentina

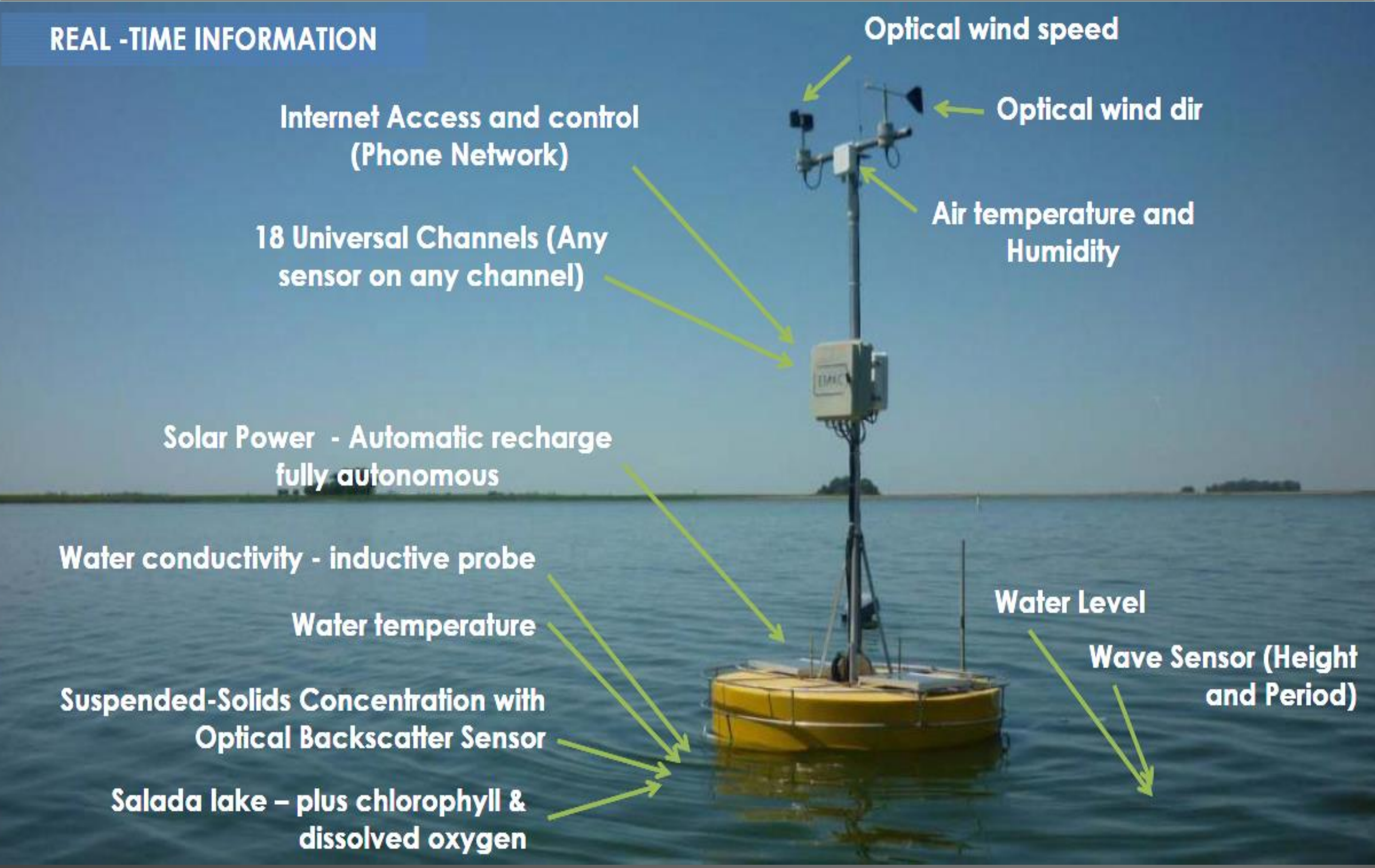
CONICET

Professor Andrés Arias

Universidad Nacional del Sur, Bahía Blanca, Argentina

Instituto Argentino de Oceanografía (IADO), Bahía Blanca, Argentina

Monitoring chemical changes in water in real-time



Remote Sensing and Open-Source Research for Nonproliferation Analysis

Case Studies from the Center for Nonproliferation Studies

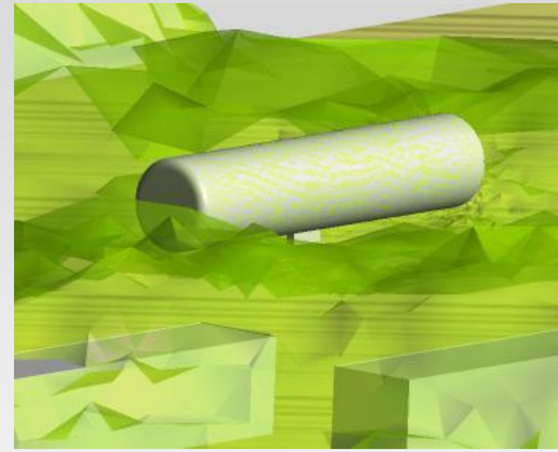
Catherine B Dill

21 June 2017

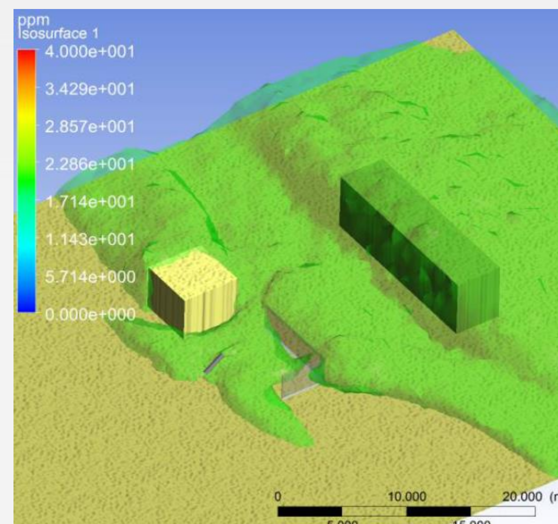
Middlebury Institute *of* International Studies at Monterey
James Martin Center for Nonproliferation Studies

Computational tools applied to implementation of the CWC

Dr Evandro de Souza Nogueria (MCTIC, Brazil) discussed some computer-aided tools useful for gas plume modelling in response to, and the investigation, of chemical incidents (e.g. chlorine releases)



Such tools can be applied to CWC implementation e.g. in disarmament, non-proliferation matters, assistance and protection, and international cooperation



Dispersion models can be helpful if the data they generate can be correlated (validated) with real-world data

Break-out sessions

The workshop concluded with four break-out sessions:

- Enhancing the capabilities of inspectors
- Standoff detection and early warning systems
- Collecting and implementing data streams
- Opportunities for new technologies in CWC implementation

They resulted in eight conclusions which are reproduced next

Outcomes for consideration at SAB-26

Bringing together international trans-disciplinary groups to share and discuss ideas is vital for meeting future challenges. This practice has been a valuable part of OPCW's S&T review process, and the TS and SAB are encouraged to continue this approach when considering S&T advancements.

Through the S&T review process, the SAB has identified a variety of innovative technologies and technology developers. The SAB could usefully facilitate engagement with these communities.

Outcomes for consideration at SAB-26

A broad set of technology exists that can potentially find application in some areas of implementation of the CWC. In general, such tools appear best suited toward non-routine (contingency) and/or assistance and protection operations, investigations, enhancement of laboratory capabilities, and stakeholder engagement.

Technologies that integrate informatics tools, mobile devices and remote sensing with an expanding range of capabilities are becoming increasingly accessible. The Convention's science review process should continue to keep abreast of developments in these areas.

Outcomes for consideration at SAB-26

The Secretariat might consider outreach strategies, such as crowd source competitions to engage and gain access to innovative technologies and ideas. Engaging relevant innovators to participate in CWC-related training and familiarisation would provide an additional avenue to reach out to innovation communities.

A number of the technologies considered during the workshop have potential for reducing the risks to personnel operating in dangerous environments. Further consideration of these technologies could assist with development of recommended best practices for operating under such conditions.

Outcomes for consideration at SAB-26

Many interesting and potentially enabling technologies were discussed. Their suitability for field use requires field testing to meet operational requirements (and fit within mission specific goals). Opportunities to engage with technology developers and evaluate new tools should be encouraged.

The insight brought to discussions by CW inspectors regarding fieldable and operational needs is essential for recognising opportunities where given technologies might prove valuable. The SAB should continue to engage with operational staff from the TS to enable it to provide appropriate scientific guidance on operational practices.

OPCW

December 2018: A Time to Review

OPCW Scientific Advisory Board Briefing to States Parties

Thursday, 19 October 2017

Ieper Room | 13:30-15:00

Light lunch served at 13:00

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Dr Christopher Timperley (SAB Chair) and Mr Cheng Tang (SAB Vice-Chair)

Demonstration: AI may help in extremely difficult tasks like navigating the OPCW website for certain bits of information

Amazon Alexa™ has a skill that can read a table extracted from 20 years of OPCW Annual Reports (all on the public website) for Article VI inspection statistics

You can ask the Alexa™ questions: some are provided in a hand-out

The demonstration shows that AI can help gather information, but it has to be trained before it is able to respond

Thank you

- Dr Jonathan Forman — OPCW Science Policy Advisor
- Ms Siqing Sun — OPCW Intern
- Ms Amy Yang — OPCW Intern

- International Union of Pure and Applied Chemistry (IUPAC)
- US National Academies of Science, Engineering & Medicine
- Brazilian Academy of Science
- Brazilian Chemical Society

- European Union (for funding)

- To all diplomats for their strong support of the OPCW SAB