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Explosives Detection Working Group (EDWG)

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EXPLOSIVES DETECTION WORKING GROUP:

NATO Project "Stand-Off Detection of Explosives"

Ing. Pierre CHARRUE, France
Chairman of the NATO/Explosive Detection Working Group

Prof. A. RIMSKI-KORSAKOV, Russia Prof. F.

CARVALHO RODRIGUES (NATO PDD)

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Explosives Detection Working Group (EDWG)

Contact Information: Tel: +32 2 707 4233 E-mail: elizabeth.cowan@hq.nato.int

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Expert Group

Ing. P. CHARRUE, France (Chairman) Dr. Lyle MALOTKY, USA Prof. A. RIMSKI-KORSAKOV, Russia Prof. J. GARDNER, United Kingdom Dr. M. KEMP, United Kingdom Dr. A. SCHOOLDERMAN, The Netherlands Dr. I. DAOUST-MALEVAL, France Dr. K. OSTERLOH, Germany NATO Maj. E. GUADALUPI (NATO RTA) Lt.Col. G. MORITTU (NATO CTU) Prof. F. CARVALHO RODRIGUES (NATO PDD) Dr. C. de WISPELAERE (NATO PDD) Mrs. E. COWAN (NATO PDD)

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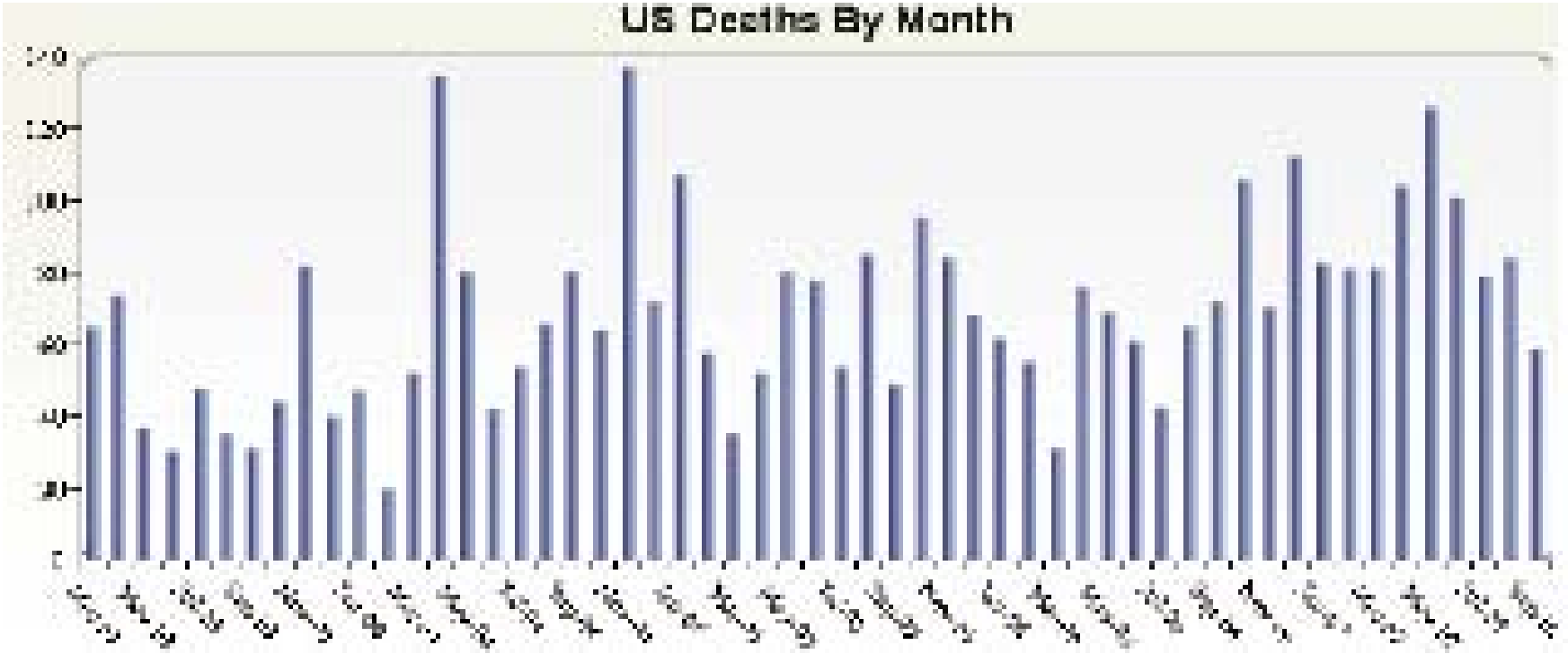
US CASUALTIES IN IRAK SINCE 2003



From March 2003 up to September 2007: > 3800 US Boys Killed

Most of the Casualties are Due to Terrorist Attacks involving IED's

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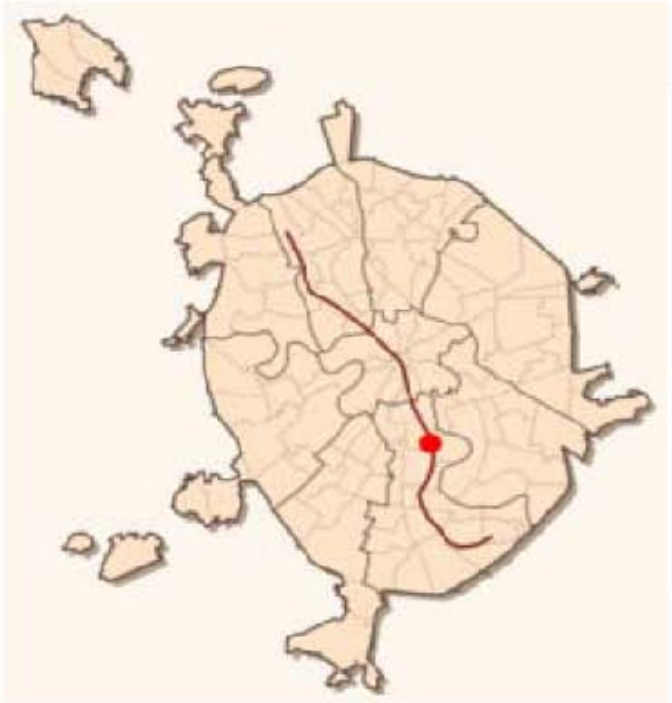
MOSCOW 2004

2004 Moscow metro bombing



The attack occurred near Avtozavodskaya station on the Zamoskvoretskaya Line

Location	Moscow, Russia
Target(s)	Moscow Metro train
Date	February 6, 2004
Attack type	suicide attack
Deaths	40
Injured	102
Perpetrator(s)	*Riyadus-Salihiin*

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MADRID 2004

“The scene I am seeing is hellish”

Total:

192 People were Killed and 1755 Wounded

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LONDON 2005

The bombers caught on CCTV at Luton railway station at 07.21 a.m. on 7 July. From left to right, Hasib Hussain, Germaine Lindsay, Mohammad Sidique Khan, and Shehzad Tanweer [18] (Image: Crown copyright)

Osman Hussain at Westbourne Park

Muktar Said Ibrahim on Number 26 bus

Ramzi Mohammed at Oval

Location	London, United Kingdom
Target(s)	London Underground and a double-decker bus
Date	7 July 2005 8:50 am – 9:47 am (UTC+1)
Attack type	Suicide bombings
Deaths	52
Injured	≈700
Perpetrator (s)	Hasib Hussain, Mohammad Sidique Khan, Germaine Lindsay, and Shehzad Tanweer

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The Explosives Detection Working Group (EDWG)

met during an Advanced Research Workshop on

"Stand-off Detection of Suicide Bombers and Mobile Subjects"

from 13-15 December 2005 in Germany.

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Explosives Detection Working Group (EDWG)

The EDWG considered the various approaches to stand-off detection of concealed explosives:

-electromagnetic methods using penetrating radiation (microwave, millimetre wave, terahertz)

-trace detection using stand-off laser probes of explosive vapour or particle residues

-trace detection by direct capture of explosive vapours or particles in the air, transported to the detector

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Chairman of EDWG **New Threats and Challenges Section** Pierre.ch

The group considered that system solutions using each of the three approaches should be considered in order both to maximise the chances of selecting a successful technologies that might ultimately be combined (sensor fusion) to increase the effectiveness of detection.

For a promising action the group considered a global detection strategy of these fused technologies in terms of: -close detection zone -mid-range detection zone -long-range detection zone

Depending on these detection zones different technologies also in a fused system should be considered as a suitable approach.

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EDWG-Criteria for Evaluation of Proposals:

-technical feasibility -management plan -novelty concept and improvement contribution compare with the state of art of the considered technology -prototyping potential (duration, complexity and risk) -potential as a stand-off technique

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CONSEQUENCES :

Definition of a Configuration of Use:

- *Mass Transport*
- *Metro or Railways Station*

- Definition of Testing Protocols to Validate the Developed Technologies in « On Site » Configuration:

- *Big City Metro Trials*

- Integration in Final Testing Phase of Available Technologies to Validate the Data Merging Concept And its Ability to be Upgraded:

- *MmWaves or THz Machines Commercially Available*
- *Other Prototypes of advanced technologies*

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NATO EXPLOSIVES STAND-OFF DETECTION PROGRAM CONTENT

• **Project 1:** Stand-off Detection of Surface Contaminations with Explosives Residues using Laser Spectroscopic Methods (proposed by Fraunhofer Institut Für Lasertechnik –Germany-and ATC Semiconductor Devices – Russia-),

• **Project 2 :** Systems for Stand-off Detection of Suicide Bombers with Active Millimeter Waves (Proposed by TNO –Netherlands-, ICT –Germany-, Khlopin Radium Institute –Russia-, APSTEC –Russia-)

- **Microwave System for Secret Remote Inspection of Person (MS-SRIP)**
- **Secret microwave "door" for inspection of people and luggage**

• **Project 3 :** DAta Merging and Alert System for data from various Stand-Off "Human Bomb" detection technologies, DAMAS Project (Proposed by CEA – France-)

• **Project 4 :** Project for Validation of the Whole Detection Systems "On site" in Metro Station, *"Big City Trials Project"*

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Project 1

Laser Explosives Detector

Stand-off detection of surface contaminations
with explosives residues using
laser-spectroscopic methods

Fraunhofer ILT Institut Lasertechnik

ATC - SEMICONDUCTOR DEVICES

Objectives

- Development of demonstrator system for stand-off detection of explosives traces on surfaces (luggage for example)

- Deployment of two optical detection methods to enhance selectivity and lower false alarm rate:
  - Raman spectroscopy to obtain „molecular fingerprints“
  - Laser-induced breakdown spectroscopy (LIBS) to analyse elemental composition

- Main focus on development of remote Raman detection module and laser source for eye-safe LIBS by ATC (Russia)

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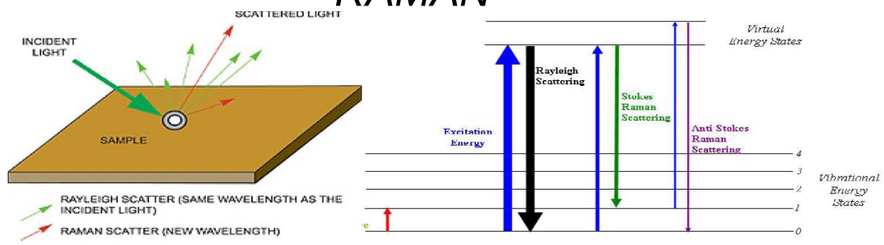
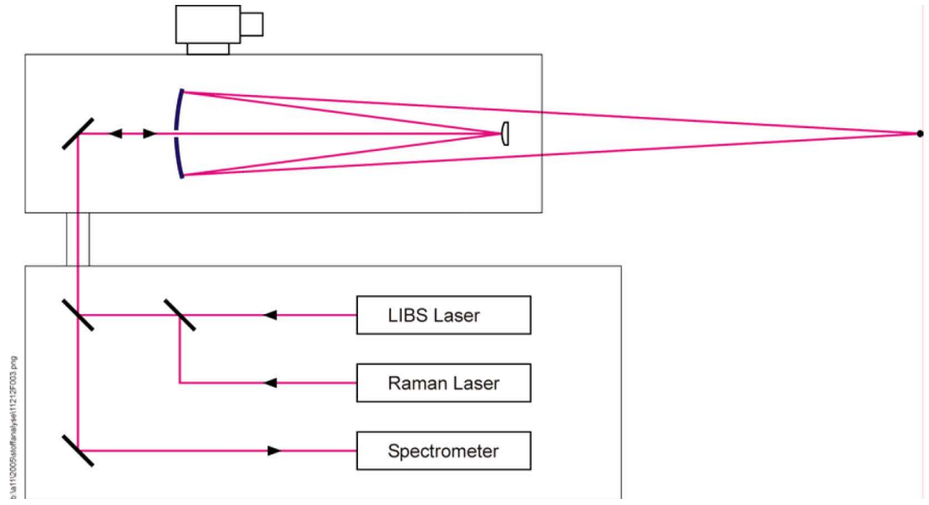
RAMAN



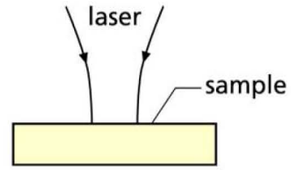
~10^{-7} of the scattered light is inelastic Raman scattering. Only the Stokes line is normally measured.

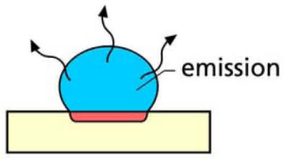


LIBS

- evaporation and excitation of surface material (nanograms, ablation depths ~ µm)
- spectroscopic analysis of the emission
- simultaneous multi-species detection

(e.g. up to 92 elements) measurement within 50 microseconds measuring frequency up to 1 kHz measuring distance 1 cm – 100 m





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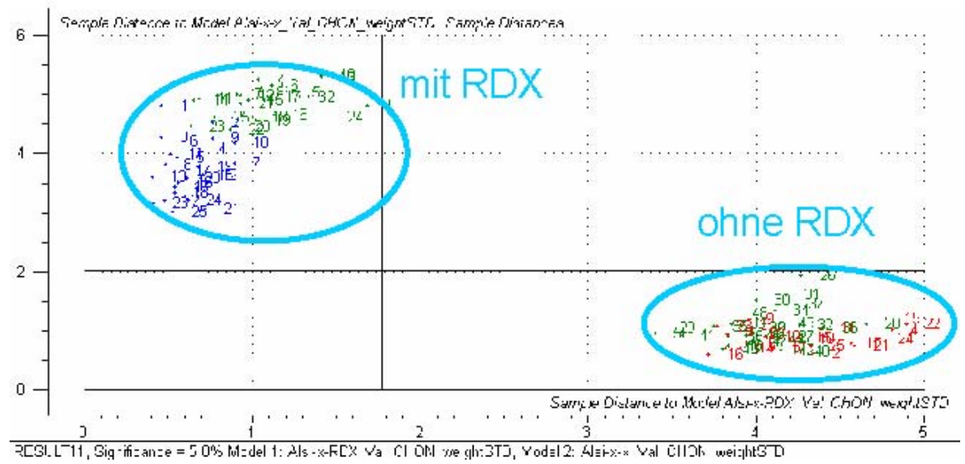
Classification of RDX on car paint

- Development of LIBS for explosives detection at ILT

- Remote excitation (5 m)
  - 25 laser pulses (red/blue) for class definition,
  - 25 laser pulses (green) for classification.
  - Each measurement is classified **correctly** and **unambiguously**.



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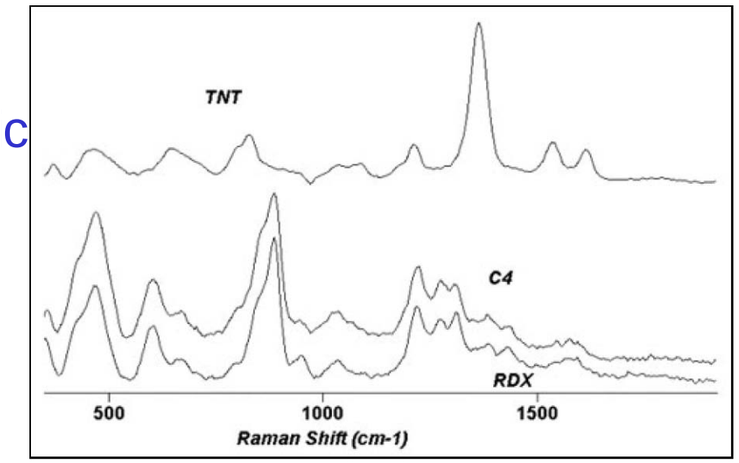
Raman spectroscopy

- Raman effect: molecular specific frequency shift
- established analytical method used in industrial applications
e.g., process control
- spectral characteristics of some explosives published
- remote (50 m) capability proven (e.g., Carter et. al. *Appl. Spectrosc.* 2005)



Ocean Optics Inc.

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Experience on remote LIBS at ILT

- Remote LIBS system for industrial application
- measuring distance 2 -12 m transportable
- integrated autofocus unit and range finder 13 species measured simultaneously with 10

Hz limit of detection < 0.1% for selected elements

- quantitative elemental analysis for Al and Fe

matrices demonstrated, $R^2 > 0.98$ know-how gained is applicable for remote detection of explosives

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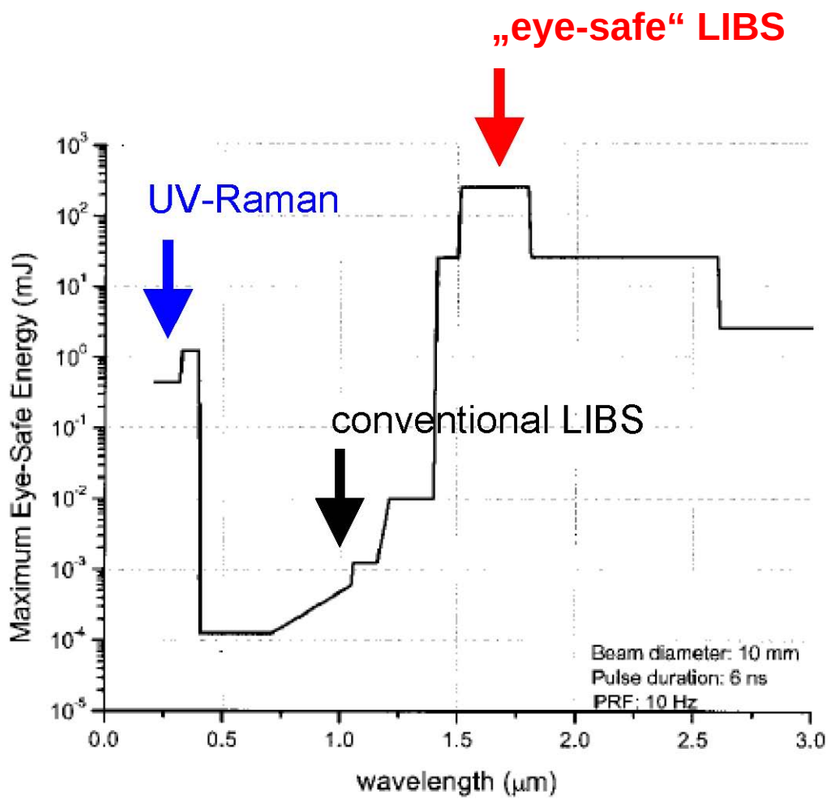
Laser safety

Maximum allowable laser exposure depends on:

- irradiance
- wavelength
- pulse duration

⇒ using an „eye-safe“ wavelength reduces risk-limit for human eye by

6 orders of magnitude



From Mayor et al., Appl. Opt., 2004. Data from ANSI-Z136.1-2000

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Concept for Lasers - Details

Eye-safe laser for LIBS system DPSSL for Raman system The main technical parameters

- Output pulse energy: > 100 mJ
- Wavelength: 1.55-1.57 µm
- Pulse length: 10 ns
- Pulse repetition rate: 30 Hz
- Beam divergence: < 6 mrad
- Pulse-to-pulse stability: < 10%

- Output pulse energy: 1 mJ
- Wavelength: 266 nm
- Pulse length: 10 ns
- Pulse repetition rate: up to 1 kHz
- Beam divergence: < 0.5 mrad
- Pulse-to-pulse stability: < 10%

The main advantages of different types of SSPL

Diode Pumped

- High efficiency
- Small sizes and weight in comparison with lamp pumped lasers
- Air cooling (no water)
- High voltage absence

Lamp Pumped

- High efficiency
- Possibility of double pulse regime
- Air cooling (internal water pump)

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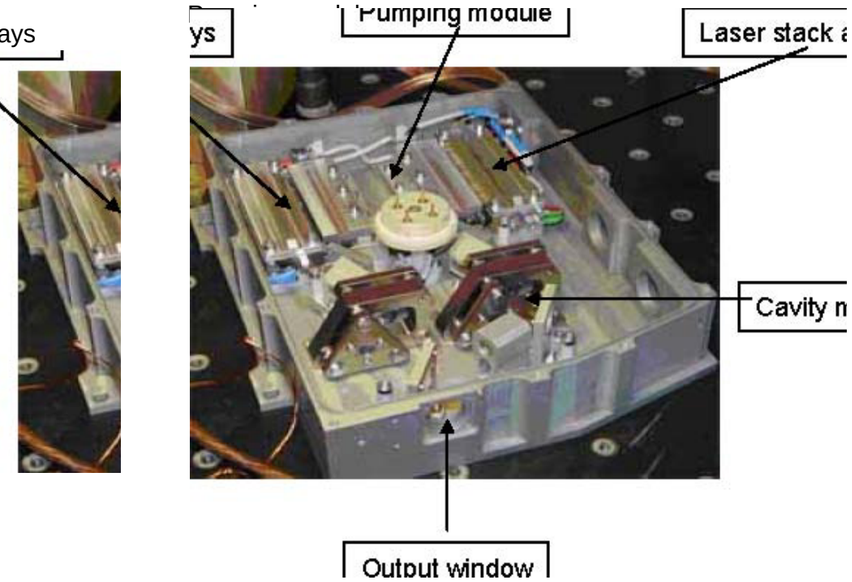
Samples of the high energy laser units for LIBS

General view of lamp-pumped solid state laser



Internal view of diode-pumped solid state laser

Fraunhofer Institut Lasertechnik

Laser spectroscopy

General Advantages

- contactless => remote detection
- real-time => moving objects, direct response
- sensitive => trace contaminations
- focusability => spatial resolution for stand-off detection
- technical maturity information
  => chemical composition:atoms, molecules, molecular fragments, high selectivity

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Project 2

Microwave System for Secret Remote Inspection of Person (MS-SRIP)

NPD: NATO Country Project Director
BECKER Wolfgang, Dr. Fraunhofer Institute for Chemical Technology (ICT), Joseph-von-Fraunhofer776327 Pfinztal,Germany

PPD: Partner Country Project Director
KUZNETSOV Andrey, Ph.D.V.G.
Khlopin Radium Institute (KRI), 28, 2nd Murinsky pr., 194021
Saint-Petersburg, Russia

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CURRENT STATUS at KRI

- **Laboratory prototype MS-SRIP was produced and tested Patent on identification**
- **of dielectric objects has been obtained 3D imaging software algorithm has been**
- **developed (non-real-time at this stage) Unique method of the image analysis for**
- **characterization of threat materials was proposed**

Patent: Russian Federation #2230342 Method of identification of dielectric objects, priority of invention date: 9 September, 2002.

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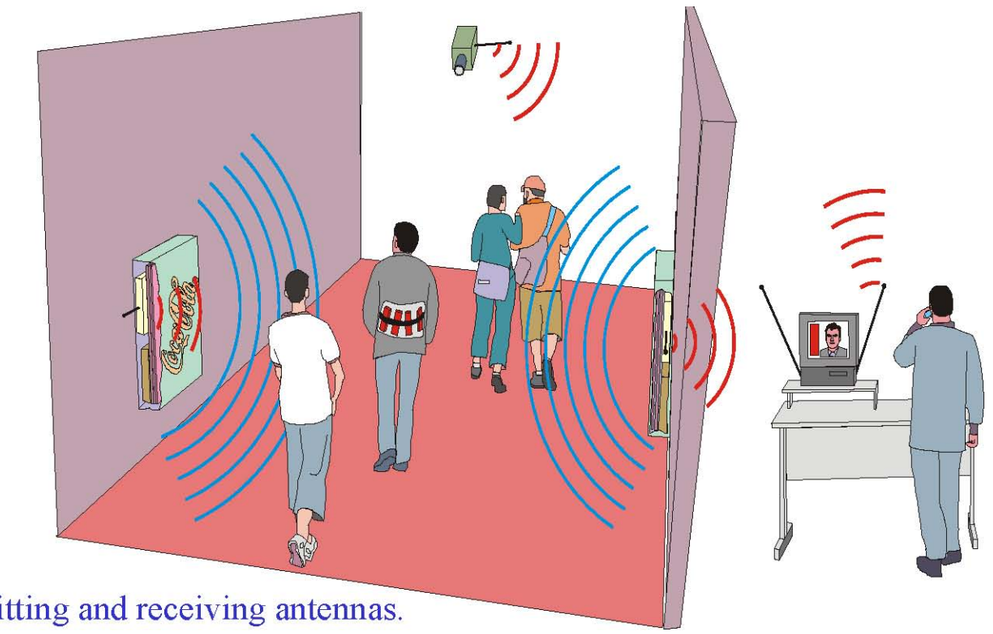
The proposed Microwave System for Secret Remote Inspection of Person (MS-SRIP) is based on active probing with microwaves.

ıceptual Design
Cor
[S-SRIP
MS



Main components of the system

- One or several masked transmitting and receiving antennas.
- Suspect tagging system (video camera).

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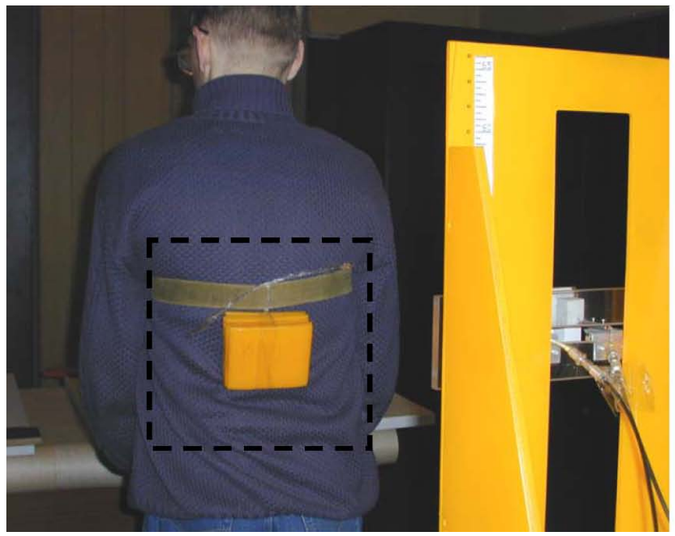
Experimental results with proof-of-principle prototype

- Characteristics of the proof-of-principle prototype
- [in brackets: value planned for the full-scale system]
- Range of frequencies: 2 – 8 GHz [10 – 30 GHz]
- Distance to human body: 0.5 m [2 – 4 m]
- Spatial resolution: 4×4×2.5 cm3 [2×2×1 cm3]



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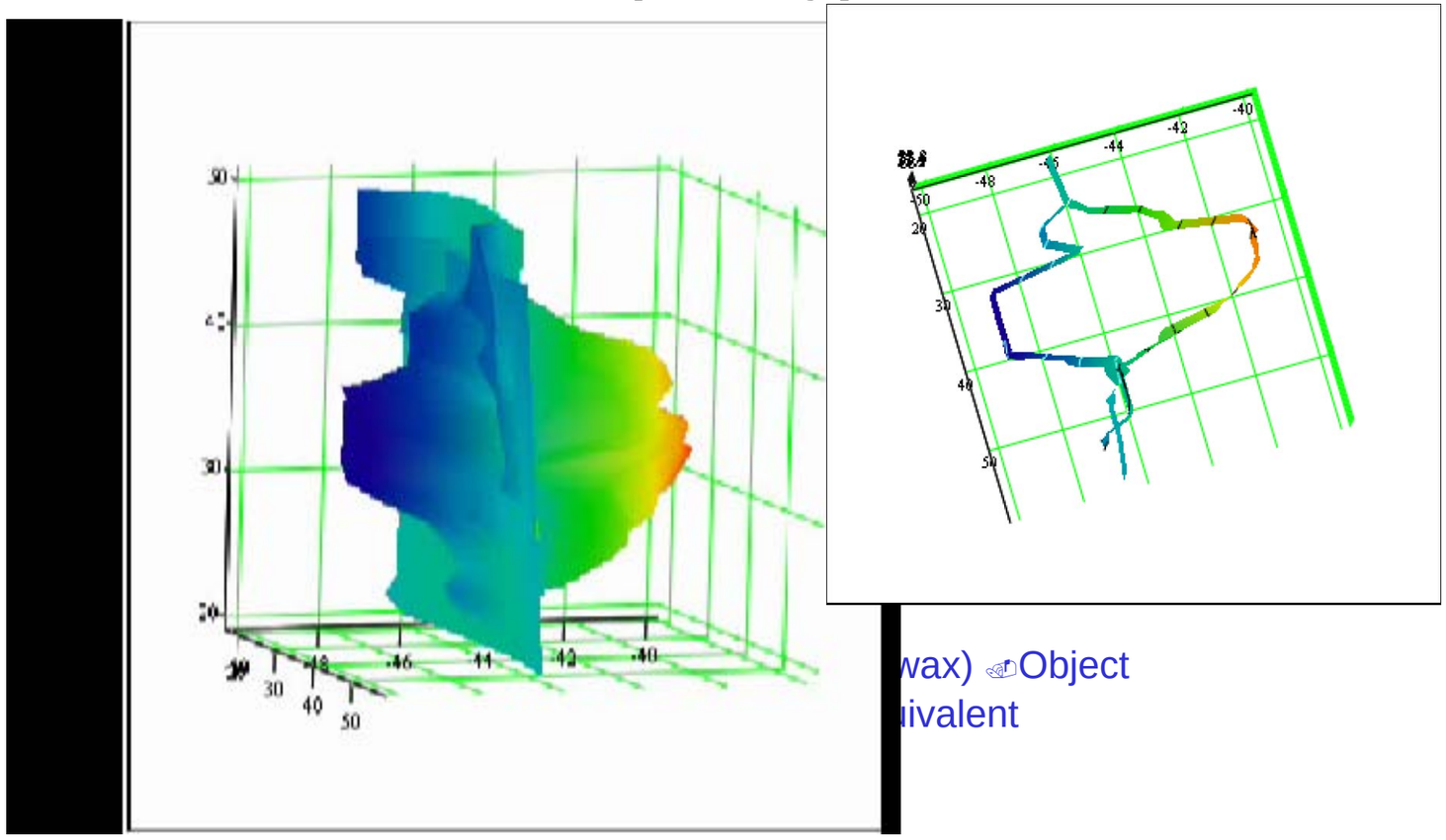
Experimental results with proof-of-principle prototype



wax) ☞Object
uivalent

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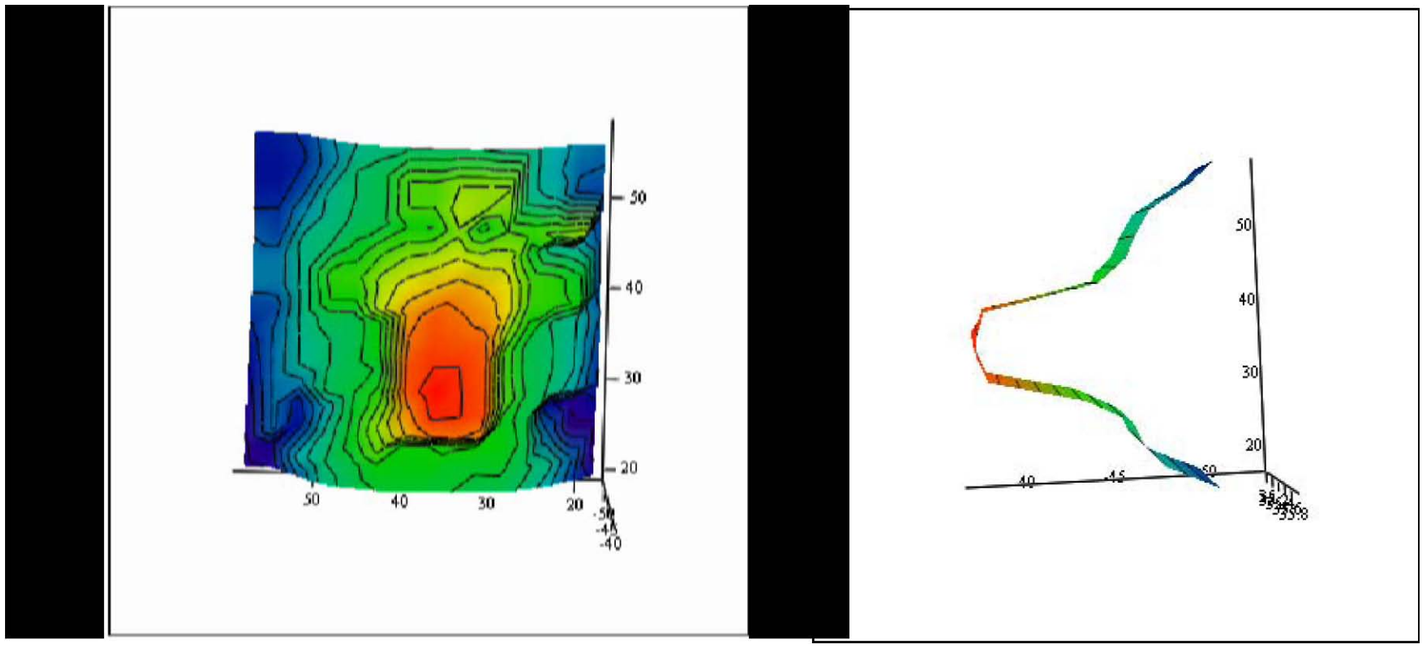
Experimental results with proof-of-principle prototype



- Images of the area with wax wrapped into metallic foil
- Object class – conductor
- Equivalent explosives mass – 2.2 kg

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Novelty in the Project

- Discreet inspection: no bulky devices or portals; antenna can be disguised e.g. as advertising board
- Stand-off inspection: works from distances of several meters
- Real time operation. People do NOT need to stop for inspection; simultaneous inspection of many people
- Selectivity of hidden threat : metallic and non-metallic objects can be visualized and identified by dielectric properties

Usual requirements for commercial device

- Totally safe for health: emitted power is 10 times less than that of an average mobile phone
- Inexpensive: electronic components are cheap and available

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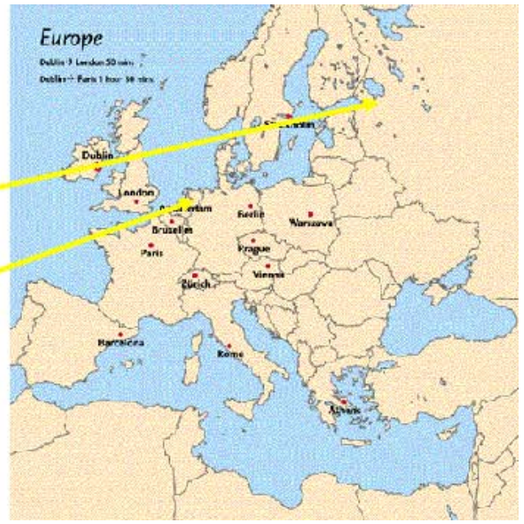
Secret microwave “door” for inspection of people and luggage

Applied Physics Science and Technology Center

APSTEC

TNO



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Applied Physics Science and Technology Center APSTEC

Goals

Development and implementation of an operational prototype of a covert and safe system at modest costs that enables real time inspection of persons and detection of suicide bombers. 3 phases:

- 1: Perform **continuous transmission screening** in real-time of every person passing through the doorway and produce an automatic alarm with height information but without imaging.

- 2: Perform **continuous reflection screening** of persons passing through the doorway and produce a (delayed) 3D-like image of the dielectric properties of the objects concealed on the body or in backpacks, without alarm decision.

- 3: Combine **continuous transmission and reflection screening** of persons passing through the covert doorway and produce a (delayed) image of the dielectric properties of the objects concealed on the body or in backpacks, and a screener alert or automatic alarm.

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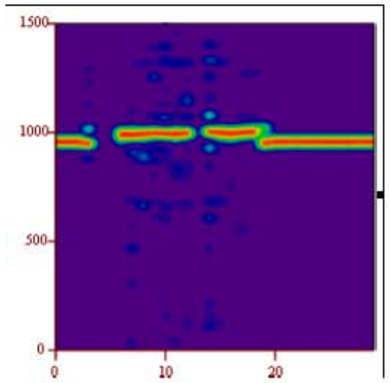
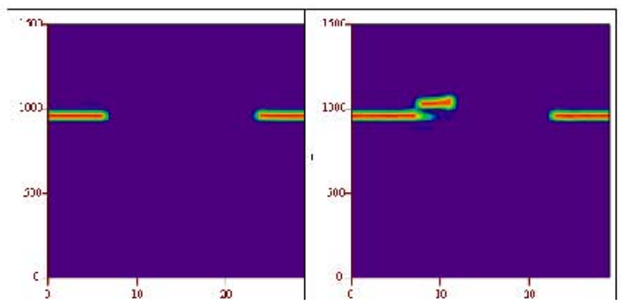
Automatic person inspection





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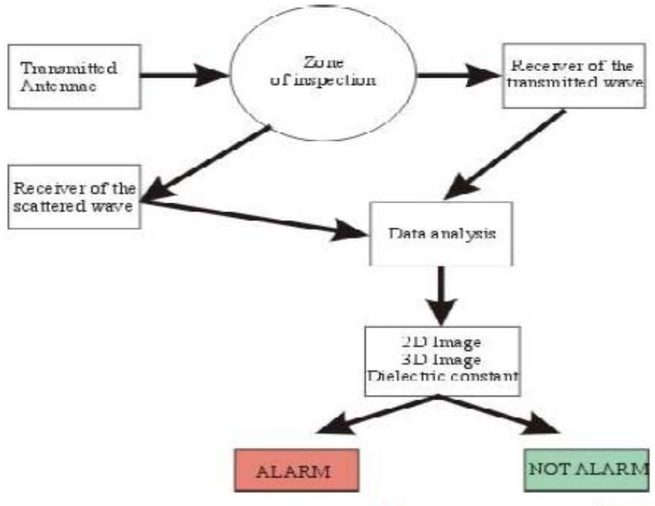
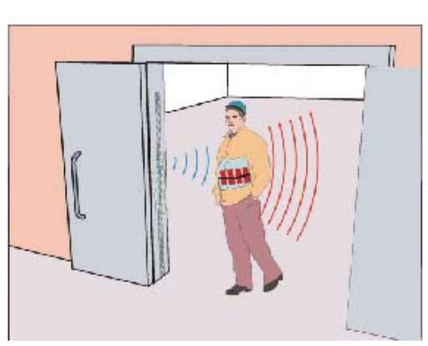
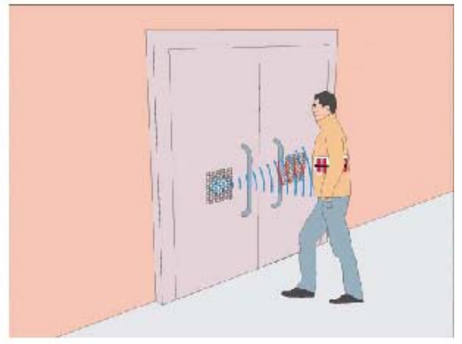
Application







Expected characteristics of active millimeter waves devices

- 3D imaging with resolution: $2\times2\times1cm^3$ at distance of 2 m. ($4\times4\times1cm^3$ at distance of 4 m; $10\times10\times1cm^3$ at distance of 10 m)
- Selectivity of hidden threat by dielectric properties
- Secrecy: the device has no significant features that make it noticeable.
- Real-time operation: imaging of moving targets -people do not have to stop in front of the device;
- Safety: no “real” focusing of microwaves; emitted power less than that of a conventional mobile phone;
- No privacy issue: resolution is enough for detection of explosives and weapons, but not enough for revealing body details.

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Project 3

DAta Merging and Alert System «for data from various Stand-Off “Human Bomb” detection technologies »

DAMAS Project

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- **Existing Technologies prone to be added during the course of the Project**
  - Passive Millimeter wave imaging combined with video images (Stand-off imaging)
  - Passive terahertz imaging (Stand-off imaging)
  - Other Sensors Prototypes usable in Stand-off Detection Configuration

- **Proposal to add and link : a dedicated Video "Tracking" Module**

  It is essential to determine as automatically as possible **which people** has triggered the **alarm**, and **correlate** alarms issued by different detection beacons.

  For that, a wide angle camera network associated with tracking algorithms, is integrated in the system to identify and localize the suspicious person.

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DAMAS Video Tracking Architecture

People walking in a corridor observed with a wide angle camera

3D tracking of a person walking in a corridor through the beacons

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The GUI gives:

- *the data view*
- *the SoH view*

User interface, with respect to the whole centralizing sub-system

A specific feature will allow to display real time video frames or to play back tracking issued by the dedicated video tracking system

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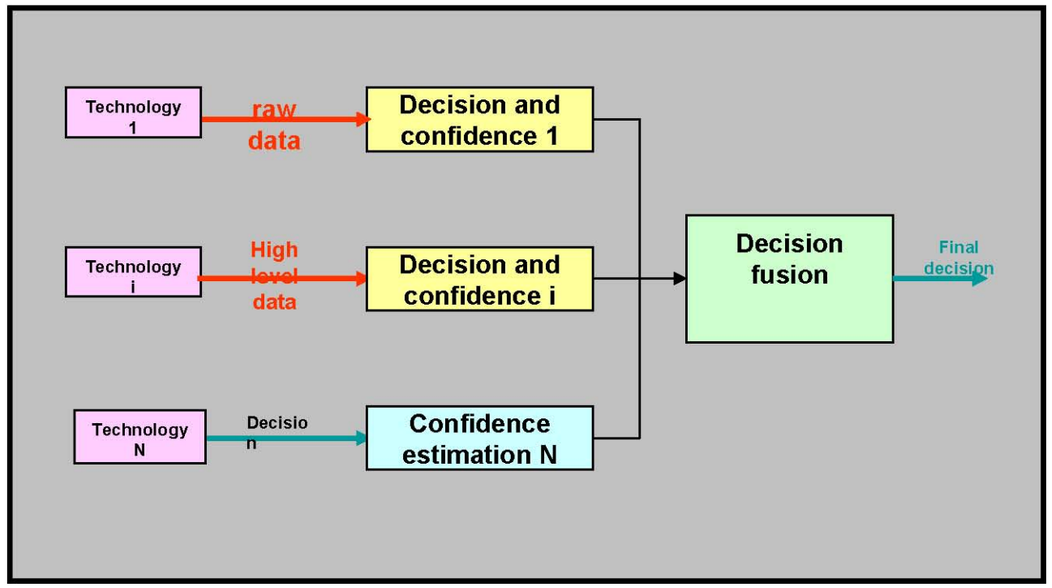
(EDWG)

Proposed architecture of the decision process

The explosive detection data will be provided by the "emulation sub-system", and may include :

- *Possible **raw data***
- ***Pre-processed data**:*
  - ❑ ***"low level data":** images, spectra, …*
  - ❑ ***"high level data":** detection information [threat location, object type, quantity and/or magnitude/ratios, confidence …], …*
- *Any available **State of Health** information from the detection technology (sensor, processing unit, measured noise level …).*



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Proposed Architecture of the Decision Process

The fusion decision process will be based on multi-criteria discrimination :

- The information brought by each sensor contributes to the final decision.
- The expected result is a decision system that is more precise and more robust than any mono-sensor system.
- The second interesting scenario is when most of the sensors are almost close to emitting an alarm. The fact that there is hesitations is suspicious.
- Therefore, even if there is no alarm emitted by any mono-sensor system, a global alarm could be generated.

Interests of such architecture:

- The first one is when mono-sensor decision processes disagree. If the most numerous and confident sensors are right, and if it is not always the same sensors that are wrong, the synergy is obvious in comparison to any mono-sensor system.
- The second interesting scenario is when most of the sensors are almost close to emitting an alarm. The fact that there is hesitations is suspicious.
- Therefore, even if there is no alarm emitted by any mono-sensor system, a global alarm could be generated.

Several techniques are candidates to fulfil this function :

- **Neural networks** which are an efficient way to merge both statistical properties of data and human knowledge about the physics and the technologies of the sensors,
- **Bayesian networks** which are an efficient, controlled and auditable solution,
- **Combination of several of these algorithms** in fusions of decision systems, which further increases reliability of even a mono-sensor

Explosives Detection Working Group (EDWG)

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- ***Alarm Triggering Off***
- ***Target Identification***
- ***Localization***

Security Forces

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Explosives Detection Working Group (EDWG)

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Project 4

BIG CITY TRIALS PROJECT

OBJECTIVES:

¾To validate «On Site » in Mass Transport Configuration the Whole of the Technologies Funded within NATO SfP Program Dedicated To The Stand-Off Detection of Explosives and Suicide Bombers,

¾To Demonstrate the Appropriateness of the System Concept and Its Ability to Integrate Existing Complementary Technologies (Ability to be Up-Graded in the Future for the End-Users),

¾To Find the Potential Weak Points in Use to Improve the System.

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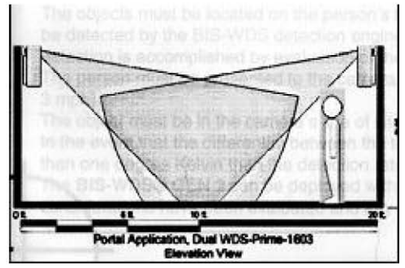
Complementary Stand-Off Technologies Existing Now which could be Integrated in The System:

- *Millimeter Waves Imaging System using a Passive Technolgy : BRIJOT BIS-WDS GEN2*
- *Terahertz Waves Imaging System using a Passive Technology : TERAVIEW T4000 System*

TERAVIEW T4000 System

Frequency ~300 GHz



BRIJOT BIS-WDS GEN2

Freauencv ~94 GHz

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BIG CITY TRIALS PROJECT

Partnerships and Project Management

The project has to be managed at two levels: ¾The end-user Level which will have in charge the general management of the tasks and the appropriateness of the developments engaged to involve the whole system « on site » in realistic configurations , ¾ The Designers level which will have to guarantee the compatibilities between the different systems involved

Sounded out Management Composition (to be confirmed):

- ***End-User Level : RATP (French Operator of Paris Metro)***
- ***Designers Level : TNO and CEA representatives already in charge of other projects***

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Main Tasks to realize

¾ To Define the Scenarios to be Played to Validate the Whole System, ¾ To Define the Interfaces Between the Effective Prototypes and the adaptation of the Connection Softwares between the Machines and the Centralizing System to be Developed, ¾ To take into account the whole of the Logistics and Security Issues, ¾ Adaptations and optimization of centralizing system, ¾ Whole system assembling, modelling and testing on real representative data, ¾ Optimization of processing, merging and decision algorithms ¾ Preparation of demonstration: shipping, purchases, installation, tuning, ¾ Demonstration

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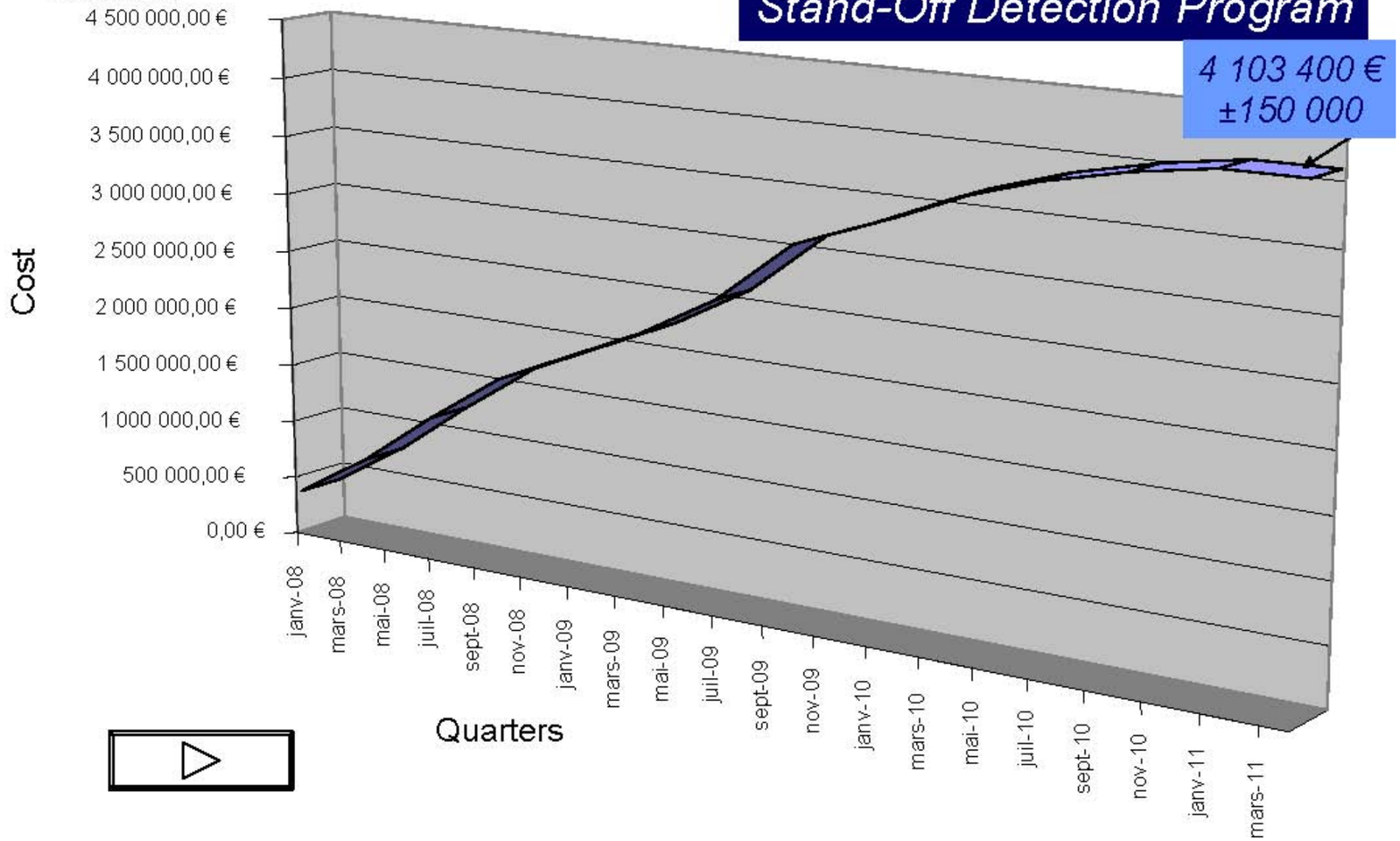
New Threats and Challenges Section

Global Costs of the Stand-Off Detection Program



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Conclusions and Perspectives

• The Stand-Off Detection of Suicide Bombers is Still a Huge Challenging Issue Due to the Factthat Unique and Reliable Technology Able to Fulfill this Need Still does not Exist,

• The Threat against the Mass Transport and more Generally the « Soft Targets »is Always Active and Potentially of High Level of Risk if we Consider the Number of Victims and the Consequences on the Disruption of Society and State Working,

• The Proposed Approach is Based Both on Advanced Scientific Developments and on Practical Analysis of the Different Projects Which have been Selected For their Potential Capabilities.

• There is a Great General Interest for the NATO Members and Partners to Engage As Soon As Possible This Program in Order to Have at Their Own Disposal a Solution to Face this kind of Threat,

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• This Challenge is Yet a Long Way to Walk but the Opportunities Which Appeared Through the NATO/Russia Partnership are able to Accelerate the Emerging of New and Efficient Technologies Which will be Combined and Adjusted to Reach the Objective,