

Title:	Conceptual design
Deliverable (ID, D or Milestone) Number:	D3
WP/Task related to:	WP 2
Nature:	Report
Dissemination Level:	Public
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Contractor(s)/Member(s) Contributing:	CEA, INFN, IPJ, SODERN,CAEN,IRB

Contractual Date of Delivery to the CEC:	February 2005
Actual Date of Delivery to the CEC:	March 2005

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Change Control

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Change History

Conceptual Design

The EURITRACK WP2 Participants

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1. Glossary

DEMONSTRATOR:	An implemented device used for the validation tests carried out at Le Havre
EURITRACK:	EUROpean Illicit TRAfficking Countermeasures Kit
MMI:	Man Machine (computer) Interface
NG:	Neutron generator
PROTOTYPE:	Device as it is to be described at the end of the EURITRACK project
TNIS:	Tagged Neutron Inspection Device: neutron generator, detectors, electronics, spectrum analysis, chemical identifications
VOXEL:	Element of volume attached to a measurement
WP:	Work Package

Denomination of the axes:

X : neutron generator beam axis

Y : longitudinal axis of the controlled vehicle

Z : vertical axis of the controlled vehicle

2. Context of the document

The purpose of the EURITRACK project is to design a non-destructive control device for transport containers by means of an active measurement technique based on the use of an external neutron source.

The success of the EURITRACK project might be measured by comparing the performance of the system to the expectation of detecting 100 kg of TNT inside a container in less than 10 minutes, when the absorption of the primary neutron beam hitting the sample due to the material inside would not be greater than a factor of 2.

The device, as it is meant to be defined at the end of the project, will correspond to a stage that we shall term "prototype".

Within the framework of this project, it has been planned to carry out validations and/or experimental qualifications.

One of these experimental stages consists in carrying out tests at the Customs on Le Havre site, within the perimeter of the control system setup using X rays (SYCOSCAN).

The device that is to be designed and built for the purpose of these tests at Le Havre corresponds to a stage of development that we shall term "demonstrator".

This demonstrator will be designed to be compatible with the various demands of the project, the major ones being of a financial nature but also involving setup and available space constraints, constraints pertaining to regulations and considerations involving deadlines.

This demonstrator will correspond in actual fact to a "degraded" version of the future prototype.

Furthermore, the prototype will be the object of a descriptive document that will first mention the design elements that have been voluntarily simplified (or "degraded") at the time of the

"demonstrator" phase and which are to be enhanced throughout the progression of the project so that elements coming from different studies and tests may be taken into account.

Development stages of the demonstrator

- Feasibility of the physical principles in the Institute Ruđer Bošković (IRB), Zagreb, with in particular, the use of a container carrying 100 kg of TNT,
- integration test of the tagged neutron inspection device (TNIS) in Cadarache (neutron generator, detectors and electronics),
- test to be carried out on the entire assembly device before its delivery to Le Havre including tests on the mechanical elements of the device (portal) and TNIS on the test platform in Cadarache.

The EURITRACK demonstrator will be tested for a period of about 6 months in real operating conditions in Le Havre site.

3. Purpose of the document

The object of the present document is to proceed in the preliminary design of the demonstrator which is to be built to meet the needs of tests planned for execution at Le Havre.

The content of this document deals with:

- The functional aspects,
- the aspects involving constraints (environment, setup) as well as demands / external needs,
- the "component" aspects (in order to take into account the furnishing of Work Packages such as they were defined at the time of project preparation),
- the interfaces between the various functions and/or components and the outside environment,
- the physical interfaces between the different components,
- the basis design interfaces between the various WPs (Work Packages),
- certain service functions that will not have been detailed at the time of the assembling and launching of the project.

The level of detail in the description of various components can be heterogeneous, in as much as it is known to correspond to the level of progression in the studies of the different WPs at this stage of the project. Annexe B views gives global description of the EURITRACK system.

4. Functions of the demonstrator

The following main functions are required:

- Access of the vehicle and container to TNIS area,
- positioning of the vehicle and container in relation to the TNIS portal,
- definition of the parameters of the control to be carried out (*),
- positioning of the measurement equipment in relation to the container,
- carrying out the measurements (**),
- interpretation of the measurements with the help of all available data,
- providing the results: chemical composition of suspicious content,
- filing and delivery of the results.

With a limited number of detectors and built-in displacements, TNIS must be capable of analysing:

- Any voxel within the container, involving:
 - Horizontal (longitudinal) Y displacement by moving the vehicle either by one's own means or by using a support trolley,
 - vertical Z displacement by moving the Neutron Generator (NG), the front side detectors, and the back side detectors
- several voxels of a same X line (Y and Z fixed), involving:
 - Horizontal (transversal) X displacement of the top detectors.

Note that additional displacements (front side and/or back side: X; top: Z) are or may be necessary to ensure the nominal distance between the detectors and the container and to meet some service constraints (see below).

(*) types of control:

case 1: The voxel to be controlled is known thanks to the analysis of the measurements carried out by the SYCOSCAN and therefore the instrumentation equipments are positioned accordingly

case 2: the voxel(s) to be examined is/are not pre-defined:

- A zone to be inspected is arbitrarily chosen (Y, Z positioning),
- a global analysis integrating all the X line is carried out,
- according to the result, one (or more) zone(s) of interest is defined,
- if deemed necessary, a second measurement is made with a re-positioning of the measurement equipment to target the zone of interest.

(**) Notion of "pre-measurement"

In order to determine whether or not the use of a collimator is necessary for some gamma measurements (in the case of organic matrix, for example), a pre-measurement is first carried out without it (detector in "lower" position). The background noise obtained is examined and according to its magnitude the position of the detector is adjusted in its collimator for the final measurements.

5. Operational Customs Requirements

In order to fulfil the Customs needs and allow a (as) normal (as possible) running of the site, the demonstrator:

- Must be capable of checking all types of containers (loaded on multiple types of vehicles),
- must ensure protection against the risk of radiation ,
- must be compatible with set-up constraints (road networks,...),
- must not disturb the operation of the SYCOSCAN system. In particular, the length of time involved in the measurement on the demonstrator may be greater than the SYCOSCAN examination: in this case, the operation of the demonstrator must not upset or hinder the circulation of vehicles in the SYCOSCAN control. In order to avoid any unfavourable incident, the TNIS must be able to shut down the NG momentarily or adjust its flux and start operating again at its normal operation without any consequences on the analysis of the measurements,
- must not provoke too great a period of immobility on the containers to be controlled,
- must be operational in external environment conditions,
- must be in conformance with the standards and regulations currently in effect.

Specifics hardware and software demands are expressed by French Customs:

- In their general requirements for EURITRACK system the Customs authorities have stated that the work station supporting the Man Machine Interface must be located inside the SYCOSCAN command premises. If not possible or not desirable for the demonstration stage it would be necessary to install it in temporary dedicated building (prefab) on the site,
- the software must use industrial standards for the file formats and the interface with the Customs existing "container management software".

The following principles are to be retained:

- Only one MMI for the whole device,
- possibility of piloting each one of the organs in a unitary manner through the MMI (switchers, NG, acquisition of detectors signals, ...).

6. Regulations and Radioprotection

6.1 General

The current standards now legally in effect shall be respected such as:

- ICRP60 - Radioprotection,
- NF M 61-002 & 003 - Sealed sources,
- NF C 15100 - Electricity,
- EEC instructions relative to dangerous machines,
- Regulatory Tests: tests in loaded conditions (portal),

6.2 Radioprotection

The decision to install the demonstrator on the site of Customs at Le Havre implies that the limits of exposure to radiation for the general public and Customs personnel must be taken into account.

The regulations to be observed indicate that an annual limit of 1mSv for the public is admissible. However, the maximum values authorised on a "punctual" basis are not specified: the translation of the annual value, mSv, into an "instantaneous" mSv/hour value must be carried out under our supervision by means of a safety analysis that will be performed by WP2 in collaboration with the DRIRE (The Regional Direction of Industry Research and Environment).

The incidence that the EURITRACK facility will have in terms of radioprotection on the personnel working on the Customs site at Le Havre shall also be taken into account in the study.

The consequences of these demands will result in setting up appropriate precautions, namely:

- exclusion zone
- interlock system
- video surveillance
- safety room for all personnel concerned.

7. Input data for the basis design

WP1 -> WP3

WP3 must have the following data:

- X ray image from SYCOSCAN and its analysis by the Customs,
- packing list,
- filling weight and height of the container,
- knowledge about the type of container (dimensions, material of which the container is made, wall thickness...).
-

WP1 -> WP4

On the SYCOSCAN set up at Le Havre, the image files are in an owner format SMITHS HEIMANN (.img) and Customs is not the owner of the image files.

Consequently, any direct retrieval of the file on the SYCOSCAN computer is not possible.

Therefore, it will be necessary to envision working on a printed image in order to pinpoint the zone to be controlled.

In order to identify the Y and Z coordinates of the voxel based on the image of the SYCOSCAN the following must be taken into account:

- the absence of identification of the dimensions in the SYCOSCAN application: the image only has a graphic superimposition of a scale which gives the equivalent of 1m in 10 segments of 10 cm at the bottom of the screen,
- the effects of geometric projection leading to a distortion of the image on the Z-axis. These aspects shall be examined by WP4 and taken into account in order to determine the actual positions of the targeted voxels in relation to a referential linked to the container.

These aspects are to be developed by WP4 in its specifications.

WP1 -> WP5

Customs will provide the following information concerning:

- The vehicles (truck, trailer, container) to determine the maximum overall dimension (dimensioning of the portal), data given on the "non horizontality" of the container loaded on the trailer (in order to determine if it is necessary to plan for an adjustment in Z in the position of the top detectors),

Customs will state on the location of the control room (MMI,...) and safety room: whether part of existing building, or in separate prefab buildings to be installed.

WP3 -> WP5

The measurements must always be carried out with the vehicle at a full stop, and the detectors in a stationary position.

WP3 will provide WP5 with the following functional data:

- Positioning of the front array:
 - o Nominal work distance in relation to the container wall: 30 cm (a value that must be finalised as well as the tolerance). This functionality can be obtained either by a positioning of the truck (guide rail,...) with the stationary front array, or by the possibility of a displacement in X of the front array (***)
 - o Z vertical displacement range: adequate in scanning the entire height of the container (between 2.438m. and 2.896m depending on the type of container (***)
 - o the neutron generator and the tagging detector are stationary on the front array

- the position of the shielded gamma detectors must be adjustable in X,Y,Z in relation to that of the neutron generator (range and accuracy must still be defined).
- positioning of the back array:
 - Nominal work distance in relation to the container wall: 30 cm (a value that must be finalised as well as the tolerance). This functionality will be obtained either by a positioning of the truck (guide rail) or by a displacement in X of the back array (***)
 - vertical displacement range in Z: subservient to that of the front array (***)
 - the neutron detector and the peripheral gamma detectors are stationary relative to the back array,
 - the gamma detector aligned in the axis of the neutron generator is mobile following the X axis (range and accuracy to be defined) in a collimator that is stationary in relation to the back array (to be confirmed).
- positioning of the top array:
 - Nominal work distance in relation to the container wall: 30 cm (value to be finalised as well as the tolerance) necessitating a Z displacement of all the detectors while also taking into account the non-horizontality of the container and its varying height according to the type of container (between 2.438m. and 2.896m.) and the overall dimensions of the vehicle (***)
 - all the detectors must be able to be displaced along the X axis (range to be defined),
 - a certain number of detectors have stationary collimators (to be confirmed) in which displacement of the detectors along the Z-axis must be possible (range and accuracy to be specified).

(***) WP5 will define the necessary displacements and range values of the captor panels according to the criteria of the relative positioning and the adjustments of the instrumentation expressed by WP3, and the demands linked to the overall dimensions of the vehicle (tractor, trailer(s), container(s): heights, widths... according to the type), manoeuvrability of this vehicle in the TNIS zone and the various mechanical constraints.

Note that with the chosen option of using only one neutron generator for the demonstrator, owing to the attenuation of the neutron flux with distance, the probability of detection of a package would be improved if we could present each of the sides of the container facing the generator. This would involve having the vehicle make the necessary manoeuvres to achieve this.

WP3 will also specify:

- The dimensions and components weight to be borne by the portal: detectors, shielding, collimators and cables (particular attention must be devoted to the tightness of the neutron generator supply cable),
- the exposure doses and the global integrated doses to which the equipment of the portal (in particular the electro-mechanical equipment) is to be submitted,
- for the definition of the exclusion zone, it will be necessary to arrange radiological protection blocks (around the neutron generator). The material for the protection (for example: concrete) should not perturb the measurements. A minimal distance of 2 metres between the neutron generator and the radiological protection is now judged advisable by WP3 on the basis of concrete protection (after review, the value may be lowered as the studies progress),

- the basis design of the radiological protection by means of calculations,
- the maximum length of the cable links between the neutron generator and the associated electronic equipment (high voltage cable: 15m. to be confirmed) and between the portal detectors and the associated electronic equipment located in a closed "electronics" room grouping the signal conditioning devices.

WP4 → WP5

WP4 shall specify:

The maximum length of the links between the electronics located in the "electronics" room and that which is located in the "control" room.

WP3 and WP4 → WP5

- cableway:
 - Each WP lists its cables: the number, type, diameter, curve radius, from-ends/to-ends, specific constraints (maximum length, incompatible environment...), and recommends, should it be necessary, the means of cableway (buried links...),
 - WP5 centralises and plans the regroupings, the cableways and in turn indicates the lengths to be produced to the other WP's.

- Environment conditions, protections:

Each WP specifies the condition and the environmental disturbances, termed atmospheric:

- temperature,
- humidity,
- rain, snow...,
- vibrations (wind...),
-

that are compatible or incompatible with the satisfactory functioning of the devices (captors, electronic, signal links...) and the interpretation of the measurements:

- Survival conditions,
- satisfactory functioning conditions, allowing measurement or valid treatments in a normal functioning mode or possibly even in a degraded one (for example, the necessity of performing manual calibration of the gamma spectra if the temperature of the detectors is not maintained within a range that makes any shifts negligible).

WP5 defines the elements of protection whose purpose is to ensure proper functioning of the devices: temperature regulations, ventilation, captor housings, cableways, conditioning of the "electronics" and "control" rooms, and if deemed necessary placing a covering over the portal (hangar with reinforced protective siding...).

Please note: WP3 and WP4 are to examine the environment conditions and to define any possible restrictions regarding the use of the TNIS demonstrator, according to the protections that will be installed.

8. Material limits and interfaces of the various WP

8.1 WP3

- Neutron generator (including control devices of the pressure in the tube) and tagging detector,
- emergency rotating light linked to the neutron generator,
- front side detectors (linked to the NG),
- back side detectors (opposite the NG),
- top detectors (above the vehicle),
- the collimators, shielding of the detectors,
- the electronic instrumentation, the cables and the connections linked to the NG and to the detectors.

Limits of the materials to be finalised

With WP4:

- Link between the "electronics" room and the "control" room.

With WP5:

- Assembly of the components on the instrumented panels of the portal
- possibility of displacing the detectors on the instrumented panels: adjustment of the positions of the gamma detectors on the front side array, displacement of the gamma detectors in the collimators on back side and top arrays,
- electrical supply of the devices, safety systems,
- protection of the detectors and of the electronic instrumentation with regard to the environmental conditions: temperature stabilisation,...

8.2 WP4

- Computer material and software to ensure the following functions:
 - o Supervision: MMI, guidance in decision-making,
 - o piloting of the TNIS, mechanics, neutron generator,
 - o safety surveillance in the EURITRACK zone,
 - o analysis and interpretation of the detector signals,
 - o integration of data supplied by the Customs organisation,
 - o filing and restitution.

Limits of the materials to be finalised

With WP3:

- link between the "electronics" room and the "control" room.

With WP5:

- Electrical supply for the devices,
- the control and operation machine for the motor of the portal, if any,
- protection of the electronics with regard to environmental conditions.

8.3 WP5

- Development of the chosen site for the demonstrator in agreement with Customs: roadwork, access and vehicle manoeuvres,
- radiological protection (walls and other),

- markings and warning signs in compliance with the standards now in legal effect pertaining to radiological risks,
- video surveillance,
- telephone and telecommunications ,
- lighting around the perimeter of the demonstrator.

- positioning, guiding of the vehicle and of the container that is to be controlled,
- control of the container's actual position in relation to the portal (in fine position of the neutron generator in relation to the voxel to be analysed),
- portal and mobile instrumented panels, which will serve as a support to the detectors and to the NG. The necessity of displacing the vertical supports according to the X axis and the horizontal supports according to the Z axis, to control the positioning of the container, to ensure the integrity of the detectors during manoeuvres and the removal of the container, are to be examined,
- elements allowing adjustment of the position of the detectors on the panels: adjustments X-Y-Z of the gamma detectors on the front side array, Z adjustments of the top array detectors in relation to their collimators, X adjustment of the central gamma detector of the back side array in its collimator.

- if they are planned to be included:
 - o Motors and captors associated to the positioning of the vehicle in relation to the portal,
 - o motors and captors associated to the displacement of all support panels of the captors,
 - o motors and captors associated to the relative displacement of the detectors in relation to the panels,
 - o Control unit or automata for the piloting and the control of all motors and captors,...(interface of this unit with WP4 to be defined).

- electrical supply of all the components of the EURITRACK device,

- premises to be defined according to the final setting up of the portal:
 - o Electronics room (remote electronics of the detectors and of the neutron generator, electrical supply cabinet, control unit and/or piloting automata and security cabinet),
 - o control room according to the Customs decision,
 - o safety room according to the Customs decision,
 - o pathways for the links between the portal and the "electronics" and "control" premises (power supply cables and measurement cables must be separated in proper way in order to avoid disturbances in the signals),
 - o adaptation of the electrical network to the power balance to be provided.

- protection of the portal (hangar providing shelter from the rain and snow...) and/or he measurement equipments that it shelters (specific housing on the neutron generator, the detectors and electronics),
- safety fences for the exclusion zone, associated access device for the vehicle (and the personnel) with locks and security contacts.

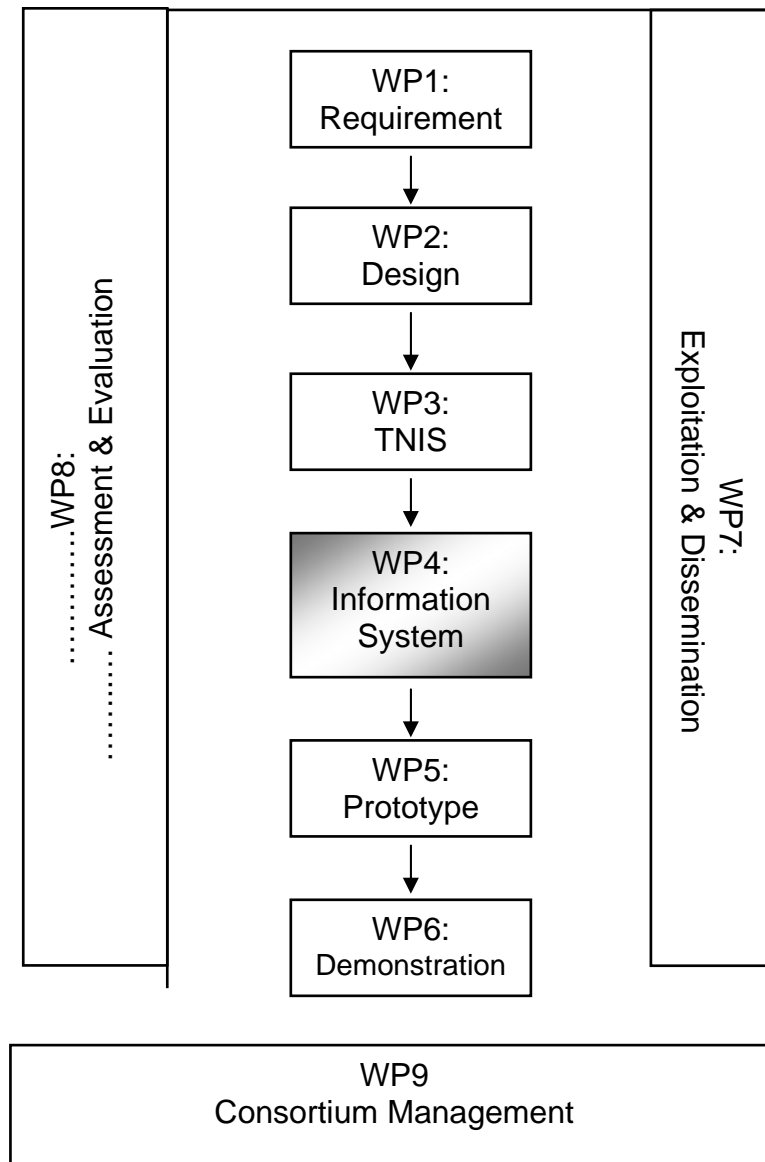
Limits of the materials to be finalised

They are defined in previous sections.

ANNEXE - A -

Graphical presentation of work packages

A schematic linear overview of the structure could be as follows :



ANNEXE - B -

Schematic views

