ContainerProbe-Net

J. Sved [1], T. Firestone [2] , R. Walker [3]

[1] NSD-Fusion GmbH, Germany
[2] NSD-Fusion/ConsortiumNeutron Systems, North America
[3] ConsortiumNeutron Systems, USA

Email contact of main author: john.sved@nsd-fusion.com

Abstract. ContainerProbe-Net is a global system concept for high throughput Risk Screening of inter-modal containers while they are in motion. It will have detection or indication capabilities for risks arising from mis-declared hazardous materials, contraband materials and terrorism materials. Neutron interrogation of each container on a train or on an automated vehicle passing through the ContainerProbe portal will provide information about the bulk elemental composition of the contents. A burst of pulsed neutrons for a combination of prompt gamma and secondary neutron emissions can provide a measured "fingerprint" which will remain constant from the start to the end of the container's journey. A period of two seconds is available per container in order to capture data for each container on a moving train. Contents of containers are already, to some extent, registered in the export logistics databases. However these disparate systems have evolved with computer science and the needs of ports and customs authorities. Today such systems are far from complete. The global access to such registered container data and the fusion of this information with actual physical measurement data is the Network part of the concept. Risk screening implies that anomalies are detected; both physically measured and filtered from the globally accessible container logistics data that is accessed by new information search tools and network infrastructure. Anomalous containers can then be sorted for further examination with high resolution but low throughput imaging systems. ContainerProbe is able to be implemented because a linear geometry or line source neutron generator with intense pulsed neutron output combined with industrial robustness and economy is able to be adapted to the application. This paper will describe the concept and indicate opportunities for the application of large area sensors in combination with the long neutron generator.

1. Introduction

There are several reasons to screen intermodal shipping containers. Different groups in various countries want to detect:

- mis-declared hazardous materials which can result in loss of vessels (maritime safety and insurance):
  illegal waste exports or imports
  hazardous materials causing many annual maritime insurance claims
  accumulated pest poisons

- contraband materials and smuggled goods as defined by customs and trade regulations including illegal waste export:
  smuggled and counterfeit goods to avoid import duties and restrictions
  narcotic drugs
  weapons for criminals
  illegal immigrants

- terrorism materials:

explosives and precursors
Weapons of Mass Destruction
fissile materials

100% risk screening of containers has been mandated by U.S.A. lawmakers [1] but the operational introduction keeps slipping because an imaging and image inspection system is impractical and too costly [2].

Active neutron interrogation for neutron and gamma spectroscopic assay **without** image inspection and **without** a scanning or object translation past a point source or narrow beam “illumination” device is proposed. Rather, the container contents are effectively probed in a single look with a flash or short bust “illumination” from line source neutron generator.

A transmission rather than backscatter configuration is illustrated below. In such cases the containers pass through the portal without stopping. At 5 m/s (~ 18 kph) pulsed bursts of neutrons can illuminate the entire container(s) on a rail wagon or an Automated Guided Vehicle. A 20 μsec neutron pulse only represents 0.1 mm of movement. The array of detectors can be arranged to commutate the gamma sensor output data flow so as to maintain synchronisation with the rate of movement. The neutron generator is long, and can be configured to suit the portal requirements. Adaptation to road vehicles is also possible if there is no driver present. Where available Automated Guided Vehicles can be routinely directed through a portal, the neutron screening proposed herein can be achieved without stopping the AGV.

Fig. 1 Gottwald Port Equipment GmbH AGVs

Fig. 2 Kalmar Automated Straddler

2. Performance Feasibility

Published reports by various projects in the U.S.A. (LLNL, INEL, K2 – Purdue) have demonstrated that neutron interrogation of large objects works in principal. The time necessary to scan a segment of a container with orthodox sealed tube point-source neutron generators is at least 30 seconds (from LLNL). This is commensurate with the specific neutron flux that can be emitted from the long NSD-NG over the entire length of the container in one moment. Depending on the spatial selectivity of each detector in the array, some positional information may be obtained if there is a concealed fissile material or a discrete non-fissile material regarded as anomalous within the particular container. Similarly, double-decker container stacks can be accommodated.

A nuclear researcher in the UK has commented to NSD-Fusion that his MCNP simulation models indicated that only one 18 μsec duration pulse would be sufficient to probe a container. The design process has to maximize the gammas to the detectors without a pile-up overload that causes detector dead time.

The MCNP simulation tool or similar packages such as GEANT shall be used by experienced nuclear physicists in conjunction with project engineering to examine achievable system configurations. The optimal system design will emerge. At that point a prototype can be constructed.

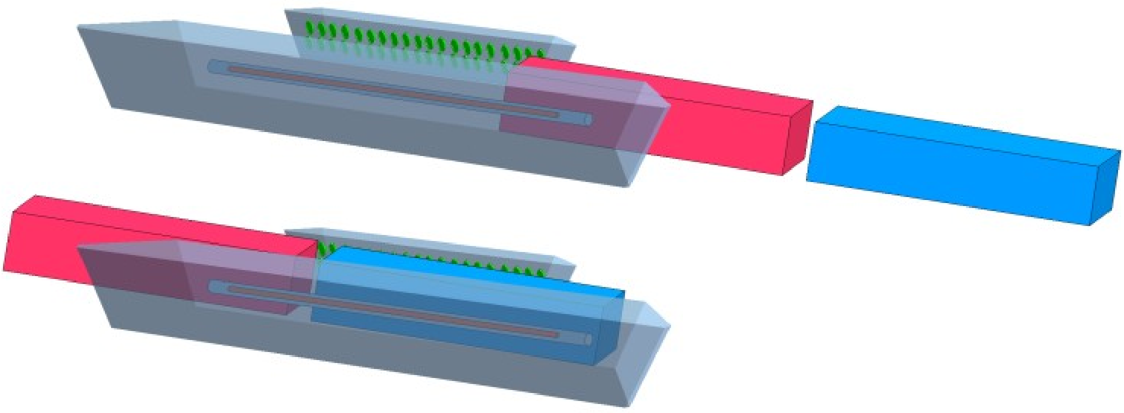

Fig. 3 ContainerProbe rail portal - no stopping. Slow train. Fast 100% screening. Divert suspects to imaging scanners.

A challenge which is still being investigated is the "data fusion" from the ContainerProbe system with the ISPS and similar shipping logistics security databases. This is the alert event trigger function in the process.

3. Component Technology

The 6 or 12 metre length of neutron generator can be configured as shown below to provide neutron emission zones at regular intervals. Insulation stand-off structures can support the segmented electrode assembly. The body or vessel wall of the neutron emission plasma reaction chamber is made from extruded aluminium with the ends machined for the vacuum seal fittings.

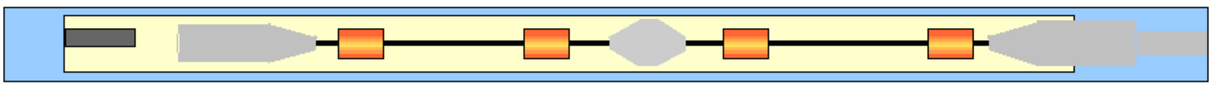

Fig 4. Linear geometry line source NSD neutron generator. Segmented electrodes provide system design optimization flexibility.

The gas supply is held in solid solution within getter pump material. The hot getter pump regulates hydrogen isotope pressure and hence voltage for glow discharge operation.

The maximum safe specific neutron output of the NSD-NG is 10 times better than orthodox solid target neutron generators. Three neutron energy outputs (2.5 MeV, 14 MeV and "white" 0.5 -9.5 MeV) can be provided with marginal cost increase for Tritium. In single-shot or low pulse rate mode, the per pulse current will go from about 10 Amp at 20 µsec pulse duration. Pulsed Inertial Electrostatic Confinement fusion super-linear scaling gives about a factor of 10 greater neutron yield than a comparable DC power . This will yield a range of performance parameters for greater system feasibility.

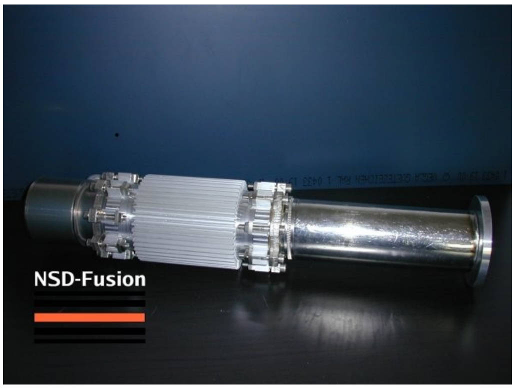

Fig. 5 NSD-NG Mk1 short electrode version

The NSD-Fusion GmbH IEC fusion linear reactor technology has been developed to commercial availability since 1996; first within a major space systems company in Germany. Advances made for the so-called Mk0 spherical configuration neutron generator were entirely the result of industrial effort. After the Mk0 project was effectively terminated despite its market entry, the NSD company was first established in 2001. The linear geometry was disclosed and proven with the Mk1 NSD Ltd (UK) neutron generator. NSD-Fusion GmbH in Germany has continued slow commercial progress with a Never Say Die attitude. Financing of the neutron generator business has been intermittent; suffering from investor ignorance. More recently nuclear technology oriented bankers were discovered. Various industrial applications projects and customers are in acquisition; one benefiting from an EU grant. Several corporate customers have contracted NSD-fusion to produce variants of its neutron generator.

Development effort is required to realise a 12 m long segmented electrode linear NSD neutron generator with high-output single- or burst-pulse performance. Pulsed operation with 1-2 µsec fall time is achieved with an innovative, compact high voltage, controlled high current, most compact power supply technology which is already available. This new module is in development to serve several industrial projects.

A 12 metre long NSD neutron generator is marginally more costly than an orthodox short lifetime solid target neutron generator of similar total neutron yield. To use 13 point source neutron generators with perhaps one tenth of the total output each would be prohibitively expensive and unreliable to regulate as a quasi-line source. The effective savings permit substantially more detector array elements of various types that can be tuned for the various neutron gamma reaction emissions.

4. Operational Concept

100% screening of all containers in a port with minimal impact on Container Port logistics should occur at the boundary before the container enters its preplanned logistics flow.

The ContainerProbe-Net risk screening function can select suspicious containers for more intense investigation by high resolution but low throughput imaging systems which can process only a few percent of the daily traffic.

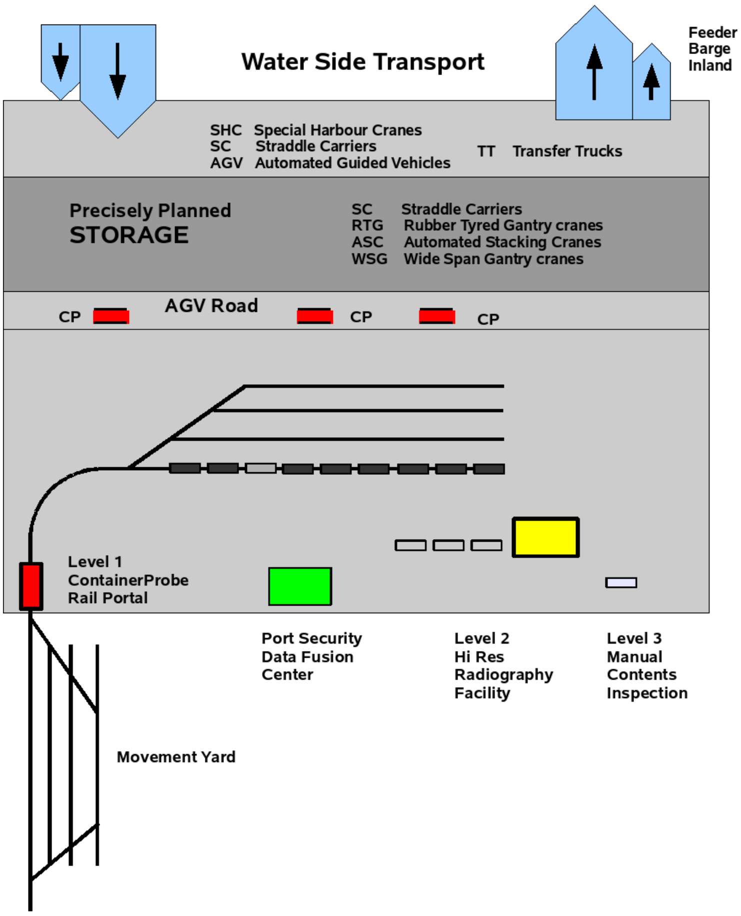

Fig. 6 Deployment of ContainerProbe portals with a port.

The ability to capture the "fingerprint", match these against control databases, apply sophisticated risk assessment rules, centrally deploy new risk assessment rules and fuse these "fingerprints" across multiple locations provides a new capability for combating terrorism and protecting civil security. The ability to deliver this solution without impeding the current, orchestrated movement of containers within a port is unique to the ContainerProbe-Net solution and a mandatory requirement.

In addition, the technology can be deployed to other solutions; for instance at:

1. Inland transport nodes such as river ports and rail logistics corridor hubs.
2. Airports to screen incoming/outgoing luggage and cargo
3. Borders to screen truck and car cargo

4. Military and security sensitive sites to screen incoming cargo and vehicle traffic

All these installations can access the same control databases and use common risk assessment rules with alerts being sent, if desired, to a central location.

ContainerNet provides a new capability to national security agencies to centrally manage and deploy the risk assessment rules being applied at every port of entry. These rules will be consistently applied and not require expensive and time consuming notification, training and deployment efforts.

5. Operational Utility Assessment Plan

The size of ContainerProbe mandates that its demonstration and evaluation be conducted in situ with many containers. Therefore location at an operational port where a large variety of container contents can be probed is essential. The deployment at a foreign port of embarkation to the U.S.A. and a port in the U.S.A. is logical**.**

A rail ContainerProbe portal is considered to be a good candidate for earliest field trials. The loading of the freight train at distant inland depots provides the train container manifest well ahead of arrival at the port. As each container passes through the ContainerProbe portal on the slow moving train, as it approaches the end of the line, its elemental content or gamma and secondary neutron profile can be measured with the active neutron interrogation. The database of declared contents and elemental signatures can be automatically populated. Initially signature spectra are collected against the cargo classification manifest database. Later these profiles can be compared to the measured profiles. Anomalies would be indicators of potential risk. An alert system would lead to the diverse of the suspect container for further inspection by "level 2" scanning systems.

There is potential to detect fissile, hazardous or mis-declared materials by defining a limited set of elemental profiles. If mis-declared contents are entered into the reference data base the next correctly declared example to be probed will alert the discrepancy.

The term "profile" is used here for a data set. The raw gamma and neutron spectral data may be abstracted to more compact data sets. This is an area of applied information technology which has potential to evolve into ever more useful data for "data fusion" and "data mining" systems. Such technologies are already available for adaptation to the ContainerProbe-Net function.

As rail born containers receive hardly any scanning, the relative performance assessment is minimal. The self learning AI technology of the ContainerProbe recognition system represents, at present, the longest development path. It follows the hardware development to deliver good data product, and relies on early operational phases to fully develop. The “data fusion” development process has aspects which will only be conclusively implemented as experience is gained.

6. Business Development

The ContainerProbe-Net concept originates from NSD-Fuison GmbH in Germany. NSD has persisted in its start-up efforts and is now funded to expand its core business of neutron generator products and applications system development for clients.

A partnership has established ConsortiumNeutron Systems Inc. in the U.S.A. ContainerProbe was proposed to the US DHS S&T in Jan. 2008. It was also accepted as technically feasible but the development time was greater than the period before the presidential election. Since then CNS has been briefing various security agency officials and senior advisers in the Washington DC community.

The U.S.A. - Germany cooperation on Security Technology Research announced 16-03-2009 provides a high priority approach to acquisition of governmental support for the R&D effort. The global character of ContainerProbe-Net provides ample opportunity to increase the stakeholder community. Indeed a neutron applications company in Russia has accepted the invitation and is seeking governmental and investor support to join the ContainerProbe-Net team.

ContainerProbe-Net establishes a standard of measurement plus security data processing and exchange. Global deployment provides regional participation within the standard.

7. References

[1] USA “Security and Accountability For Every Port Act of 2006” or the “SAFE Port Act”.

[2] Massachusetts Institute of Technology Engineering Systems Division Working Paper Series ESD-WP-2007-05 BARRIERS TO THE SUCCESS OF 100% MARITIME CARGO CONTAINER SCANNING
Final Report – ESD.10 Introduction to Technology and Policy
R. Cirincione, A.Cosmas, C.Low, J. Peck, J. Wilds,
Massachusetts Institute of Technology, Technology and Policy Program, January 2007
http://esd.mit.edu/wps/2007/esd-wp-2007-05.pdf