The site approach – lessons learned from the integrated safeguards approach for JNC-1

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Abstract. Integrated safeguards approaches for specific sites are recognized important elements in the design of a State-level approach under the concept of grouping facilities. Japan and the IAEA agreed further improvement of integrated safeguards implementation in effective and efficient manner, particularly at large complex nuclear sites in Japan. Japan and the IAEA developed the integrated safeguards approach for specific sites defined at Article 18 of Additional Protocol. In 2008, the IAEA started the three-year test implementation of JNC-1 site approach for improving the effectiveness and efficiency of the safeguards implementation of UDU material handling facilities. Japan and IAEA agreed to adopt the sector concept in order to make clear of subjected nuclear material to be verified. The sector is defined as spatial assignment that treats the same material stratum beyond MBAs in the site. The arrangement of MBAs and related material balance calculations as well as statistical analysis is maintained as a fundamental safeguards measure. At the boundaries of each sector, appropriate unattended NDA system and/or C/S system are installed, and material flows across the boundaries are verified by the system or attendance of resident inspectors. For inventory verification of the nuclear material stayed in sectors, an appropriate numbers of randomly scheduled inspections will be implemented. IAEA can access to the randomly selected sectors within 2 hours after notification. NRTA based on frequent operator's declaration will be performed for achievement of timeliness detection goal. The JNC-1 site approach has been implemented under the enhanced co-operation between the IAEA and SSAC through joint use of equipment and arrangements for DA analysis. Especially, national inspectors are working with IAEA together for coordination with operators. Because NMCC lab analyses all DA samples taken from facilities and the analysis results will be shared by the IAEA, certain numbers of DA sample shipped to the IAEA could be diminished. Random Scheduled Inspection could reduce total PDIs and peak demands in the number of inspectors at IIV regime under traditional safeguards. From operator's point of view, the impact on plant operation could be minimized by improvement of efficiency of safeguards activities under the site approach. The concept could be extent to other sites, such as JNC-2 and JNC-4, and the same types of facilities, such as LWRs without MOX and LEU Fuel fabrication facilities. The site approaches in Japan have a possibility of the further improvement of enhanced co-operation with IAEA for implementation of the State-level concept and integrated safeguards.

1. Introduction

It is sure that inspection efforts including Person Days of Inspection (PDIs) for Japan were streamlined after movement to the integrated safeguards. However, even though safeguards activities implement under the integrated safeguards, the PDIs for Japan are still large, because Japan operates a large size and further complex fuel cycle. Japan do believe that good contribution to the IAEA is to further improve the efficiency of inspection activities to Japan through establishment and maintain the cooperative state system of accounting for and control (SSAC) without compromise the effectiveness of safeguards. Japan expects that amounts of PDIs that could be cut off from current safeguards activities for Japan, would be allocated to other significant safeguards issues.

As a part of the state level safeguards approach (hereafter we express SLA), Japan and the IAEA would intend to establish the site level approach (hereafter we express Site Approach). Conventional safeguards

approach was applied to each type of facility and to material balance areas (MBAs) in the facility. Previously, inspection was planned for each facility depending on types of nuclear material and their amounts with significant level. In Japan, the many nuclear facilities are usually placed at the same location so called nuclear sites. The Site Approach is to focus on the significant complex facilities with coherent and sequential nuclear material flows in the same location.

Japanese Government and the IAEA agreed to start the study of the Site Approach in September 2004 and firstly JNC-1 (JAEA Tokai works including Tokai Reprocessing Plant: TRP, Plutonium Conversion Development Facility: PCDF, and Plutonium Fuel Production Facility: PFPF and other facilities) site was selected for the discussion. A reason that JNC-1 site was selected is the site was consuming significant PDIs in Japan because the site treats significant un-irradiated direct use and historically these facilities introduced innovative measurement system in conjunction with automated process operations. Sequentially, discussion of JNC-2 (JAEA Oharai works including JOYO First Neutron Reactor and related facility such as FMF) and JNC-4(JAEA Monju Fast Breeder Reactor and related facilities) were conducted. At present Site Approaches for three sites are agreed with Japanese Government and the IAEA.

Japan and the IAEA obtained a lot of wisdom for improvement of efficiency. The experiences through the studies and discussions would be expected to expand to other objects.

2. Recognition of Site Approach

At the starting time of the study, we could not find any definition about Site Approach including application concepts in formal document. In the meeting with Japanese authority and the IAEA, both side consented that the Site Approaches for specific sites were a recognized element in the design of a State Level Approach under the concept of grouping facilities.[1]

3. Technical Elements applied to JNC-1 Site Approach

As innovative concepts and advanced technologies for integrated safeguards activities, several items were identified at various official documents.[2] Conventionally, it was expected that the introduction of unattended and remote monitoring system (UNARM) could be taken toward reducing inspection efforts in facilities. For development of integrated safeguards, generally, the use of unannounced inspection scheme and the procedures for the randomized selection of facilities for inspection under well cooperation between the SSAC and the IAEA were identified as candidate measures.

3.1 UNARM

As for the unattended and remote monitoring system, we can find the assessment of the inspection cost saving by the utility of unattended NDA and C/S systems as part of Task 2 of programme 93+2.[3] The use of unattended NDA and C/S system can lead to a reduction in the physical presence of inspectors in facilities, and hence, savings in inspection effort and associated inspection travel costs. The SGOA also recommended that “Where appropriate and cost justified, for more sensitive nuclear materials, surveillance, and unattended radiation monitoring data would be remotely transmitted to the IAEA site offices. Due to use of local site telephone network, the cost of data transmission could be reduced. It would allow quick, sometimes immediate resolution of inconclusive surveillance or unattended and remote monitoring results.”[4]

Remote monitoring can improve the efficiency of the IAEA safeguards by replacing certain inspection activities associated with unattended monitoring and measurement systems with data collection review and evaluation at a remote location. Additionally, it is expected that remote monitoring has a possibility to achieve the timeliness detection goal by any-time reviews and evaluations at a regional office or IAEA headquarters.

3.2 Randomly Scheduled Inspection with unannounced or short notice mode

Guidelines for Unannounced and Short Notice Inspections under Integrated Safeguards were prepared by SGCP in 2002.[5] The guideline suggested that when the IAEA was able to draw a conclusion of the absence of undeclared nuclear material and activities in a State, reductions in accountancy safeguards applied to certain types of nuclear materials and facilities in the State could be justified.

The Guideline indicated three objectives of unannounced and short notice inspections:

- providing a detection and deterrence capability against diversion or facility misuse;
- assuring the effectiveness of IAEA co-operation arrangements with States or regional systems of accounting for and control; and
- contributing to the effective use of the IAEA's short notice rights of complementary access.

A major feature of randomly scheduled inspections is to increase verification coverage of items, flow and inventories. Unpredictability in the timing of an inspection strengthens the IAEA ability and likelihood to detect and deter some types of diversions or facility misuse. However, the high detection probabilities and the timely detection requirement that govern the extent and intensity of safeguards applied to UDU materials will be supplemented by other measures such as UNARM. Further, the use of unpredictability to reduce verification requirements on declared nuclear material is not identified as an objective of unannounced and short notice inspections.

3.3 Frequent data provision

Supporting to implementations of randomly scheduled inspection with unannounced or shortly noticed bases, frequent data provision of safeguards relevant information must be necessary. Improved transparency on operational activities of safeguards relevance at the facilities that handle the UDU material is needed. The facility operator will provide further information about nuclear material accountancy, i.e., further detailed information than required for conventional material accountancy will be submitted in a more frequent manner. Advance provision of safeguards relevant information is needed for the effective implementation of randomly scheduled inspections. A "mail box" approach with remote data transmission, where the facility operator deposits accountancy reports or operating records in a pre-arranged location, is a candidate arrangement for data submission. Declaration of activities relevant to safeguards will be provided in advance electronically with updates as necessary. The frequency and contents of these declarations will be defined by mutual agreement on facility specific. Mainly they will depend on the type and scale of nuclear activities and/or the quantity of nuclear material in the subject facility.

3.4 Near Real Time Accountancy (NRTA)

For high throughput bulk facilities frequent data provision is indispensable condition for NRTA. NRTA has become an essential safeguards measure for UDU material handling facilities to achieve the timeliness detection goal. Sequential accountancy data at several KMPs are input to the NRTA system, and additionally, the data provide a clear accountability of material flows in the MBA as well as further transparency of facility operations. The NRTA system allows material balances to be closed at any point in time when declarations are updated. This improves the effectiveness of safeguards and enables the IAEA to attain the timeliness goal. Statistical tests using sequential accountancy data are applied to reduce the sampling rates and size without decreasing the detection sensitivity. The facilities in JNC-1 site such as TRP PFPF and PPFF introduced NRTA systems years ago.

3.5 Introduction of Sector concept

A sector concept is introduced to the JNC-1 site in order to make clear of subjected material to be verified. There are same strata distributed in the site, e.g., plutonium nitrate stored in TRP product tanks and PCDF feed tanks and MOX powder in PCDF product storage and PFPF feed storage. The sector is assigned as the space that is treated the same material stratum beyond MBAs and facilities.

3.6 Conventional MUF evaluation based on MBA assignment

Assignment of MBAs and related material balance calculations as well as MUF evaluation are maintained as a fundamental safeguards measures for drawing quantitative conclusions of material diversion.

4. Outline of JNC-1 Site Approach

4.1 Sectors assigned in JNC-1

The sectors assigned in JNC-1 are shown in below;

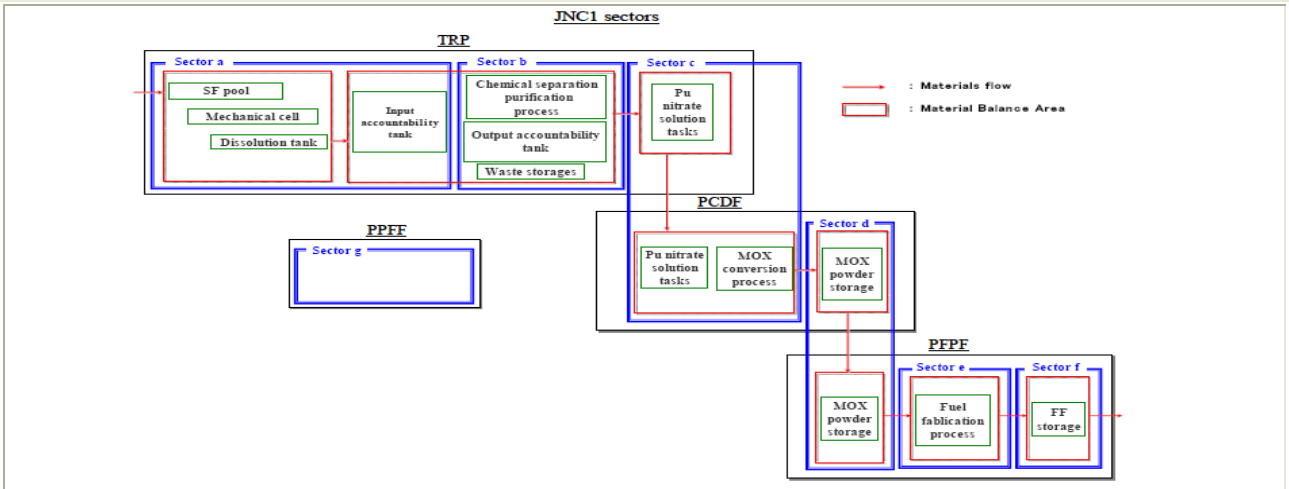

Figure-1 Assignment of Sectors in JNC-1

4.2 100% Flow Verification at each boundary of sector

Appropriate unattended NDA and/or C/S system are installed at almost boundaries of each sector. All material flows, come into and gone out from each sector, are verified by unattended mode NDA or resident inspectors with appropriate measurement system. Small quantity transfers from/to PFPF and PPFF are covered by random inspection basis.

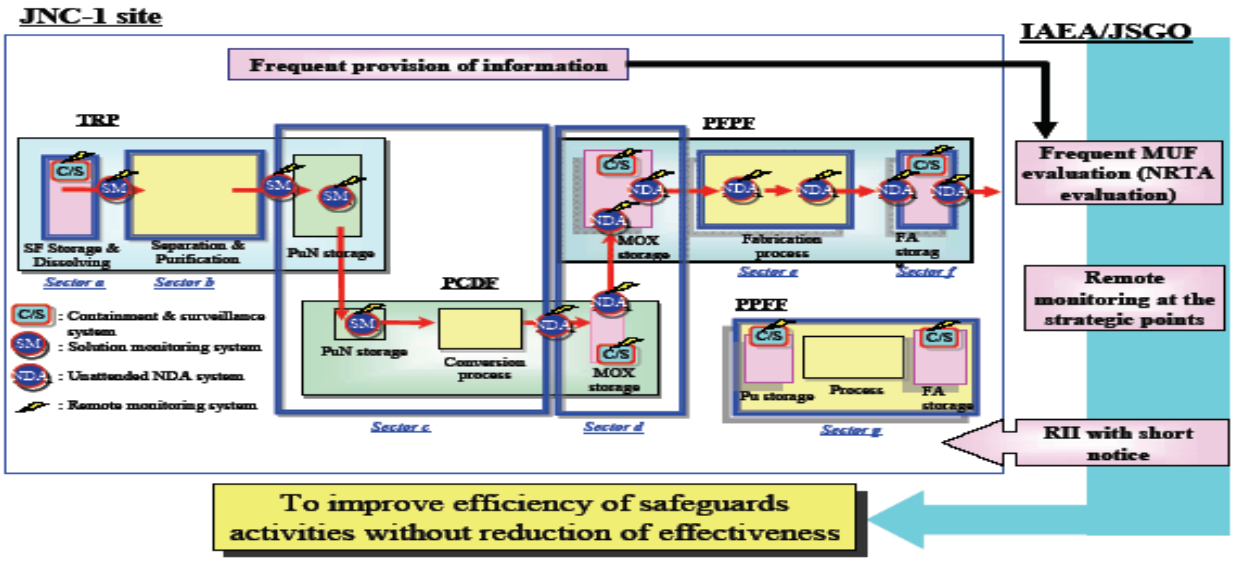

Figure-2 Application of equipment to JNC-1 site

4.3 Timeliness detection goal achievement

For achieving timeliness detection requirement, the remote monitoring technology for unattended mode NDA and C/S system are introduced. The resident inspectors in the TRP have a right to access anytime and anyplace in the JNC-1 site for inspection and complementary access within shorter time after notifications. The data under the remote monitoring are transferred to IAEA site office and Tokyo Regional Office, and such data can be verified any time by the IAEA inspector.

4.4 Frequent data submission by operator and NRTA

The facility operators in the site, i.e., TRP, PCDF, PFPF and PPFF submit information relevant to the nuclear material flows and inventories associated with the sectors, frequently, e.g., weekly or monthly, at an appropriate cut off time of facility operation that could indicate clear inventories of each sector. Based on the information, inspectorates can calculate frequent material balances of each sector (same strata) and evaluate dynamic material balances by the NRTA method.

4.5 Randomly scheduled inspection for inventory (RANDOM SCHEDULED INSPECTION)

Fundamentally, the resident inspection scheme in the TRP is maintained. The IAEA inspectors are staying at the inspector's office in JNC-1 site. Inspectorates have opportunities to implement the randomly scheduled inspections for the inventories in each sector with short advanced notice (approximately within 2 hours). Inspectorates can select inspection times and sectors to be accessed, randomly. At the time that randomly scheduled inspection is triggered by IAEA, operator will provide inspectorates with the detailed information relevant to the inventories and associated material flows of subject sector, rapidly. Inspectorates can also identify the items randomly to be measured by the NDAs and, takes appropriate numbers of DA sample. Randomly scheduled inspection also has an effectiveness to detect borrowing activities among sectors as well as within a sector in the site. IAEA stated that average 30 to 36 times of randomly scheduled inspection will be implemented in the JNC-1 site per year.

4.6 D statistics and MUF evaluation

The IAEA can introduce the inspector's estimate of MUF. 100% flow verification data at every flow key measurement point by unattended NDA systems are very useful for calculation of the inspector's estimate of MUF. The inspector's estimate of MUF provides a higher probability of detecting diversion into D than the 'D statistic'. When most of the major strata have been measured by the inspector, the statistic is capable of detecting both diversion into MUF and diversion into D.

D statistic of flow measurement can be evaluated each values compared with the operators submitted information and 100% independent measurement results at each boundary of sectors. D statistic of inventory measurement can be obtained by independent NDA measurement results of inventories as well as DA results with appropriate sampling plans at the RANDOM SCHEDULED INSPECTION s bring the possibility to evaluate the inventory D.

4.7 Complementary Access at any location in JNC-1 site

Based on the requirement from the additional protocol (AP), the IAEA inspector has a right to access to any place in JNC-1 site with 2 hours notification as a Complementary Access (CA).

5. Other experiences to apply Site Approach for JNC-2 and JNC-4

5.1 Main technical elements for JNC-2 and JNC-4

Discussion of Site Approach for JNC-2 was started from November 2007. JNC-2 includes Joyo that is a Fast Neutron Reactor (without Blanket Fuel) and FMF that is a Facility for Post Irradiation Examination, monitoring Irradiated Fuels from Joyo and Monju. On the other hand, discussion of Site Approach for JNC-4 was started from January 2008. JNC-4 includes Monju that is a Fast Breeder Reactor and LOF that is a waste disposal and storage buildings for maintenance of the fuel handling and major equipment and a low level waste treatment system and storage.

Main technical elements to be applied to the JNC-2 and JNC-4 are almost the same because these configurations of the equipment and fuel handling structures composed in the reactors are almost the same. Main technical elements are as follows;

- Application of Sector concept,
- Advance Site Information including process operation schedules, e.g., receipt/shipment of nuclear material, core loading/discharge and program for facility equipment maintenance, provided monthly and updated by the operator,
- Unattended Radiation Monitoring (URM) and C/S in RM data transmission mode,
- On-site inspections consisting of annual PIVs, Random Interim Inspection with 2 hours or 2days advanced notification, including remote monitoring inspection, foreseen to randomly verify the receipts/shipment of nuclear materials, to detect and deter for undeclared activities, to check the completeness and correctness of the advanced site information, as well as to assure the absence of tampering with monitoring devices,
- DIVs will be performed in conjunction with the PIV,
- Nuclear material accountancy similar to conventional manners,

- CAs at any location in the site based on the requirement from AP, and
- Evaluation of RM transmitted data in the headquarters.

5.2 Sectors assigned in JNC-2 and JNC-4

Sectors assigned in JNC-2 and JNC-4 are shown in below;

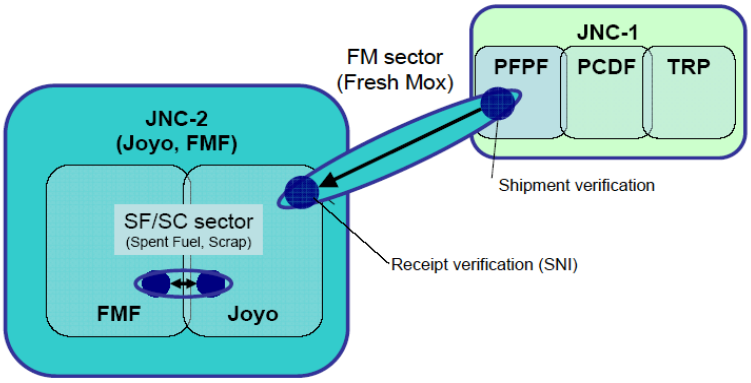

Figure -3 Sector assignment for JNC-2

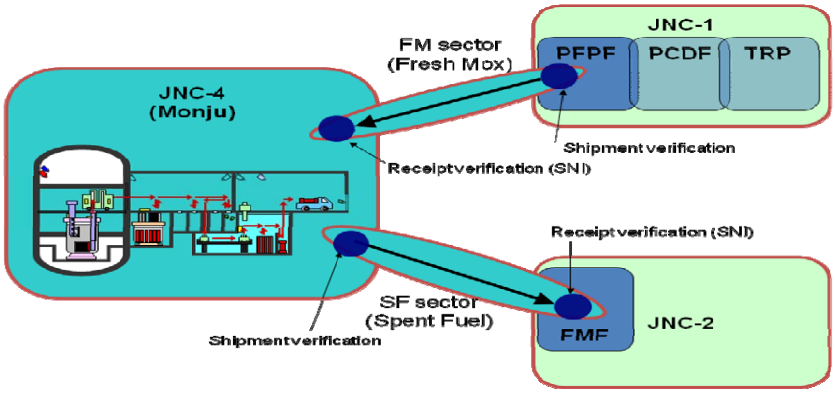

Figure-4 Sector assignment for JNC-4

5.3 Applications of URM and C/S in RM data transmission mode

Applications of URM and C/S in RM data transmission mode in JNC-2 and JNC-4 are shown in below;

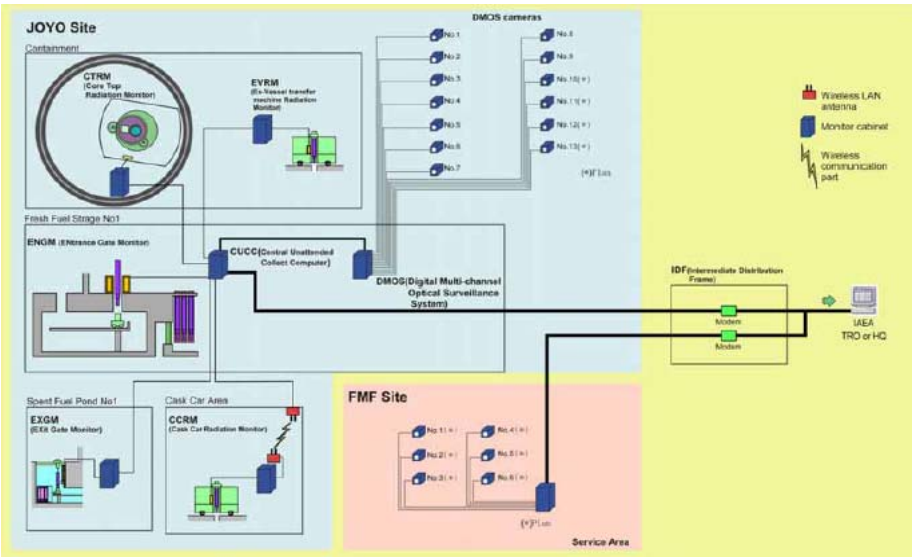

Figure-5 Applications of URM and C/S with RM for JNC-2

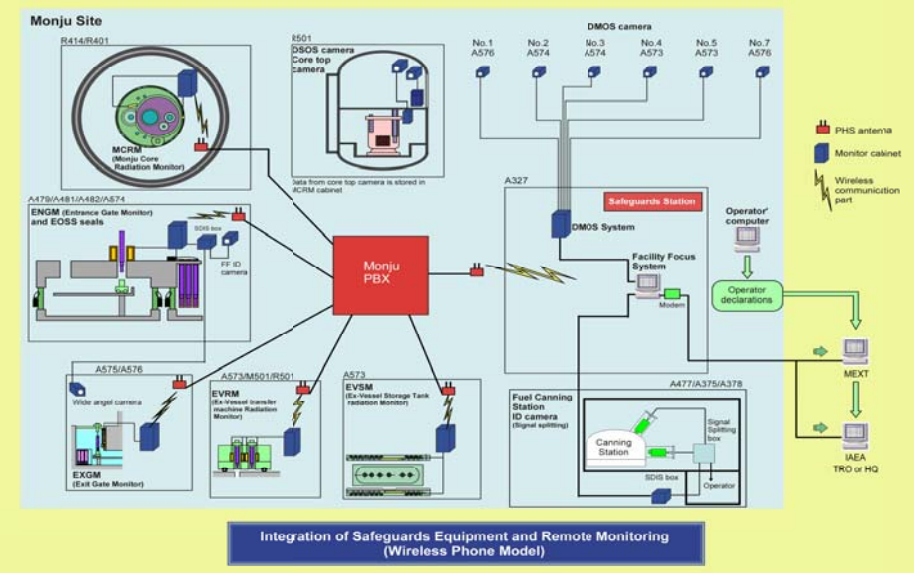

Figure-6 Applications of URM and C/S with RM for JNC-4

6. Summary of applications of technical elements

From experience about studies on Site Approach for JNC-1, JNC-2 and JNC-4, applications of technical elements are summarized in Table-1.

Table-1 Summary of applications of technical elements

Main Technical Elements for Site Approach	JNC-1 (Bulk)	JNC-2 (Item)	JNC-4 (Item)	Remarks
1. Application of sector concept and assignment appropriate sectors to the same stratum in the sites	Yes	Yes	Yes	Sector concept is a main feature of Site Approach for focusing verification to subject material.
2. Unattended and Remote Monitoring System for NDA, C/S and Radiation Monitor at flow SPs/ KMPs and inventory KMPs	Yes	Yes	Yes	RMs to transmit data is helping to improve the effectiveness and efficiency of SG implementation.[6]
3. Verification of information through remote monitoring in the Headquarter or regional office at appropriate time	Yes	Yes	Yes	The IAEA RM Data Center is able to monitor systems on a near real time basis.[6]
4. Random Scheduled Inspection for inventory verification with unannounced or short notice base	Yes	Yes	Yes	Range 30 to 36 RIIs for JNC-1 At least 6 RIIs for JNC-2 (Joyo and FMF) excluding DCA Average 5 RIIs for JNC-4
5. Advanced and frequent provision of information including operation schedule as well as operated data including receipts/shipment, material flows and inventories	Yes	Yes	Yes	
6. Application of NRTA	Yes	No	No	No requirement for item facility
7. Nuclear Material Accountancy	Yes	Yes	Yes	Essential measures for SG to draw the conclusion
8. Complementary Accesses at any location in the sites	Yes	Yes	Yes	Requirements from the additional protocol

7. Conclusion and aspect

Through the studies for improvement of efficiency about 3 sites, it could be expected that the PDIs will be saved without compromised effectiveness of safeguards. As for the PDIs of national inspection for JNC-1 site, about 30% of PDIs could be actually reduced compared with conventional activities, but in practice, two national inspectors stand by for Random Scheduled Inspection s triggered by the IAEA. Similar level of reduction might be achieved for the IAEA, because national inspection is carried out together with IAEA's inspection. Unfortunately, statistics relevant to other sites could not indicate, because Site Approaches for JNC-2 may be applied from October 2010 and JNC-4 has just been started recently. We can not collect annually data.

The timeliness goal and certain level of detection probability for flow verifications at boundaries of major sector could be achieved by the 100% coverage and anytime verification with unattended NDA with remote monitoring function. Discussion point could be identified that how the timeliness goal and certain level of detection probability for the inventory verification would be achieved by the RANDOM SCHEDULED INSPECTION regime with extensive advanced technology and further transparency of material flows and inventories under the condition of improvement for efficiency relevant to the inspections (PDIs) .

Advantage points of the Site Approach could be identified as follows;

a. We introduce the sector concept to optimize the space of the same material strata handling place for increasing transparency.
b. As for flow verifications at boundaries of major sector, 100% flows are verifiable with anytime by the unattended NDA and C/S with remote monitoring function. This is big advantage point from previous conditions.
c. As for inventory verification, SSAC submits frequent inventory information of sectors subjected to NRTA and operation schedules in advance. The IAEA has a possibility to confirm the validity of SSAC's declaration of inventories by comparison with the independent book inventories based on every verifiable flow data and PIL information at previous PIV, and to calculate the NRTA frequently.
d. When discrepancy is noticed between the SSAC's declaration and the independent measurement results by unattended NDA/radiation monitor or when the results of calculated NRTA indicates some anomalies, the IAEA must take some actions for inventory verification to subject sector(s) immediately. Because if diverter would conceal the inventory information after diversions, discrepancy might be noticed between the declaration and the independent book inventory information. On the other hand, if diverter would not conceal the inventory information after diversions, the results might indicate some anomalies.
e. Additionally, in principle, the randomly scheduled inspection has an unpredictable feature. This is a promising measure for deterrence of diversion by the risk of early detection.

As a future aspects to further improvement, we would suggest following matters;

a. The IAEA must seek establishment of progressive safeguards policy by qualitative aggregation of the advantage points to optimize the numbers of randomly scheduled inspection. Randomly scheduled inspection application alone at the large scale UDU material handling facility without advance technologies and further transparencies must be difficult to assure not only the timeliness requirement but also certain level of detection probability.
b. The IAEA and the SSAC including facility operator should improve accuracy and precision of NDA and DA to be used for verification, because the accuracy and precision of the measurement must reflect the frequency and assurance levels of verification at the randomly scheduled inspection.
c. For a large scale bulk handling facilities, the IAEA needs to make several simulations to obtain an appropriate situation of the randomly scheduled inspection, taking into consideration of several conditions, e.g., an assignment of sectors, the accuracy and precision of NDA and DA to be used, and frequency of declarations and NRTA calculations.
d. The IAEA and the SSAC including facility operator should develop an appropriate C/S system to support the implementation of the randomly scheduled inspection.
e. The IAEA and the SSAC should seek further cooperative activities to ensure effectiveness of safeguards.

References

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[2] "Strengthening the Effectiveness and Improving the Efficiency of Safeguards System including implementation of Additional Protocols, GC847)/8 Date: 23 July 2003

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[4] V. Rukhlo, et.al, "SITE-LEVEL SAFEGUARDS APPROACHS", presented at INMM annual meeting in 2004, p.5

[5] Guidelines for Unannounced and Short Notice Inspections in Integrated Safeguards, Rev.2, 2002-09-18

[6] Annual Report of 2009, p.84