LESSONS LEARNED FROM IRRS MISSIONS TO COUNTRIES WITH OPERATING NPPS, 2006-2013

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I. EXECUTIVE SUMMARY

The purpose of an Integrated Regulatory Review Service (IRRS) mission is to conduct a review of the effectiveness of the Member State’s radiation and nuclear safety regulatory framework and activities and to exchange information and experience in the areas covered by the IRRS. The IRRS review process compares the national regulatory infrastructure of the Member State against the requirements of the IAEA Safety Standards.

IRRS missions result in findings that are classified as Recommendations, Suggestions or Good Practices. The number of each is in no way a measure of the status of the regulatory body and comparisons of such numbers between IRRS reports should not be attempted.

The Agency has analysed the results of its 2006-2013 IRRS missions to Member States with operating nuclear power plants and this report provides an overview of the analysis and the relevant information from the missions, which are contained in two reports [7, 8] and available on the Agency’s website at: http://gnssn.iaea.org/regnet/irrs/Pages/IRRS_pub_docs.aspx.

In order to increase consistency in the implementation of the IRRS programme, the Agency published in 2013, the IRRS Guidelines, which are available at: http://www-pub.iaea.org/MTCD/publications/PDF/SVS-23_web.pdf.

Since each IRRS review team is different in terms of composition, expertise and experience, some variation between reports and number of findings is to be expected. The Agency now provides training to potential IRRS review team members, which is also to improve effectiveness and eliminate potential subjectivity.

GSR Part 1 is the primary IAEA Safety Standard used for IRRS missions. Although the IRRS compares the Member State programme against all 36 requirements in GSR Part 1, the requirements most frequently referenced in IRRS mission reports are:

1. Demonstration of safety for the authorization of facilities and activities (Requirement 24);
2. Staffing and competence of the regulatory body (Requirement 18);
3. Liaison with advisory bodies and support organizations (Requirement 20); and,
4. Establishing regulations and guides (Requirement 32).

The analysis of the IRRS missions results indicate that the vast majority of Recommendations and Suggestions are related to the core regulatory functions (establishing regulations and guides, review and assessment, authorization, inspection and enforcement).

Although there are wide variations between Member States, the analysis did identify that regulatory bodies tend to have strong programmes for:

- Interested party involvement in the regulatory process;
- Training of regulatory body staff; and,
- Follow-up of inspection findings.

At the same time, the analysis identified that most regulatory bodies tend to have opportunities to improve in the areas of:

- The legal framework;
- The inspection programme;
- The review of regulations and guides;
- The development of the regulatory body integrated management system; and,
- Emergency preparedness and response.

Many IRRS missions also identified that the regulatory body did not have enough resources for all of its assigned responsibilities.
IRRS follow-up missions confirm that issues raised during the initial IRRS missions which are within the full control of the regulatory body tend to be adequately addressed, while those requiring involvement of others, particularly the government, are more likely to remain open. The areas containing the most findings which remained open are related to the management system and resources of the regulatory body.

An important conclusion of the analysis is that there are no important differences between the missions conducted to EU Member States and missions to non-EU Member States, or the results.

The Agency has established 16 performance indicators that will assist in analysing IRRS mission effectiveness and efficiency. These performance indicators, which were applied to IRRS missions conducted from 2011 to 2013 show that the IRRS process is effective and there is an improving trend.
II. INTRODUCTION

II.1. Objectives

The main objective of this report is to summarize and evaluate the lessons learned from the Integrated Regulatory Review Service (IRRS) missions conducted in Member States operating nuclear power plants in the period of 2006 – 2013. The following specific objectives are considered in reaching the main objective:

- Summarize characteristic statistical and factual data related to the IRRS missions and topics in the scope of the evaluation (Chapters III and IV);
- Draw conclusions on the regulatory framework of the Member States, based on the analysis and evaluation of the results of the IRRS missions and on the implementation of recommendations and suggestions made by missions (Chapter V); and,
- Draw conclusions from the IRRS process (show weak and strong points and possible areas of further development; discuss implementation of recommendations by missions; possible inputs to the IAEA safety standards, if applicable) (Chapter VI).

The report also draws conclusions on differences or similarities between IRRS missions to EU and non-EU Member States and includes two Appendices with additional information. Facts of interest resulting from the analysis are summarized in Lessons Learned, important consequences and facts needing further attention are emphasized in Conclusions throughout the report.

II.2. Scope

This evaluation of the IRRS missions and process covers only nuclear safety aspects and therefore only considers IRRS missions to Member States with nuclear installations. Accordingly (c.f. also Section III.1 and Figure 1), Modules 1 through 10 (the ‘core review areas’) of the IRRS missions shall be considered, Modules 5 to 9 (i.e. the ‘core regulatory processes’) extended to cover the following facilities and activities: nuclear power plants, research reactors, fuel cycle facilities, and decommissioning of nuclear facilities. This is further discussed in Section III.1.

II.3. Intended audience

This report may be of interest to governmental and regulatory bodies in the field of nuclear safety, international organisations including the European Union and the OECD NEA, Technical Support Organizations of regulatory bodies in IAEA Member States, the IAEA Secretariat, but also to other parties sharing an interest in the results of peer reviews of the nuclear regulatory activities.
III. BACKGROUND

III.1. The IRRS process

The IAEA Integrated Regulatory Review Service (IRRS) has been established to strengthen and enhance the effectiveness of national regulatory infrastructures for nuclear, radiation, radioactive waste and transport safety and the security of radioactive sources whilst recognizing the ultimate responsibility of each State to ensure safety. The IRRS process sets out to accomplish this through consideration of both regulatory technical and regulatory policy issues against IAEA safety standards.

The IRRS has a modular structure (see Figure 1 below) designed to be tailored to both generic and country-specific needs and to facilitate the review of circumstances where the scope of regulatory responsibility may be changing. Figure 1 illustrates facilities and activities within the scope of the IRRS and how core regulatory functions interface with them.

### Figure 1: IRRS Modules

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Responsibilities and functions of the government</td>
</tr>
<tr>
<td>2.</td>
<td>Global nuclear safety regime</td>
</tr>
<tr>
<td>3.</td>
<td>Responsibilities and functions of the regulatory body</td>
</tr>
<tr>
<td>4.</td>
<td>Management system of the regulatory body</td>
</tr>
<tr>
<td>5.</td>
<td>Authorization</td>
</tr>
<tr>
<td>6.</td>
<td>Review and Assessment</td>
</tr>
<tr>
<td>7.</td>
<td>Inspection</td>
</tr>
<tr>
<td>8.</td>
<td>Enforcement</td>
</tr>
<tr>
<td>9.</td>
<td>Regulations and Guides</td>
</tr>
<tr>
<td>10.</td>
<td>Emergency preparedness and response</td>
</tr>
<tr>
<td>11.</td>
<td>Thematic areas</td>
</tr>
<tr>
<td>12.</td>
<td>Interfaces with nuclear security</td>
</tr>
<tr>
<td>Tailored modules</td>
<td></td>
</tr>
</tbody>
</table>

Modules 1 through 10 are called the ‘core modules’ which are necessarily in the scope of an IRRS mission, Modules 11 and 12 as well as any Tailored module (at present, the module on the regulatory implications of the Fukushima accident and the module for countries embarking in nuclear power programmes) are included in the scope if wished for by the host country. The ‘core regulatory functions’ in Modules 5 through 9 may cover the facilities and activities listed in the right hand side of Figure 1.

The observations arising from an IRRS mission are gathered in the mission report as ‘Recommendations’ (which reflect non-compliance with specific IAEA Safety Requirements), ‘Suggestions’ (which identify opportunities for further improvement) and ‘Good Practices’ (which recognise outstanding regulatory practices superior to those generally observed elsewhere).

In order to review the progress in the implementation of the Recommendations and Suggestions of an IRRS mission, a follow-up mission is usually invited two to four years after the first mission. A follow-up mission results in a report whereby the Recommendations and Suggestions of the initial mission are rated either ‘closed’ (either actually or foreseen based on progress and confidence) or
A follow-up mission may also yield further observations. In follow-up missions, Modules not reviewed in the initial missions may also be reviewed; in these cases, the mission is called an ‘extended follow-up mission’.

Detailed information about the IRRS may be found in Service Series 23; ‘Integrated Regulatory Review Service (IRRS) Guidelines for the Preparation and Conduct of IRRS Missions’ [1].

III.2. IRRS Modules and GSR Part 1 Requirements

The ‘IAEA Fundamental Safety Principles’ (SF-1) [2] provides the basis for the IAEA safety standards and for safety related programmes. In support of effective regulation, the IAEA has established safety standards in the area of the ‘Governmental, Legal and Regulatory Framework for Safety’ (GSR Part 1), ‘The Management System for Facilities and Activities’ (GS-R-3), ‘Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards’ (GSR Part 3 interim edition) and ‘Preparedness and Response for a Nuclear or Radiological Emergency’ (GS-R-2) [3-6].

<table>
<thead>
<tr>
<th>Module No</th>
<th>GSR Part 1 Overarching Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R1: National policy and strategy</td>
</tr>
<tr>
<td></td>
<td>R2: Establishment of a framework for safety</td>
</tr>
<tr>
<td></td>
<td>R3: Establishment of a regulatory body</td>
</tr>
<tr>
<td></td>
<td>R4: Independence of the regulatory body</td>
</tr>
<tr>
<td></td>
<td>R5: Prime responsibility for safety</td>
</tr>
<tr>
<td></td>
<td>R6: Compliance with regulations and responsibility for safety</td>
</tr>
<tr>
<td></td>
<td>R7: Coordination of different authorities with responsibilities for safety within the regulatory framework for safety</td>
</tr>
<tr>
<td></td>
<td>R9: System for protective actions to reduce existing or unregulated radiation risks</td>
</tr>
<tr>
<td></td>
<td>R10: Provision for the decommissioning of facilities and the management of radioactive waste and of spent fuel</td>
</tr>
<tr>
<td></td>
<td>R11: Competence for safety</td>
</tr>
<tr>
<td></td>
<td>R12: Provision of technical services</td>
</tr>
<tr>
<td>2</td>
<td>R13: International obligations and arrangements for international cooperation</td>
</tr>
<tr>
<td></td>
<td>R14: Sharing of operating experience and regulatory experience</td>
</tr>
<tr>
<td>3</td>
<td>R15: Effective independence in the performance of regulatory functions</td>
</tr>
<tr>
<td></td>
<td>R16: Organizational structure of the regulatory body and allocation of resources</td>
</tr>
<tr>
<td></td>
<td>R17: Staffing and competence of the regulatory body</td>
</tr>
<tr>
<td></td>
<td>R20: Liaison with advisory bodies and support organizations</td>
</tr>
<tr>
<td></td>
<td>R21: Liaison between the regulatory body and authorized parties</td>
</tr>
<tr>
<td></td>
<td>R22: Stability and consistency of regulatory control</td>
</tr>
<tr>
<td></td>
<td>R35: Safety related records</td>
</tr>
<tr>
<td></td>
<td>R36: Communication and consultation with interested parties</td>
</tr>
<tr>
<td>4</td>
<td>R18: The management system of the regulatory body</td>
</tr>
<tr>
<td>5</td>
<td>R19: Authorization of facilities and activities by the regulatory body</td>
</tr>
<tr>
<td></td>
<td>R23: Demonstration of safety for the authorization of facilities and activities</td>
</tr>
<tr>
<td>6</td>
<td>R24: Review and assessment of information relevant to safety</td>
</tr>
<tr>
<td></td>
<td>R25: Graded approach to review and assessment of a facility or an activity</td>
</tr>
<tr>
<td>7</td>
<td>R26: Inspection of facilities and activities</td>
</tr>
<tr>
<td></td>
<td>R27: Types of inspection of facilities and activities</td>
</tr>
<tr>
<td></td>
<td>R28: Graded approach to inspections of facilities and activities</td>
</tr>
<tr>
<td>8</td>
<td>R30: Establishment of an enforcement policy</td>
</tr>
<tr>
<td></td>
<td>R31: Requiring of corrective action by authorized parties</td>
</tr>
<tr>
<td>9</td>
<td>R32: Regulations and guides</td>
</tr>
<tr>
<td></td>
<td>R33: Review of regulations and guides</td>
</tr>
<tr>
<td></td>
<td>R34: Promotion of regulations and guides to interested parties</td>
</tr>
<tr>
<td>10</td>
<td>R35: Emergency preparedness and response</td>
</tr>
<tr>
<td>12</td>
<td>R12: Interfaces of safety with nuclear security and with the State system of accounting for, and control of, nuclear material</td>
</tr>
</tbody>
</table>

Figure 2: GSR Part 1 Requirements by IRRS Module
GSR Part 1 comprises of 36 overarching requirements on the governmental, legal and regulatory framework for safety. These requirements are addressed in all IRRS Modules and as such represent the backbone of the IRRS. Figure 2 above shows the GSR Part 1 Requirements (R1 - R36) in relation to the various IRRS Modules.

III.3. Member States involvement in the IRRS process

The IRRS review team comprises international experts recruited by the IAEA from the regulatory bodies and support organizations of its Member States. In the 50 missions conducted between 2006 and 2013 (c.f. Figure 4 below), 351 experts participated, representing 57 Members States and the IAEA altogether in 645 occasions. Figure 3 shows the number of experts having taken part in IRRS missions from the various Member States (red columns) and the number of occasions the experts from the Member States took part in missions (blue columns).

III.4. Missions included in the analysis and evaluation

The present report covers lessons learned from 22 initial and nine follow-up IRRS missions conducted in countries with operating NPPs (including Iran which put an NPP into operation after the mission). Although the scope of the analysis and evaluation is intended to cover the period 2006 – 2013, the follow-up mission to the USA in 2014 has also been included in order to cover the maximum number of missions.

The analysis was conducted in the framework of an Agreement between the IAEA and the European Commission and also covers a comparison between missions to EU Member States (+Switzerland) and non-EU states in order to identify possible differences or similarities between the two sets of missions. Figure 4 lists all IRRS missions held, the IRRS-recipient countries included in this analysis are marked in colour, countries with missions not covered by this analysis are marked in grey. Follow-up missions are denoted by (f), UK part 2 mission was a mixture of follow-up and initial missions. (Note that the various colours have no specific meaning.)
III.5. Observations and references

The purpose of the IRRS is to assess the host country’s national regulatory infrastructure against the relevant IAEA safety standards through a peer review. The main results of the peer review are summarized in ‘observations’ (i.e. Recommendations, Suggestions and Good Practices as introduced in Section III.1). Recommendations and Suggestions together are called ‘findings’. The findings point to issues where either a non-compliance with IAEA safety requirements was observed or opportunities for improved compliance with IAEA safety standards were identified. Accordingly, all observations need to be based on IAEA safety standards and are clearly documented in the mission report together with their basis (i.e. the particular requirement(s) from the relevant safety standard).

Potentially, any IAEA safety requirement may form the ‘basis’ for an IRRS observation. The term ‘references’, as used in this report, means the act of referencing those requirements in the IAEA safety standards that serve as bases for IRRS mission observations. Figure 5 gives examples of such bases and the formulation of the observations.

![Figure 5: Examples of IAEA requirements used as references for observations](http://gnssn.iaea.org/regnet/irrs/pages/default.aspx)

III.6. Background publications

This report is a summary of the analysis, evaluation and development work performed in recent years related to the IRRS missions to nuclear countries in 2006-2013. Details of this work are given in two background Working Documents of the IAEA [7, 8], both available from the IAEA homepage on the IAEA website.

IV. THE IRRS PROCESS AND THE IAEA SAFETY STANDARDS

This chapter summarizes the statistical characteristics of the numbers of references to the various IAEA safety standards in general and to GSR Part 1 (the basic standard in IRRS) in detail. The results of the chapter give deeper insight into the role of the various IAEA safety requirements in the IRRS process and in regulatory activities.

IV.1. References to IAEA safety standards

As discussed in the previous chapter, the observations in an IRRS mission need to refer to IAEA safety standard requirements. Therefore, the frequency of references to various safety standards

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may provide information on both the IRRS process and the frequently encountered regulatory issues (or good practices).

Section II.2 discussed the IAEA safety standards forming the basis of the IRRS process. In what follows is the investigation as to what extent and in what proportions this is realized in actual IRRS missions. Figure 6 shows the ratios of references from the various IRRS Modules to the basic standard GSR Part 1 [3] and to other safety standards from findings (Recommendations and Suggestions - R&S, left hand side figure) and from Good Practices (GP – right hand side figure).

The distribution of references to IAEA safety standards different from GSR Part 1 is further detailed in Figure 7, while the references from Module 6 to other safety standards are shown in Figure 8.

**Lesson Learned 1:** The IRRS Modules have the following referencing character:

- Module 4 (Management system of the regulatory body) mainly refers to GS-R-3 [4];
- Module 10 (Emergency Preparedness and Response) mainly refers to GS-R-2 [6];
Module 6 (Review and assessment) extensively refers both to GSR Part 1 and to other standards;
The majority of the references from other IRRS core Modules relate to GSR Part 1 [3].

The numbers below characterize the role of the IAEA safety standards in the IRRS process:

- References to GSR Part 1: 654 times;
- References to GS-R-3: 192 times;
- References to GS-R-2: 83 times;
- References to GS-G-1.3 [11]: 55 times;
- References to all other IAEA safety standards: 222 times.

Conclusion 1: The data presented above confirm that the General Safety Requirements, and primarily GSR Part 1, provide basis for the IRRS process, further basic references are GS-R-3 and GS-R-2.

Figure 9: References to GSR Part 1 and to other safety standards

Figures 7 through 9 also reflect the following:

Conclusion 2: There is no substantial difference between the EU and non-EU missions in referencing the IAEA safety standards.

IV.2. References to GSR Part 1 Requirements

GSR Part 1 has 36 Requirements as listed in Figure 2 and all Requirements are unanimously linked to one of the IRRS Modules as also seen there. In this section, referencing of the GSR Part 1 Requirements is analysed.

Figure 10: References per missions to GSR Part 1 Requirements from findings (left) and GPs (right)
Figure 10 summarizes the frequency of references per missions to the various GSR Part 1 Requirements from findings and from Good Practices (GPs) in EU and in non-EU missions.

The Requirements belonging to the various IRRS Modules are shaded in colour. The reference frequency is shown in Figure 11 in decreasing order, while Figure 12 displays the eight largest values among the most frequently referenced Requirements.

![Figure 11: Average number of references to GSR Part 1 Requirements from findings per mission](image1)

![Figure 12: The GSR Part 1 Requirements most frequently referenced by findings in initial missions](image2)

The integers on the top are the IRRS Module numbers where the Requirements belong to. The values above the bars in Figure 12 give the average number of references to the given Requirements from findings. The average number of references from findings in a mission is 29.7.

The four most frequently referred to GSR Part 1 Requirements are markedly above all others. These are:

- R24: Demonstration of safety for the authorization of facilities and activities (most frequent in non-EU missions) in Module 5;
• R18: Staffing and competence of the regulatory body in Module 3;
• R20: Liaison with advisory bodies and support organizations in Module 3;
• R32: Regulations and guides (most frequent in EU missions) in Module 9.

It is interesting to note that the seven most frequently referred to Requirements from Good Practices are R24, R36, R18, R27, R25, R26, R33, i.e. four of them (in bold) are also among the most frequent findings references. (The average number of references per missions from Good Practices is 8.32)

Further insight into the mechanism of referencing is given in Figures 13 and 14. Figure 13 shows the distribution of the number of references to the most referenced Requirements within the IRRS Modules. Figure 14 showcases the distribution of the number of references among the missions (denoted by capital letters).

The figures outline that:

**Lesson Learned 2:** The most frequent Requirements
- are mostly referred to in those IRRS Modules to which they are connected to in GSR Part 1;
- do not seem to be attributed to a particular single mission, but their references are fairly evenly distributed among several missions.

**Conclusion 3:** The GSR Part 1 Requirements which seem to fit with the issues encountered in IRRS missions the most are R24, R18, R20 and R32.

Figure 12 also leads to the following assumptions:

**Lesson Learned 3:** Among the most frequently referred to GSR Part 1 Requirements
- five (R24, 32, 27, 25, 29) are related to core regulatory functions (Modules 5 through 9) and make up almost one third of all references to sum up to 9.18 references/initial mission;
- R20 in third place – although not belonging to the core regulatory modules 5 through 9, is directly related to the core regulatory functions.

**Conclusion 4:** Recommendations and Suggestions, referencing GSR Part 1 Requirements relating to core regulatory functions from initial missions, comprise a dominant part of all references.

The reason for this dominance may be one or more of the following:
- the international regulatory framework is afflicted by problems in these areas;
- issues are of particular regulatory importance and can be relatively easily identified;
- the IRRS process is biased towards these areas;
- the GSR Part 1 requirements related to these areas have broader validity and may be applied to other areas as well.
In order to draw further conclusions on the nature of GSR Part 1 Requirement referencing, Figure 15 is examined. The figure shows the cumulated number of references of GSR Part 1 Requirements derived from findings in initial missions. The reference frequency is summed up from the largest to the smallest (blue curve) and from the smallest to the largest (red curve), respectively.

**Lesson Learned 4:**
- 10 Requirements (28% of all) receive about 60% of the references from the recommendations and suggestions of all missions (c.f. green arrow in the figure);
- 17 Requirements (47%) are the subject of about 80% of the references (c.f. red arrow);
- the nine least referenced Requirements (25% of all) are the subject of about 5% of the references (blue arrow). Each was referenced less than eight times out of a total number of 654 references.

**Lesson Learned 5:** There may be several reasons for the low reference rate of particular GSR Part 1 Requirements, e.g. because it
- refers to a safety requirement generally complied with and not posing problems in the international regulatory framework;
- falls out of the scope of the IRRS process, thus indicating potential weakness therein; or
- does not address a realistic case, which might necessitate revision of this part of GSR Part 1.

**Conclusion 5:** Further investigation of the frequency of references may lead to a better knowledge of the Member States’ regulatory infrastructure, of the IRRS process and may also provide further ideas on the possible development of IAEA safety standards.
V. LESSONS LEARNED ON THE REGULATORY FRAMEWORK

In this chapter, the number, distribution, correlation and technical contents of the various observations of the IRRS missions are investigated. Through the frequency of the various Subject Groups of observations, the most frequent issues in the regulatory framework are pointed at. An indicator that shows the issues mainly appearing in findings or in Good Practices (called Balance value) is introduced to indicate more clearly the key issues. Lessons learned from the follow-up missions are also discussed in brief.

V.1. Numerical characteristics of observations

The overall number of observations and their distribution are informative to examine specific IRRS Modules and general trends. Figure 17 and Table 1 show the distribution of the various observations from 22 initial missions (13 EU and nine non-EU) by Module and nine follow-up IRRS missions, included in the present analysis (c.f. Figure 4).

![Figure 17: Total number of observations derived from all missions](image)

<table>
<thead>
<tr>
<th>Observations</th>
<th>EU</th>
<th>non-EU</th>
<th>Follow-up</th>
<th>Summed</th>
<th>Av±st.dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommendations</td>
<td>161</td>
<td>127</td>
<td>24</td>
<td>312</td>
<td>13.1 ± 6.9</td>
</tr>
<tr>
<td>Suggestions</td>
<td>223</td>
<td>172</td>
<td>41</td>
<td>436</td>
<td>18.0 ± 6.5</td>
</tr>
<tr>
<td>Good Practices</td>
<td>110</td>
<td>94</td>
<td>25</td>
<td>229</td>
<td>9.3 ± 6.0</td>
</tr>
<tr>
<td>Summed</td>
<td>494</td>
<td>393</td>
<td>90</td>
<td>977</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Number of observations derived from all IRRS missions analysed

The average values and standard deviations in initial missions are given in the last column of the table.

Figures 18 present the numbers of observations from the 22 initial missions analysed in two forms. It is seen that these numbers vary substantially from mission to mission, yet (apart from outlying values), they are quite uniformly scattered around their average values.

Figure 19a presents the frequency of the distribution of the observations. It also reflects that – apart from a few outlying values – the distribution resembles a normal distribution. The frequency of the distribution of individual observation types (Recommendations, Suggestion and Good Practices) is similar (c.f. [7]). In Figure 19b the average and range of the various observations are given for the EU and non-EU missions.
Lesson Learned 6: Although the number of observations in various missions may reflect specific differences in regulatory frameworks of the host countries, the overall picture of the distribution of the observations is fairly uniform.

The statement above calls forth the following:

Conclusion 6: The number of observations arising from missions confirms that the practice followed ensures a reasonable distribution for these numbers.

Figure 19b suggests the following:

Conclusion 7: There seems to be no essential difference between EU and non-EU missions in the statistical characters of the observations.

It is also to be stressed that the number of Recommendations, Suggestions and Good Practices is in no way a measure of the status of the regulatory body and comparison of such numbers among IRRS missions to various countries provides no meaningful information and shall not be attempted here.

V.2. Distribution of observations

In Figure 17 above the distribution of the various observations (Recommendations, Suggestions and Good Practices) is shown among the core regulatory Modules from the nuclear safety subjects in the missions investigated. The same distribution is shown in another format in Figure 20.
Lessons Learned 7:

- The basic modules related to the regulatory regime (Modules 1, 3, 5, 6, 7, 9, 10) show a fairly uniform distribution of findings, with Module 3 (Responsibilities and functions of the regulatory body) having the maximum number of findings and observations;
- Module 2 (Global Nuclear Safety Regime) has considerably fewer observations than other Modules. (Note that the Global Nuclear Safety Regime is part of the IRRS programme since 2010; earlier missions did not include it, and this is taken into account in the averaging.) This module covers a very limited area and apparently raises only a few specific regulatory or governmental issues that might result in observations;
- Module 8 (Enforcement) also only has a few observations. The reason for that may be that the module covers only a very limited portion of regulatory activities;
- Modules having the most GPs are No. 6 (Review and assessment), 7 (Inspection), and 3 (Role and responsibilities of the regulatory body).

The figures and the statement above lead to:

Conclusion 8: Recommendations and Suggestions, relating to most of the core regulatory functions from initial missions demonstrate equal emphasis by the peer review, while Modules 2 and 8 have a considerable lower rate of findings. The definition of the IRRS Modules may therefore need revision to be better balanced out.

Notwithstanding what was stated in Conclusion 6, there may be logical natural rules valid to the relative numbers of observations in missions the knowledge of which might help increasing the effectiveness and objectivity of the missions.

The following relationships seem intuitively logical:

1. In missions where the number of Recommendations is considerably higher than the average, the number of Good Practices is expected to be lower than the average. This may be true as a high number of Recommendations reflects a relatively weaker compliance with the safety requirements, which usually implies a relatively lower number of achievements with outstanding performance.
2. In the same missions i.e. where the number of Recommendations is considerably higher than the average, the number of Suggestions is also expected to be higher than the average. This is again logical as in circumstances where noncompliance with safety standards is more frequent than the average; more room for Suggestions on further improvements is likely to be available.
It is to be stressed that these intuitive relations are expected to manifest themselves as tendencies while the number of the various observations in the various missions may show fluctuations and deviations from the intuitive rules.

Figure 21 visualizes the correlation between the number of Recommendations and the number of Good Practices observed in the various missions. The red and green arrows show examples and make it obvious that wherever the number of Recommendations is high, the number of Good Practices is low and vice versa. Figure 22 shows the correlation of Recommendations and Suggestions for the same missions.

These figures suggest the following:

**Lesson Learned 8:**
- The intuitive relationship between the number of Recommendations and Good Practices seems to be proven by the actual number of observations, yet in certain missions, the negative correlation of Recommendations and Good Practices is less pronounced than expected;
- the intuitive relationship between Recommendations and Suggestions appears to be true in some missions; in some others (especially those where the number of Recommendations is higher than the number of Suggestions) the positive correlation among the number of Recommendations and Suggestions is weaker.

Numerical correlation analysis supporting the statements above is presented in Reference [7].

**Conclusion 9:** More detailed analysis may be necessary for the reasons of those mission results that do not reflect the expected correlations.

Further arguments supporting the assumed correlation of Recommendations and Suggestions are given in Section V.6.

It is interesting to investigate the correlation of Suggestions and Good Practices. The number of these observations is shown in Figure 23. The figure shows that in many cases these numbers run parallel, i.e. there is a tendency of positive correlation between the number of Suggestions and of Good Practices, in other cases this tendency is opposite. Numerical analysis in Reference [7] shows that in total the correlation is nearly zero. This issue, with other examples, will be further discussed in Section VI.1.
V.3. Technical contents of findings

In order to analyse the technical contents of the findings (as well as of Good Practices, see in the next section), they are classified into Subject Groups (SGs). The purpose of this grouping is to collect the observations with similar characters into statistically meaningful groups and to try to identify which specific topics, within the various modules, may need further consideration as they often appear in Recommendations and Suggestions. The SGs defined by past mission observations are introduced in Ref.7. The full list of SGs belonging to the various IRRS Modules and the number of observations falling into the various SGs are given in Appendix 1. In what follows is a discussion on those SGs with the highest population of findings. For more details, please refer to Reference [7].

Figure 24 summarizes the number of findings (Recommendations and Suggestions) for all missions belonging to the various SGs, in decreasing order of frequency.

The first ten Subject Groups in the figure are as follows:

1.d: Providing/using legal framework for regulatory activities
7.a: Developing the inspection programme
9.b: Reviewing regulations and guides
7.c: Procedures and guides for inspection
3.a: Staffing of regulatory body
4.a: Developing an (integrated) Management System in general
10.e: Complying with emergency preparedness and response technical requirements
3.f: External involvement in the regulatory process
4.b: Details of the MS, developing MS manual
9.a: Developing regulations and guides in general
Figure 25: Subject Groups with highest population of findings

The number in the SG identifier refers to the IRRS Module where it belongs to, while the letter is the identifier within the Module as defined in Appendix 1.

The figure shows that the first SG is considerably more populated than the second one and also there is a fast decrease in the frequency in subsequent SGs’ finding.

It can also be seen that there are two SGs in the top ten belonging to each of the IRRS Modules 3, 4, 7 and 9, while four SGs belonging to Module 3 (Responsibilities and functions of the regulatory body) appear among the 12 most populated ones. This is very much in line with Figure 17 and Statement 7 that express that from among the IRRS Modules, Module 3 received the largest number of findings.

Typical issues from the top seven SGs as formulated in mission findings are listed below.

1.d: Providing/using legal framework for regulatory activities

The Government should
- establish a regulatory framework with clear empowerment, responsibilities and functions;
- provide the regulatory body with the necessary authority (to issue regulatory requirements; to conduct inspection of suppliers; of authorization of various activities; in accordance with the IAEA safety standards);
- ensure the effective independence of the regulatory body;
- remove time constraints of regulatory decision making.

7.a: Developing the inspection programme

The regulatory body should
- establish an inspection programme, which is
  - planned / systematic / comprehensive;
  - adequately covers all levels of defence in depth / all areas relevant to safety;
  - monitors on-site operations / supervision of safety system operability/ practical activities conducted by the licensee /activities by suppliers, vendors, manufacturers;
- conduct inspections
  - outside normal working hours;
  - more frequently unannounced;
  - with higher frequency;
  - on human and organizational factors / on management system;
  - jointly with other authorities.
9.b: **Reviewing regulations and guides**

The regulatory body should

- systematically carry out regular periodic review of the regulations and guides in order to
  - to keep regulatory safety requirements complete and up-to-date;
  - incorporate / better reflect international standards;
  - determine need for new regulations;
  - account for feedbacks;
- facilitate the review of regulations and guides by
  - review plans / comprehensive review programme;
  - consultations with interested parties / taking experience feedback;
  - implementing procedures / internal directives;
  - addressing possible inconsistencies taken from foreign sources.

7.c: **Procedures and guides for inspection**

The regulatory body should

- develop guidance / procedures in order to
  - perform inspections in nuclear facilities / in various areas and practices / in all areas of responsibility;
  - define criteria for reactive inspections;
  - support its regional inspectors;
  - establishing expectations for its non-resident inspectors;
  - improve consistency of its decision making;
  - finalize the event follow-up;
  - perform comprehensive inspections;
  - support graded approach in inspection;
- review / revise its inspection guidance.

3.a: **Staffing of regulatory body**

The regulatory body should develop

- an integrated recruitment and retention programme / strategy / human resource management programme;
- near-term recruitment and staffing plan and long-term succession planning strategy;
- staff/job rotation frequencies and patterns;
- methods to improve retention, hiring and motivation;
- efforts to attract suitable qualified staff and fill vacancies.

4.a: **Developing an (integrated) Management System, general**

- The regulatory body should start / continue / complete the development of and integrated management system complying with the requirements by the IAEA safety standards.
- The senior management of the regulatory body should be actively involved in the development of the management system.

10.e: **Complying with emergency preparedness and response technical requirements**

- The regulatory body should review and revise its emergency preparedness and response capability and system in order to comply with the IAEA technical requirements, in specific related to
  - threat assessment / response criteria;
  - staffing and team availability;
  - emergency classification;
  - emergency notification timing.
• The Government / regulatory body should review / revise intervention levels against IAEA safety standards.

V.4. Technical contents of Good Practices

Figure 26 summarizes the number of Good Practices for all missions belonging to the various SGs, in decreasing order of frequency.

![Figure 26: Frequency of Good Practices in various Subject Groups](image)

The most frequent GPs are shown in Figure 27. The first six SGs in the figure are as follows:

3.f: External involvement in the regulatory process;
3.g: Training of the RB;
7.d: Follow-up of inspections;
1.e: Transparency, public involvement;
10.b: Emergency Preparedness and Response communication and cooperation;
9.a: Developing regulations and guides in general.

![Figure 27: Subject Groups with highest population of Good Practices](image)

Here again, the number in the Subject Group identifier refers to the IRRS Module to which it belongs to, while the letter is its identifier within the Module as defined in Appendix 1.

Frequent Good Practices in the top six SGs as formulated in missions are listed below.

3.f: External involvement in the regulatory process

The regulatory body

• makes use of the support of advisory committees / Technical Support Organizations;
• has cooperation with other agencies / authorities;
• exchanges information with licensees / manufacturers.
3.g: **Training of the RB**

The training programme of the regulatory body is commended

- in general;
- in its specific aspects or topics.

7.d: **Follow-up of inspections**

Inspection findings are regularly

- collected and published / shared;
- tracked / discussed / assessed.

1.e: **Transparency, public involvement**

The regulatory body is commended for its

- transparency in licensing / inspection;
- communication with the public;
- consulting with / informing the interested parties;
- publishing events of interest.

10.b: **Emergency Preparedness and Response communication and cooperation**

Coordination and cooperation of the regulatory body with external / federal / other national / foreign organizations is exemplary.

9.a: **Developing regulations and guides in general**

The regulatory body developed regulations, guides, and standards

- in a comprehensive / systematic / transparent / well documented way;
- making use of IAEA safety standards / results of other countries.

V.5: **Balance-value of observations**

Figure 28 shows that there are four SGs that appear in the top 10, both for findings and for Good Practices (3.f, 9.a, 7.a and 3.a). It also follows that no SG exists that is among the seven most populated ones for both findings and Good Practices. This fact may suggest that there are issues of more or less general nature and which are a subject of findings, while there are other instances of the regulatory regime which are more likely to be commended. In what follows is an attempt to quantify and illustrate this concept.

**Figure 28: Top ten SGs for findings and for GPs**

Let $f_n$ denote the fraction (in %) of the findings belonging to the Subject Group $n$ (i.e. $n$ may be one of the SGs of 1.a, 1.b, ..., 10.e) and thus $f_n$ is the number of findings in SG $n$ divided by the total number of findings and multiplied by 100. Similarly let $g_n$ be the fraction (in %) of the Good Practices in Subject Group $n$. We define the ‘Balance-value’ $B_n$ of SG $n$ as the difference of $g_n$ and $f_n$, i.e. for Subject Group $n$ the Balance-value is

$$B_n = g_n - f_n$$

The Balance-value is intended to express in how far the given SG represents an issue as judged from the IRRS results. In this sense, the number of Good Practices and the number of findings in a SG may balance each other out and the more their difference is positive, the less the given subject is considered an issue. It is to be stressed that this approach is highly heuristic and mechanical and is not intended to define a measure of the seriousness of the findings or the related issues, yet it may offer a deeper insight into the general nature of the IRRS observations. This approach may also help
to point to the generally most favourable and most questionable subjects raised during the IRRS missions.

Figure 29 shows the Balance-values for all SGs in decreasing order. The green square on the left hand side encloses the SGs with the most positive values (being above 2%), i.e. those subjects which are dominated by Good Practices; whereas the red square on the right hand side encompasses the SGs dominated by findings with the lowest (below -2%) Balance-values.

Figure 29: Differences in the fractions of Good Practices and findings belonging to the same SGs

The SGs with the top positive Balance-values (> 2%) are:

7.d: Follow-up of inspections;
3.f: External involvement in the regulatory process;
1.e: Transparency, public involvement;
3.g: Training of the RB;
10.b: Emergency Preparedness and Response communication and cooperation;
2.a: Operational experience exchange with international community;
6.a: Developing the review and assessment process;

These SGs are all among the ten most frequent SGs with Good Practices as seen in Figures 26 and 27.

The SGs with the lowest negative Balance-values (< -2%) are:

1.d: Providing/using legal framework for regulatory activities;
7.c: Procedures and guides for inspection;
3.c: Resources of the RB;
4.b: Details of the MS, developing MS manual;
1.a: Cooperation/interaction among organizations, bodies.

Comparing this list with Figures 24 and 27, it becomes apparent that only three of these SGs belong to the ten SGs most populated by findings (while SG 4.b is only the ninth therein), whereas SGs 3.c and 1.a are not among the most frequent ones. For the sake of completeness, the typical technical contents of the findings in Subject Groups 3.c and 1.a are given below.

3.c: Resources of the regulatory body

- The resources necessary to accomplish the functions and responsibilities of the regulatory body need to be provided
- The resources of the regulatory body need to be allocated according to a graded approach
- The regulatory body should charge licensees by appropriate fees for its activity

1.a: Cooperation/interaction among organizations, bodies.

- Need for coordination and cooperation among various institutions having roles and responsibilities in nuclear and radiation safety
- Need for agreements or MoU between the various participants
Table 2: Most populated SGs vs. their Balance-values

Table 2 summarizes the relationship of the most populated SGs with the SGs of highest and lowest Balance-values. The row $SG_{n^{-rank}}$ contains the position of the given SG in the list of most populated ones for Good Practices (left-hand side) and findings (right-hand side), respectively. The row $B_n$ lists the Balance-values of the Subject Groups in the $SG_{n}$ row. Row $B_{n^{-rank}}$ contains the position of the SG in the list by Balance-values (in decreasing order of absolute values). Asterisks in this row denote those SGs which are ranked top ten in the opposite group of observations (e.g. $SG_{7.a}$ with asterisk in the GP side is ranked 2 among the SGs of findings and vice versa).

The Balance-values are differences of the relative frequencies of the SGs among the Good Practices and the findings and as such they tacitly assign equal weights ('importance') to the two types of observations. An alternative approach of characterizing the issues represented by the SGs is to simply take the difference of the number of Good Practices and findings belonging to the same SGs. This approach is also followed through in Reference [7] and there it is shown that it concludes in results identical to the above for SGs at the two extremes. Thus $SG_{1.d}$ has the largest negative difference and $SG_{7.d}$ has the largest positive difference, just as in the case of the Balance-values as expressed in Conclusions 10 and 11.

The SGs dominated by one of the observation types can be used to draw conclusions on problematic as well as on commendable issues generally appearing in IRRS missions. As an example for this, let us note that Module 7 (Inspection) often appears in this frequency analysis. $SG_{7.d}$ (Follow-up of inspections) is on the top of the GP list, while $SG_{7.c}$ (Procedures and guides for inspection) is second in the findings list based on the Balance-values as per Table 2. Furthermore $SG_{7.a}$ (Developing the inspection programme) is the second in the list of most populated SGs by findings and is the 8th in the most populated GP list (c.f. Figure 27 and Table 2).

**Lesson Learned 9:**
- The Balance-value approach tends to emphasize those SGs which are dominated either by Good Practices or by findings; and a near-zero Balance-value is the result of those SGs which have both types of observations (c.f. Figure 28);
- the most frequent Good Practice subjects seldom appear in findings;
- many of the most frequent finding subjects are also subjects of Good Practices.

**Conclusion 10:** The issues most frequently raised by findings and seldom mentioned as Good Practices are related to the provision and use of the legal framework for regulatory activities.

**Conclusion 11:** The subject most frequently appraised by Good Practices is the follow-up of inspections.

**Conclusion 12:** Activities related to inspection are frequently highlighted as non-compliances as well as good practices.

**Lesson Learned 10:** Conclusions 10 through 12 point to possible weak and strong points as well as to issues of interest in the regulatory framework of the Member States. In-depth analysis of the observations in these areas may highlight the underlying causes for these weak and strong points.

V.6. Follow-up missions

Follow-up missions are primarily meant to review the progress in addressing the Recommendations and Suggestions of the initial missions. Additionally, however, new observations may be formulated, either because the review process raises new issues or because the follow-up mission is an
Lessons Learned from IRRS Missions (2006-2013) to Countries with NPPs

*extended follow-up mission* (i.e. it includes new modules/topics not reviewed in the initial mission). In this section, some lessons learned from the nine follow-up missions held between 2006 and the closure of the manuscript of this report (August 2014) are investigated. More details are available in Reference [7].

If those observations arising from extended follow-up missions (i.e. those modules which were not reviewed in the initial missions) are not counted, the average number of observations in the follow-up missions is as follows:

- Average number of Recommendations/follow-ups: 2.0
- Average number of Suggestions/follow-ups: 3.9
- Average number of Good Practices/follow-ups: 2.6

These numbers may be compared to the respective average numbers in the initial missions quoted following Table 1 in Section V.1.

The progress reached by host countries after initial missions can be measured by the ratio of the number of closed issues to the number of original Recommendations and Suggestions. Figure 30 shows the average values as well as the range of closed Recommendations and Suggestions and the sum of them.

The average percentage of Recommendations and Suggestions not closed since the initial missions are as follows:

- Recommendations remaining open: 30%
- Suggestions remaining open: 20%
- In sum, findings remaining open: 23%}

Figure 31 summarizes the number of Recommendations and Suggestions per Module from the initial and follow-up missions. Figure 32 shows the distribution by Module of open and new findings relative to the initial mission.

Although the number of follow-up missions is too low to be statistically significant and the findings are unevenly distributed among the various follow-up missions, based on the figures above one concludes that:

![Figure 30 Range of open issues](image)

![Figure 31: Progress since initial missions](image)

![Figure 32: Progress status as shown by the follow-ups](image)
Conclusion 13: The progress made by host countries between initial and follow-up missions was higher in Modules 5 through 9 (i.e. in the core regulatory functions) than in Modules 1, 3, 4.

Conclusion 14: The relatively high number of issues that remained open suggests that either the time between the initial and follow-up missions were sometimes not sufficient to reach compliance with the findings of the initial missions, or the host country did not or could not place equal emphasis on all improvements.

It is often argued that Recommendations or Suggestions addressed to the government need substantially more time to solve than those addressed to the regulatory body. Table 3 shows the percentages of open issues and those of the initial findings addressed to the governments:

<table>
<thead>
<tr>
<th>Mission</th>
<th>Gov/all in initial [%]</th>
<th>Gov/all open [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>F3</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>F5</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>F8</td>
<td>20</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 3: Findings addressed to governments in initial missions and remained open in follow-up missions

Lesson Learned 11: Although in most missions with follow-ups (six out of nine), no finding was addressed to the government, in the remaining three, the findings that were addressed to the government and remained open, represent larger portions than the corresponding ratio in the initial missions.

Conclusion 15: Based on the limited data available it appears that complying with findings addressed to the government needs more time, or needs other prerequisites than those for the regulatory body. The reasons for this should be investigated further

Although the statistics of the findings remaining unresolved is fairly poor, it may be instructive to see the Subject Groups containing the highest number of open issues. Figure 33 shows the most frequent SGs of the open issues.

Figure 33: Subject Groups containing the highest number of open issues

Accordingly, from among the 69 open issues, the SGs 4.b: Details of the MS, developing MS manual and 3.c: Resources of the RB; contain six and five findings, respectively. It is interesting to note that these Subject Groups are the ninth and eleventh among the most frequently populated ones (c.f. Figure 25), but are the third and fourth in the list of findings with the highest balance values.
In other words, the issues that probably are the most persistent are not necessarily among the most frequent ones, yet are predominantly covered by findings and seldom appear in good practices.

This also shows that:

**Lesson Learned 12:** The Balance value of a Subject Group is very likely a good measure of the general safety importance of the issues summarized by the SG.

To conclude this section, it is noted that follow-up missions (not counting those from the extension modules) result on average, in additional observations as below:

- New Recommendations relative to initial missions: 19%
- New Suggestions relative to initial missions: 19%
- New Good Practices relative to initial missions: 23%

**VI. LESSONS LEARNED ON THE IRRS PROCESS**

In this chapter, the lessons learned from previous missions are drawn through statements and conclusions based on the correlation properties of the quantities so far investigated; on the quantitative values of a set of Performance Indicators introduced to evaluate effectiveness and efficiency of the IRRS missions, and on the global effectiveness values of past missions.

**VI.1. Correlations of observations**

In Section V.2 the correlations of observations in various IRRS Modules and in various missions were briefly discussed. In this section the various correlations among the observations are analysed in a broader and systematic context and conclusions are drawn on certain characteristics of the IRRS process.

Correlations of the various observations within four types of data-sets are investigated:

- number of references from the observations to various GSR Part 1 Requirements;
- number of observations in various missions;
- number of observations in various IRRS Modules;
- number of observations in various Subject Groups.

Numerical values of the correlation coefficients related to the various data-sets are reported in Reference [7], plots and graphs visualizing the correlations are quoted here.

**A. Correlation of Recommendations and Suggestions**

![Figure 34: Number of references to GSR Part 1 Requirements from observations](image)
Figure 34 shows the number of references made to the Requirements in GSR Part 1 derived from the various observations. The figure illustrates very well that these numbers exhibit similarly changes for all types of observations, i.e. they are correlated.

Specifically, in Ref.7 it is numerically shown that there is indeed a very strong positive correlation between the number of references to GSR Part 1 from Suggestions and from Recommendations.

As it is shown in Section V.2 (c.f. Figure 22 and Statement 8), the number of Recommendations and Suggestions in various missions – although expected to positively correlate – in many cases do not exhibit this correlation.

Also in Section V.2 (c.f. Figure 20), a great similarity in the variation of number of Recommendations and Suggestions along IRRS Modules was demonstrated. The corresponding strong positive correlation was calculated in Ref. [7].

Figure 35 shows the distribution of findings among the Subject Groups. This figure shows a picture more refined than in Figure 20 by providing a detailed distribution within the Modules.

The figure illustrates the correlated nature of the two types of findings in a suggestive manner. This is also proven in numerical form in Reference [7]. The facts presented above lead to the following:

**Lesson Learned 13:** Recommendations and Suggestions exhibit the following relational characters:
- their numbers are strongly (positively) correlated regarding the references to GSR Part 1 Requirements, regarding IRRS Modules and Subject Groups;
- they fail to show a definite correlation with IRRS missions.

One may thus draw on the following:

**Conclusion 16:** The frequency of Recommendations and Suggestions has very similar characteristics in all cuts of the IRRS process (i.e. by references, missions, Modules and Subject Groups).

**Conclusion 17:**
The lack of distinct positive mission-wise correlations between the numbers of Suggestions and of Recommendations may be attributed to the observations that in some missions Recommendations are converted to Suggestions as results of compromises between the team and the hosts; whereas in other cases (especially when there are a number of serious findings) the team tends to offer Recommendations although a Suggestion might be more adequate.

It may be interesting to investigate the ratio of number of Suggestions to that of Recommendations in various missions. Figure 36 displays these ratios.
It can be seen that in the majority of the missions, these ratios do not vary too much from one another (it is around 1.6 – marked by the green line). There are, however, a few missions with very much differing ratios (as marked by coloured circles). Red circles represent those missions to which the first reason in Conclusion 17 may refer to; some of the missions, marked by orange circles, may represent the second case outlined in Conclusion 17. Further analysis of these missions would be instructive.

**Figure 36: Ratio of number of Recommendations and of Suggestions**

### B. Correlation of Recommendations and Good Practices

As seen from Figure 34 above, the number of references to GSR Part 1 from Good Practices also positively correlates with that from Recommendations. The numerical results presented in Ref. [7] also show this positive correlation.

Regarding the number of Recommendations and of Good Practices in various missions, Section V.2 (c.f. Figure 21 and Statement 8) showed that although they are negatively correlated as expected, this correlation is less pronounced in some missions. In Figure 37 the square root of the product of number of Good Practices and Recommendations (divided by a normalizing factor) is shown. This quantity is expected to be around a constant value for various missions if the negative correlation of the two sets of numbers is given. It can be seen that two of the missions (marked by circles) are definitely outlying the general trend.

**Figure 37: Square root of product of the number of observations (R and GP)**

By leaving the outlying missions out from the analysis, the resulting correlation of Recommendations and Good Practices is indeed strongly negative. In these outlying missions, either the number of Recommendations or the number of Good Practices is considerably higher than the average while the other number is also high.

In Figure 20 it can be seen that for some Modules the number of Recommendations and Good Practices runs fairly parallel; for other Modules, they do not, thus resulting in a medium high positive correlation. A similarly moderate correlation is seen in Figure 38 for the Subject Groups.

**Figure 38: Number of Recommendations and Good Practices belonging to the various Subject Groups**
Accordingly, one can formulate the following:

**Lesson Learned 14:** Recommendations and Good Practices exhibit the following relational characters:

- their numbers show moderately positive correlation over references to GSR Part 1 Requirements, over IRRS Modules and over Subject Groups;
- this correlation may be attributed to the similarities of the topics addressed by all kinds of observations and to the fact - also expressed in Statement 9 - that in most cases issues are raised in some missions for the very same subject and exemplary practices are found in others;
- the lower than expected negative correlation over missions may be attributed to a few particular missions, detailed analysis of which would give valuable insight.

**C. Correlation of Suggestions and Good Practices**

As shown above, in certain aspects, Suggestions and Recommendations have different statistical characters and especially in their mission-wise distribution they show a much weaker correlation than expected. Therefore, an examination of the correlation of Suggestions and Good Practices may reveal further characteristics of the IRRS process.

Referring again to Figure 34 above, we see that these two observations have similar characters in referencing GSR Part 1 Requirements. As it is quoted in Ref. [7], the correlation of the two sets is indeed very strongly positive.

One would expect that similarly to the case of Recommendation-Good Practice, the number of Suggestions in various missions would negatively correlate with the number of Good Practices (by arguing that whenever there is room for development, less outstanding practices are expected). This, however, is not the case; as discussed in Figure 23 – due to a strong positive correlation in some of the missions – in total, there is practically no correlation between these two sets. Similarly to Figure 37 for Recommendations, Figure 39 shows the square root of the product of numbers of Good Practices and Suggestions (divided by a normalizing factor).

**Figure 39:** Square root of product of the number of observations (S and GP)

Circles show the most outlying missions. The comparison with Figure 36 indicates that in some missions, the relative number of the various observations was very much different from the average.

As seen in Figure 20 and also shown numerically in Ref. [7], the numbers of Suggestions and Good Practices by IRRS Modules show a very strong positive correlation. In other words, in those modules where the number of Suggestions is high/low the number of Good Practices tends to be high/low too.

A similar tendency is shown in Figure 40 for the number of observations falling into the various Subject Groups.

**Lesson Learned 15:** Suggestions and Good Practices exhibit the following relational characters:

- their number shows strong positive correlation over references to GSR Part 1 very likely for the same reasons as discussed in Statement 14;
- the lack of negative correlation of their numbers over missions may partly be attributed to the specificities of certain missions (to be further analysed), partly to other reasons discussed in the subsequent Conclusion 18;
• the very strong correlation of these numbers over the various Subject Groups also suggests a generic reason for parallel establishing Suggestions and Good Practices

Figure 40: Number of Suggestions and Good Practices belonging to the various Subject Groups

Conclusion 18:
• The numbers of Suggestions and Good Practices are positively correlated over IRRS Modules as well as over Subject Groups since there possibly are topics that are particularly important in the regulatory practice (or are consistently pointed out by the missions);
• another reason (more psychological than technical) may be that reviewers formulating a number of findings unintentionally feel obliged to compensate by also offering Good Practices;
• these issues need to be part of the reviewer training.

The results of this section lead to the following general conclusion:

Conclusion 19:
• All observations tend to refer to GSR Part 1 in a statistically consistent way;
• in certain missions, the relative number of the various observations highly differ from what would be expected from common sense and previous practice. There may be specific reasons that justify these unusual observation ratios. These reasons are worth being investigated further;
• in other cases, the mission-wise observation-numbers are unduly influenced by subjective effects that should be avoided in order to make the IRRS process even more objective and effective.

D. Correlation of EU and non-EU missions

Possible differences and similarities of missions to EU and non-EU Member States have been investigated in Section IV.1 with regards to the references to IAEA safety standards derived from observations. It was concluded that there is no essential difference between these references. Figures 10 through 12 in Section IV.2 illustrate the reference frequencies specifically to the GSR Part 1 Requirements. These figures showcase, but also shown numerically in Ref. [7], that the number of such references from EU and non-EU missions show a very strong positive correlation (in line with Conclusion 2).

Conclusion 7 summarized that statistical characters of the observations in EU and non-EU missions are similar. The distribution of observations is investigated further in this section. Figure 41 shows the number of the various observations for the two sets of missions. It can be seen that in most cases, these numbers run fairly parallel to each other for EU and non-EU missions, although there are exceptions and also the values (e.g. in case of Suggestions) are sometimes very different.
LESSONS LEARNED FROM IRRS MISSIONS (2006-2013) TO COUNTRIES WITH NPPS

Figure 41: Number of observations per missions from EU and non-EU missions in various Modules

The correlation coefficients calculated in Reference [7] show a very strong positive correlation in the number of Recommendations, a strong positive correlation in Good Practices and a fairly high positive correlation in Suggestions. Figure 41 above suggests that the correlation of the number of Suggestions is weakened by the differing trends for Module 4 in the two sets. This may be due to specific mission(s); reasons for this might be interesting to investigate further.

In Figure 42, the number of findings in the various Subject Groups is shown for EU and non-EU missions, respectively. The figure demonstrates a fairly parallel run of the two sets.

Figure 42: Number of findings belonging to the various Subject Groups from EU and non-EU missions

Again, the EU and non-EU missions show a very strong correlation in the number of findings falling into the various Subject Groups (although the absolute values in Figure 42 should not be compared to as they originate from different number of missions).

Conclusion 20: The IRRS missions to EU and non-EU Member States seem to exhibit very similar distributions of observations.

VI.2 Measuring effectiveness and efficiency of the IRRS process

The ultimate goal of the present work as well as of the initiatives meant to develop the IRRS process further is the maximization of the benefits offered to the Member States through the IRRS missions, correlating with the maximization of the effectiveness of the IRRS process. There are only a few possibilities for direct assessment of the overall effectiveness; however, the effectiveness of a method would be positively influenced by efficiency. This is the reason why both effectiveness and efficiency criteria are investigated here. Details related to the Performance Indicators and the analyses quoted in this report are given in Reference [8].

Effectiveness of the IRRS missions can be characterized by how the mission meets the general objectives a) through k) of the IRRS missions as listed in the IRRS Guidelines [1]. Efficiency generally describes the extent to which time, effort or cost is well used for the intended task or purpose, in this case for IRRS missions. When introducing a Performance Indicator (PI in what follows) characterizing the effectiveness and/or efficiency of a mission, the PI may be correlated to one or more relevant IRRS objective(s) as detailed in Ref. [8].
Each of the IRRS performance indicators, defining the overall effectiveness of an IRRS mission, may fall into one of the following ranges

- Optimum range (colour code: green)
- Acceptable range (colour code: yellow)
- Needing attention range (colour code: red)

depending on their values with respect to criteria (limit values). Optimum values of the PIs are defined through experience from past missions as well as by common sense; the ranges are defined relative to these optimum values.

A relative distance of the actual value from its optimum range is calculated for every PI of a mission. The relative distances are averaged to yield an Average Measure of Deviation denoted by $\Delta$. The effectiveness of the mission is then defined by the

Overall Effectiveness Criterion:

- Optimum (green) if $\Delta = 0$
- Effective (white) if $0 < \Delta \leq 0.1$
- Acceptable (yellow) if $0.1 < \Delta \leq 0.2$
- To be analysed (red) if $0.2 < \Delta$

depending on the value of the Average Measure of Deviation.

The Average Measure of Deviation gives the average distance of the mission from an optimum one. Thus a mission is optimum if every performance indicator of the mission is within the optimum range. The mission is effective if the average deviation of the performance indicators from their optimum ranges does not exceed 10%. The other ranges have similar explanations. Note that weighting of various individual distance values by their importance in E&E in averaging is expected to yield an even more realistic Average Measure of Deviation; furthermore, a sensitivity analysis would provide information on the role of the ranges.

Many of the PIs introduced are related to the ‘effective size’ of the IRRS mission. The effective size is introduced in Ref. [8] and it depends on such quantitative characteristics of a mission as the number of modules, facilities, activities and policy discussions that may influence the work to be invested by the team. It is also dependent on the size of the nuclear programme of the host country [8].

VI.3 Performance Indicators characterizing the effectiveness and efficiency of IRRS missions

In Ref. [8] 16 PIs are introduced to characterize any IRRS mission. These indicators shall be briefly quoted here and applied to recent IRRS missions.

Conclusions are drawn on the lessons learned and developments foreseen whenever possible.

A. Size of the IRRS team

The effectiveness and efficiency of a team is highly influenced by its size. Teams which are too small may not review the modules in the required details (may not be sufficiently effective); teams which are too large are a waste of time and money (not efficient). The optimum team size ($T_{opt}$) is supposed to be a linear function of the mission size (more work needs more reviewers) [8].

Figure 43: Team size – mission size relationship
This assumption is supported by Figure 43 that shows the relationship of mission sizes and actual past team sizes in initial missions.

The ranges (optimum, acceptable, needing attention; see VI.2) are demonstrated in the figure below:

![Diagram showing mission sizes and team sizes](image)

This is a brief illustration that the optimum range is ± 10% around the optimum value; the acceptable range is within 20%. The linear dependence of the team size was calculated by fitting to the actual team size of missions to nuclear countries in 2006-2013. The results are shown in Figure 44:

![Figure 44: Team size compared to optimum values](image)

**Lesson Learned 16:**

- The team size tends to stabilize in the proximity of their optimum values;
- as the optimum team size values were derived from the actual values of the missions, teams of any future missions can only be optimized as relative to past experience. Absolute optimization needs further consideration.

**Conclusion 21:** It appears that there is a linear dependence of the optimum team size on the mission size.

### B. Length of the IRRS Mission Report

The effectiveness and efficiency of the IRRS team can also be characterized by their main product, i.e. by the IRRS mission report. Most naturally a report with an optimum length represents the most efficient working method and as such is expected to best contribute to the effectiveness of the mission. Reports which are too short may not capture the results of the review in sufficient details (not effective); reports which are too long may be left unread by the intended readership (not efficient).

The optimum report length ($P_{opt}$) is supposed to be a linear function of both the mission size and the number of observations in the mission [8]. Calculation of the optimum linear coefficients was based on the past report length values under the assumption that most of the reports were about 10% longer than optimum. The range of the PI (similarly to the case of team size) is shown below:

![Diagram showing report lengths](image)

i.e. the range is ± 10 and 20% around the optimum value.

In Figure 45, the lengths of the mission reports relative to their optimum values are shown for all missions to nuclear countries in chronological order. The red vertical line denotes the date when this PI was introduced in practice.
Lesson Learned 17: The length of mission reports tends to stabilize in the proximity of their optimum values.

C. Time available for ARM review

The results and outcomes of the mission are largely influenced by the preparedness of the reviewers. This however, is very much related to the time available for reviewing the Advance Reference Material (ARM). In cases where there is not sufficient time available for the reviewer to consult with the ARM, there is a real danger that the reviewer will not be properly prepared for the review which may detriment both the effectiveness and efficiency.

The IRRS Guidelines[1] require the ARM to be provided at least two months prior to the mission. This, however, was often not done in recent past missions; therefore, a less strict condition of a minimum 45 days has been stipulated for the optimum range. The range applied is shown below:

Figure 46 illustrates the actual situation in past missions. Values in the positive range represent more than 45 days available for review. The negative values still above the red line show the cases when the time available was still above 30 days. The cases below the red line are in the red range. In missions above the blue line there were more than 60 days available for reviewing the ARM.

Lesson Learned 18: In most missions, the time available for ARM review is above 45 days, but it seldom exceeds 60 days.

Note that this stabilization was effectively supported by the introduction of the Standard IRRS Mission Report Template.
Conclusion 22: The ARM should be provided with sufficient time preceding the IRRS mission.

D. Advance comments from reviewers

As discussed above, the effectiveness of a mission largely depends on the competence and preparedness of the participating reviewers. Preparedness primarily means to be aware of the contents of the part of the self-assessment realized by the host country which concerns the module(s) reviewed. In case of recent missions, the reviewers were requested to provide their first impressions and potential questions prior to the mission (Advance Written Comments) based on the ARM received. It is assumed that in an ideal case, the number of advanced written comments should be proportional to the size of the mission (denoted by $\sigma$). The figure below shows the PI range in terms of the mission size:

In Figure 47, the number reviewers providing advance comments relative to the optimum limit (0.8 $\sigma$) is shown. Values above the green line are optimal, values between the red and green lines are acceptable.

![Figure 47: Number of advance comments on ARM relative to the optimum](image)

Lesson Learned 19: In most missions, the number of advance comments on ARM is acceptable; in a few of them it is optimum. There were no missions where the number of comments was below acceptable.

Conclusion 23: The almost uniform practice of recent missions suggests that the range of Performance Indicators of the number of advance comments on ARM may need revision and correction.

E. Feedback from the team and from the host

Subjective judgement on various aspects of the missions can be quantified and used as a measure of efficiency and effectiveness by requesting the participants of the IRRS process to answer marked questions characterizing the process. Four types of questionnaires were used in recent missions to obtain feedback from the reviewers and from the host representatives, each containing a number of questions relevant for the given subject. Details of the questionnaires are given in Ref. [8]. The following questionnaires are applied:

1. Feedback from the team on the quality of the ARM (at the beginning of the mission)
2. Feedback from the team on the effectiveness of the mission (at the end of the mission)
3. Feedback from the host on the effectiveness of the mission (after the mission)
4. Feedback from the host on the usefulness of the initial mission findings (before the follow-up mission)

Each question in the questionnaires is given a mark between 1 and 5 (5 represents the most favourable opinion) and the average of the marks are calculated for each questionnaire. (Note that
comments and suggestions can also be provided in the questionnaires, these are taken into account in the preparation of the Prompt Evaluation Report, see Section VI.5)

The Range of the respective PIs is illustrated in the figure below:

![Figure 48: Feedback on the ARM](image)

![Figure 49: Feedback from the team members](image)

1. Summary of the feedback on the quality of the ARM in recent missions is given in Figure 48.

Lesson Learned 20: In most missions, the quality of the ARM was evaluated to be around 3.5 in a scale of five.

Conclusion 24: The quality of the ARM needs substantial improvement; for that purpose, the hosts may need further guidance.

2. Effectiveness of the missions was evaluated by the teams as shown in Figure 49.

Lesson Learned 21: In all missions so far evaluated, the effectiveness was evaluated by the team at or above 4 in a scale of five thus reflecting a fairly high satisfaction.

3. The corresponding evaluation by the hosts is shown in Figure 50.

Lesson Learned 22: In contrast to the uniformity of the team feedback, the opinion of the hosts substantially varies from mission to mission.

Conclusion 25: The contradicting results of the two feedbacks suggest the need for further analysis.

![Figure 50: Feedback from the host country](image)

Note that standard application of the ARM Summary Report Template, being under finalization, may serve this purpose.
4. There have only been two follow-up missions so far where the host provided feedback on the usefulness of the initial mission. In both cases, the average marks are around 4.2 [8]. Such a small sample does not make it possible to draw conclusions.

**F. IRRS experience of the team members**

Further to what was said in Section D above, an essential constituent of the effectiveness and efficiency is the experience of the team members in conducting IRRS missions. The more IRRS-experienced a team member is, the more effective and efficient work can be expected from her/him. Therefore, it is expedient to characterize the expected effectiveness of a team by the relative number of reviewers who have previously taken part in IRRS mission(s). The range of this PI is different for initial and for follow-up missions and is shown below:

<table>
<thead>
<tr>
<th>For initial missions</th>
<th>For follow-up missions</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.33</td>
</tr>
<tr>
<td>0.5</td>
<td>0.66</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

We consider an initial mission team optimum from the point of view of experience if at least half and no more than 2/3 of the reviewers have previously taken part in IRRS missions. The experience is still acceptable if this ratio is one third. The upper limit is set to allow for the inclusion of new reviewers into initial missions. In follow-up missions the very optimum would be to have every team member from the team of the initial mission, but we still call a composition optimum with 2/3 experienced staff and in any case half of the team must be experienced.

Figure 51 shows the team experience values in the past missions.

**Lesson Learned 23:**
- In many of the initial missions, the team experience is considerably below optimum;
- In most follow-up missions, the team experience is in the optimum range.

**Conclusion 26:** When recruiting the IRRS team, more attention should be paid to the inclusion of sufficient number of experienced reviewers.

**G. Extent and coverage of the Action Plan**

As part of the Advance Reference Material, the host country prepares an Action Plan that lists those actions which are deemed necessary in order to comply with the requirements of the IAEA safety standards. On the one hand, the effectiveness of a mission can be characterized by the extent of the Action Plan (i.e. the number of items found necessary to include) and, on the other hand, by how well the team is able to cover the Action Plan through their findings. Three PI’s have been defined to cover this topic:

1. The number of items included into the Action Plan (Extent of Action Plan)
2. The ratio of Action Plan items covered by mission findings (Coverage of Action Plan)
3. The amount of findings that are not covered by the Action Plan (Beyond Action Plan Coverage)
All three PIs are defined in Ref. [8] as ratios (relative to the mission size or the number of items in the Action Plan, respectively) in order to make the definitions independent of the actual mission data. The ratios are defined in such a way that the optimum range of all three PIs is above unity, i.e. the ranges are illustrated as below:

1. The number of Action Plan items (relative to the mission sizes) is shown in Figure 52 for recent missions.

![Figure 52: Number of Action Plan items relative to the mission size](image)

**Lesson Learned 24:** The number of Action Plan items in various missions is very different.

**Conclusion 27:** More guidance might be expedient on the preparation of Action Plans.

2. Coverage of the Action Plan by findings is illustrated in Figure 53 (PI values minus 1 are depicted). Positive values are in the optimum range, the values below the red line are in the red range.

![Figure 53: Coverage of Action Plan items by mission findings](image)  ![Figure 54: Mission findings beyond Action Plan Coverage](image)

**Lesson Learned 25:** The coverage of Action Plan items in various missions is very different.

**Conclusion 28:** Reviewers need to be made aware of the importance of reviewing the Action Plan prepared by the host.

3. The relative number of findings (decreased by 1) that is not covered by the Action Plan is shown in figure 54.

**Lesson Learned 26:** In most missions, the number of findings not covered by Action Plan items is in the optimum range.
Note that in the case of the last two PIs, both values are within the red range for one of the missions. The reason for this is that the host country prepared a very extensive Action Plan (as also seen in Figure 52), full coverage of which would have not been expedient. In this case, the effectiveness of the missions should not be questioned in spite of the red PIs.

### H. Balance of findings

Correlations among the various observations of a mission were discussed in Sections V.2 and VI.1.

1. For the number of Recommendations and of Good Practices in a mission it was shown (c.f. Figures 21 and 37) that in most cases, they are negatively correlated in the sense that their product is expected to fluctuate around a constant value. A Performance Indicator was introduced in Reference [8] to measure this correlation (square root of the product of the two numbers divided by a normalizing factor that moves the optimum range around unity).

The values of the R-GP balance Performance Indicator (relative to their optimum, 1) are shown in Figure 55 (the optimum range is within the green lines).

![Figure 55: Balance of Recommendations and Good Practices in past missions](image)

The average of the product of the numbers of Good Practices and Recommendations over the past missions and included in the scope of this analysis is 103.

**Lesson Learned 27:** Most of the PI values on balance of Recommendations and Good Practices fall outside the optimum range (although all but one are within the acceptable range).

2. Similarly, in Sections V.2 and VI.1 correlation of the number of Recommendations and Suggestions were discussed (c.f. Figures 22 and 36). A tendency of parallel behaviour of the two numbers was observed. To describe this a Performance Indicator (normalized square root of the ratio of these numbers) was introduced in Ref.[8].

![Figure 56: Balance of Recommendations and Suggestions in past missions](image)

The values of the R-S balance Performance Indicator (relative to their optimum, 1) are shown in Figure 56 (the optimum range is within the green lines, the acceptable range is between the red and the nearest green lines).

The average of the number of Recommendations/ number of Suggestions over the past missions in the scope of the present analysis is 0.86.
**Lesson Learned 28:** Most of the PI values regarding the balance of Recommendations and Suggestions fall into the optimum range, some of them are in the acceptable range and only one is outside these ranges.

**Conclusion 29:** It would be beneficial to invite experienced IRRS reviewers to discuss the relevance and possible application of the balance of various observations in future missions.

I. Conciseness of Mission Report

Although the IRRS Guidelines define the structure and contents of an IRRS report, this definition provides the report writer with quite some freedom regarding the inclusion or omission of certain details. An effective and efficient mission needs to consider every important topic of the regulatory regime of the host country. Therefore, it appears to be a good idea to compare the contents of a mission report to an “ideal one”. In this paper, ideal refers to the one report that includes all issues proved to be important in past missions. Based on the topics suggested by the IRRS Guidelines, the table of contents of an ideal mission report has been compiled. This contents was used for the comparison of the contents with the actual mission reports in the end of 2012. In the last mission of 2012 and in subsequent missions, a Standard Mission Report Template was introduced to guide the reviewers in their reviews and report writing.

*Figure 57: Conciseness of recent mission reports*

Since then, the Standard Template is considered to be the “ideal one” and is used for comparison purposes. The range of this PI is shown below:

This PI applies to initial missions only. Its values (in fact subtracted from 1) for the recent missions are shown in Figure 57

**Lesson Learned 29:** Only a few mission reports cover the report topics in an optimum way, most reports are in the acceptable range, the contents of a few reports would need attention.

**Conclusion 30:** Reviewers should be trained to use the IRRS Mission Report Template in a comprehensive manner.

J. Completion time of Mission Report

The final product of a mission is the mission report and as such, in an efficient mission, it should be completed as soon as possible. The completion of the report after the end of the mission is a collective activity, it includes: editing and formatting by the IAEA, commenting by the host country and proofreading by the team leader and by the team members. The range of this PI is shown in the figure below:

*Figure 58: Completion time of IRRS mission reports*
The actual completion time is shown in Figure 58.

**Lesson Learned 30:** Only a few mission reports have been completed within 90 days (optimum range) and some recent reports were within the red range (above 120 days).

**Conclusion 31:** The IAEA should investigate possible ways of speeding up report completion.

### K. Open issues in a follow-up mission

The primary purpose of follow-up missions is to review the progress made by the host in response to recommendations and suggestions concluded in initial missions. It is reasonable to assume that a measure of the effectiveness of the initial IRRS mission (and also of the IRRS process) may be based on the number of issues that have been closed (or are left open) by the host country. There may be several reasons for an issue to remain open (e.g. the host could not deal with the issue, the recommendation or suggestion was not properly formulated or more time is needed for the completion), this can be assessed on the basis of the host feedback before the follow-up mission as discussed in Subsection E above. In Ref.[8] a PI measuring the overall progress through the relative number of issues remaining open after the follow-up mission is introduced. The related ranges are shown in the figure below:

In Figure 31 (Section V.6), these values are presented to illustrate the progress made between the initial and follow-up missions. In Figure 59, the ratio of the number of issues remaining open to the number of initial findings is presented. As quoted in Section V.6, the average ratio of the number of findings remaining open to the number of initial findings is 0.23.

![Figure 59: Ratio of open issues in the follow-up missions](image)

**Lesson Learned 31:**
- There are large differences among the follow-up missions in the number of issues remaining open;
- The average number of open issues (23%) seems to be rather high.

### VI.4 Efficiency and effectiveness of recent missions

The Performance Indicators shown in the previous section have been applied to the recent missions. The Average Measure of Deviation from optimum was calculated as discussed in Section VI.3 and these values defined the range where the efficiency and effectiveness of the missions belong. Figure 60 summarizes the overall efficiency and effectiveness of recent missions in terms of Average Measure of Deviation from optimum.
Conclusion 32: The efficiency and effectiveness of all missions, as demonstrated by the PIs proposed in this study fall into the effective range; the values, although fluctuating show an improving trend.

VI.5 Prompt Evaluation of IRRS missions

The Performance Indicators introduced in [8] and quoted in Section VI.3 are used in the preparation of reports evaluating all missions since 2011 right after their completion. The table of contents of the Prompt Evaluation Report is shown in Figure 61.

Figure 60: Variation in time of the Average Measure of Deviation of missions

Figure 61: Table of contents of a mission Prompt Evaluation Report

The reports are distributed to the host country and to the team and shall be made public soon.
REFERENCES


APPENDIX 1: Findings in Subject Groups of various IRRS Modules

In Reference [7], the analysis of the past IRRS missions to countries with operating NPPs is presented. The observations offered in these missions are sorted into typical topical Subject Groups. The results of this grouping are quoted below in tabular form.

The number of observations (Recommendations, Suggestions and Good Practices) from the 18 EU (13 initial and 5 follow-up) and 13 non-EU missions (9 initial and 4 follow-up, as listed in Figure 4, in Section I.4) are presented for each Module and each Subject Group therein. The most frequent SGs are highlighted.

**Module 1 – Responsibilities and Functions of the Government**

<table>
<thead>
<tr>
<th>Subject groups in Module 1</th>
<th>R EU</th>
<th>R nEU</th>
<th>S EU</th>
<th>S nEU</th>
<th>GP EU</th>
<th>GP nEU</th>
<th>Σ EU</th>
<th>Σ nEU</th>
<th>Σ GP</th>
<th>% R+GP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Co-operation/interaction among organizations, bodies</td>
<td>5 1</td>
<td>5 7</td>
<td>0 0</td>
<td>0 12</td>
<td>0 0</td>
<td>16.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b National policies, strategies</td>
<td>9 1</td>
<td>4 2</td>
<td>0 2</td>
<td>10 6</td>
<td>2 12.6</td>
<td></td>
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<tr>
<td>c Providing resources to the RB</td>
<td>5 7</td>
<td>2 1</td>
<td>1 12</td>
<td>4 2</td>
<td>14.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d Providing/using legal framework for regulatory activities</td>
<td>23 11</td>
<td>6 7</td>
<td>2 2</td>
<td>34 13</td>
<td>4 39.3</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>e Transparency, public involvement</td>
<td>1 1</td>
<td>8 3</td>
<td>7 5</td>
<td>2 11</td>
<td>12 9.6</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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<td>1 2</td>
<td>1 0</td>
<td>2 3</td>
<td>1 3.7</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>g Building competence in nuclear safety</td>
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<td>1 1</td>
<td>1 3</td>
<td>1 2</td>
<td>4 2.2</td>
<td></td>
<td></td>
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<td>0 1</td>
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<td>1 2.2</td>
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<td>68 52</td>
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**Module 2 – Global Nuclear Safety Regime**

<table>
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<th>Subject groups in Module 2</th>
<th>R EU</th>
<th>R nEU</th>
<th>S EU</th>
<th>S nEU</th>
<th>GP EU</th>
<th>GP nEU</th>
<th>Σ EU</th>
<th>Σ nEU</th>
<th>Σ GP</th>
<th>% R+GP</th>
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<td>2 1</td>
<td>5 0</td>
<td>3 2</td>
<td>8 41.7</td>
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<td>b Relationship with international organizations</td>
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<td>1 1</td>
<td>4 1</td>
<td>3 2</td>
<td>5 41.7</td>
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<td>x Other</td>
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<td>0 2</td>
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</tr>
<tr>
<td>Σ Sum of Observations in the Module</td>
<td>2 3</td>
<td>4 3</td>
<td>9 4</td>
<td>5 7</td>
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</table>

**Module 3 – Responsibilities and Functions of the Regulatory Body**

<table>
<thead>
<tr>
<th>Subject groups in Module 3</th>
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<th>R nEU</th>
<th>S EU</th>
<th>S nEU</th>
<th>GP EU</th>
<th>GP nEU</th>
<th>Σ EU</th>
<th>Σ nEU</th>
<th>Σ GP</th>
<th>% R+GP</th>
</tr>
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<tbody>
<tr>
<td>a Staffing of the regulatory body</td>
<td>6 8</td>
<td>5 5</td>
<td>2 5</td>
<td>14 10</td>
<td>7 18.3</td>
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</tr>
<tr>
<td>b Competence of the regulatory body</td>
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<td>5 1</td>
<td>0 2</td>
<td>10 6</td>
<td>2 12.2</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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### Module 10 – Emergency Preparedness and Response (regulatory aspects)

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<td>8</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>12</td>
<td>12</td>
<td>4</td>
<td>30.4</td>
</tr>
<tr>
<td>x Other</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>6.3</td>
</tr>
<tr>
<td>Σ Sum of Observations in the Module</td>
<td>24</td>
<td>16</td>
<td>37</td>
<td>23</td>
<td>11</td>
<td>11</td>
<td>40</td>
<td>60</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 2: Summary of Lessons Learned and Conclusions

THE IRRS PROCESS AND THE IAEA SAFETY STANDARDS

References to IAEA safety standards

**Lesson Learned 1:** The IRRS Modules have the following referencing character:
- Module 4 (Management system of the regulatory body) mainly refers to GS-R-3 [4];
- Module 10 (Emergency Preparedness and Response) mainly refers to GS-R-2 [6];
- Module 6 (Review and assessment) extensively refers both to GSR Part 1 and to other standards;
- The majority of the references from other IRRS core Modules relate to GSR Part 1 [3].

**Conclusion 1:** The data presented confirm that the General Safety Requirements, and primarily GSR Part 1, provide basis for the IRRS process, further basic references are GS-R-3 and GS-R-2.

**Conclusion 2:** There is no substantial difference between the EU and non-EU missions in referencing the IAEA safety standards.

References to GSR Part 1 Requirements

**Lesson Learned 2:** The most frequent Requirements
- are mostly referred to in those IRRS Modules to which they are connected in GSR Part 1;
- do not seem to be attributed to a particular single missions, but their references are fairly evenly distributed among several missions.

**Conclusion 3:** The GSR Part 1 Requirements which seem to fit with the issues encountered in IRRS missions the most are R24, R18, R20 and R32.

**Lesson Learned 3:** Among the most frequently referred to GSR Part 1 Requirements
- five (R24, 32, 27, 25, 29) are related to core regulatory functions (Modules 5 through 9) and make up almost one third of all references to sum up to 9.18 references/initial mission;
- R20 in third place – although not belonging to the core regulatory modules 5 through 9, is directly related to the core regulatory functions.

**Conclusion 4:** Recommendations and Suggestions, referencing GSR Part 1 Requirements relating to core regulatory functions from initial missions comprise a dominant part of all references.

**Lesson Learned 4:**
- 10 Requirements (28% of all) receive about 60% of the references from the recommendations and suggestions of all missions;
- 17 Requirements (47%) are the subject of about 80% of the references;
- the nine least referenced Requirements (25% of all) are the subject of about 5% of the references. Each was referenced less than eight times out of a total number of 654 references.

**Lesson Learned 5:** There may be several reasons for the low reference rate of particular GSR Part 1 Requirements, e.g. because it
- refers to a safety requirement generally complied with and not posing problems in the international regulatory framework;
- falls out of the scope of the IRRS process, thus indicating potential weakness therein; or
- does not address a realistic case, which might necessitate revision of this part of GSR Part 1.

**Conclusion 5:** Further investigation of the frequency of references may lead to a better knowledge of the Member States’ regulatory infrastructure, of the IRRS process and may also provide further ideas on the possible development of the IAEA safety standards.
LESSONS LEARNED ON THE REGULATORY FRAMEWORK

Numerical characteristics of observations

Lesson Learned 6: Although the number of observations in various missions may reflect specific differences in regulatory frameworks of the host countries, the overall picture of the distribution of the observations is fairly uniform.

Conclusion 6: The number of observations arising from missions confirms that the practice followed ensures a reasonable distribution for these numbers.

Conclusion 7: There seems to be no essential difference between EU and non-EU missions in the statistical characters of the observations.

Distribution of observations

Lesson Learned 7:
- The basic modules related to the regulatory regime (Modules 1, 3, 5, 6, 7, 9, 10) show fairly uniform distribution of findings, with Module 3 (Responsibilities and functions of the regulatory body) having the maximum number of findings and observations;
- Module 2 (Global Nuclear Safety Regime) has considerably fewer observations than other Modules. (Note that the Global Nuclear Safety Regime is part of the IRRS programme since 2010, earlier missions did not include it, and this is taken into account in the averaging.) This module apparently raises only a few specific regulatory or governmental issues that might result in observations;
- Module 8 (Enforcement) also only has only a few observations. The reason for that may be that the module covers only a very limited portion of regulatory activities;
- Modules, having the most GPs are No. 6 (Review and assessment), 7 (Inspection), and 3 (Role and responsibilities of the regulatory body).

Conclusion 8: Recommendations and Suggestions, relating to most of the core regulatory functions from initial missions demonstrate equal emphasis by the peer review, while Modules 2 and 8 have a considerable lower rate of findings. The definition of the IRRS Modules may therefore need revision to be better balanced out.

Lesson Learned 8:
- The intuitive relationship between the number of Recommendations and Good Practices seems to be proven by the actual number of observations, yet in certain missions, the negative correlation of Recommendations and Good Practices is less pronounced than expected;
- the intuitive relationship between Recommendations and Suggestions appears to be true in some missions; in some others (especially those where the number of Recommendations is higher than the number of Suggestions) the positive correlation among the number of Recommendations and Suggestions is weaker.

Conclusion 9: More detailed analysis may be necessary for the reasons of those mission results that do not reflect the expected correlations.

Balance of observations

Lesson Learned 9:
- The Balance-value approach tends to emphasize those SGs which are dominated either by Good Practices or by findings; and a near-zero Balance-value is the result of those SGs which have both types of observations;
- the most frequent Good Practice subjects seldom appear in findings;
- many of the most frequent finding subjects are also subjects of Good Practices.
Conclusion 10: The issues most frequently raised by findings and seldom mentioned as Good Practices are related to the provision and use of the legal framework for regulatory activities.

Conclusion 11: The subject most frequently appraised by Good Practices is the follow-up of inspections.

Conclusion 12: Activities related to inspection are frequently highlighted as non-compliances as well as good practices.

Lesson Learned 10: Conclusions 10 through 12 point to possible weak and strong points as well as to issues of interest in the regulatory framework of the Member States. In-depth analysis of the observations in these areas may highlight the underlying causes for these weak and strong points.

Follow-up missions

Conclusion 13: The progress made by host countries between initial and follow-up missions was higher in Modules 5 through 9 (i.e. in the core regulatory functions) than in Modules 1, 3, 4.

Conclusion 14: The relatively high number of issues that remained open suggests that either the time between the initial and follow-up missions were sometimes not sufficient to reach compliance with the findings of the initial missions, or the host country did not or could not place equal emphasis on all improvements.

Lesson Learned 11: Although in most missions with follow-ups (six out of nine), no finding was addressed to the government, in the remaining three, the findings that were addressed to the government and remained open, represent larger portions than the corresponding ratio in the initial missions.

Conclusion 15: Based on the limited data available it appears that complying with findings addressed to the government needs more time, or needs other prerequisites than those for the regulatory body. The reasons for this should be investigated further.

Lesson Learned 12: The Balance value of a Subject Group is very likely a good measure of the general safety importance of the issues summarized by the SG.

LESSONS LEARNED ON THE IRRS PROCESS

Correlations of observations

Lesson Learned 13: Recommendations and Suggestions exhibit the following relational characters:
- their numbers are strongly (positively) correlated regarding the references to GSR Part 1 Requirements, regarding IRRS Modules and Subject Groups;
- they fail to show a definite correlation with IRRS missions.

Conclusion 16: The frequency of Recommendations and Suggestions has very similar characteristics in all cuts of the IRRS process (i.e. by references, missions, Modules and Subject Groups).

Conclusion 17: The lack of distinct positive mission-wise correlations between the numbers of Suggestions and of Recommendations may be attributed to the observations that in some missions Recommendations are converted to Suggestions as results of compromises between the team and the hosts; whereas in other cases (especially when there are a number of serious findings) the team tends to offer Recommendations although a Suggestion might be more adequate.

Lesson Learned 14: Recommendations and Good Practices exhibit the following relational characters:
- their numbers show moderately positive correlation over references to GSR Part 1 Requirements, over IRRS Modules and over Subject Groups;
• this correlation may be attributed to the similarities of the topics addressed by all kinds of observations and to the fact - also expressed in Statement 9 - that in most cases issues are raised in some missions for the very same subject and exemplary practices are found in others;
• the lower than expected negative correlation over missions may be attributed to a few particular missions, detailed analysis of which would give valuable insight.

Lesson Learned 15: Suggestions and Good Practices exhibit the following relational characters:
• their number shows strong positive correlation over references to GSR Part 1 very likely for the same reasons as discussed in Statement 14;
• the lack of negative correlation of their numbers over missions may partly be attributed to the specificities of certain missions (to be further analysed), partly to other reasons discussed in the subsequent Conclusion 18;
• the very strong correlation of these numbers over the various Subject Groups also suggests a generic reason for parallel establishing Suggestions and Good Practices.

Conclusion 18:
• The numbers of Suggestions and Good Practices are positively correlated over IRRS Modules as well as over Subject Groups since there possibly are topics that are particularly important in the regulatory practice (or are consistently pointed out by the missions);
• another reason (more psychological than technical) may be that reviewers formulating a number of findings unintentionally feel obliged to compensate by also offering Good Practices;
• these issues need to be part of the reviewer training.

Conclusion 19:
• All observations tend to refer to GSR Part 1 in a statistically consistent way;
• in certain missions, the relative number of the various observations highly differ from what would be expected from common sense and previous practice. There may be specific reasons that justify these unusual observation ratios. These reasons are worth being investigated further;
• in other cases, the mission-wise observation-numbers are unduly influenced by subjective effects that should be avoided in order to make the IRRS process even more objective and effective.

Conclusion 20: The IRRS missions to EU and non-EU Member States seem to exhibit very similar distributions of observations.

Performance Indicators characterizing the effectiveness and efficiency of the IRRS missions

Lesson Learned 16:
• The team size tends to stabilize in the proximity of their optimum values;
• as the optimum team size values were derived from the actual values of the missions, teams of any future missions can only be optimized as relative to past experience. Absolute optimization needs further consideration.

Conclusion 21: It appears that there is a linear dependence of the optimum team size on the mission size.

Lesson Learned 17: The length of mission reports tends to stabilize in the proximity of their optimum values.


**Lesson Learned 18:** In most missions, the time available for ARM review is above 45 days, but it seldom exceeds 60 days.

**Conclusion 22:** The ARM should be provided with sufficient time preceding the IRRS mission.

**Lesson Learned 19:** In most missions, the number of advance comments on ARM is acceptable; in a few of them it is optimum. There were no missions where the number of comments was below acceptable.

**Conclusion 23:** The almost uniform practice of recent missions suggests that the range of Performance Indicators of the number of advance comments on ARM may need revision and correction.

**Lesson Learned 20:** In most missions, the quality of the ARM was evaluated to be around 3.5 in a scale of five.

**Conclusion 24:** The quality of the ARM needs substantial improvement; for that purpose, the hosts may need further guidance.

**Lesson Learned 21:** In all missions so far evaluated, the effectiveness was evaluated by the team at or above 4 in a scale of five thus reflecting a fairly high satisfaction.

**Lesson Learned 22:** In contrast to the uniformity of the team feedback, the opinion of the hosts substantially varies from mission to mission.

**Conclusion 25:** The contradicting results of the two feedbacks suggest the need for further analysis.

**Lesson Learned 23:**
- In many of the initial missions, the team experience is considerably below optimum;
- In most follow-up missions, the team experience is in the optimum range.

**Conclusion 26:** When recruiting the IRRS team, more attention should be paid to the inclusion of sufficient number of experienced reviewers.

**Lesson Learned 24:** The number of Action Plan items in various missions is very different.

**Conclusion 27:** More guidance might be expedient on the preparation of Action Plans.

**Lesson Learned 25:** The coverage of Action Plan items in various missions is very different.

**Conclusion 28:** Reviewers need to be made aware of the importance of reviewing the Action Plan prepared by the host.

**Lesson Learned 26:** In most missions, the number of findings not covered by Action Plan items is in the optimum range.

**Lesson Learned 27:** Most of the PI values on balance of Recommendations and Good Practices fall outside the optimum range (although all but one are within the acceptable range).

**Lesson Learned 28:** Most of the PI values regarding the balance of Recommendations and Suggestions fall into the optimum range, some of them are in the acceptable range and only one is outside these ranges.

**Conclusion 29:** It would be beneficial to invite experienced IRRS reviewers to discuss the relevance and possible application of the balance of various observations in future missions.

**Lesson Learned 29:** Only a few mission reports cover the report topics in an optimum way, most reports are in the acceptable range, the contents of a few reports would need attention.

**Conclusion 30:** Reviewers should be trained to use the IRRS Mission Report Template in a comprehensive manner.
Lesson Learned 30: Only a few mission reports have been completed within 90 days (optimum range) and some recent reports were within the red range (above 120 days).

Conclusion 31: The IAEA should investigate possible ways of speeding up report completion.

Lesson Learned 31:

- There are large differences among the follow-up missions in the number of issues remaining open;
- The average number of open issues (23%) seems to be rather high.

Conclusion 32: The efficiency and effectiveness of all missions, as demonstrated by the PIs proposed in this study fall into the effective range; the values, although fluctuating show an improving trend.