Regulatory Body Integration and the Safety–Security–Safeguards Interface : A Comparison of Six National Arrangements

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1. Introduction

Nuclear regulation addresses three concurrent objectives: safety, security and safeguards, collectively referred to as the 3S. Because these functions apply to the same facilities, systems and personnel, their requirements are inherently interdependent and may be mutually reinforcing or potentially conflicting.

States have adopted different institutional arrangements to manage these interactions. In the United States, the Nuclear Regulatory Commission (NRC) exercises regulatory responsibility for all three functions. In Korea, the Korea Institute of Nuclear Safety (KINS) provides technical support for safety, while the Korea Institute of Nuclear Nonproliferation and Control (KINAC) supports security and safeguards; regulatory authority and decision-making rest with the Nuclear Safety and Security Commission (NSSC). Among the twelve states examined in the underlying comparative study, no comparable arrangement was identified in which safety and security are supported by separate technical support organisations under a common regulatory authority.

Assessments of the Korean arrangement differ. The 2024 Integrated Regulatory Review Service (IRRS) mission issued neither a recommendation nor a suggestion on the safety–security interface and positively assessed cooperation among NSSC, KINS and KINAC [1]. By contrast, a domestic policy assessment identified functional overlap and budgetary inefficiencies and considered a possible merger of KINS and KINAC [2]. The government's SMR regulatory roadmap continues to assign safety review to KINS and security and safeguards review to KINAC, while introducing an integrated 3S safety confirmation system from the design stage and, from 2027, a comprehensive management system for the 3S interface [3].

Against this background, this study aims to identify regulatory arrangements that support effective and coordinated management of the 3S functions. Using comparative evidence, the analysis focuses on organisational structure, allocation of regulatory responsibilities, coordination mechanisms and licensing processes, without assuming that organisational integration is inherently superior to institutional separation.

Section 2 establishes the comparative framework, including the classification criteria and the position of international norms on organisational form. Section 3 applies the framework to six states, examining the origin, current structure, strengths and limitations of each arrangement. Section 4 develops cross-cutting observations and implications for Korea, and Section 5 presents the conclusions and limitations. Each state was surveyed using a common schema covering organisation and legal basis, allocation of functions, interface mechanisms, licensing and inspection, resources, regulatory methodology, formation history and boundary issues.

2. Framework for the Comparison

2.1. Classification Criteria

This study classifies national 3S regulatory arrangements using two criteria that represent distinct dimensions of institutional integration. Criterion 1 concerns whether the regulatory functions for safety, security and safeguards are assigned to a single body or distributed among separate organisations. Criterion 2 concerns whether regulatory decision-making authority and technical support are located within the same organisation or institutionally separated.

The two criteria are adopted for two reasons. First, a simple integrated/separated dichotomy lacks sufficient discriminating power because it cannot distinguish integration of the 3S functions from integration of regulatory authority and technical support. France, for example, is integrated under Criterion 2 but separated under Criterion 1, whereas the United Kingdom is integrated under both. Japan is one of several states in the sample integrated under both criteria, yet it provides the closest structural comparator to Korea because both arrangements originated from a promotion–regulation split undertaken in the early 2010s, notwithstanding Korea's separation under both criteria. In Korea, the division of technical responsibilities between KINS and KINAC constitutes separation under Criterion 1, while the institutional separation of NSSC from the two technical support institutes constitutes separation under Criterion 2.

Second, the two criteria reflect institutional decisions made separately in practice. In the cases examined, the allocation of the 3S functions and the institutional

placement of technical support were determined at different times and for different purposes. They are therefore treated as independent dimensions rather than as measures of a single degree of integration.

2.2. Implementation Forms and Linkage Layers

Coordination under Criterion 1 is implemented in four forms, distinguished by where the 3S interface is managed. In the embedded form, safety, security and safeguards are incorporated into a common regulatory review structure, as in Canada [4, 5]. In the aligned-process form, a unified regulatory body manages the interface through dedicated processes or teams, as in the United Kingdom [5]. In the documented-procedure form, coordination is established through formal internal procedures and corresponding operator requirements, as in Japan [6]. In the consultative form, separate organisations coordinate through formal consultation mechanisms, as in Korea [1].

A dedicated coordination procedure therefore does not, by itself, indicate the degree of integration. In an embedded system, coordination may be achieved through the review structure without a separate procedure or body. The absence of an identified mechanism should not be interpreted as the absence of coordination without first considering the implementation form.

The 3S functions may also be linked at regulatory layers independent of organisational structure. Eight linkage layers were identified: integration of a specific function, cross-referencing of legal instruments, operator duties, scope of requirements, licensing review structure, assessment principles, regulatory procedures and statutory definitions [4–8]. Organisational integration is not itself a linkage layer; even within a single regulatory body, explicit arrangements may be required to coordinate internally separated safety and security functions [5, 9].

2.3. Position of International Norms

Because the classification criteria concern organisational form, the normative status of organisational integration determines how the comparative results should be interpreted. International norms neither require integration nor treat organisational form as irrelevant. These positions must be distinguished because they lead to different implications for regulatory design. The relevant provisions are summarised in **Table I**.

Table I. Normative status of elements of the 3S interface

Element	Normative basis	Character	Source
Interface management	Safety and security measures must be designed and implemented in an integrated manner; the government is to ensure adequate arrangements for the interfaces of safety with nuclear security.	Obligation	[5]
Coordination arrangements	Coordination arrangements are described as necessary both where safety and security functions are assigned to separate organisations and where a single regulatory body assigns them to separate internal units.	Guidance	[5, 9]
Organisational integration	Many States see advantages in a single regulator for safety and security, and placing the functions in one organisation has been recorded as good practice in peer review.	Good practice	[5, 10]
Organisational form	Peer-review good practices include a single organisation for the three functions, assignment of physical protection to the safety division and a common department; no form is prescribed.	Choice	[5]
Operator management structure	Ultimate responsibility for safety and security at a site should be attained through a single, unified management structure.	Recommendation	[10]

Three implications follow for the comparative analysis. First, the provisions stated in mandatory terms concern interface management rather than organisational form, and the remaining provisions are guidance. INSAG-24 states the condition in outcome terms: security regulations should not compromise safety, and safety regulations should not compromise security; where the authorities are not integrated in a single agency, consultation and coordination mechanisms are needed [10]. Second, IAEA guidance describes coordination arrangements as necessary both for separate organisations and for a single regulatory body that divides the functions internally [5, 9]. Integration therefore relocates the coordination interface rather than removing it. Third, the norms are more prescriptive for the operator than for the regulator. INSAG-24 recommends that the operator's ultimate responsibility for safety and security at a site be attained through a single, unified management structure, while accepting organisational separation at the regulatory level subject to consultation and coordination mechanisms [10]. This asymmetry reflects the operational reality that safety and security measures act on the same facility, whereas the regulator reviews their implementation and outcomes.

The norms also identify trade-offs associated with integration. Harmonisation of regulations and guidance should not diminish the specialised expertise required for each function, and regulatory practice has evolved in both directions between harmonisation and specialisation [5]. Similar terminology may also obscure substantive differences; for example, defence in depth is used in both safety and security but implemented differently [5]. A further difference arises in personnel management: safety practice encourages staff to report problems, including their own mistakes, whereas security examines problems caused by individuals for a potential insider threat, although the same source regards both as requiring a balance between complacency and understanding [5]. Trustworthiness programmes focus assessment on observable behaviour and can draw on measures in safety and human reliability programmes [11], but they introduce an additional coordination requirement. Conversely, assigning safety and security to separate organisations may result in a lack of effective cooperation or, in extreme cases, competition between the two functions [9]. International norms therefore identify risks associated with both integration and separation without establishing either as inherently superior.

3. National Arrangements

This section applies the framework to six states selected to represent both classification criteria and the principal implementation forms observed. For each state, the origin of the present arrangement is examined first, followed by its current structure and the strengths and limitations identified in the available record.

3.1. United States

The present U.S. regulatory structure originated from the separation of nuclear promotion from regulation rather than from a deliberate decision to integrate the 3S functions. Under the Atomic Energy Act of 1954, the Atomic Energy Commission (AEC) was responsible for both promoting civilian nuclear energy and protecting public health and safety. The conflict inherent in this dual mandate led to the 1974 reorganisation, which separated promotional and developmental activities from safety regulation; the legislative record stated that a regulatory agency should never be placed in a position to generate, and then have to defend, basic design data of its own [12]. The Energy Reorganization Act of 1974 abolished the AEC and transferred regulatory functions to the Nuclear Regulatory Commission (NRC), while research and development functions were assigned to the Energy Research and Development Administration [12, 13]. Safeguards responsibilities were incorporated into the NRC at its establishment through the Office of Nuclear Material Safety and Safeguards [12]. Thus, the present integration of the 3S functions resulted from the transfer of existing regulatory responsibilities rather than from an explicit policy decision to integrate them.

The U.S. arrangement is integrated under both classification criteria: the NRC holds responsibility for all three functions and performs technical review in house. The principal interface-management duty, however, is imposed on the licensee. Before implementing changes affecting plant configuration, facility conditions or security, the licensee must assess and manage the potential for adverse effects on safety and security, including the site emergency plan, communicate identified conflicts to appropriate licensee personnel and take compensatory or mitigative actions [7]. The associated regulatory guidance is likewise directed primarily to the licensee, and no dedicated internal NRC procedure for 3S coordination was identified.

A principal strength of this arrangement is that interface management is established as an enforceable operator requirement at the facility level, where safety, security and safeguards measures are implemented. Two limitations remain. First, organisational integration does not necessarily produce integrated licensing review. The Standard Review Plan, for example, assigns primary responsibility for cyber security plan review to the Office of Nuclear Security and Incident Response without designating the safety organisation as a secondary reviewer, although the plan covers digital systems supporting safety, security and emergency preparedness functions; coordination between review areas is maintained largely through cross-reference [14]. Second, the Government Accountability Office has identified continuing difficulties in recruiting and retaining staff needed for advanced-reactor licensing [15], indicating that organisational integration does not eliminate regulatory resource constraints.

3.2. United Kingdom

The United Kingdom provides the clearest documented case of the objectives underlying regulatory consolidation. The establishment of the Office for Nuclear Regulation (ONR) as a statutory body was described by the government as completing a process initiated in 2007 to consolidate the nuclear regulatory framework, improve regulatory consistency and reduce interfaces for duty holders [16]. The corresponding impact assessment records that the consolidation begun in 2007 aimed to improve regulatory consistency, reduce interfaces for duty holders, improve the integration of functions, reduce duplication and facilitate the sharing of best practice [17]. Management of the safety–security interface was not identified as a primary driver; the consolidation was principally intended to improve regulatory efficiency. These objectives are broadly comparable to those cited in the 2010 National Assembly committee review of a possible merger of KINS and KINAC, which cited reduced burden on inspected organisations and reduced

administrative support staff as advantages of a merger [18].

The U.K. arrangement is integrated under both criteria and follows the aligned-process form. Section 67 of the Energy Act 2013 reflects this consolidation by defining the purposes of the ONR through parallel provisions for nuclear safety, security and safeguards [19]. Coordination between safety and security is achieved in part through aligned assessment principles: the Security Assessment Principles were drafted to be closely aligned with the Safety Assessment Principles, adopting concepts that are the same wherever possible and different where necessary [5].

A principal strength is that coordination is achieved at the level of assessment principles without requiring documentary unification, consistent with the principle 'the same wherever possible, different wherever necessary' that international guidance describes as useful [5]. However, organisational consolidation did not remove functional boundaries: the government's post-implementation review noted that, on occasion, internal functions dealing with different purposes within the ONR operated in silos, leading to internal and external inefficiency [20].

3.3. France

France illustrates the need for the two-criterion classification. The 2025 reform merged the nuclear safety authority with its technical support institute into the Autorité de sûreté nucléaire et de radioprotection (ASNR) [21, 22], producing integration under Criterion 2. Security, however, remains administered outside the nuclear safety regulator by the Senior Defence and Security Official of the ministry responsible for energy [21, 23], so the arrangement is separated under Criterion 1. A single-criterion classification would therefore group France with the United Kingdom despite their different arrangements for 3S coordination.

A principal strength is that technical assessment and regulatory decision-making are located within one organisation, removing an institutional boundary where technical judgement is converted into regulatory action. The principal limitations concern the evidence rather than the arrangement itself. The ASNR was established in 2025 and had accumulated no operating record by the cut-off date; moreover, only 13 of 24 French items were confirmed against source texts, and the institutional location of safeguards competence was not established. Findings for France are therefore reported with these reservations and are not used as the sole basis for any conclusion.

3.4. Japan

Japan is one of several states in the sample integrated under both criteria, although this integration resulted from a reform undertaken for another purpose. Before the NRA was established in 2012, regulation was divided among ministries according to the form of nuclear use, with energy use under METI and research and development under MEXT [24]. Following the Fukushima Daiichi accident, regulatory independence, organisational factors and deficiencies in safety culture were identified as contributing concerns [24]. The Nuclear Regulation Authority (NRA) was established as an external bureau of the Ministry of the Environment by separating promotion from regulation to eliminate the problems associated with combining both functions within one administrative organisation [24], closely paralleling the U.S. rationale of 1974. Because the reorganisation absorbed nuclear safety, non-proliferation and safeguards functions from several ministries and abolished the technical support organisation, integration occurred under both criteria.

Japan is also the only state in which a written internal 3S coordination procedure was identified within the regulatory body. Established in April 2023, the procedure covers review, inspection and the collection of interface cases. During review, the responsible division shares information on potential effects on the other two S's through an internal tool, with joint review conducted where necessary; a change to a physical protection programme following revision of an information-system security standard was reviewed on this basis. During inspection, physical protection inspectors are assigned to regional offices alongside operating inspectors and share observations relevant to the other functions. For case collection, interface cases are gathered and operators' 3S impact assessment reports are examined at quarterly meetings within the NRA Secretariat [6]. The interface is also included as a performance objective in the regulator's medium-term plan.

This arrangement provides the most fully specified interface mechanism in the sample, extending from review and inspection to the collection of interface cases and requiring operator impact assessment. Two limitations remain. The peer review found no legal basis for preventing adverse interactions between safety and security at radiation facilities and activities, despite the three functions being located within one body [25]; organisational integration therefore does not eliminate gaps in regulatory scope. The same mission also noted the need to expand capacity for oversight of safety and security as the Rokkasho reprocessing plant and the MOX fuel fabrication plant enter full-scale operation [25].

3.5. Canada

Canada differs from the other cases in that international control formed part of the regulatory mandate from the outset. The Atomic Energy Control Board was established in 1946 to control and supervise the development, application and use of atomic energy and to enable Canada to participate effectively in measures of international control [26]. The Nuclear

Safety and Control Act, which replaced that statute in 2000, retains this dual emphasis by combining the limitation of risks to national security, health, safety and the environment with implementation of Canada's international control commitments, including nuclear non-proliferation [27].

The Canadian arrangement is integrated under both criteria and follows the embedded form. Security and safeguards are included alongside safety within the fourteen safety and control areas, and the requirements themselves span all three functions [4, 5]. Coordination therefore occurs within the ordinary regulatory review structure.

The strength of the embedded form is that coordination is built into the review structure and does not depend on a separate procedure being convened or maintained. Its corresponding limitation for comparative analysis is that no dedicated 3S coordination instrument exists to assess directly; the adequacy of coordination must instead be inferred from the review structure itself.

3.6. Republic of Korea

The Korean arrangement likewise did not originate from a deliberate 3S design. Before 2011, safety regulation was administered by a bureau of the Ministry of Education, Science and Technology, while the Commission's predecessor was a non-standing advisory committee [28]. In July 2011, the Atomic Energy Act was divided into separate legislation for promotion, the Commission and nuclear safety, and the Commission was elevated to an administrative commission with strengthened responsibility for nuclear safety management [29]. This reform separated regulation from promotion. Physical protection and emergency preparedness, however, had already been governed by separate legislation, the Act on Physical Protection and Radiological Emergency, enacted in 2003 and in force from 2004 [30], which remained separate after the reform and was amended only to transfer competence to the Commission. The present dual-statute structure is therefore a consequence of the 2011 reorganisation rather than a deliberate 3S design. The Commission was described at its establishment as encompassing safety, security and non-proliferation [28]; separation under Criterion 1 thus arises primarily from the allocation of technical support functions between the specialist institutes.

The Korean arrangement is separated under both criteria and follows the consultative form. A consultative body for nuclear safety policy is established under the Prime Minister and chaired by the chairperson of the regulatory commission, while a separate council exists for physical protection [1]. Coordination is therefore located at the government level rather than within a single regulatory or technical support organisation. At the licensing stage, the preliminary safety analysis report and physical protection plan are submitted with the construction permit application [1], although no joint review procedure for the two was identified.

Three strengths are evident in the available record. First, the coordination mechanisms have a statutory basis and therefore do not depend solely on internal administrative practice. Second, the peer review examined the interface in a dedicated module, issued neither a recommendation nor a suggestion, and commended cooperation among the three organisations, particularly at the regional offices [1]. Third, an operator duty already exists in law: under Article 7(5) of the Enforcement Decree of the Act on Physical Protection and Radiological Emergency, the measures that the Commission may require of operators include assessment of the effects of the design, operation and modification of the physical protection system on facility safety and implementation of remedial measures [31].

Three limitations are also identified. First, the 3S functions are distributed across two Acts, with delegation to the two technical institutes based on separate provisions, so interface changes may require amendments to multiple legal instruments. Second, the existing operator duty is unidirectional, from physical protection to safety; no corresponding duty from safety to physical protection, or extending to safeguards, was identified. Third, codification of the operator's prime responsibility for safety in primary legislation, as recommended by the peer review [1], remains outstanding.

3.7. Comparison of the Arrangements

Table II compares the six national arrangements using the features defined in the analytical framework. The column headed Coordination locus indicates where the 3S interface is principally coordinated: through a licensee duty, within the regulatory body, through the licensing review structure, or in government-level consultative bodies above the regulatory commission. It does not indicate where responsibility for safety and security lies; INSAG-24 places the ultimate responsibility at the site for both with the operating organisation [10].

Table II. Comparison of national 3S regulatory arrangements by classification criteria, implementation form, coordination locus, statutory structure and origin

State	Criterion 1	Criterion 2	Form	Coordination locus	3S in single statute	Origin
United States	Integrated	Integrated	Operator duty	Operator	No	Promotion–regulation split, 1974
United Kingdom	Integrated	Integrated	Aligned process	Regulatory body	Yes	Regulatory efficiency, 2007–2014
France	Separated	Integrated	Not established	Not confirmed	No	Authority–TSO merger, 2025
Japan	Integrated	Integrated	Documented procedure	Regulatory body	Yes	Promotion–regulation split after 2011
Canada	Integrated	Integrated	Embedded	Review structure	Yes	Founding statute, 1946 and 2000
Republic of Korea	Separated	Separated	Consultative	Government level	No, two Acts	Residue of the 2011 Act division

Note: In the column headed 3S in single statute, the statutory basis is Section 67 of the Energy Act 2013 for the United Kingdom, which states the purposes of the ONR [19], and Section 3 of the Nuclear Safety and Control Act for Canada, which states the purpose of the Act [27]. In Japan the three functions are placed within a single statute, the Reactor Regulation Act, in separate chapters and articles, with only the objective clause referring to all three [24].

Table II shows that the locus of coordination does not follow directly from Criterion 1. Among states integrated under Criterion 1, the United States places the principal duty on the operator, while Japan locates coordination within the regulatory body; Korea, although separated under Criterion 1, locates coordination at the government level. Organisational integration also does not determine legal architecture: the United States is integrated without placing all three functions in a common statutory provision, whereas Canada, Japan and the United Kingdom do so in their governing instruments.

4. Discussion

4.1. Features that Vary Independently of Organisational Form

The comparison identifies three features through which the 3S interface is implemented in practice, each varying independently of organisational form.

First, the locus of coordination ranges from the operator and regulatory body to the review structure and government-level consultative mechanisms, without tracking either classification criterion. Second, the structure of governing instruments determines whether interface changes require action in one legal instrument or several. Third, the licensing review structure is likewise independent of organisational form: integration does not necessarily produce joint review, as the United States illustrates, while separation does not preclude simultaneous submission, as in Korea.

Compliance with international standards therefore does not depend on organisational form alone. The relevant provisions can be fulfilled under either integrated or separated arrangements, and neither structure satisfies them automatically. Nor can the organisational structure required of the operator be inferred to apply to the regulator: the norms impose more prescriptive integration requirements on the operator while permitting institutional separation at the regulatory level.

4.2. Evidence from Regulatory Reorganisation

The evidence on regulatory reorganisation is asymmetric. Anticipated benefits are generally documented before consolidation in normative or policy arguments, whereas costs and implementation difficulties are observed only after reorganisation.

Three observations are relevant. Hungary promulgated decrees at the end of 2015 establishing a regulatory system intended to harmonise safety and security oversight, the only case in the set whose stated objective explicitly addressed the interface; its account notes that implementation by a single regulatory body requires sufficient human and other resources, and staff increases of 76 and then 10 posts were authorised in 2015 in connection with newly delegated radiation protection and building oversight [5]. Sweden merged its nuclear safety inspectorate and radiation protection institute in 2008 under the concept of radiation safety, but its account notes that radiation protection, nuclear safety and nuclear security were in practice managed largely separately; the concept was formally defined in the first level of a new regulatory code in 2018 [5]. The U.K. post-implementation review likewise identified silo working after consolidation [20]. These cases provide no evidence that consolidation inherently reduces resource requirements; rather, coordination requirements remain and may shift within the consolidated organisation.

The Korean evidence is complementary rather than contradictory. The domestic policy assessment identified duplicated expenditure as an inefficiency of the separated arrangement and cited it as a reason to

consider merger [2]. The international cases describe transition and implementation costs associated with consolidation, whereas the Korean assessment concerns recurring duplication under separation. A merger may therefore exchange one type of cost for another, but their relative magnitude cannot be determined from the available evidence.

4.3. Implications for the Korean Framework

Improving the 3S interface and reducing duplicated work are distinct policy objectives. A merger justified by duplication is therefore an administrative-efficiency measure and does not, by itself, establish an improvement in 3S coordination. Conversely, the favourable peer-review assessment of the existing interface does not resolve questions of administrative efficiency. The two assessments cited in Section 1 are thus not necessarily inconsistent because they address different objectives. This distinction is also consistent with the Sandia National Laboratories framework of 2007, which addresses integration through the design and operation of facilities using combined safety, security and safeguards analysis, without reference to the organisation of the regulator [32].

Of the eight linkage layers identified in Section 2.2, three can be applied to the Korean system without organisational change: cross-referencing between legal instruments, operator duties and licensing review structure. The most direct measure builds on an existing legal requirement. Extending the current operator duty from its unidirectional safety effect assessment to interactions among all three S's would broaden an existing instrument rather than create a new one and, to the extent that it remains within the delegation in Article 4(3) of the Act, could be implemented through amendment of the Presidential Decree [30, 31]. Relative to the Japanese 3S impact assessment, the principal differences concern directionality, the stage of the licensing process at which the assessment applies and the absence of a specified review procedure.

The corresponding implementation burden on the operator may be limited because safety and security functions already interact at the site level. Within the Korean operator, reassessment of vital areas—areas containing equipment whose sabotage could cause a radiological hazard [31]—is performed by a safety analysis organisation [33]. Vital-area identification traces core-damage pathways arising from sabotage using safety-analysis logic and therefore requires safety competence. This practice represents a substantive coupling of safety and security expertise within the domestic industry, in contrast to the regulatory support structure in which the two competences reside in different institutes. These measures are consistent with the direction already adopted by the government [3].

One measure has priority irrespective of organisational reform. Codification of the operator's prime responsibility for safety in primary legislation was recommended by the peer review [1] and is independent of the institutional arrangement among NSSC, KINS and KINAC.

5. Conclusions

A simple integrated/separated dichotomy is insufficient to classify 3S regulatory systems. The two criteria distinguish, for example, France from the United Kingdom, which would otherwise appear in the same category despite different allocations of 3S functions. Criterion 1 also encompasses multiple implementation forms, and integration can vary by regulatory layer. Organisational integration should therefore be assessed only with explicit reference to the criterion, implementation form and linkage layer concerned.

Application of the framework to six states yields three principal findings. First, international norms require interface management, describe coordination arrangements as necessary and treat organisational integration as an option recorded as good practice rather than a universal requirement; coordination remains necessary even within a single body. Second, except for Hungary, the observed reorganisations were undertaken for purposes other than management of the 3S interface. Third, the practical features that govern the interface—the locus of coordination, the structure of governing instruments and the licensing review process—vary independently of organisational form. For Korea, the measures with the clearest normative and comparative basis can therefore be pursued without prior organisational restructuring, with codification of the operator's prime responsibility for safety as the first priority.

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