



Mapping Standards for Integrated Development

**NDIA Systems Engineering Division
AIA Engineering Management Council**

**NDIA CMMI[®] Working Group
Standards Mapping Team**

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Table of Contents

1.0 INTRODUCTION 4

 1.1 Concept 4

 1.2 Scope 5

 1.3 Mapping Confidence 6

 1.4 About This Version 7

2.0 REFERENCES 8

APPENDIX A – STANDARDS MAPPINGS 9

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1.0 INTRODUCTION

Most companies align their business processes with industry standards and best practices – whether motivated internally to improve their operational effectiveness, or externally by customers levying these standards on acquisition contracts. Often multiple such standards are levied, with varying degrees of overlap of the practices or products required. This can result in some redundancy in effort, cost, and resources by organizations to implement, manage, and show compliance of their respective implementations of these standards – even if those practices are fully integrated into their business processes. Frequently separate independent audit or appraisal events are needed to obtain required ratings or to determine conformance.

Some companies manage their adherence to multiple standards through common integrated processes, infrastructure, and assets – for them, it is primarily a mapping, data collection, and compliance exercise to demonstrate conformance against each standard. Other companies may have separate functions or groups focused on these standards individually, such as an ISO 9001 Quality Management group and a CMMI process improvement group – for them, there is a greater risk of inefficiency, redundancy, and rework, with hidden costs that are often difficult to recognize. In either case, and at varying degrees, there is additional cost associated with managing conformance to multiple standards that must be absorbed, such as:

- Diverting resources that could be otherwise prioritized with greater business value.
- Direct charges to customers where these standards are levied.
- Indirect costs that are passed along to all customers in overhead rates.

In a defense market of declining budgets and fewer new programs, these are potentially lost opportunities for us all to “do more with less.” The prevalence of audits and standards on defense programs is often cited as a primary target for streamlining in acquisition reform, including recent suggestions to Congress from both [NDIA](#) and [AIA](#) to improve the affordability of defense programs.

NDIA and AIA believe that, as an industry, we can do better. A vision for more efficiently managing the current situation where multiple standards are levied might include ideas such as the following:

- Encourage integrated and coordinated company initiatives aligned with multiple standards, as opposed to separate functions or groups managing implementations and conformance to standards independently.
- Encourage acquirers to converge on a common, reduced set of standards (or subsets of the standards themselves) that support effective program performance and adequately address the potential risks to acquisition. As new improved standards are added, consider if others should be removed.
- Consider integrated frameworks, auditing approaches, or appraisal methods that support multiple standards concurrently.
- Develop mappings between standards to help organizations understand the relationships between them, and to consider common processes or data collection strategies to manage conformance against multiple standards.

It is the latter point toward which this document is initially focused.

1.1 Concept

The intent of this document is to provide organizations with initial consensus mappings between commonly used standards and process models to help organizations cost-effectively manage their conformance and demonstrate compliance against multiple standards in an integrated approach. Organizations can extend these standards mappings as needed to include their own organizational or project processes, and to define the work products and outcomes that are expected through their implementation of those processes. Examples of this might include:

- Integrated processes with activities and work products that satisfy the corresponding requirements of multiple standards concurrently.
- Consolidated data collection strategies that can be used to support multiple internal or external appraisal/audit events, thereby reducing the effort needed to prepare for these events separately.

By publishing these mappings, developed by consensus of subject matter experts, NDIA hopes to reduce the effort needed by organizations to develop mappings internally or to transition to new standards when they are levied. Organizations can simply leverage this work and focus on their own implementations of these standards, as depicted in Figure 1.

These initial NDIA mappings can also establish a foundation for future work, such as development of meta-model frameworks or integrated appraisal/auditing methods that can lead to further efficiencies by organizations working in a multi-model environment.

Conformance or compliance to standards can be determined objectively through external audits, appraisals, or verification of work products that demonstrate adherence to practices of the standards. Mappings between standards can greatly help reduce the effort needed by leveraging common work products. A concept of operations reflecting how these mappings might be used in practice to implement new standards and prepare for external verification events is also depicted in Figure 1.

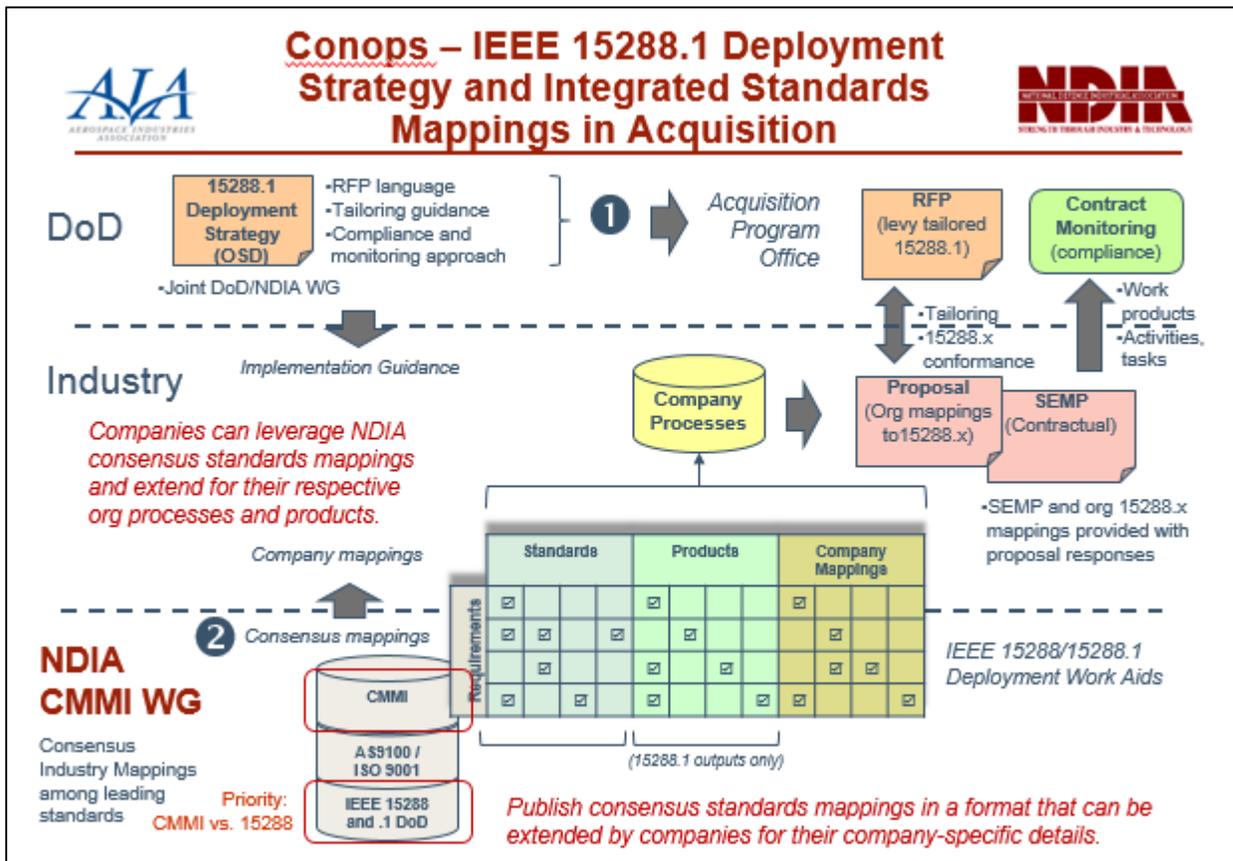


Figure 1 - Standards Mapping Concept of Operations

1.2 Scope

The standards (or models) selected for these initial mappings were determined by organizations represented on the NDIA CMMI Working Group as those most likely to be levied on customer acquisition contracts: [see section 2.0 References]

- CMMI for Development (CMMI-DEV), version 1.3 [9]

- AS9100, revision C [7]
- IEEE 15288-2015 [4], and derivative standards IEEE 15288.1-2014 [5] and IEEE 15288.2-2014 [6] developed for use on U.S. Department of Defense (DoD) programs and other defense agencies.

Of these, CMMI-DEV and IEEE 15288:2015 were prioritized in order to help prepare the defense industry for the release of the IEEE standards, which were expected to be levied by DoD on defense acquisitions. The NDIA member organizations selected CMMI-DEV v1.3 as the basis for the mappings, since it was believed that CMMI was most commonly used by companies as a basis for mappings to organizational standard processes.

Mappings between AS9100 and CMMI, or other standards, will be developed in subsequent releases of this document. In general, the body of this document is intended to address the overall mapping approach and guidance applicable across all standards. Guidance or comments specific to a single standard are provided in the respective appendix.

Note that the mappings do not assume adopting organizations currently hold any particular certification, capability levels, maturity level, or other rating. Each standard can be implemented on its own, without dependence on other standards. However, those organizations with such certifications or ratings based on robust, disciplined implementations of a given standard may find it an easier transition to other standards, due to the extent of alignment between the associated practices.

1.3 Mapping Confidence

The mappings contained in this document were developed, reviewed, and validated by consensus of an NDIA team of subject matter experts.

Ideally standards would be related by a 1-to-1 mapping between associated practices. However, there are often instances where 1-to-many or many-to-many mappings between standards exist, i.e., multiple statements in the mapped (destination) document are needed in order to claim coverage of a statement in the source document. Conversely, a single statement in the destination document may correspond to multiple statements in the source document.

Qualitative confidence factors (derived from [1]) have been assigned to characterize the strength of coverage and alignment between the mapped standards, as described in Table 1.

Table 1 - Mapping Confidence Factors

Mapping Confidence	Comment
No map	Statement in the source document is not significantly addressed in the mapped (destination) document. In aggregate, the intent is not met.
Weak	The statement in the source document does not clearly correspond to statement(s) in the mapped (destination) document, but may be interpreted and implemented to have some relevance. The intent is considered partially met.
Medium	The match between the statement in the source document and the mapped (destination) document is incomplete, but with some interpretation may satisfy the intent. The intent is considered significantly but not fully met.
Strong	There is a strong relationship and alignment between the statement in the source document and the statement(s) in the mapped (destination) document. The intent is considered fully met.

Confidence factors are assigned conservatively for each pair of mapped practice statements. This is in order to facilitate bi-directional traceability and reporting of the potential reverse relationships between the statements, and avoid potentially over-inflating the effect of a single statement. Where multiple practices are mapped (1-to-many) an aggregate confidence factor is also assigned to characterize the extent to how they, in aggregate, address the content of the mapped standard. The aggregate mapping was determined by team consensus and judgment based on the mapping values and gaps of its components. Typically the aggregate mapping is consistent with the strongest mapping of its component practices (i.e., Strong > Strong, Medium > Medium), but in some situations “the whole may exceed the sum of its parts” and a stronger overall relationship is warranted in aggregate. For any aggregate mapping confidence level less than Strong (fully met), a comment is provided identifying the gap between standards.

The resulting mappings are neither an exhaustive list of possible associated practices, nor a minimal mapping, but the set considered most strongly aligned and likely to be of value to organizations looking to leverage their existing mappings to organizational processes.

As with any mapping activity, there is considerable judgment involved and the extent of coverage between these standards is subjective. These mappings reflect the consensus judgments of this team of experts, but other alternative solutions and opinions may exist. Ultimately, it is the responsibility of organizations using these mappings to assure their respective confidence and enhance the mappings to the extent needed.

Note that the mappings contained in this document were developed uni-directionally, from the perspective of essential coverage of one standard by the other with no objective for bi-directional completeness. That is, while reverse mappings could be of some use to adopters, they are opportunistic and provided “as is”, but they have not been reviewed and likely have large gaps, inconsistencies, or extraneous linkages when reviewed in the reverse direction.

Further, neither NDIA nor AIA claims that these mappings will assure compliance or successful external appraisals/audits against the respective standards – that judgment is the responsibility of the implementing organizations. It is the goal of this document that these mappings can help organizations more efficiently and effectively integrate their respective processes and infrastructure to better prepare, comply, respond, and leverage their implementations of these standards in an integrated way.

1.4 About This Version

This document version (v0.7) contains initial mappings between IEEE 15288-2015 [4] and CMMI for Development, v1.3 [9], targeted to align as closely as possible with the recent publication (May 2015) of the IEEE 15288 set of systems engineering standards [4, 5, 6]. The intent is to provide a work aid to assist organizations with mapping and implementing their organizational processes for conformance with these IEEE standards in order to prepare for their use by the U.S. Department of Defense on acquisition contracts.

As such, the schedule for completion of these initial mappings was a priority. The mappings should be considered a beta product. All mappings for each IEEE 15288 process were peer reviewed by teams of experts, with a high level horizontal review of the integrated mapping set to achieve a level of integration and consistency across author teams. Yet, further improvements to the mappings and consistency are surely possible. For this reason, this mapping document is being published “as is” in a v0.7 release, with further improvements deferred to a subsequent v1.0 release.

Further note that all mappings involve subjectivity, and organizations may find other mappings between these standards relevant to their IEEE 15288 transition initiatives.

Other future revisions of this document are also planned to include other standards, such as AS9100 [7].

The NDIA/AIA standards mapping team welcomes those that would like to contribute toward further improvement of this document.

2.0 REFERENCES

The following references, resources, and assets were used by the NDIA/AIA standards mapping team in the development of this document. NDIA and AIA gratefully appreciate the contributions of the providers as described in Acknowledgments.

1. *Mapping ISO Standards to CMMI-DEV v1.2*, Mutafelija and Stromberg. *Process Improvement with CMMI v1.2 and ISO Standards*, Mutafelija and Stromberg. CRC Press, 2008.
2. *Model Wizard™*, Integrated System Diagnostics, Inc. <http://isd-inc.com/tools.modelWizard/>
3. *Integrated System Framework™*, Integrated System Diagnostics, Inc. <http://isd-inc.com/tools.isf/>
4. *ISO/IEC/IEEE 15288-2015, Systems and software engineering – System life cycle processes*, http://www.techstreet.com/ieee/products/vendor_id/5673
5. *IEEE 15288.1-2014, Standard for Application of Systems Engineering on Defense Programs*, May 2015. <http://www.techstreet.com/ieee/products/1895162>
6. *IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs*, May 2015. <http://www.techstreet.com/ieee/products/1895163>
7. *AS9100, Quality Management Systems – Requirements for Aviation, Space and Defense Organizations, Revision C*, 2009. <http://standards.sae.org/as9100c/>
8. *ISO 9001:2008, Quality Management Systems*. http://www.iso.org/iso/iso_9000/
9. CMMI Product Team, *CMMI® for Development, Version 1.3 (CMU/SEI-2010-TR-033)*. Software Engineering Institute, Carnegie Mellon University, 2010. <http://cmmiinstitute.com/resources/cmmi-development-version-13>

APPENDIX A – STANDARDS MAPPINGS

This appendix summarizes the consensus mappings of the NDIA mapping team between the standards listed in section 1.2 Scope. These standards were prioritized by a survey of participating companies on the NDIA CMMI Working Group as having greatest significance to their respective businesses and most likely to be levied by customers.

Refer to section 1.0 of this document for further information on the mapping processes and attributes.

Due to copyright constraints, contents of the standards themselves cannot be included in these mappings. Mappings are specified at a unique identifier level (e.g., paragraph, section, clause, activity, or task), with keywords provided to aid in interpreting the intended content implied by the mapping. Users of these mappings must have copies of each standard available for the details needed to take action upon the mappings for their respective organizational processes. Copies of the standards can be obtained from the respective copyright holder.

Mappings between standards are published in Microsoft Excel format. This document contains excerpts of the mappings only, to provide illustrative examples and informative guidance for users. The full mappings are published in source format on the NDIA CMMI Working Group web page (http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/CMMI_Working_Group.aspx) for download and use by implementing organizations, such as to add mappings between these standards and organizational standards or project processes.

The NDIA mapping team plans to also implement and maintain these mappings in a relational database in the Model Wizard™ tool [2]; this database will also be published on the NDIA web page above as an aid to organizations using that tool for their business processes. This does not imply an NDIA recommendation or endorsement of this tool, as other tool solutions may also exist.

Mappings are provided in the following general format:

Source Section	Source Keywords	Destination Section	Confidence (Practices)	Aggregate Confidence	Gap Comment
Unique identifier for the single practice being mapped from the source standard	Abstraction of the practice from the source standard (description)	Unique identifier(s) for the practice(s) being mapped in the destination standard	Mapping confidence levels at the practice-to-practice level (1..n) <ul style="list-style-type: none"> • No map • Weak • Medium • Strong 	Mapping confidence for the full set of practices in aggregate for the destination standard <ul style="list-style-type: none"> • No map • Weak • Medium • Strong 	For any aggregate mapping confidence level less than Strong (fully met), a description of the gap between mapped standards. i.e., what aspect of the source practice is not covered by the destination practice(s)?

Excerpts of the actual mappings are provided in the sections following.

Appendix A.1 – Mappings between CMMI-DEV v1.3 and IEEE 15288.1

An example of the mappings between CMMI-DEV v1.3 and IEEE 15288.1 is provided below for illustration purposes. This is an excerpt of the full mappings which are available as specified in Appendix A. Note also that the mappings provided are for only the CMMI for Development (CMMI-DEV) constellation. Other CMMI constellations, such as CMMI for Services (CMMI-SVC v1.3, <http://cmminstitute.com/resources/cmmi-services-version-13>) may provide additional mappings that could help address some of the gaps identified.

Additionally, the following guidelines were used for developing the CMMI mappings:

- No assumptions of CMMI maturity levels required should be inferred from these mappings; it is possible to comply with the IEEE 15288 standard without having achieved any maturity level.
- CMMI high maturity process areas (those staged at maturity levels 4-5) were not targeted for these mappings. Nothing in the IEEE 15288 standard requires high maturity practices or ratings. They have been included in these mappings only on an exception basis where particularly relevant to the context of a given IEEE 15288 activity or task (e.g., causal analysis of defects), but no implication of CMMI maturity levels or high maturity behavior should be inferred. Some of the CMMI high maturity practices, if implemented by adopting organizations, could also help complement additional coverage of the IEEE 15288 standard or the effectiveness of its implementation.
- CMMI generic practices (or their instantiations for a given process area) are included in the mappings only where directly relevant to the context for a IEEE 15288 practice. For instance, planning (GP2.2), providing resources (GP2.3), or controlling work products (GP2.6) for a given IEEE 15288 process. Furthermore, there are interactions between CMMI generic practices and their enabling process areas or specific practices that were applied only in certain instances where strongly relevant. No attempt was made to establish coverage of all CMMI generic practices, nor are they all considered necessary (at any level of CMMI process capability/maturity) to claim conformance to the IEEE 15288 standard. Similar to high maturity practices, organizations may find that implementation of the full set of CMMI generic practices is useful in improving the effectiveness of their planned and implemented processes, but they are not strictly required across all processes for IEEE 15288 conformance.

Mapping Standards for Integrated Development

Figure A.1-1. Example Mapping Between IEEE 15288.1-2014 and CMMI-DEV

IEEE 15288 Section	IEEE 15288 Keyword	CMMI-DEV Practices	Mapping Confidence (Practices)	Aggregate Confidence	Gap Comment (for aggregate < Strong)
6.3.7	Measurement Process				
6.3.7.3	Activities and Tasks				
6.3.7.3a	Prepare for Measurement				
6.3.7.3a 1	Define strategy	MA SP 1.1 MA GP 2.2	Strong Strong	Strong	
6.3.7.3a 2	Describe relevant characteristics	MA SP 1.1 IPM SP 1.2	Strong Medium	Strong	
6.3.7.3a 3	Identify information needs	MA SP 1.1	Strong	Strong	
6.3.7.3a 4	Select measures	MA SP 1.2	Strong	Strong	
6.3.7.3a 5	Define procedures	MA SP 1.3 MA SP1.4	Strong Strong	Strong	
6.3.7.3a 6	Define evaluation criteria	MA SP 1.4	Strong	Strong	
6.3.7.3a 7	Plan for systems or services	MA GP 2.2 MA GP 2.3 MA SP 1.3	Medium Medium Strong	Strong	
6.3.7.3b	Perform measurement				
6.3.7.3b 1	Integrate procedures	MA.SP1.3 MA.SP1.4 IPM.SP1.4 OPD.SP1.4	Medium Weak Strong Weak	Strong	
6.3.7.3b 2	Collect data	MA SP 2.1 MA SP 2.3	Strong Strong	Strong	
...					
6.4.14	Disposal Process				Disposal is not significantly addressed in CMMI-DEV
6.4.14.3	Activities and Tasks				
6.4.14.3a 1	Define disposal strategy	PP SP 1.3 RD SP 3.1 TS SP 2.2	Weak Weak Weak	Weak	Disposal is not significantly addressed in CMMI-DEV
6.4.14.3a 2	Identify constraints	RD SP 2.1	Weak	Weak	Disposal is not significantly addressed in CMMI-DEV
...					