Title: **Broad Guidance on Standardization, Development, Consensus-Building, Adoption, Use, Maintenance, and Referencing for the Field of Artificial Intelligence Standards**

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Author: Frank Farance, Farance Inc., frank@farance.com

Our organization has been involved in national and international standardization in information and communication technologies for four decades, including areas such as: programming languages and operating systems; data interoperability and metadata; document management and interchange; learning, education, and training technologies; disability, access, and functional needs; information security; big data; sensor networks; cloud computing; massively parallel computation and storage; internet of things; artificial intelligence and knowledge management; terminology.

This paper outlines several recommendations - some of them very broad, some very specific. The field of AI promises great benefits to societies and individuals: who wouldn't like a "dollop" of AI added to my automobile to help me drive safer? However, there are significant consequences of adding automation (do automated systems perform well in all conditions?) and how well and consistently do they work with the human managers, operators, and users of such systems? For example, recent news articles concern failure modes of automated flight control systems than have had tragic results. Surely, these kinds of technologies could be described as some kind of "Artificial Intelligence" that is assisting the pilots. However, as we humans hand over more control to such automated systems, we need to understand the risks and consequences — questions that probably need to be answered for society as a whole, not merely the purchaser or user of such systems.

In other words, what makes Artificial Intelligence so exciting (from the perspective of standardization) is not the new ways in which society will be improved, but the ways in which decision-making is handed off to automated systems that (we hope) will perform with the consideration, robustness, and resiliency that we expect of humans — that will be our standardization challenge.

Our organization has had the good fortune of being at the forefront of many waves of "new" technologies and standardization; AND we've continued to see their outcome 5, 10, and 20 years later. Generally, there is much enthusiasm at the early stages, which wanes, and leaves a standardization work product based upon the consensus and enthusiasm a half decade or so later. We cannot predict where we will be a decade from now, but our first recommendation comes from 20-20 hindsight in multiple industries, and is our most important recommendation.

Recommendation #1: Recognize that success or failure will be determined 5-8 years later.

There is much enthusiasm with new waves of technology and the excitement of standardization. The techniques of the consensus-building effort, the standardization, the industry's embrace (or not) of the standards, and the quality of standards (measured in defect reports and consistency

of formal interpretation of the standards) will not be known until 5-8 years later: the time to write and approve standards (typically, 3-5 years), for the industry to adopt the standards (typically, 18-36 months), and for a standards maintenance cycle to complete (yet another 2-3 years).

Here are success and failure tips:

- Standards developed as a large monolithic document are at much higher risk because the industry and technology are changing during the development of the standard. **Recommendation:** break standardization into pieces.
- New technologies can be hard to standardize as all their consequences aren't yet fully known. **Recommendation:** use a minimalist or conservative approach; avoid tendencies to maximize technical scoping.
- Data collected today will have to be interpreted tomorrow. Fundamentally, creating data is a task of classification among strata of possible values. **Recommendation:** standardizing subjective data (e.g., Low, Medium, High) also requires standardizing classification methods and techniques, e.g., library cataloging data is of no use unless librarians catalog books consistently.
- Architectures that look good today, change tomorrow. **Recommendation:** avoid architecture standardization unless it reflects consistency across waves of new technologies.
- The writers of standards today, will not be the same readers and interpreters tomorrow. **Recommendation:** use thought experiments to test every provision in a standard - what is the most hostile interpretation of the standard? How can the reader of the standard known what I mean if I am not there to assist him/her?

Recommendation #2: Use Fundamental Concepts of Normative Documents

The following concepts[1] describe the inherent nature of standards documents:

> **standardization:** activity of establishing, with regard to actual or potential problems, provisions for common and repeated use, aimed at the achievement of the optimum degree of order in a given context
> NOTES
> 1 In particular, the activity consists of the processes of formulating, issuing and implementing standards.
> 2 Important benefits of standardization are improvement of the suitability of products, processes and services for their intended purposes, prevention of barriers to trade and facilitation of technological cooperation.
>
> **consensus:** general agreement, characterized by the absence of sustained opposition to substantial issues by any important part of the concerned interests and by a process that involves seeking to take into account the views of all parties concerned and to reconcile any conflicting arguments
> NOTE — Consensus need not imply unanimity.

[1] From ISO/IEC Guide 2:1996, Standardization and Related Activities — General Vocabulary.

state of the art: developed stage of technical capability at a given time as regards products, processes and services, based on the relevant consolidated findings of science, technology and experience

acknowledged rule of technology: technical provision acknowledged by a majority of representative experts as reflecting the state of the art
NOTE — A normative document on a technical subject, if prepared with the cooperation of concerned interests by consultation and consensus procedures, is presumed to constitute an acknowledged rule of technology at the time of its approval.

The following describe some of the aims of standardization: "The general aims of standardization follow from [its definition]. Standardization may have one or more specific aims, to make a product, process or service fit for its purpose. Such aims can be, but are not restricted to, variety control, usability, compatibility, interchange ability, health, safety, protection of the environment, product protection, mutual understanding, economic performance, trade. They can be overlapping."

fitness for purpose: ability of a product, process or service to serve a defined purpose under specific conditions

compatibility: suitability of products, processes or services for use together under specific conditions to fulfil relevant requirements without causing unacceptable interactions

interchangeability: ability of one product, process or service to be used in place of another to fulfil the same requirements
NOTE — The functional aspect of interchangeability is called "functional interchangeability", and the dimensional aspect "dimensional interchangeability".

variety control: selection of the optimum number of sizes or types of products, processes or services to meet prevailing needs
NOTE — Variety control is usually concerned with variety reduction.

safety: freedom from unacceptable risk of harm
NOTE — In standardization, the safety of products, processes and services is generally considered with a view to achieving the optimum balance of a number of factors, including non-technical factors such as human behavior, that will eliminate avoidable risks of harm to persons and goods to an acceptable degree.

protection of the environment: preservation of the environment from unacceptable damage from the effects and operations of products, processes and services

product protection: protection of a product against climatic or other adverse conditions during its use, transport or storage

Fundamentally, normative documents can be decomposed into provisions; and provisions are of four varieties: information, instruction, recommendation, requirement. The following describes the main elements of the content of normative documents:

> **provision:** expression in the content of a normative document, that takes the form of a statement, an instruction, a recommendation or a requirement
> NOTE — These types of provision are distinguished by the form of wording they employ; e.g. instructions are expressed in the imperative mood, recommendations by the use of the auxiliary "should" and requirements by the use of the auxiliary "shall".
>
> **statement:** provision that conveys information
>
> **instruction:** provision that conveys an action to be performed
>
> **recommendation:** provision that conveys advice or guidance
>
> **requirement:** provision that conveys criteria to be fulfilled
>
> **exclusive requirement, mandatory requirement:** requirement of a normative document that must necessarily be fulfilled in order to comply with that document
>
> **optional requirement:** requirement of a normative document that must be fulfilled in order to comply with a particular option permitted by that document
> NOTE — An optional requirement may be either
> a) one of two or more alternative requirements; or
> b) an additional requirement that must be fulfilled only if applicable and that may otherwise be disregarded.
>
> **deemed-to-satisfy provision:** provision that indicates one or more means of compliance with a requirement of a normative document
>
> **descriptive provision:** provision for fitness for purpose that concerns the characteristics of a product, process or service
> NOTE — A descriptive provision usually conveys design, constructional details, etc. with dimensions and material composition.
>
> **performance provision:** provision for fitness for purpose that concerns the behavior of a product, process or service in or related to use

Recommendation #3: Recognize Different Geopolitical Scopes of Standardization

The level of standardization is, largely, its geopolitical scope:

> **level of standardization:** geographical, political or economic extent of involvement in standardization

international standardization: standardization in which involvement is open to relevant bodies from all countries

international standard: standard that is adopted by an international standardizing/standards organization and made available to the public

regional standardization: standardization in which involvement is open to relevant bodies from countries from only one geographical, political or economic area of the world

regional standard: standard that is adopted by a regional standardizing/standards organization and made available to the public

national standardization: standardization that takes place at the level of one specific country
NOTE — Within a country or a territorial division of a country, standardization may also take place on a branch or sectoral basis (e.g. ministries), at local levels, at association and company levels in industry and in individual factories, workshops and offices.

national standard: standard that is adopted by a national standards body and made available to the public

provincial standardization: standardization that takes place at the level of a territorial division of a country
NOTE — Within a country or a territorial division of a country, standardization may also take place on a branch or sectoral basis (e.g. ministries), at local levels, at association and company levels in industry and in individual factories, workshops and offices. In the United States, provincial standardization is at the state level.

provincial standard: standard that is adopted at the level of a territorial division of a country and made available to the public

Other standards (specifications) may also be adopted on other bases, e.g. branch standards and company standards. Such standards may have a geographical impact covering several countries.

Recommendation #4: Recognize Different Levels of Standards Documents

The following describe different levels and types of standards development:

normative document: document that provides rules, guidelines or characteristics for activities or their results
NOTES
1 The term "normative document" is a generic term that covers such documents as standards, technical specifications, codes of practice and regulations.
2 A "document" is to be understood as any medium with information recorded on or in it.
3 The terms for different kinds of normative documents are defined considering the document and its content as a single entity.

standard: document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context
NOTE — Standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits.

prestandard: document that is adopted provisionally by a stan¬dardizing body and made available to the public in order that the necessary experience may be gained from its application on which to base a standard

technical specification: document that prescribes technical requirements to be fulfilled by a product, process or service
NOTES
1 A technical specification should indicate, whenever appropriate, the procedure(s) by means of which it may be determined whether the requirements given are fulfilled.
2 A technical specification may be a standard, a part of a standard or independent of a standard.

code of practice: document that recommends practices or procedures for the design, manufacture, installation, maintenance or utilization of equipment, structures or products
NOTE — A code of practice may be a standard, a part of a standard or independent of a standard.

regulation: document providing binding legislative rules, that is adopted by an authority

technical regulation: regulation that provides technical requirements, either directly or by referring to or incorporating the content of a standard, technical specification or code of practice
NOTE — A technical regulation may be supplemented by technical guidance that outlines some means of compliance with the requirements of the regulation, i.e. deemed-to-satisfy provision.

Recommendation #5: Recognize Different Types of Standards

The following types of standards are common types. Actual standards might involve a combination of types.

basic standard: standard that has a wide-ranging coverage or contains general provisions for one particular field
NOTE — A basic standard may function as a standard for direct application or as a basis for other standards.

terminology standard: standard that is concerned with terms, usually accompanied by their definitions, and sometimes by explanatory notes, illustrations, examples, etc.

testing standard: standard that is concerned with test methods, sometimes supplemented with other provisions related to testing, such as sampling, use of statistical methods, sequence of tests

product standard: standard that specifies requirements to be fulfilled by a product or a group of products, to establish its fitness for purpose
NOTES
1 A product standard may include in addition to the fitness for purpose requirements, directly or by reference, aspects such as terminology, sampling, testing, packaging and labelling and, sometimes, processing requirements.
2 A product standard can be either complete or not, according to whether it specifies all or only a part of the necessary requirements. In this respect, one may differentiate between standards such as dimensional, material, and technical delivery standards.

process standard: standard that specifies requirements to be fulfilled by a process, to establish its fitness for purpose

service standard: standard that specifies requirements to be fulfilled by a service, to establish its fitness for purpose
NOTE — Service standards may be prepared in fields such as laundering, hotel-keeping, transport, car-servicing, telecommunications, insurance, banking, trading.

interface standard: standard that specifies requirements concerned with the compatibility of products or systems at their points of interconnection

standard on data to be provided: standard that contains a list of characteristics for which values or other data are to be stated for specifying the product, process or service
NOTE — Some standards, typically, provide for data to be stated by suppliers, others by purchasers.

Recommendation #6: Harmonize Standards

Some standards might by similar, but not identical. In general, the elimination of gratuitous incompatibilities is an important goal in standardization. The following concepts are essential for understanding same-ness among standards:

harmonized standards, equivalent standards: standards on the same subject approved by different standardizing bodies, that establish interchangeability of products, processes and services, or mutual understanding of test results or information provided according to these standards
NOTE — Within this definition, harmonized standards might have differences in presentation and even in substance, e.g. in explanatory notes, guidance on how to fulfil the requirements of the standard, preferences for alternatives and varieties.

unified standards: harmonized standards that are identical in substance but not in presentation

identical standards: harmonized standards that are identical in both substance and presentation
NOTES
1 Identification of the standards may be different.
2 If in different languages, the standards are accurate translations.

Recommendation #7: Use Fundamental Concepts of Conformity

The following concepts describe conformity in general:

conformity: fulfilment by a product, process or service of specified requirements

conformity assessment: any activity concerned with determining directly or indirectly that relevant requirements are fulfilled
NOTES
1 Typical examples of conformity assessment activities are sampling, testing and Inspection; evaluation, verification and assurance of conformity (supplier's declaration, certification); registration, accreditation and approval as well as their combinations. Different standards use different conformance paradigms, for example: data coding standard has the conformance paradigm of a data instance (conforming data), a data reader (a system that reads the data in a conforming way), a data writer (a system that writes the data in a conforming way), and a data repository (a system that stores and retrieves the data in a conforming way).

Standards might permit different levels of conformance, such as "strictly conforming" that is maximally interoperable and without extensions; and "(merely) confirming" that conforms but permits extensions.

Recommendation #8: Use Both Standards and Specifications

In the United States, standards are developed by accredited standards development organizations (ANSI does accreditation). ANSI accreditation mandates: openness (anyone can become a member), fairness (all members are treated similarly), due process (standards are developed consistently according to procedure), and balance (a spectrum of membership, including producers, consumers, government, industry, big organizations, small organizations, etc.). Specifications are developed by other organizations, such as consortia and fora. Essentially, a standard is a specification developed by an accredited organization.

Recommendation #9: As Government Entities, Adopt Priorities of Standards Usage

The following should be the priorities of government entities and agencies in their adoption and incorporation of standards to maximum interoperability:

- International Standards, e.g., ISO, IEC, ITU
- National Standards, e.g., INCITS, ASTM
- Consortia, e.g., W3C, OMG
- Membership, e.g., IEEE, IETF

- Federal Standards
- Agency Standards, e.g., MILSTD

In other words, if there is an equivalent international standard, it should be used with priority over a Federal standard.

Recommendation #10: Use Common Architecture Methodologies and Work Products

The following should be core guidance documents for developing architectural and engineering documents and artifacts:

- **ISO/IEC 42010, Systems and software engineering — Architecture description is an international standard for architecture descriptions of systems and software.** This document describes an "architecture", a "viewpoint", and other key concepts for developing architecture documents.

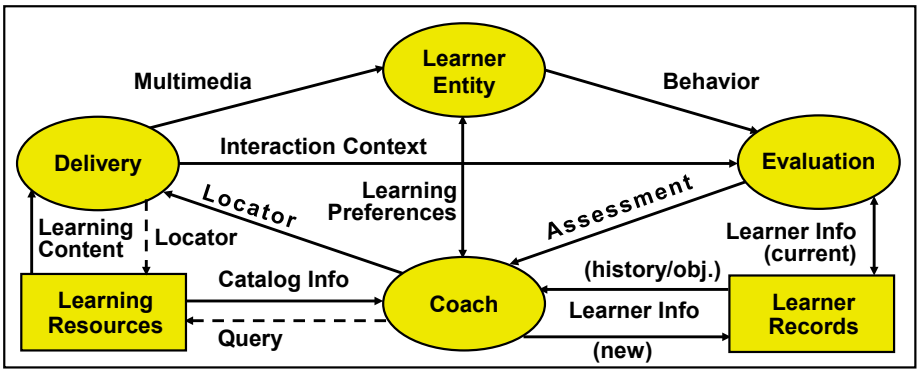
- **DODAF: Department of Defense Architecture Framework.** Use DODAF as guidance for developing viewpoint documents. Important: Not all DODAF work products should be developed, only spend effort on core features, which should be less than a half-dozen document types.

- **FEA: Federal Enterprise Architecture.** Use FEA as an analytical tool for IT systems, use the tool to assist in completeness of enterprise solutions.

- **Gartner Patterns and Bricks Methodology:** Bricks describe components of business architectures (business process), information architectures (shared data), and technology architectures (actual system implementation). Patterns are an abstraction of those bricks (business, information, technology). Patterns and brick provide a useful tool for technology roadmaps with horizons at: present to 1 year; 2-3 years; 5 years. Note: the business-information-technology axes are not the same as FEA, and both approaches can be used simultaneously.

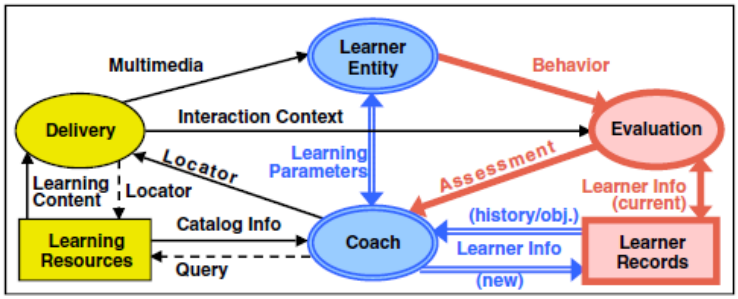
Recommendation #11: Identify Stakeholders and Use-Cases

The identification of stakeholders (as per ISO/IEC 42010) and use-cases (e.g., UML) can help with the consolidation of technical themes, such as common architectures and design patterns. For example, IEEE 1484.1 Learning Technology Systems Architecture (LTSA), used a common diagram to explore interoperability and to understand stakeholder perspectives. The following diagram was used:



Then, this diagram was reused and colored to identify different stakeholders and their design priorities, such an "Assessment-Centered" stakeholder:

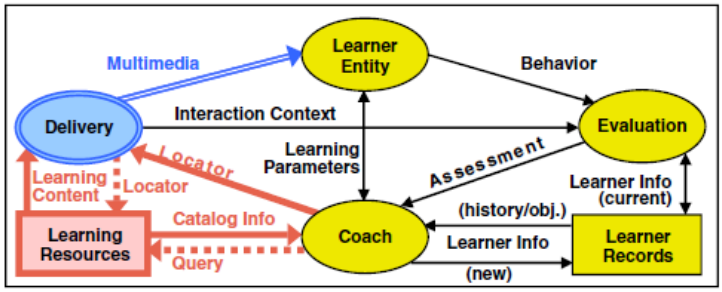
D.3.2 Assessment-centered



Summary	Educational standards, assessment, and record keeping.
LTSA Design Priorities	*Primary:* The standards, procedures, methods, protocols, and formats of behavior observation. The scope, functionality, and interfaces of the evaluation process. The protocols, semantics, and formats of assessment information. The protocols and formats of the learner information. The formats, indexing, storage, and retrieval of information in the learner records. *Secondary:* The interface to the learner entity. The protocol and format of learning parameters. The scope, functionality, and interfaces of the coach.
Non-LTSA Focus	*Primary:* Evaluation and assessment of learners. Education standards. Maintenance of the learner's records. Reporting systems. *Secondary:* Adapting the system's teaching methods based on the assessment of the student body.
Other Issues	Aggregation of the learner entity's comprehensive learner records and other records.

and a "Digital Libraries" stakeholder:

D.3.11 Digital libraries



Summary	Automated and distributed libraries of electronic media.
LTSA Design Priorities	*Primary:* The protocols and formats of the queries, catalog info, and locators of the learning resources, e.g., a digital library of learning content. The organization and structure of units of knowledge and information, as organized by the learning resources. The protocols and formats of learning content generated by or extracted from the learning resources. *Secondary:* The scope, functionality, and interfaces of the delivery process. The QoS of multimedia connections. The protocols and formats of multimedia.
Non-LTSA Focus	*Primary:* A rich, diverse repository of electronic learning materials. *Secondary:* The infrastructure to support the delivery of learning materials.
Other Issues	Integration with other libraries and cataloging systems.

The enumeration and mapping of stakeholders supported the standards committee's consensus-building efforts across a wide community of interest.

CONCLUSIONS

These recommendations are a starting point and not an exhaustive list. Still, Recommendation #1 is most important: we won't know the quality of our standardization work until 5-8 years from now, so the use of such Best Practices as a good strategy for risk mitigation in the long-term consensus-building and collaborative engineering effort.

Frank Farance