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**AMENDMENT 1**
2005-08-15

# Industrial automation systems — Requirements for enterprise-reference architectures and methodologies —

## AMENDMENT 1: Additional views for user concerns



*Systèmes d'automatisation industrielle — Prescriptions pour architectures de référence entreprise et méthodologies —*

*AMENDEMENT 1: Vues additionnelles pour les intérêts de l'usager*



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## Foreword

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Amendment 1 to International Standard ISO 15704:2000 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC 5, *Architecture, communications and integration frameworks*. In preparing this amendment, substantive contributions were received from groups involved with enterprise-reference architectures such as the Purdue Enterprise-Reference Architecture (PERA), the Graphes et Résultats et Activités Interreliés GRAI Integrated Methodology (GRAI GIM), the Computer Integrated Manufacturing Open System Architecture (CIMOSA), and the Generalised Enterprise-Reference Architecture and Methodology (GERAM).

# Industrial automation systems — Requirements for enterprise-reference architectures and methodologies —

## AMENDMENT 1: Additional views for user concerns

*Page vi, Foreword*

Replace the last paragraph with the following:

> "Annexes A, B, C, and D are informative. Annex A is based on version 1.6.2 of GERAM developed by the IFIP/IFAC Task Force on Architectures for Enterprise Integration who granted permission for its inclusion in ISO 15704. Annex B is based on the economic view found in A Stair-Like CIM System Architecture of Chen and Tseng. Annex C is based upon the decisional view found in CEN/TS14818 Technical Specification – Enterprise Integration – Decisional Reference Model."

*Page 1, subclause 3.2*

Replace (a) in the note with the following:



"a) system architectures (sometimes referred to as "type 1" architectures) that deal with the design of a system, e.g. the computer control system part of an overall enterprise integration system;"



*Page 5, subclause 4.2.6*

Replace with the following:

> "Enterprise-reference architectures and methodologies shall exhibit the capability to represent any process and its constituent activities for the accomplishment of the management and control in support of the established mission of the enterprise according to the criteria established by enterprise management."

*Page 6, subclause 4.2.10*

Add the following paragraph after the last paragraph:

> "Model developers may generate additional views for particular user concerns, and these can then be used by any concerned stakeholder. Examples of additional views are found in annexes B and C."

*Page 41, annex B*

Add the following two annexes before the existing Annex B and renumber the existing Annex B and its subclauses accordingly.

# Annex B
(informative)

# Economic View in CIM system architecture

## B.1 General

### B.1.1 Introduction

For entrepreneurs and business managers, confidence in advanced CIM technology depends upon the realization of a return on investment projected from design phase activities of both new system implementations and system up-grades and re-organizations/integrations. Since both tangible and intangible benefits must be considered, evaluating the return is a difficult problem. An essential aspect of any mechanism to resolve the problem is the ability to evaluate different alternatives using models of existing and proposed system architectures in a manner that connects functionality with economic consequence so that design trade-off decisions are possible. In particular, the evaluation of intangible benefits is often a barrier to Computer Integrated Manufacturing investments.

An Economic View presents model content relative to economic decisions. It draws upon existing model content and established analytical methods to inform decision makers. The view is most critical early in the life cycle when the majority of economic commitments are encountered and late in the life cycle when economic performance is measured.



### B.1.2 Support for enterprise managers

As guidance for enterprise managers, the Economic View can help them to:



a) predict the influences of system integration on the enterprise,

b) evaluate necessary investment and possible benefits,

c) make decisions and improve their correctness, and

d) monitor the implementation process and application of the integrated system.

### B.1.3 Support for enterprise model developers and analyzers

As guidance for model developers and analyzers, the Economic View helps them to:

a) describe the economic elements,

b) understand relationships between these elements and other components in an integrated system,

c) describe economic relationships among enterprise strategic targets, the framework of the integrated system and its components, and

d) identify economic benefits of enterprise re-organization.

### B.1.4 Support for system developers

As guidance for the system developers, the Economic View provides:

a) methods to evaluate economic consequences of system function modifications during the system development, and

b) scoping of software tool use for economic modeling and analysis.

## B.2 Framework for Economic View

In system implementation/integration projects, the goals and corresponding demands of the project target are reflected in the demands of the economic characteristics. Their economic implications/influences on the system are realized through the integration strategy and the technology project. The Economic View establishes the relations between the economic target and the engineering project. It describes economic elements, influence factors and scalar indices manifested in the integrated system and their relationships that allow the determination of their impacts on the economic targets in the system integration project. These indices, factors, and elements are constructs and their properties taken from or derived from the four mandatory model-content views (4.2.10)

In an integrated system, the Economic View consists of a grouping of models, which is used to describe economic components and their relationships. Many methods, e.g., graphical, mathematical, and even descriptive ones, may describe economic components. In order to improve the compatibility and assure the successful operation of an enterprise, a three-layer framework is constructed, expressed in graphic form, based on enterprise modeling methods and reference models in the general enterprise reference architecture, as shown in Figure B1.



The three layers in the Framework for Economic View (Indices, Factors, Elements) possess different economic attributes and the relationships among layers have different attributes as well. The framework establishes the relationships between layers of detail from the top level strategic targets of an enterprise to the bottom basic economic elements with intervening indices and factors. To correctly establish the relationships among different layers, both clustering and classification methods should be used to gather information from the generic and partial model pool for the applicable life cycle phases and then classify the information to establish the particular trees and relationships.

Early in the life-cycle, economic targets (ET) and constraints are established, e.g., return on investment, and pricing levels. Relative to this domain identification and concept definition, sets of economic indices ($I_j$) bearing on the targets and constraints are arranged and analytic methods are chosen with increasing levels of detail exposed as the life cycle progresses. At the factors layer, process related cost factors are derived from the decomposition of process models into activities ($f_P$). At this layer other economic factors result from the analytical breakdown of expected value that can be both tangible and intangible ($f_A$). All of the indices have both tangible and intangible factors. Even the most tangible indices, cost ($I_C$) and time ($I_T$) may have intangible factor influences that need to be taken into consideration. The explicit intangible factors, service ($I_S$) and environment ($I_E$) may have tangible factors as well, e.g., response time, pollution rate, etc. Tangible factors have diverse forms and representation. They can be expressed in mathematical equations ($f_E$), matrices, tables ($f_T$), boxes in graphical models, etc. In Figure B.1, the design phase is shown with greater elaboration using a tree of decomposed indices, process factors ($f_P$) depicted as a process model fragment, analytical factors ($f_A$) depicted as hierarchy models, equation factors ($f_E$) depicted as a formula, and table factors ($f_T$) depicted as a data table.

For factors, the element layer identifies the basic economic elements that comprise the variables in the mathematical equations ($\epsilon_E$), the entries in the matrices and tables ($\epsilon_T$), the activities (such as an activity box, e.g., in the lowest level IDEF3 model, ($\epsilon_A$)), etc., from which the factor cost or value are derived. These elements are usually simple attribute values characterized as indivisible, and can be used to measure, monitor, or control the related factors. In general the elements are properties of resources used to value and cost an activity.

Economic indices, factors, and elements can be of generic types collected as a pool of constructs for use at the various layers. These generic types can be formed into partial models of indices and factors to be used as an aide for populating a particular economic view through specialization.

Analysis methods vary by layer with, for example, tree hierarchy analysis techniques appropriate at the Indices layer, and process structure model simulation, hierarchy analysis, physics formulas, fit and interpolation methods at the Factor layer. These analysis methods collect data and support the decision optimization of the enterprise. Optimization results can be imposed on attributes to realize the enterprise strategy and improve its competitive ability. Two iterations of optimization and control exist - the target decomposition from the top down at Requirements, followed by system analysis from the bottom up at Design occurs early in the life cycle and then the system implementation from the top down at Implementation and the system monitor and control from the bottom up at Operation occurs later in the life cycle. The first iteration results in the roll-up of economic valuations for comparison against the targets and constraints. The second iteration provides measures of economic performance.

Such methods can assure the realization of the enterprise target, the fundamental information collection and analysis, the rationalized target fulfillment and the system monitoring. Implementation of the framework should be supported by correct methodology, rich engineering practices and advanced theories and methods of system integration. Initiatives in concurrent engineering, cell technologies, and total quality management may be coupled with capital and labor investment for economic benefit.

The analysis and evaluation of different implementation alternatives of CIMS can be performed using the Economic View. The selection of the best alternative from many opportunities to implement system integration and the improvement of the enterprise competency is achieved as a result of specific modeling methods.

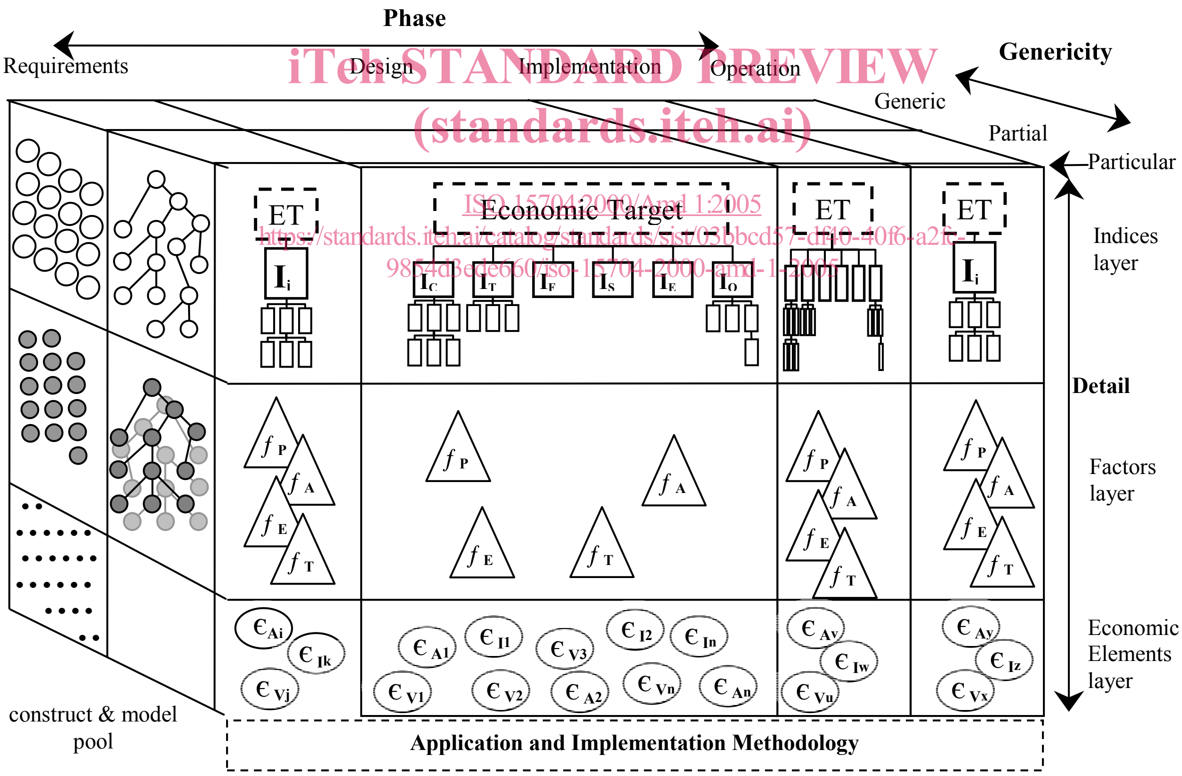
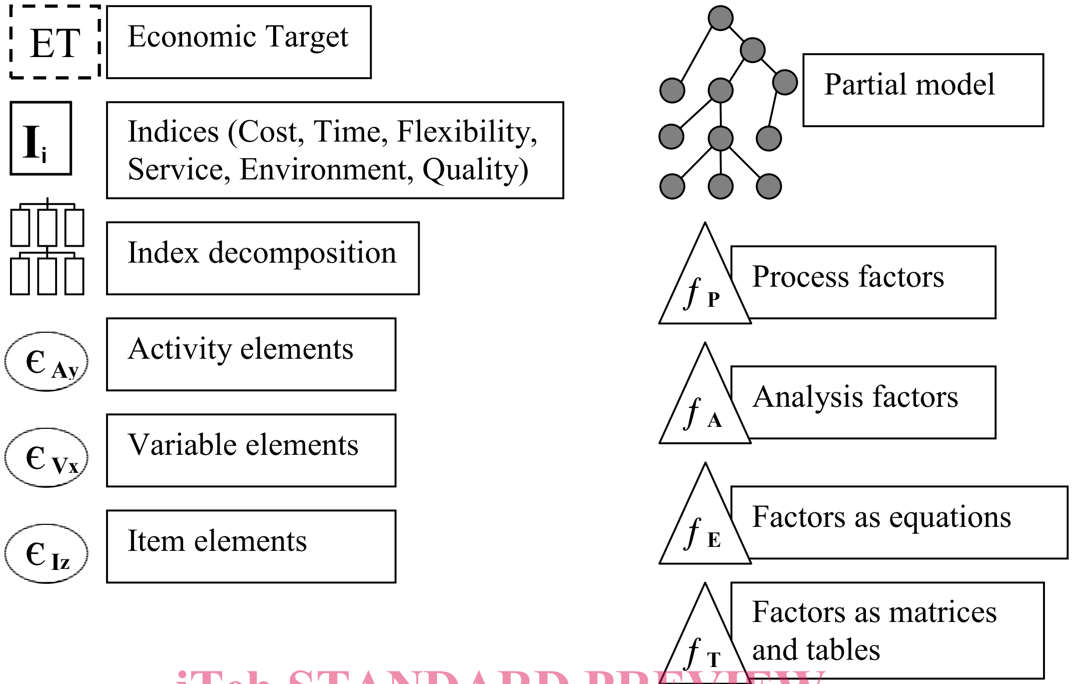




**Figure B.1 — Framework for Economic View**

**Table B.1 — Icons for Figure B.1**






## B.3 Candidate modelling methods

### B.3.1 Introduction

Two methods used at the Factor layer, depicted in Figure B.1 as $f_A$ and as hierarchy models, are presented below and followed by illustrative examples.

### B.3.2 Activity Based Costing

Activity Based Costing (ABC) is a method to measure the cost and performance of an organization based on the activities, which the organization uses in producing its output. ABC differs from traditional cost accounting techniques in that it accounts for all "fixed" and indirect costs as variables, without allocating costs based upon a customer's unit volume, total days in production or percentage of indirect costs. Information gathered through ABC should provide a cross-functional, integrated view of your organization, including its activities and its business processes. [1]

### B.3.3 Analytic Hierarchy Process/Analytic Network Process

The Analytic Hierarchy Process (AHP) is a decision making process to help set priorities and make decisions when both qualitative and quantitative aspects of a decision need to be considered. By reducing complex decisions to a series of one-to-one comparisons, then synthesizing the results, AHP helps decision makers arrive at optimal decisions and provides a clear rationale for those decisions. The AHP engages decision makers in breaking down a decision making procedure into smaller parts, proceeding from the goal to criteria and sub-criteria from the Indices layer, down to the alternative courses of action. Decision makers then make simple pair wise comparison judgments throughout the hierarchy to arrive at overall priorities for the alternatives. The decision problem may involve social, political, technical, and economic factors. The AHP method helps people cope with the intuitive, the rational and the irrational factors, and with risk and uncertainty in complex settings. It can be used to: predict likely outcomes, plan projected and desired future, facilitate group decision making, exercise control over changes in the decision making system, allocate resources, select alternatives, do cost/benefit comparisons, evaluate employees and allocate wage increases. [2]

The Analytic Network Process (ANP) is a general theory of relative measurement for deriving composite priority ratio scales from individual ratio scales that represent relative measurements of the influence of attributes that interact with respect to control criteria. Through its super matrix, whose attributes are themselves matrices of column priorities, the ANP captures the outcome of dependence and feedback within and between clusters of attributes. The Analytic Hierarchy Process (AHP), with its dependence assumptions on clusters and attributes, is a special case of the ANP. ANP augments the linear structures used in traditional approaches and their inability to deal with feedback in order to choose alternatives. ANP offers decision making according to attributes and criteria as well as according to both positive and negative consequences.[3]

## B.4 Applying Economic View in model development

### B.4.1 Introduction

Using the candidate methods of B.3, a subset of an Economic View as an example is presented below. The models chosen help decision makers align costs and value with targets and constraints.

### B.4.2 ABC Method example

In order to accurately assess CIM technology benefits to enterprises, a costing technique that considers not only production but also other processes is required. For this example the modeling formalism is based on the IDEF0 method.[4] Since both ABC and IDEF0 focus on functional activities, the IDEF0 model is extended to include activity based costing data. In this way we assure that no activity cost assignment will be missed during the integration with an IDEF0 model. Here, a separate economic model that corresponds to the IDEF0 model of function view is constructed. There are four attributes in each model block: 1) node number, 2) activity name, 3) cost driver and 4) cost value. The first two attributes are taken directly from an IDEF0 model, whereas the latter two are to be defined by designers. As shown in Figure B2., the cost model forms a hierarchy exactly like the IDEF0 model. Sub-processes are defined down to Element layer activities that are the most basic.



Guidelines for constructing an ABC economic model include:

a) No attribute can be left empty;

b) Cost value of a parent process must be the sum of the cost values of all its lower-level sub-processes or activities;

c) If there is a cost for coordinating activities of the same level, coordination should be modeled as an activity of that level;

d) The model can be decomposed as a hierarchy equivalent to the IDEF0 hierarchy;

e) Assignment of cost values should be done in a bottom up manner, so that higher-level activity cost values can be consolidated and assigned accordingly.

For example, as shown in Figure B.2, the cost drivers of the process ‘Delivery of Part As’, ‘Preparation of raw material’, ‘Production of Part As’, ‘Purchasing material’, ‘Work order control for part delivery’, ‘Preparation of NC program’, ‘Machine set-up’, and ‘Machining’, are defined. Then we assign cost values for ‘Preparation of NC program’, ‘Machine set-up’ and ‘Machining’ (basic economic Elements). Hence, the cost value for ‘Production of Part As’ is calculated by summing the A2 cost values (A21 + A22 + A23). Similarly, the cost values for ‘Preparation of raw material’, ‘Purchasing material’, and ‘Work order control for part delivery’, are assigned. Finally the cost for ‘Delivery of Part As’ is determined. In order to deliver a product, processes like production planning and shipping are necessary and thus the costs for these processes are added to determine the total cost of a product. Note that the ABC modeling method can be applied to the existing processes as well as estimating costs for new systems. The objective is to accurately capture or estimate the project costs.

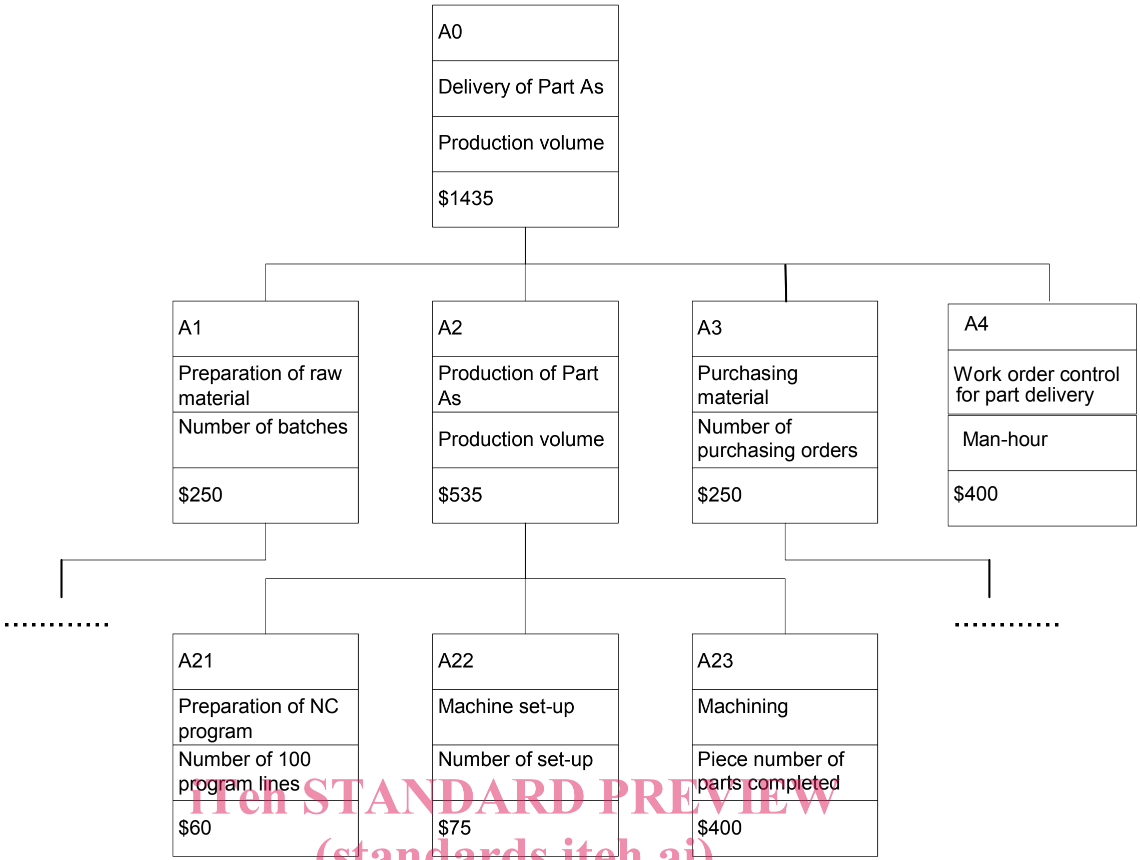





**Figure B.2 — Example of a cost hierarchy**

### B.4.3 AHP Method example

Since investing in CIM often is not for the sake of the technology itself, it is especially important that the resulting business and manufacturing processes meet the target performance. Operational measures of performance should be derived from company goals that align with corporate strategies at Indices layer. The questions to resolve are: 1) whether the technology investment can effectively bring the business to the target, and 2) is the investment economically sound. The Activity Based Costing technique discussed in the above section (B.3.3) addresses the tangible aspect and deals with the second question. The first question is addressed using the Analytic Hierarchy Process (AHP) method at the Factors layer.

For example, a manufacturing company is launching a technology advancement project in order to keep company growth on target. Funds are reserved for the first stage of project effort. Due to a budget limit for the first phase, a team of managers, analysts and engineers are asked to make an investment proposal. The AHP method is employed by the team to decide which area of the project will receive initial funds allocation. A hierarchy of the advancement investment problem is constructed as in Figure B.3.

During the analysis, it is observed that product cost, production lead time, product quality and customer service contribute differently to market share and profitability. Similarly, increasing market share and enhancing profitability are contributing differently to the goal of company growth. The Analytical Hierarchy Process method weights the contributions of alternatives to the goal.