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Industrial Information Systems – ISA88/95 based Functional Definition

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ISA88, ISA95, MESA, Industrial Information System Lifecycle, Information Factory,

ABSTRACT

"Industrial Information system (IIS) is a critical element in implementing the Company's strategy and synchronizing the physical and financial flows. It is an enabler to reaching higher levels in financial performance. On the contrary, a poorly designed and tuned IIS definitely is detrimental to the plant's ability to serve the Company's goal of sustaining and increasing profits."

Such an exciting statement is generally expressed by vendors, integrators and consultants, though sometimes industry middle management speak it out. However, industry business owners are still reluctant to invest great amounts of money in IIS: they recently spent millions in business IT systems

that were never covered by higher sales and profit. IIS is another story: it is not mandatory, the economic justification is questionable and the functional scope is unclear.

Working with production managers, industrial IT managers and control system engineers in order to help them design systems following ISA88 and ISA95 standards, I became to realize that they are thwarted by more and more difficulties figuring out clear directions. They were drowning into plethoric software offerings, facing fuzzy business requirements, and next dealing with user dissatisfaction and questioning upper management. The logical outcome is a significant rate of project failures while the acronym MES has become unwelcome in many companies.

Solution vendors and service providers are not wrong or business thirsty, business owners are not stupid or stubborn. They just suffer from the misunderstanding of the actual role of IIS from strategic as well as user point of view and/or lack of a shared functional requirement framework.

Ideally IIS provides information infrastructure, information processing services and orchestration that constantly adapt to actual resources, products, business and decision processes and allows implementing differentiating, winning strategies. Available solutions already provide useful functionalities while technology progresses make the dream almost reachable. The critical issue is for the Industry to aim at the highest level of maturity in developing and maintaining its IIS which allows with minimized effort to:

- Add new capabilities, cancel, extend, and improve existing capabilities in “real time”
- Capture existing constraints impacting the bottom line as user requirements
- Implement or support continuously improving manufacturing and business processes
- Allow to take benefit of the technology as it becomes available, when and where appropriate

Initially published in a MESA White Paper, this article was deeply restructured to introduce an extensive, holistic approach to industrial information systems lifecycle management. It links the Enterprise strategy and the user requirements to build and maintain a dynamic and supporting information system that purposely and efficiently supports physical and business processes. It sets a Company wide IIS lifecycle management process that handles the system’s development and evolution based on responsiveness to strategy directions and users satisfaction, benefiting from proven BPM and management practices (Lean management, 6 Sigma, Theory of constraints…)

It focuses on the ISA88/95 based functional requirement management sub-process of the holistic approach.

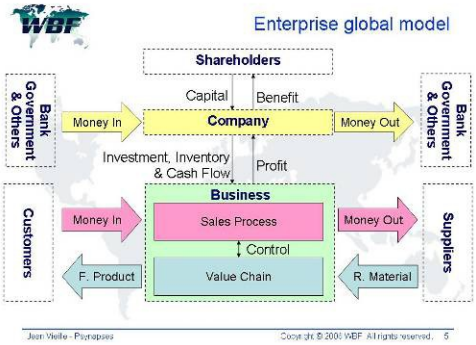
This article might be considered as an input for the ISA95 part 4, ISA88/ISA95 convergence, and ISA88 update efforts.

PAPER

1 Industrial Enterprise

In order to clarify the role if the IIS, we must first consider the big picture from the global purpose of the Industrial Enterprise to its specific part where the IIS operates.

- An industrial enterprise's purpose is to make money by selling physical, tangible entities: products, goods, energy. This Enterprise has 3 main entities:
- The Shareholders who expect revenue from their investment
- The Company owned by the Shareholders, managing the shareholders capital and providing financial resources to the Business
- The Business owned by the Company, leveraging Company's capital

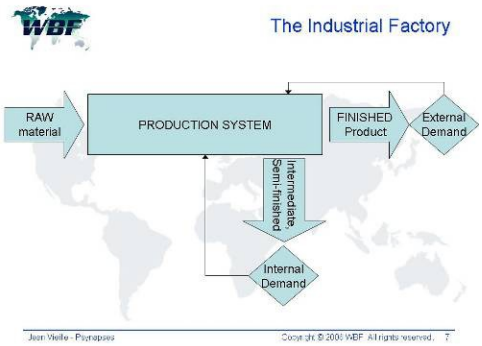


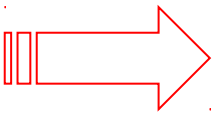
The Enterprise runs 2 main Processes

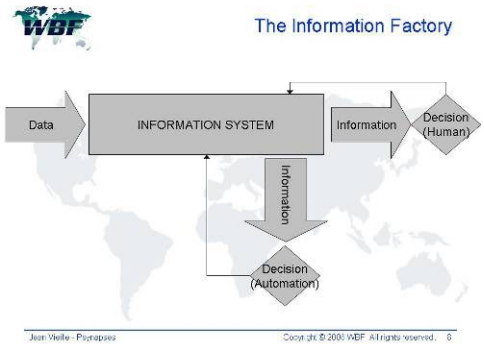
- The Value Chain creates Value that is perceived by the customers – making requested products – and handles physical Flows and Transformation
- The Sales Process creates Value for the capital shareholders by connecting the Value Chain to the Market. It includes activities not related to physical F & T and directs the Value Chain : Marketing, R&D, Sales, Purchasing, Planning

2 The Information Factory

As an emerging technology, Information systems are generally considered as a very specific asset and treated by IT people from their technology focus. Today, IT becomes a standard enterprise asset that progressively attenuates its flashy, novelty character. We definitely leap over the last fascination-based IT management habits by considering that an IT system is an Information Factory. Let's look at this analogy:







In the Information Factory we just process raw data into information instead of raw material into finish products (as for the later, raw data and information qualifiers depend from which side we look at them)

- Decision needs replaces product demand
- Automation represents the case were the decision is made by the information system itself. This is generally the case where the IIS supports transformation processes, but this can equally happen in other processes.

  Automation addresses mostly internal processes. It can also apply externally i.e. when the product demand is self-managed by sophisticated CRM (external demand)

We can exploit this analogy through the Industrial facility's main processes:

1. Product Development = Information Support Development

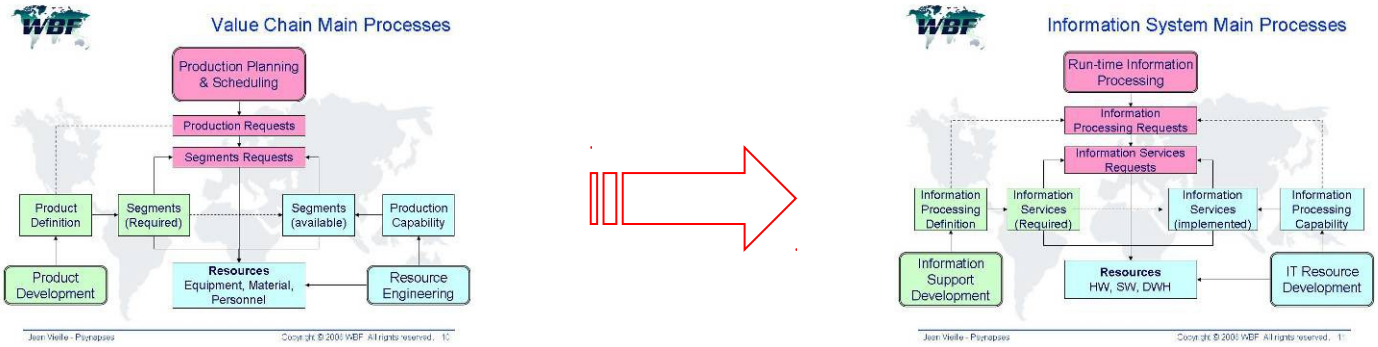
   The information factory must define its requirements for serving its users (customers): Transforming raw information into valuable, actionable information

2. Resources Engineering = IT Resource Development

   The information Factory must acquire and build the IT resources for implementing the required information support: HW/SW + custom information processing capabilities

3. Production Planning & Scheduling = Run time usage of information processing services

   The Information Factory must run smoothly making the best use of resources and serving its users timely and accurately.



This analogy highlights how the flexibility is achieved

- ISA88 splits General Recipe / Master Recipe / Equipment control
- ISA95 splits product and process segments
- SOA (Service Oriented Architecture) splits standardized information processing services and custom orchestration

An industrial factory can handle

- Low product variability by presetting production lines and machines in a rigid manner for high level capabilities, single purpose production system,
- High flexibility regarding feasible products by identifying elementary process services that can be assembled at run time to make anything that fits with its physical processing capabilities.

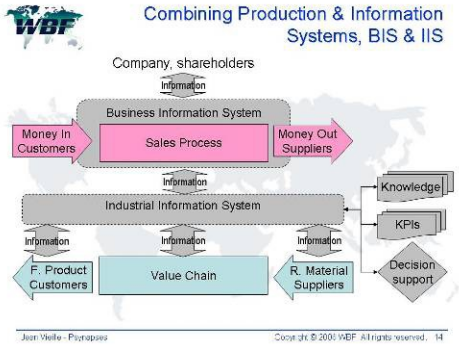
An information factory has exactly the same choice:

- Implement a rigid large scope, specific purpose designed off-the-shelf solution (i.e. industry vertical specific packages) or a totally customized solution by an external integrator
- Implement a set of elementary information processing services that can be pre-orchestrated by the "information support development" internal department or even defined on the spot and "scheduled" on request by the users.

3 Combining Industrial & Information Systems

At this point, we have to clarify the difference between an Industrial Information System (IIS) and a Business Information System (BIS):

- A Business Information System Supports the Sales Process, it is informational in essence.
- An Industrial Information System supports the Value Chain Process, it is Physical in essence.

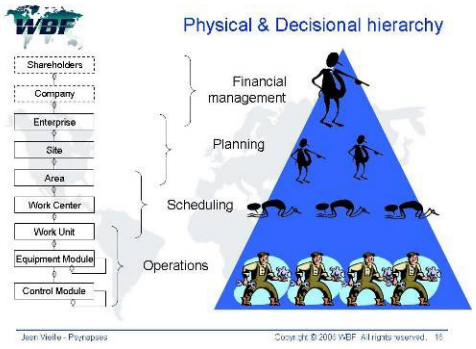


In consequence, the BIS seems closely coupled with business processes for supporting the Sales Process, while the apparently orthogonal nature of the intangible information and physical happenings of the Value Chain suggests a different approach to the IIS.

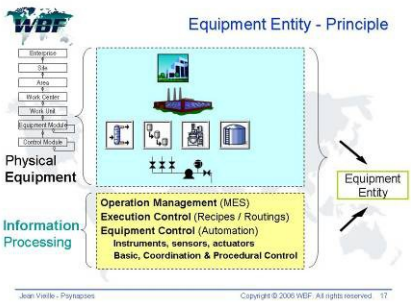
ISA88 came up with the elegant concept of Equipment Entity. The basic idea is that any information processing feature is embedded within the physical equipment elements throughout its hierarchy. The result is a consistent approach that aligns the IIS with the physical nature of its supported entity, preventing the information system to become a constraint against the inherent flexibility of the processes it serves.

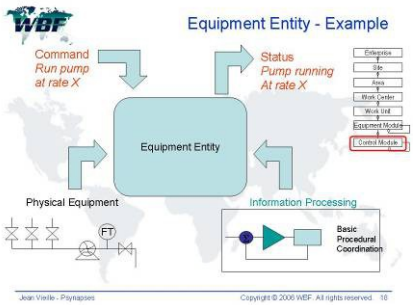
Following this concept, the Physical (production) System itself provides the IIS framework:

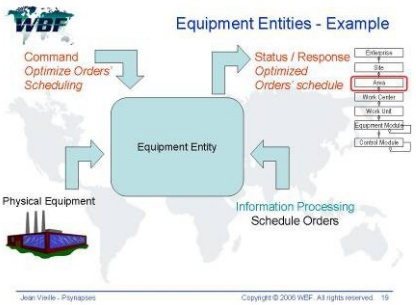
- The Physical hierarchy corresponds globally to the Decision hierarchy (see facing figure)
- Any Information service or process is embedded within a specific Equipment entity, at any level. The IIS doesn't exist by itself in the vacuum…
- The information system is a supporting, not a leading entity



The Equipment entity concept is valid for all the IIS scope and can be illustrated as follows:







4 IIS lifecycle management

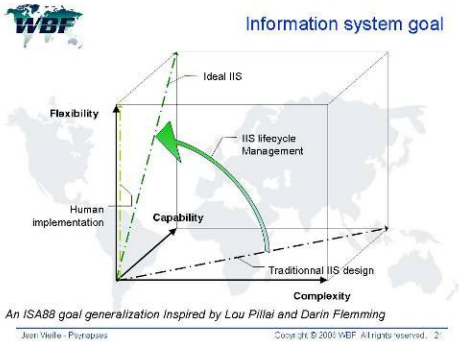
Information technology is new and still far from maturity. Significant progresses are made in the most exciting or financial rewarding domains. Internet in every home – every pocket – delivers unquestionable perceived value for users. Technology has almost disappeared from user's interest while they frenetically hit keys and get what they search for without relying on rigid pre-defined patterns. Yet, in most cases users still need to learn the IT system, although this should be the other way around.

In comparison IT is still in its early stages in Industry. While the same technology is available, Business systems are still based on full scope software packages with preconfigured functions & processes based on common practices. SOA architectures slowly surface for ISA88 style flexibility, but they are still confined within a proprietary domain.

Paradoxically, Control systems are more mature. Real time flexibility in operations is required for productivity since some time. Totally customizable, ISA88 designed systems support this flexibility.

The opposite figure is derived from the Flemming/Pillai[1] diagram expressing the goal of "Strategic automation". This extrapolation is valid for the entire industrial information system.

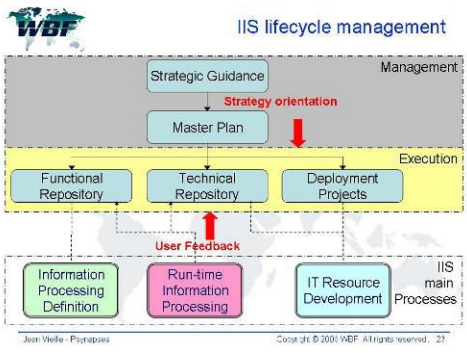
The mere ISA88 paradigm was replaced by a more global set of concepts and processes that are called IIS Lifecycle Management or Control Chain Management® (CCM)[2] which:



- Defines and designs information processing requirements
- Aligns Enterprise Strategy and User Requirements
- Plans the IIS development and deployment
- Builds, Maintains, and Improves the IIS

The main process for managing the IIS lifecycle is presented in the opposite figure. This process has 5 sub-processes:

- Strategic guidance providing input for setting IIS directions and master planning



[1] S88 imp… the Process Industries

[2] CCM is … al group of experts. It is registered by Psynapses

- Master planning for guiding IIS development, deployment, improvement
- Functional Repository to manage business knowledge related information support development
- Technical Repository to manage technical implementation knowledge to fulfil the Functional requirements
- Deployment projects where Technical Repository elements are installed for a given set of Functional Repository requirements

They map to the information system's main processes discussed above:

- The Functional Repository sub-process corresponds to the definition of information processing requirements Process
- The technical Repository and Deployment sub-processes correspond to the IT Resource Development Process
- Run-time information processing (actual usage of the information system) has no corresponding process, but provides feedback from users to other sub-processes

5 IIS value and performance

To summarize this approach:

- IIS is an Information Factory
- IIS lifecycle is managed as a process

This allows to seamlessly applying industrial management methods to both aspects of the IIS construction and operation performance.

5.1 Improving the Information Factory

The performance of an Industrial Factory can be simply measured by its profit. However, for an industrial business (i.e. not selling information like Dunn & Bradsteet or Gartner), the Information Factory does not produce value, it only supports and serves the value making processes. One way to assess the Information Factory performance is to consider its users satisfaction: this is true at run time as satisfied users mean that the provided functions perform appropriately. However, this is far from sufficient:

- "Good" functions may not bring value to business after all (more money for shareholders)
- Functions for improving business bottom line may be missing, with no one realizing the lack

Management methods help set the right objectives and build the right system on a dynamic basis:

Theory of Constraints: Prioritizes and focuses on supporting the most constraining processes regarding the Enterprises Goal of making more Money

Lean Management: Considers user most valuable services in the most responsive way, Eliminates IT "Mudda", i.e. fancy unneeded Whistles & Bells

Six Sigma: Monitors and improves quality of Information processing features

5.2 Improving the IIS Lifecycle Process

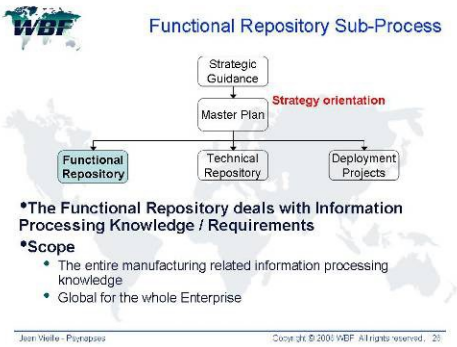
Managing the IIS lifecycle is a process that must perform efficiently and improve on a continuous basis. Management methods apply to this process in a conventional way:

Theory of Constraints: Evaluates the IT development effort and Sets IT Objectives

Lean Management: Keeps the process simple and responsive

Six Sigma: Monitors and improves process performance and sub-process links

6 ISA88/95 Functional framework



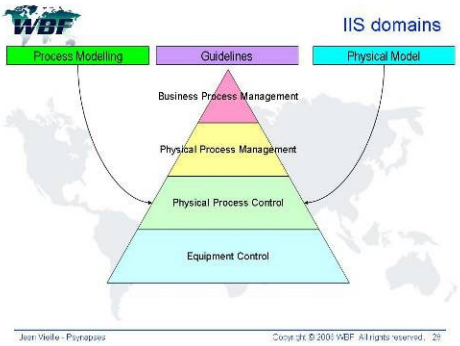
6.1 IIS functional domain

We finally get into the heart of the subject: how to leverage the ISA88 and ISA95 standards to define a consistent IIS functional framework. This directly fits into the 3rd IIS lifecycle management sub-process – the Functional Repository.

This sub-process is independent of actual IT solution design and deployment. Its role is to provide a framework for structuring business and physical process knowledge, allowing the capturing and the delivering of this knowledge:

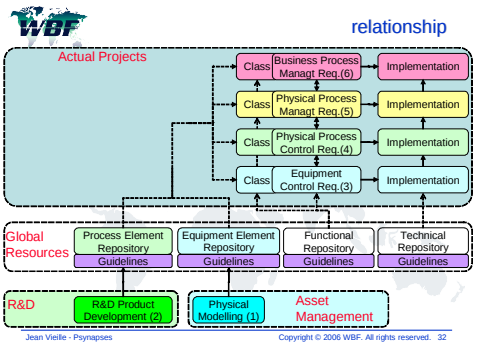
- to and from actual IIS development/projects
- to and from actual run-time usage

It is also essential for mastering the development planning.



Both ISA88 and ISA95 standards have evolved independently with a different focus. In consequence they sometime appear as conflicting or inconsistent. Actually, we did not have much difficulty to consistently map both standards models once we clarified the IIS scope and domains as shown on the opposite figure. From Bottom to Top:

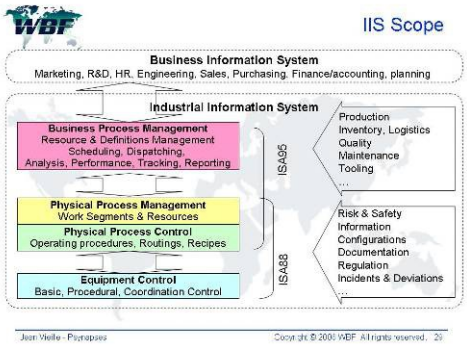
1. Equipment control is the traditional automation domain and corresponds to ISA88 equipment side of control including procedural, basic and coordination.
2. Physical Process Control is the ISA88 Recipe domain. The term *Recipe* was replaced to address any *Physical Process*. This is the realm of flexible control which allows the user to apply his specific knowledge for managing physical processes (i.e. making product).
3. Physical Process Management is supported by ISA95 part 1 Process Segment / Product Definition / Resource domain. It differs from the previous domain in the sense that it doesn't explicitly deal with detailed instructions to process the materials, but with providing the view and monitoring management grip on operations to drive them efficiency within the Value Chain and to handle information flows with the Sales Process



4. Business Process Management is supported by ISA95 part 3 (and SCOR) activity models. It covers the business aspect of the operation activity in opposition to (2) and (3) which concentrate on physical aspects.

Domains (1) and (2) control the actual physical process while (3) and (4) manage the activities in terms of resource usage, performance perceived by the Sales Process, and integration with the Sales Process

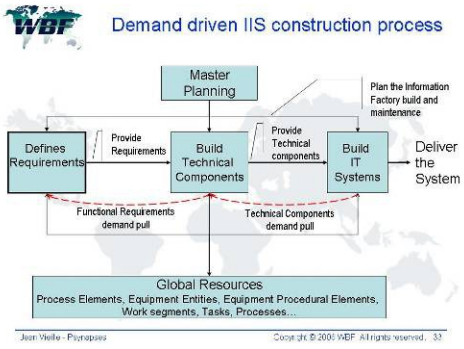
6.2 Methodology



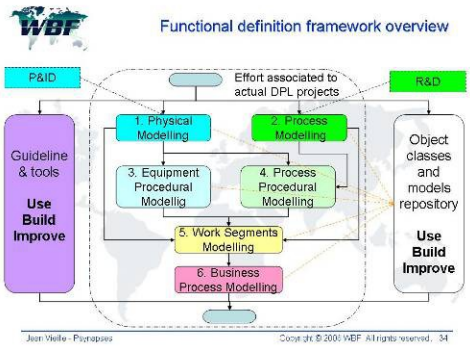
The relationships between the 4 IIS functional domains are shown on the opposite figure.

Physical facility and product specification models provide the common basis for all IIS functional domains. They represent the very specifics of the enterprise, under respectively asset management and product development responsibilities.

The functional repository manages both classes (reusable objects that gather knowledge) and instances (usage of the knowledge). The Technical Repository concerns actual implementations.



Though it is theoretically possible to build classes upfront (gather current knowledge extensively), it is more common to take benefit of actual projects focusing on specific information support implementation. The Master Planning sub-process decides which identified functions have to be studied, implemented and deployed. The detailed scheduling is then synchronized with the actual project development in a Kanban style demand driven construction process through a 3 stage construction process: Build the actual system (the IT Project) -> Build the generic technical components (Technical Repository Sub-Process) to be incorporated in the actual system -> Define the generic requirements –Functional Repository Sub-Process).



The global methodology is synthesized in the opposite figure. Starting from physical/equipment layout (1 - physical modelling) and equipment independent physical process definition (2 – Process modelling, i.e. product definition / general recipe), Equipment (3) and physical procedural (4) modelling can be performed. Work segment modelling (5) can also be performed at the same time, though at some point the procedural elements will be associated with (embedded in) work segments. ISA88 procedural elements appear to be the behavioural part of ISA 95 segments. The common Process Modelling guarantees the homothetic relation between segments and procedural elements.

Finally, business processes (6) can be defined based on segment and resources modelling (5). All this process:

- is controlled by Guidelines (i.e. ISA88 and ISA95 standards + complementary / alternate company's regulations) and makes use of existing classes,
- provides feedback to Guidelines and Classes improving from project to project.

7 Conclusion

IT is maturing, but Industry is still behind. The difficulties with MES implementation project have many explanations. Among them, the technology focus and fascination often occults the actual purpose of the IIS. The inner conviction of Industrial IT department in charge is no longer sufficient to leverage the appropriate budgets that are necessary to deliver the appropriate IT support which in return will release significant financial reward.

“Information Factory” analogy is a guidance to implement a more mature IT lifecycle management process.

As an industrial factory, the Information Factory needs flexibility to address appropriately the request of its users (customers). ISA88 Equipment Entity concept and object oriented approach can be extended as a flexible design model to the whole IIS scope. Also it is interesting to note that the quite new SOA is no more than a simplified ISA88 concept of Recipe / Equipment separation.

Within the global IIS lifecycle management process, the Functional Requirement sub-process plays a centric role by providing the global IIS framework for reference by all other aspects of the IIS planning, construction and deployment.

It is adequately supported by ISA88/95 models. A proper IIS domain split permits to clarify the exclusive scope and overlap of both standards. Only slight terminology changes and limited exegesis are needed to cover consistently the full scope of the IIS functional framework

8 Annexes

8.1 Functional framework objects

The resulting framework defines the following objects:

Domain	Model	Std	Objects classes	Objects Instances	Owner
Asset Management	Physical	ISA88-1 ISA95-1	▪ Equipment	▪ Equipment	Asset Management
Product Development Management	Process	ISA88-3	▪ Process Elements ▪ Material ▪ Equipment Constraint	▪ Product Requirement ▪ Process Element ▪ Material Definition ▪ Equipment Constraint	Product Research
Equipment Control	Procedural	ISA88-1	▪ Equipment Procedural Elements	▪ Equipment Procedural Element	Automation Engineering
Physical Process Control	Procedural	ISA88-1	▪ Process *(Recipe)* Procedural Element	▪ Physical Process *(Recipe)* ▪ Physical Process *(Recipe)* Transform Components ▪ Process *(Recipe)* Procedural Element	Product Development
Physical Process Management	Work Segment Work Definition	ISA95-1	▪ MOC ▪ Work Process ▪ Work Segments ▪ Personnel	▪ MOC ▪ Work Process *(Process Segment/Product Definition)* ▪ Work *(Process)* Segment ▪ Personnel	Planning, Cost Accounting & HR
Business Process Management	Operation Activity	ISA95-3	▪ Business Process ▪ Tasks	▪ Business Process ▪ Tasks	Production Management

8.2 Generalized / converged terminology

CCM term	*Acronym*	*Definitions*	*ISA88*	*ISA95*
Functional repository	FRP			
Physical Model				
Asset Management	AM			
Equipment	EE	Ref. ISA95	Equipment	Equipment
Equipment Class	EE	Ref. ISA95	Equipment Class	Equipment Class
Enterprise		Ref. ISA88/ISA95	Enterprise	Enterprise
Site		Ref. ISA88/ISA95	Site	Site
Area		Ref. ISA88/ISA95	Area	Area
Work Center		Ref. ISA88/ISA95	Process Cell	Work Center
Work Unit		Ref. ISA88/ISA95	Unit	Work Unit
Equipment Module		Ref. ISA88	Equipment Module	Equipment Module
Control Module		Ref. ISA88	Control Module	Control Module
Device Module			Device Module	Device Module
Process model	Rational : 1) It is about Product definition from R&D, typically independent of Equipment. 2) It corresponds to ISA88 General/Site Recipes. “Product Definition” generalizes “General Recipe” / It might conflict with ISA95 “Product Definition 3) It typically only applies to Production manufacturing Operations			
Product Development Management	PDM			
Product Definition			General/Site Recipe	Product Definition
Process Element	PE	Ref. ISA88-3	Process Element	
Process Element Class	PE	Ref. ISA88-3	Process Element Class	
Material Definition		Ref. ISA88-3/ISA95	Material Definition	Material Definition
Material Class		Ref. ISA95		Material Class
Equipment Constraint	EC	Ref. ISA88-3	Equipment Constraint	
Equipment Constraint Class	EC	Ref. ISA88-3	Equipment Constraint Class	
Process		Ref. ISA88	Process	Product Definition
Process Stage		Ref. ISA88	Process Stage	Product Segment
Process Operation		Ref. ISA88	Process Operation	Product Segment
Process Action		Ref. ISA88	Process Action	Product Segment
Procedural Model	Rational: 1) Procedural refer to physical process. When “procedural” is not quoted, “physical process” must appear 2) 2) “Physical Process” generalizes ISA88 “Recipe”			
Equipment Procedural Modelling				
Equipment Control				
Equipment Procedural Element	EPE	Ref. ISA88	Equipment Procedural Element	
Equipment Procedural Element Class	EPE	Ref. ISA88	Equipment Procedural Element Class	
Process Procedural Modelling				
Physical Process Control				
Physical Process			Master Recipe	

Physical Process Transform Components	PPTC	Ref. ISA88	Master Recipe Transform Component	
Process Procedural Element	PPE	Ref. ISA88	Recipe Procedural Element	
Process Procedural Element Class	PPE	Ref. ISA88	Recipe Procedural Element Class	
Procedure		Ref. ISA88	Procedure	
Unit Procedure		Ref. ISA88	Unit Procedure	
Operation		Ref. ISA88	Operation	
Phase		Ref. ISA88	Phase	
Work Segment Model	Rational : 1) Work Segment replaces ISA95 Process Segment 2) Work Process replaces ISA95 Product Definition when owned by the manufacturing side – It shall correspond to “Master Recipes”			
Work Segment Modelling				
Physical Process Management	PPM			
Manufacturing Operation Category	MOC	Ref. ISA95		Manufacturing Operation Category
Manufacturing Operation Category class	MOC			-
Work Process	WP	Ref. ISA95		Process Segment Product Definition
Work Process Class	WP			-
Work Segment	WS	Ref. ISA95		Process Segment
Work Segment Class	WS			-
Personnel		Ref. ISA95		Personnel
Personnel class		Ref. ISA95		Personnel class
Operation Activity Model				
Business Process Modelling				
Business Process Management	BPM			
Business Process	BP			
Business Process class	BP			
Activity		Ref. ISA95		Activity
Tasks		Ref. ISA95		Task
Tasks class				