Key Performance Indicators: linking with ISA-95 and moving toward KPI-driven factory

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This paper provides a summarized overview of key performance indicators beginning with the definition, use in the production process, linking with ISA-95 factory modeling standard, discussion on the overall KPI and statements for the building of KPI-driven factories.

Introduction

According to [4], term KPI is defined as follows:

"Key Performance Indicators, also known as KPIs or Key Success Indicators (KSI), help an organization define and measure progress toward organizational goals. "

In other words, KPIs are quantifiable measurements reflecting the critical success factors (CSF) of an organization. Different types of organizations have different success factors, that is why every organization may define their own KPIs. Here are some examples: one of the main KPIs for a business may be the percentage of the income that comes from the customers. A school may focus its KPIs on the ratio of entered/graduated students and students' graduation rates. An oil refinery may consider the amount of crude oil losses during its production.

The main points of KPIs, according to [2, 4], is that KPIs must reflect the organization's goals, they must be key to its success, and they must be measurable.

The examples of possible KPIs are shown on Figure 1.

A range of techniques has been developed for defining KPIs, for more details see [2]. Just to mention the main steps: "using the PMI™ technique, once the functional analysis is completed, CSFs must be identified to ensure the overall stakeholder needs, or goal will be attained. Using a "functional

breakdown structure" (FBS) separates the need from the actual solution used to fulfill this need." [2]

Linking KPIs and ISA-95

Using the ISA-95 standard, operations and financial managers are able to achieve alignment between strategic expectations, capital expenditure spending and expected operations KPI measurement. ISA-95 information exchanges aggregate key metrics from operations and production into enterprise planning and supply chain algorithms and data models. Leveraging KPIs derived from ISA-95 Part 3 manufacturing operations exchanges, the resulting operational metrics measure and then align true operational and financial benefits sought tactically by the organization. Relevant production measures for KPI construction are defined

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from manufacturing processes. The “high-performance organization” aims at achieving operational excellence by minimizing low-level process variability through the Part 3 manufacturing operations analytics. Manufacturing analytics aggregate the large number and quantity of low-level, real-time I/O measures.

Several organizations like Supply Chain Council and it SCOR Model, the Project Management Institute (PMI™), authors like Kaplan and Norton (Balance Scoreboard) and business/manufacturing intelligence software companies are all involved in defining and using enterprise-level KPIs. This ISA-95 best practice document intends to facilitate the use of ISA-95 standard when applying and constructing these enterprise-level KPIs and operations metrics.

As ISA-95 is a standard for building object models for enterprises, the object-model interrelations are very important. Fig. 2 shows an example of such relations.

KPI-driven Factory and Overall KPI

In this short paragraph we want to open a discussion about the KPI-driven factory and its possible mathematical interpretation.

Regarding the factories, it is still in progress with implementing KPIs in the production process and company management. And, moreover, there is a problem with monitoring these KPIs in the real-time mode. This is connected with achieving the desirable values of certain KPIs, which brings us to the idea of KPI-driven factory.

From the mathematical point of view, KPI-driven factory means using KPIs as objective functions. As a KPI is a complex value dependant on many processes and parameters, we can speak of it in terms of function, which makes it possible to formulate optimization problems, taking function parameters as variables and applying relevant constraints to them.

The theory of multi objective optimization leads us to the idea of Overall KPI, a value that takes into account all other KPIs.

One of the most simple formulations of the Overall KPI may be:

$F_{OverallKPI} = C_1*F_{K1} + C_2*F_{K2} + \ldots + C_n*F_{Kn},$ where F_{Ki} is a function of i-th KPI and C_i is a weighting factor.

C_i can be KPI priorities, for an example see fig. 3.

KPI problems

Defining and monitoring of KPIs can be expensive or difficult for organizations. Indicators such as staff morale may be impossible to quantify. Another serious issue in practice is that once a measure is created, it becomes difficult to adjust to changing needs as historical comparisons will be lost. Conversely, measures are often of dubious relevance, because history does exist.

Furthermore, since businesses with similar backgrounds are often used as a benchmark for such measures, measures based only on in-house practices make it difficult for an organization to compare with these outside benchmarks.

Measures are also used as a rough guide rather than a precise benchmark.

Also, as mentioned in [1], together with timelines and Gantt charts the production process or project overview should contain respective KPIs.

To summarize, KPIs should be standardized characteristics, with possible absolute values and measuring methodology. Tools for incorporating them in the ERP, project management systems, scheduling software should be developed.

Category	KPI
Order Fulfillment	Actual production rate as a percentage of the maximum capable production rate
	Percentage of lots or jobs expedited by bumping other lots or jobs from schedule
	Production and test equipment set-up time
	Production schedules met (percentage of time)
	Actual versus planned volume
Asset Utilization	Average machine availability rate or machine uptime
	Percentage of tools that fail certification
	Hours lost due to equipment downtime
	Cumulative count of machine breakdown
Quality	Major component first-pass yield
	First product, first pass quality yield
	Reject or return rate on finished products
	Reject-rate reduction
	Rework-repair hours compared to direct mfg. hours
	Scrap and rework as a percentage of sales
	Scrap and rework percentage reduction
	Rework and repair labor cost compared to total manufacturing labor cost
	Number of process changes per operation due to errors
	Number of training days
	Yield improvement
Personnel	Percentage increase in output per employee
	Percentage unplanned overtime
	Safety and Security incidents
	Percentage of operators with expired certifications
Productivity	Percentage of assembly steps automated
	Percentage reduction in manufacturing cycle time
	Productivity: units per labor hour
Engineering	HMI data entry count
	Percentage of alarm reduction
Material	Time line is down due to sub-assembly shortage
	Count of supplier shortages per period
	Material consumption variances from standards
Planning	Percentage reduction in component lot sizes
	Manufacturing cycle time for a typical product
	Percentage error in yield projections
	Standard order-to-shipment lead time for major products
	Time required to incorporate engineering changes

Figure 1. Examples of KPIs [2].

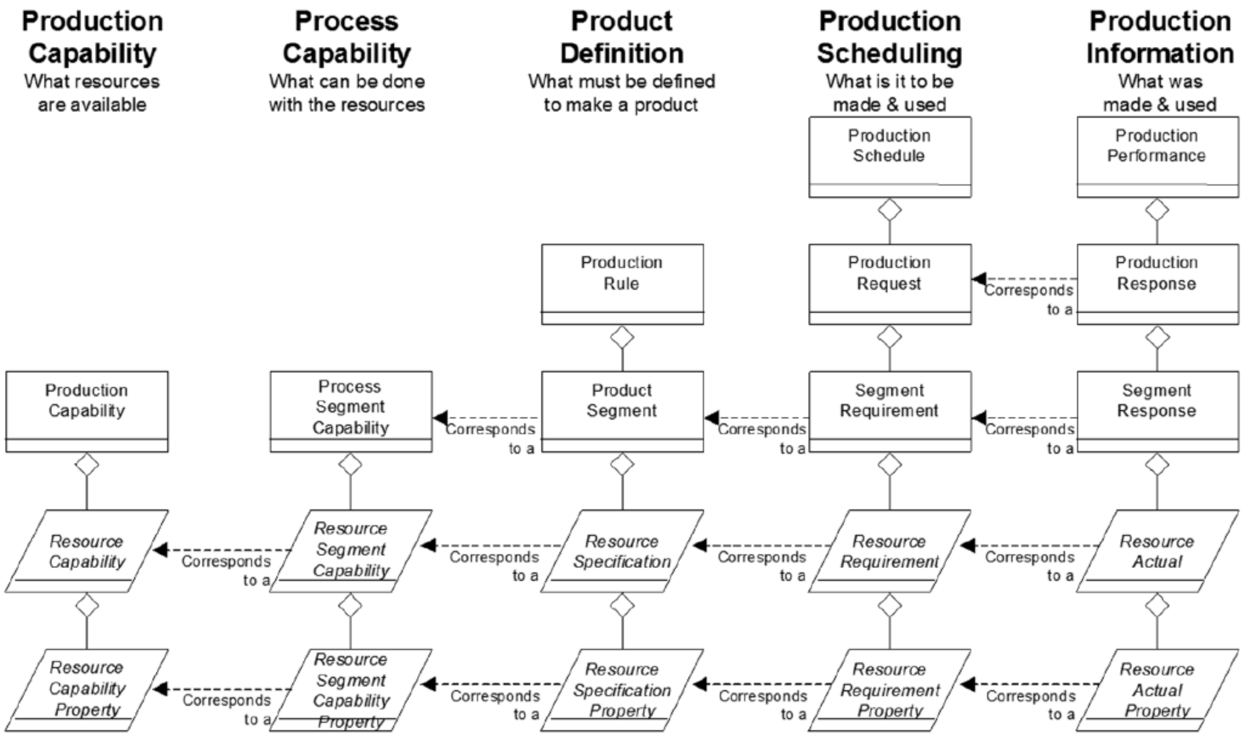

Figure 2. Object Model Inter-Relations [2].

KPIs				Category	Options / Project 1 Electronic Data Collection	2 Track against Prod.Order/WC	3 Personnel Training	4 Measure failures	5 Resouces tracking	6 Share Production Forecasts
Actual versus planned volume				Order Fulfillment				X		
Percentage of tools that fail certification				Asset Utilization		X				
Percentage reduction in component lot sizes				Planning		X				
Percentage reduction in manufacturing cycle time				Planning					X	
Percentage of operators with expired certifications				Personnel			X			
Production schedules met (percentage of time)				Order Fulfillment					X	
Productivity: units per labor hour				Productivity				X		
Reject-rate reduction				Quality				X		
Rework and repair hours compared to direct manufacturing hours				Quality		X				
Percentage of assembly steps automated				Engineering	X					
First product, first pass quality yield				Quality		X				
Hours lost due to equipment downtime				Asset Utilization				X		
# HMI Data Entry Points				Engineering	X					
# Automatic Data Entry Points				Engineering	X					
Man-days of training				Personnel			X			
Cumulative # Equipment Breakdown				Asset Utilization				X		
% utilization				Asset Utilization					X	
# Supplier shortages per period				Supplier						X

Figure 3. KPI-priorities [2].

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Available online at
http://global.wonderware.com/EN/PDF%20Library/MESA%20Whitepaper_ISA-95-Based%20Operations%20and%20KPI%20Metrics%20Assessment%20and%20Analysis.pdf
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