Jürgen Kletti (Ed.)

Manufacturing Execution Systems – MES
Manufacturing Execution Systems – MES

With 100 Figures
The transformation of the classic factory from a production facility into a modern service center has resulted in management problems for which many companies are not yet prepared. The economic efficiency of modern value creation is not a property of the products but rather of the process. What this means is that the decisive potentials of companies are to be found not so much in their production capability but in their process capability.

For manufacturers, the requirement for process capability, which has in the meantime become the basis of the certification codes, gives rise in turn to the requirement that all value-adding processes be geared to the process result and thus to the customer. A necessary condition of process transparency is the ability to map the company's value stream in real time, without the acquisition process involving major outlay – a capability which is beyond the dominant ERP systems.

Today modern manufacturing execution systems (MES) can offer real-time applications. They generate current and even historical maps for production equipment and can thus be used as a basis for optimization processes. As early as the beginning of the 1980s work started on methods of this kind which were then known as production data acquisition or machine data collection. But while the main emphasis in the past was on achieving improvements in machine utilization, today the concern is predominantly to obtain real-time mapping of the value stream (supply chain).

Here the increasing complexity of production calls for a holistic view of production and services equipment and facilities: detailed planning, status detection, quality, performance analysis, material tracking and so on have to be registered and displayed in an integrated manner.

In the mid-1990s the concept of the manufacturing execution system developed in the USA from out of these exigencies. A non-profit organization with the name of MESA (Manufacturing Execution System Association) started standardizing these applications and thereby raised three application layers of a production facility into a principle. MESA defines the level of production itself, the level of production management (in other words, MES), and the level of corporate management.

Further works of standardization relating to this subject area are already in the process of development. Accordingly, an ISA S95 has been approved,
whereby NAMUR, an association of process manufacturers, has come up with its own guideline for its own particular area of manufacturing.

Very recently too the Verein Deutscher Ingenieure (VDI) has picked up this topic and is working on issuing a guideline tailored to the particular concerns of European manufacturers.

The expectations placed upon a manufacturing execution system for increasing performance are correspondingly high. The practitioner will have a particular interest in topics such as TQM, SIX Sigma, operations planning or optimized material movements.

Even today the growing interest in this area is indicated by the increasing use of the term “MES” in specialist literature and market surveys not to mention in work on standardization in which a number of committees are involved.

The term MES should be methodically systematized in order to give manufacturers the broadest overview possible of the capabilities and the different practical possibilities of an MES and thus put them in a position of exploiting this overview to orient themselves within the broad supply of goods to the market. In the present book, experienced specialists in the field throw detailed light on different aspects of an MES without which it is not possible to run a modern company profitably today.

Gaining control of the processes is more and more becoming a central requirement for companies if they are to be able to produce profitably even in a location such as Germany.

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1 New ways for the effective factory

1.1 Requirements for tomorrow’s manufacturing

The classic factory has been defined by its manufacturing of goods. The goods and their value have been measured primarily by their material components. This is no longer adequate today. Increasing globalization is necessarily leading towards more anonymous products out of long supply chains and with an increasing complexity to track their origins. This implies a shifted focus from control of production creation (vertical integration) to control of product perception by the customer (OEM). Customers today take it for granted that products will be of first-class quality. Anyone wishing to stand out from the competition in the future needs a strategy which offers the customer an additional added value, such as, for example, high flexibility, short delivery times, high delivery reliability, wide range of variants, shorter product life cycles – properties which are not created by production but by the processes. The term “adaptive manufacturing”, which is heard more and more often these days, describes this approach as “connecting the machines to the markets.”

For this reason many classic manufacturers today already define their production facilities as a service center, thereby signaling to the customer that they understand the processing of material into a finished product as also being a service for the customer. This increase in closeness to the customer initially results in cost increases. Modern producers attempt to cancel out these increased costs by rethinking their vertical integration, in some cases by using standard components or by sourcing suitable components on the global market. The modern producer is thus faced with forces which can be referred to as networking, dynamization and individualization.

The term “networking” means the increasing inter-company cooperation. In today’s public discussion is principle is named globalization. Thanks to this networking the manufacturer can purchase on the market the components he needs thus leaving him able to concentrate on his core competences which he then, in a supply chain management strategy, incorporates effectively into the total product manufacturing chain.

Dynamization originates in strong market fluctuations which, driven by more information and ever more rapidly disseminated information,
encourage customers to make rapid changes in their purchasing habits. The ever faster turning wheel of technological development makes a further contribution to these effects. Errors are more likely in complex, collaborative processes than in simple, closely coupled processes. The failure management resulting from this and also the frequent and faster changes in customer orders further stimulate the dynamics.

The change towards buyer’s markets and greater focusing on the customer demands more individualization from manufacturers. What the customer wants is a product which is tailored to his requirements. The logical consequence is an increase in the range of variants which the producing company must offer to its customer.

Networking, dynamization and individualization create increased risks and complexities in the production facilities and demand that producers be capable of change. This turbulence is characterized by new requirements in the internal processing of orders and also in external market dynamics. These changed requirements are characterized by stronger external networking, by collaboration with multiple and/or with new partners, and by faster internal structural and technical adaptations. This new process instability makes manufacturing close to an economic optimum more difficult and also fosters not only inefficient information management but also outdated business processes. The consequence for the customer is poor delivery reliability and lead times as well as unsatisfactory product quality. In many cases the manufacturer experiences long delivery times which in turn result in excessive inventory levels. The consequence is that more capital is tied up.

The list of effects generated by turbulence and changeability can be continued. These effects impact on every level in a manufacturing company, often in different ways with different effects. The consequences of these effects can be resisted by creating more transparency within the levels and between the levels, by improving reaction capabilities, and by securing cost-efficiency.

To increase transparency, there must be greater integration of the business processes affected. Impediments and obstructions which still exist today in communications between the corporate levels of management, production management and also the production department itself must be dismantled and removed. Information will need to flow faster and more effectively within the levels. The vertical integration or continuity from management to production so often required today should be supplemented by horizontal integration. Improved reaction capability will develop on this basis of increased transparency. Faster information means that problems and unplanned events will be detected faster. This makes faster reaction possible and remedial action can be taken faster. With these resources,
production planning can be set up which is characterized by short reaction times and which thus earns its description as a fine planning control system with short control cycles.

With this set of tools, deliveries or services can be modified at short notice in an economic and cost-oriented manner thereby complying with customer for flexibility. But the efficient introduction of changes, a satisfactory level of adaptability to the changing needs of the company, and the ability of existing technologies and systems to be readily integrated also have to be developed and refined in a manufacturing company.

The potential benefits which emerge from these elements – such as better customer service due to improved delivery reliability and delivery capability, as also product quality and information capabilities, cost savings due to inventory reductions, improved workforce position, motivation arising from control of production, and so on – supply decisively important key performance indicators for the current competitive environment.

These three elements in an improvement process – transparency, responsiveness and cost efficiency – have been partially put into practice in industry in recent years. Some advances have been made here, particularly on the level of corporate management. In the commercial departments of corporate management, changes do not come into effect in seconds, minutes or hours but rather in days, weeks or months. The situation is completely different in the field of production management and automation. Many short-term activities are required here and they in turn call for tools that support online ad hoc decisions. Every minute of downtime for a machine or part of a plant costs money. Every minute of these production problems eats into profits. In cases of this kind it is very easy to demonstrate a clear relationship between the benefits and the costs of measures and tools for preventing or reducing breakdowns.

Today, particularly in production management, the aim of “increasing transparency, responsiveness and cost efficiency” means that new paths must be taken and increased effort applied to measures which have already been introduced. One tool which supports these objectives is the so-called MES system (manufacturing execution system). MES is a method that has developed from what tend to be the classic disciplines, such as production data acquisition, staff work time logging, quality assurance and finite scheduling. The homogenized and compacted version of these techniques can be grouped under the heading MES. The aim of an MES is to make the value-adding processes transparent and on the basis of this transparency to create not only horizontal but also vertical control cycles. The cycle time of these control cycles will depend on the tasks being performed and, to take the example of production, be measured not in days or shifts as is normal in a traditional ERP environment but rather in multiples of minutes. In this
way production can react quickly and cost-effectively to meet new requirements.

The present book is intended to throw light on various aspects of MES and the use of MES and should also describe how potentials for improvement can be identified and exploited, even in a heavily automated industry.

1.2 Production structures

The aim of achieving an improvement in economic efficiency is not, of course, a new demand but is rather a permanent process which has increasingly challenged manufacturing industry over the last few decades. In the media we only hear about particularly major pushes made in this direction (such as the case of Ignazio Lopez or jobs being exported from Germany). Alongside the improvement in processing technology and the reduction in material and labor costs, this striving for greater efficiency has initially been met by an improvement in production structures and control methods with the aim of improving the passage of an order through production. For this reason new approaches have been developed in recent years which satisfy demands for shorter lead times and greater flexibility, particularly with regard to the increasing number of product variants. Some of these production structures and control methods will be dealt with briefly below.

1.2.1 Orientation towards metrics

Different factors must be taken into account in the selection of suitable production structures. One important criterion is the production quantity planned. Due to the high degree of automation, the line structure delivers the highest productivity but recouping the high investment costs necessitates producing large quantities over long periods. Other important criteria are flexibility with respect to product change, production of variants, volume changes, work in progress inventory, working conditions, and so on. Here it is necessary to identify the maximum benefits by making an evaluation of the various structures with regard to these criteria.

Shop production

In shop production all machines which carry out the same tasks are grouped together into shops – for example, all lathes and turning machines in the turning shop, all milling machines in the milling shop (layout by machine). In this case the time flow of production is tied to batches. Not until the last workpiece in a batch has been processed are all members of
the batch sent on to the next operation. The result of this in a multi-step process is an unclear flow of material with long transportation paths, queuing and waiting times, large work in progress inventories and poor compliance with scheduled times. Shop production originated in the pursuit of high flexibility and simplified layout planning.

**Production in decentralized structures**

Product- or customer-oriented organizational units are grouped into decentralized structures which include several production stages (the factory in the factory). The objective is to combine the cost and productivity benefits of line or continuous production with the high flexibility of shop production. The assumption underlying the decentralized structures approach is that it is easier to coordinate small units since all of the units needed to carry out the task are grouped together in one area. Decentralized structures can thus be intensively aligned to specific competitive strategies.

**Line flow production**

Here machines and operations are organized in accordance with the order in which a product is processed (layout by product). Due to the fine time coordination and interlinking required for the individual operations (cycle timing) this structure is very sensitive to breakdowns as well as inflexible product variations. In addition, installations of this kind have high investment costs which is why they can be used economically only in large-scale production. Here line flow production does, however, offer the greatest productivity advantages over other production structures since queuing and waiting times, work in progress inventories as well as transportation paths are minimized.

**1.2.2 Control methods**

The selection of suitable control methods depends to a considerable extent on the production structure (for example, shop production or flow production). However, the type of orders to be processed (for example, customer or stock order, quantities, number of variants, spread of the orders, and so on) also plays an important role. In principle a distinction can be drawn here between the push principle and the pull principle.

**Push principle**

The push principle means that production orders are generated in a central production planning and control facility and are then executed in the production department. Examples of push methods of this kind are:
MRP II (manufacturing requirement planning)
The MRP II method developed out of MRP I (material requirements planning) by the incorporation of manpower and machine capacities in calculations. It is used primarily in normal and small series production on the shop principle since multistage production structures require an increased level of planning.

Cumulative number concept
With the cumulative number concept, material movements are recorded cumulatively over time (actual CN) with the aid of a cumulative number (CN) and compared with the planned value (target CN). Use of the cumulative number concept requires large production quantities and a linear production structure. For this reason this method is primarily suitable in full-scale and mass production with line or flow production.

Load-dependent order release
Load-dependent order release was developed in particular for one-off and quantity production on the shop principle of products which have a large number of variants. It regards machines as hoppers whose fill levels (number of orders) are controlled.

Pull principle
With the pull principle, items are only produced in response to a customer demand for them. The customer order generates a requirement in the final assembly department. This requirement in turn generates a requirement in pre-assembly, and so on – in other words, the sales order works its way backwards through production until it reaches material procurement. The aim of the pull principle is to reduce the control overhead and to make production more transparent and less inventory-hungry. Examples of pull methods of this kind are:

- Kanban
  The kanban method is based on autonomous control cycles between a consuming station and a producing station. Here the producing station receives a signal which tells it what parts are needed in what quantity at what time by the consuming station. The signal is given by means of kanban cards. Kanban is used predominantly in mass production on a flow production basis.

- CONWIP (constant work-in-process) is based on the kanban system but still includes the control cycles of several stations found in flow production.

- Synchronous production
  In synchronous production the ideal production line produces with the same work cycles as the customer or in accordance with customer call-
offs. Chaining the work steps means that it is only necessary to control a single process step in the entire process chain. The pacemaker process is the process which is directly controlled by the customer. The aim of this method is to achieve a continuous flow (one-piece flow).

- Agent control
  Higher level IT systems determine start dates on the basis of the customer dates. On the basis of this information, work pieces, installations and transportation systems negotiate the process flow decentrally and autonomously while taking the current state of production into account at all times.

1.2.3 Combinations of production structure and control method

As has already been said, not every control method is suitable for every production structure. In practice the following combinations are encountered:

<table>
<thead>
<tr>
<th>Which control method is suitable for which production structure and can be found as combination in practice?</th>
<th>Push-control, MRP II, BOM etc.</th>
<th>PULL-control, KANBAN, CONWIP</th>
<th>Structured production control decentral intelligence</th>
</tr>
</thead>
<tbody>
<tr>
<td>shop production</td>
<td>+</td>
<td>+</td>
<td>O</td>
</tr>
<tr>
<td>Production in decentral structures</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Line/flow production</td>
<td>O</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Fig. 1.1. Control methods in relation to the production structure (Fraunhofer IITB, 2005)

1.2.4 Weaknesses in traditional PPS systems

Despite some sophisticated control methods, traditional production planning and control has serious weak points in the planning and scheduling of production orders. This is why we can see a trend towards pull approaches. These weak points include:
– Planning with uncertain planning input data (processing times, machine utilization, etc.)
– Planning split too coarse due to planning by the week or at best by the day
– Planning without an updated load horizon
– Missing or excessively late feedback about progress towards completion, faults and so on; this means only delayed control is possible
– Inflexible as regards rush orders or changes in requirements or dates
– Does not take actual capacity utilization into consideration

In the PPS strategies a tendency towards planning can be seen – in other words, towards a one way street principle without feedback. Transparency and responsiveness are thus not achieved. In principle an improvement process involving better planning must end at a specific point. Without real-time confirmation of completion, the control cycle consisting of the production plan and production itself will in the best case be run through once a day since inputs first need to be checked, corrected and incorporated into the new plan.

1.2.5 Function levels

The production structures and control methods considered in the previous section are coordinated and organized by the higher levels in a manufacturing company. For a closer examination it would be advisable to subdivide a company of this kind into its different levels.

Corporate management

The level of corporate management will, of course, be concerned primarily with commercial duties. From sales and design activities emerges product range planning and the associated quantity planning. Once quantity planning has been completed on a customer-, order- or stock-oriented basis, the order release will be given. As a result of this, or even dependent on it, the time scheduling and capacity requirements planning must start for production. In virtually all cases this planning step will be rough planning – in other words, using a rough grid commensurate with the processing time period, the capacities available are examined and also the units to be manufactured on these capacities. On the basis of the information flowing back from production the inputs for the next production period or for the next planning section can be changed if necessary.
**Production management**

Production management receives the order loading and the corresponding dates from corporate management and carries out sequencing and loading planning. This planning step should be referred to as “finite planning”. Here the orders or operations are scheduled out to the available capacities with the most exact start dates possible being determined and passed on to the actual production department. This production management level also includes collection of the production data with whose help a real-time target/actual comparison can be carried out between input requirements and the real information.

All types of resource management are normally carried out on this level. The preparation of personnel deployment plans is a special task which is usually performed by production management. Even quality assurance with its wide range of functions regarding data acquisition and evaluation is normally a task which falls under production management.

**The production level (automation level)**

Machine and system control and also stock control are now assigned to the actual production department. In the same way, transportation control, maintenance and the actual manufacture of goods are tasks for the production level. Further on in this book this level will also be frequently referred to as the automation level.

Within the context of the present book, examination of production management plays a central role. This is where flows of material and of information intersect decisively in a manufacturing company. Production management also makes a substantial contribution to value creation. At this point unsuitable mechanisms may mean that not only no money is earned but also burned.

Production management determines the logistical performance of a company, particularly regarding its responsiveness to market influences. More recent control methods tend to be decentralized and responsibility delegated to lower hierarchy. In this way production management gains more and more responsibility and importance. Inter-company networking in the supply chain management environment takes place today more and more often on the level of actual production or of production management. Within this book this particular arrangement of levels is intended to serve as a model for all types of production departments.
1.2.6 Types of production

Three different so-called production types are to be distinguished. These are: discrete or shop production, process-line production or mass production, and the make-to-order manufacturer or plant and equipment manufacturer. The distinction is important at this point as further on in the book. We intend to show how these types of production require MES functionality. A brief summary of the basic characteristics of the three types follows.

Discrete or shop production

Here we have production orders from a series of operations which in some cases can be regrouped into assemblies. The discrete manufacturer would prefer transitions between his processing steps to be as short and smooth as possible. The availability of intermediate products is an important variable, as is organizing these intermediate products in interim storage facilities. Specific variables here are resource availability and above all flexibility in the processing of orders.

Process lines or mass production

The mass, process or line manufacturer links together his systems and machines to form lines which normally produce large quantities of a product. Flexible changes in order processing are only possible with qualifications. The fact that a line runs permanently is of central importance. Due to the complexity of installations, shifting orders to different resources is often impossible or if so, only to a limited extent. This means that a special logic will also have to be taken into account in production planning.

Make-to-order production/plant and equipment manufacturing

The make-to-order manufacturer or plant and equipment manufacturing typically has comprehensive bills of material which are often processed in manufacturing cells or in dedicated shops. These manufacturing cells have a certain amount of independence which means that sometimes there can be transitions between them which are not time-critical. Depending on the products being manufactured this kind of manufacturer may also have full-scale or small-series production facilities.

The relative closeness of deadlines shown in the diagram is intended to provide a qualitative representation of the different time horizons within which the three levels carry out their tasks. The range extends from long-term in ERP production range planning to virtually real-time or online on the automation level.
1.3 Classic IT support in production

In the early years of information technology, manufacturing enterprises were mainly “controlled” by commercially oriented systems. It was a gigantic step forward to automate classic manually oriented commercial services and to manage bookkeeping, inventory and orders received electronically. In the next stage of this process of automation it was possible to provide some of the above-mentioned production structures and control methods with support from so-called EDP systems. The milestones here were detailed planning of orders, resolution of orders into individual operations or sequences of operations, and the breaking down of products into individual assemblies. Supervisors in production were supplied with lists which contained sales planning information and the customer orders to be produced. Consumption of time, materials and other resources were reported back to the EDP system from production and this information recorded there – a complex method which was also likely to be encumbered with errors. Simpler and better was to send a status report once individual departments started to be equipped with dedicated data collection systems. In this way the EDP side was provided with a production data acquisition facility, the personnel department with staff work-time logging and the quality assurance department with a so-called CAQ system. It was
possible to achieve considerable reductions in the cost of data acquisition and the different expenditures on this could be assigned to individual products or production orders more accurately than previously as regarding their origins.

These mechanisms, however, only covered the tasks to be performed by corporate management. Production management itself continued to be supplied as before with the corresponding lists, order-accompanying documents, material-accompanying documents, and so on. Although status reports no longer had to be manually recorded, checked for plausibility and corrected, they were however only available in a limited scope for production personnel.

As has already been described in our first section, there have been drastic changes in recent decades in the requirements made of the production department. Process instability and the compulsion towards fast change have an effect on the manufacturer to position his production close to an economic optimum. They demand that he has a powerful information management capability. If the manufacturer cannot provide these capabilities fast enough, the result will be inefficient business processes which in turn lead to poor on-time delivery performance, poor delivery times, unsatisfactory product quality, long lead times and excessively high inventory levels. In this regard, ERP/PPS systems have retained a high proportion of their old characteristics even until today. They do not, for example, support hierarchization and separation into levels as would be required in a production facility. The focus of all instances of optimization relates to planning – in other words, the "one-way street principle" and neglects control capability. Even now, the control cycles of an ERP system are longer than a shift while the production scheduler on the spot actually needs control cycles of the order of several minutes. Control cycles this fast are not to be found in an ERP-supported manufacturing organization. For this reason open control chains are predominant. The information flowing back from production is in some cases not available in a processed form until the next shift which means that it cannot be used as online information by the persons in charge in production.

Certain aspects of this problem area are defused into APS functionalities (Advanced Planning and Scheduling). Here the control cycles do not even last a week but can be reduced to one or two days. However even with APS we still are faced with the problem that control mechanisms within a shift or a day are only possible to a very limited extent and that the focus still remains on load planning and less on the control of production.

What we can compare with the APS functions are industry specific control stations. Here planning can be carried out not only almost in real time but also oriented to a certain extent to the technology. A typical control
station takes into account aspects relating to the particular branch of industry such as, for example, the color sequence in injection molding or the suitability of tools and machine combinations for producing specific articles. But this control station approach still can only deliver a limited amount of improvement. If the current actual situation is not included in the corresponding new planning, we do not have a control facility here but rather a planning facility, as previously. If ERP-based planning is referred to as rough planning, the use of APS or control-station–oriented planning means that so-called detailed planning can be achieved.

More detailed and dedicated functionalities, such as online display of current states, display of utilization ratios, online interpretation of registered and unsatisfactory qualities, and also the display of incorrect states are missing in control station. Evaluations which tell you tomorrow what you could have done better today are only of interest in a statistical respectively historical view.

At this point even the term “transparency” takes on a new meaning. Transparency in modern production no longer only means the ability to comprehend past history without omission or gaps and from this to derive recommendations for future actions. Today, transparency also means visualizing realities in real time, drawing conclusions from this, and then communicating recommendations to the appropriate persons in order to put an immediate end to incorrect states.

1.4 Manufacturing Execution Systems (MES)

1.4.1 Emergence of the MES concept

The origins of the MES concept are to be found in the data collection systems of the early 1980s. The various disciplines in corporate management such as production planning, personnel, and quality assurance were furnished with dedicated data collection systems. This situation is shown in the following diagram: task areas which are almost mutually independent are equipped with special data collection systems.

With the rise of the CIM concept (Computer Integrated Manufacturing) a start was made on reproducing the interdependencies of these task areas in the IT systems as well. Production, personnel and quality were no longer seen as completely independent but rather data crossovers were permitted from one task to another. Unfortunately this approach, correct as it was in principle, did not emerge as a real and strong IT discipline. Trivialization of the problem definition and a misuse of the term by smaller system vendors in the sense that with time every data collection terminal
was labeled a CIM system. In this way CIM had spoiled its standardization potential as a problem-solving IT discipline for production. In the early and mid-1990s the manufacturers of data collection systems commenced upgrading their in some cases specialized systems (labor time, PDA, CAQ, DNC, and so on) by adding features from associated fields (for example: staff work time logging with PDA, PDA together with MDE). With a small number of combination systems of this kind it was already possible to put together a data collection (and sometimes a data evaluation) system for many functional areas of a manufacturing company. The system components were, however, independent of each other and synchronizing them required major work on interfacing. Over the course of time three groups of data collection/evaluation systems formed. From the independent data collection systems, combination systems emerged, some of which performed several tasks. All in all, the functionality of these combination systems describes the functional scope of MES today:

- For production matters: PDA, MDE, DNC, control station;
- For personnel matters: staff work time logging, access control, short-term manpower planning;
- For quality assurance matters: CAQ, measured data acquisition.

In the real world of production these three task areas cannot be separated from each other. Production accordingly needs suitable personnel to
1.4 Manufacturing Execution Systems (MES)

Fig. 1.4. MES integrates originally separate data collection systems

Fig. 1.5. Mutually independent data collection systems were networked and in some cases connected to corporate management and automation via uniform interfaces
be able to produce and must know as fast as possible about the level of quality it is producing. If mutually independent systems exchange their data via interfaces or if data exchange actually takes place via systems on the corporate level, too much of the time is lost which really ought to be available to allow an effective reaction. Therefore the demand arose that systems must be more connected or even horizontally integrated. To point out straight: only a few systems available on today’s market support this kind of deep horizontal integration.

Networked data acquisition and evaluation systems make it possible to homogenize data exchange with the ERP system or with the automation level. Here data is received from or sent to external systems via standardized interface mechanisms. Provided these basic conditions of networking and of unified interface technology are satisfied, data collection systems are already coming close to the MES concept. Systems of this kind thus support manufacturing operations by complying with the so-called 6 R’s rule which states:

A product will not be created in the most economically efficient manner unless the right resources are available in the right quantity at the right place at the right time with the right quality and with the right costs throughout the entire business process.

If the networked data collection systems are supplemented with elements of quality assurance, document management document preparation and also performance analysis, the whole can already be regarded as a powerful MES system. It is now possible to evaluate unexpectedly arising production problems to be evaluated in real time and with the appropriate counter measures. As long as this condition is not satisfied cannot have a well-grounded production control system on the basis of an online image of production. Figure 1.6 shows technology- and situation-dependent decision-making requirements as a function of processing time. The more closely the delivery date for an order approaches, the higher will be the requirement to make “corrector” decisions faster and as a function of available resources. This is therefore less a planning task but rather one of short-term control, and this shifts the responsibility from the ERP to the MES level. Accordingly, at the beginning of processing, the ERP system plans an order load on the basis of an average capacity. The extent to which planning decisions are dependent on situations or technology is relatively low. The closer the delivery dates of an order load approach, the more it will become necessary to make adaptations in response to unforeseen problems. The closer the delivery date approaches the more this control function will be dependent on technology, situation and remaining capacities.
1.4.2 Current standards

The subject of MES has been taken up by a number of institutions which are attempting, to protect the term MES against trivialization. Various implementations types may be found and in the present context only the two most important ones here. MES for the process industry and MES for discrete industry. In the first case, machine and plant control systems will form a very great part of MES. In the second case, MES is more an online information system, a feedback and control system for production. Of the attempts to achieve standardization which we have mentioned, only a few need to be discussed here:

MESA

MESA (Manufacturing Execution Solutions Association) already has the concept as part of its name and as the first organization to adopt this concept is probably the most experienced to report on it. MESA’s approach here is a very pragmatic one and describes twelve function groups which are required for an effective support of production management. These function groups are: