Integrated manufacturing of high-standing dresses for customised satisfaction

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Abstract

The paper investigates the prospects of extending intelligent manufacturing in the field of clothing industries. Actual facilities lack behind the currently exploited options of automation, already in use for most of the business, as effectiveness is hunted for by productive break-up, moving outside labour intensive phases. The investment cost in computer-integration, indeed, is possibly partially recovered with productivity and, much more, by production quality.

Keywords

Garments production automation, virtual reality simulation

1 INTRODUCTION

The European apparel manufacture is asked to accomplish a complete upheaval to win back competitiveness in world-wide markets, with buyers requesting customised dresses and garments, facing continuously changing fashions and advertising/selling frames with quick evolving supporting technologies. Textile and clothing industries have, up now, exploited to a very small extent computer integration and the principal material flow (from fabrics and supplies, to suits and

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apparels) runs separately from the conditioning information flow (from ideation and management, to production and communication). The situation is particularly critical in the area of high standing suits, which are marketed with a relevant added-value, pertaining to aesthetic features and promotion images for consumers' satisfaction (Adam *et al.*, 1996).

To day, the transparent monitoring of value forming, by respect with cost build-up, cannot be neglected: · to anticipate achievements or drawbacks of competing strategies; · to evaluate the effectiveness of the actually selected development policy; · to establish current enterprise forecast. To bet on intelligent factory, the dresses industry is lagging behind by respect of most enterprises, with cautions and qualms, also, risen by highly qualified business of the field, since the innovation would mean to transform a (still) very work-intensive process into a (mainly) technology-driven one, without clear acknowledgement of the return on investment.

Presently, in fact, many firms look for competitiveness through extended break-up, separating not only styling and designing, but even segmenting the processing, so that the most work-intensive phases (such as sewing) are decentralised where the operators wages are smaller (House *et al.*, 1996). The overall business becomes effective for ready-made suits or dresses standardly replicated and delivered according to season's batches for predictable (and large) amounts of items. Small betterment to flexibility is eventually obtained enhancing 'quick response' techniques and using telecommunication for the on-process management of the extra items, timely manufactured to personalise size and details of current orders. Now, the ability of monitoring quality build-up and of recording the transferred value, shall be said, might be consistent with the productive decentralisation of self-sufficient sub-assemblies; it is quite questionable in front of the break-up of production cycles serially required for single artefacts (such as customised dresses) and the resulting business will hardly provide reliable 'added' value, with concern to the quality of the personalised items.

The paper is reconsidering the all track of the fitness-with-purpose production for consumers' satisfaction, exploring the option of rapid and virtual prototyping with distributed resources based on integrated information and on collaborative design-and-manufacturing. At the moment, these inter-related opportunities have separately been examined and the achievements, which might ensue, need be assessed, before stating the reach of actually integrated solutions.

Automation, in fact, faces more problems in clothing manufacturing than in many other industrial areas, because of many peculiarities, such as the limp behaviour of fabrics, the need of creating 3D shapes by the adaptive warping 2D pieces, the wide range of skills used during the process and, in general, the lack of standard work-cycles, uniquely assessed by sequence of elemental actions and, on the contrary, the large resort to craft and training of expert operators. Thereafter, to satisfy changing market's requirements, the automated systems would be required to possess broad dexterity, efficiency, flexibility and versatility figures and the equipment setting and resetting should be comparable, as commitment and time, with human adaptivity.

In the practice, experimenting on real set-ups becomes quite demanding, to be in position of granting effectiveness. Then the innovation is first better investigated by expert simulation, (Acaccia *et al.*, 1988, 1997, House *et al.*, 1996, Imaoka, 1996, Kalta *et al.*, 1996, Leung and Tyler, 1994, McWaters and Clapp, 1994, PenistonBird, 1994, Rosser *et al.*, 1991, Tyler *et al.*, 1994), based on a functional model of the manufacturing resources behaviour, when engaged to perform actual work-schedules. Besides, in the modern production engineering, the 'expert' simulation is used aiming at the 'intelligent' factory, at the design/development stage and at the management/fitting stage of the facilities; at the first stage, resources setting is established according to the enterprise marketing strategies, thus, the production programmes are stated aiming at granted throughput and due time; at the second stage, production schedules are selected to face planned (order's entry itemisation) or unpredictable (failure yield) discontinuities with effective exploitation of the resources versatility.

The example development, discussed in the paper, deals with the manufacturing of quality suits. The process description has been based on a modular lay-out, in order to separate the effect of the many influence quantities and to make possible the investigation of details, while preserving the overall view of the business. In fact, as previously pointed out, the 'intelligent' factory setting is not yet popular by the clothing industry and might, possibly, be introduced gradually, only for subsets of the processing operations. The simulation results are, thereafter, specifically particularised with focus on the laying and cutting phases, where the automation has already reached reasonable acceptation. The study is pushed up to assess facilities with different levels of integration, since today plants are highly conditioned by contingencies which might frustrate expensive changes, when the actual options are left un-exploited.

2 THE APPAREL MANUFACTURING SPECIFICATION

Aiming at intelligent manufacturing facilities, the functional description of the process plans and of the (physical and logic) resources evolution needs be detailed, with account of each relevant factor. The existing technical literature (Adam *et al.*, 1996, Acar, 1995, Berkstresser and Hunter, 1995, Bowers and Agarwal, 1993, Chen *et al.*, 1992, Leung and Tyler, 1994, McWaters and Clapp, 1994, Postle and Postle 1994, Rosser *et al.*, 1991, Stylios *et al.*, 1994, Tabucanon and Estraza, 1989, Tyler *et al.*, 1990), already provide the basic precepts. The reference concepts of intelligent manufacturing are, in fact, properly assesses (Michelini *et al.*, 1992), with the many industrial applications (Michelini *et al.*, 1997) showing the return on investment, at least aiming at machines and mechanical items production; in these areas, the options disclosed by the integrated management of, both, material and information, flows provide a substantially different approach for the enterprises' competitivity, as compared to the earlier "economy of scale" of mass production, namely the new "economy of scope", supporting just-in-time schedules, with flexible production plans and varying artefact mixes for customised delivery.

Textile and clothes industries, as said, still prefer to preserve high-intensive direct human work, with fragmentation of the material flow; qualified businesses, perhaps, look, nowadays, to computer aids, aiming at information flow automation to oversee the material procurement, the marketing orders, or, to a lower extent, to rule the shop floor schedules. These aims are certainly reductive. Suits manufacture is asked to face demanding challenges, with pressure on prices, item customisation, fast changing fashion, etc., by means of strategies based on certified quality, large product mixes, quick response with reliable due-dates, etc.. Here too, economy of 'scope' might replace economy of 'scale', according to sets of actions (Michelini *et al.*, 1994) such as: flexible specialisation, lean engineering, company-wide quality, continuous betterment, etc., which happen to be enabled by knowledge intensive organisations, supporting: - integrated control and management; - flexibility exploitation at the strategic, tactical and execution levels; - removal of resources redundancy; - etc., so that return on investment is sought, by the transparency of the productive cycles, optimising the plant effectiveness with the build-up of artefacts' value at buyer's satisfaction.

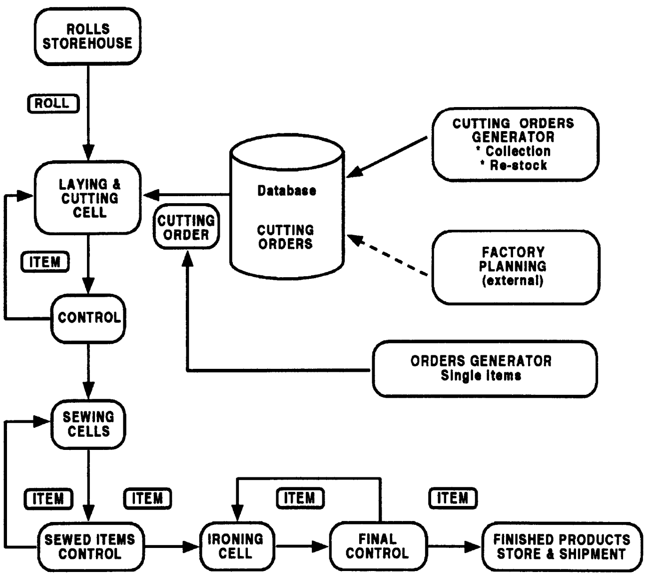

Figure 1 - Structure of the simulated plant

The habit of the productive decentralisation, looking after low-cost labour for the manufacture phases requiring manpower concentration, turns out achievable goals, such as steady high quality apparel with customised variability. Indeed, the 'creation' of high-standing dresses includes skilled labour mainly at the ideation phases and the strategy of keeping the 'critical' jobs inside, while distributing outside the labour intensive cycles can only be pursued for prompt returns; on middle to long horizons, on the contrary, a throughout analysis of these enterprise's policies might issue unwonted surprises, in fact:

- the design has technology unitariness (productive decentralisation grants return, when several technologies are integrated into complex artefacts);
- the final products require quality features strictly embedded at each work-cycle step and addition of overall approval tests is against the economy of scope precepts;
- the enterprise's know-how cannot be protected, as the quality checks need be distributed over the process, with risk of cooperating to rise trained competitors;
- the marketing organisation advantages, based on 'quick response' set-ups, cannot be conceived, due to material dispatching delay and enterprise's logistic ruling.

The integrated manufacturing alternative, with the drawback of requiring material and human resources innovation, offers practical advantages, on condition that:

- the work-cycles and the production plans are balanced, on the strategic horizons, with proper exploitation of all available resources;
- the monitoring maintenance of the manufacturing process is followed up, for steady quality of the zero-defect production;
- the integrated control-and-management of the plant versatility is exploited to deliver the product mixes with just-in-time schedules, within the clients' due dates;
- the simultaneous product-and-process upgrading is carried over, having transparent assessment of each intermediate achievement.

The reach of each conditional feature is acknowledged by ‘intelligent’ manufacturing as a all; textile and clothing manufacturers’ challenge is open, to look for actual set-ups, winning world-wide primacy.

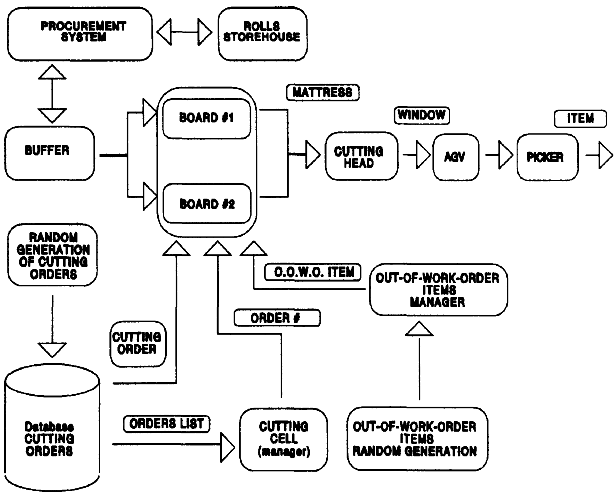

Figure 2 - A laying & cutting cell (functional model)

2.1. The process functional description

Aiming at integrated manufacturing set-ups, computer simulation is a reference support, with twofold purposes: - during the development stage, to acknowledge the production capabilities between competing facilities, in order to select the lay-out better suiting the enterprise objectives; - at the life-long stage, to evaluate the fabrication agendas performance between competing schedules, in order to adapt the plans to the highest effectiveness. The purposes require detailed functional models in order to work a quantitative description of the time evolution of, both, the physical and the logical resources. These models are conveniently dressed with a modular architecture, using, for instance, object oriented coding, in view to make easy the addition, removal or modification of individual functional details. The present study is organised this way, reserving the attention at the shop-floor description and using the MODSIM II language. The resulting simulator, LCX-SIFIP, will accordingly supply the analysis of the complete manufacture, Figure 1:

- fabric warehouse, with related sorting, dispatching and buffering facilities;
- laying stations, with local storing, addressing and handling fixtures;
- cutting units, with suitable picking stocking out and forwarding equipment;
- sewing sections, with proper delivering, feeding and collecting rigs;
- pressing stations, with annexed fitting out and latching/unlatching devices;
- apparel warehouse, with appropriate checking, packing and shipping set-ups.

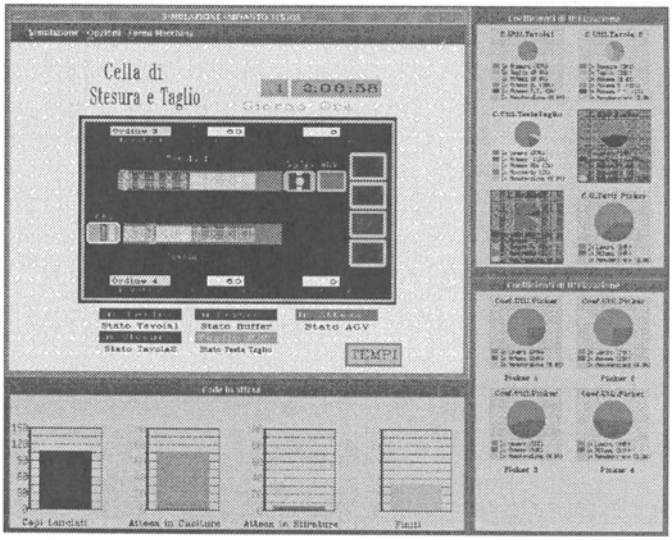

Figure 3 - Simulator's graphical restitution of cell current parameters

Computer integration provides visibility on the current evolution of each resource so that up-dated information is continuously available to adapt the production plans, in relation with the product mix timely on process and with the desired due dates. The option is exploited to make possible the interlaced processing: · of the sorted out batches, according to optimal schedules on the tactical horizons; and: · of one-of-a-kind items, according to customers driven orders, within the span of the executional horizons (granting 'quick-response' reactivity).

On these premises, the product programming could afford to operate with just-in-time organisation and 'optimal' schedules on the tactical horizons, while managing the material procuration as needs arise and dispatching the workpieces depending on the resources availability with a supervisor of job-shop logistics, to make feasible one-of-a-kind artefacts, with due exploitation of the plant versatility.

The concurrent exploitation of the flexibility:

- at the organisational range, to select the over all product mix variability on the strategic horizons;
- at the co-ordination range, to optimise the product batches and fabrication agendas on the tactical horizons;
- at the operation range, to deal with discontinuities (single items order or unexpected misfits) on the executional horizons;

requires a properly sophisticated govern framework. Aiming at factory automation, the different ranges are enabled by the suitable blocks, namely, by: · process attuned managers, · decentralised controllers; · real time supervisors. The govern actions are selected by an 'expert' module, yielding decisions according to plausibility ranks, by means of heuristic rules and qualitative reasoning. The number of feasible options is generally quite large and the effects of (strategic, tactical or execution) flexibility are so cross-coupled, that company-wide descriptions most of the times rise at levels of high complexity to understand the actual reach of each decision.

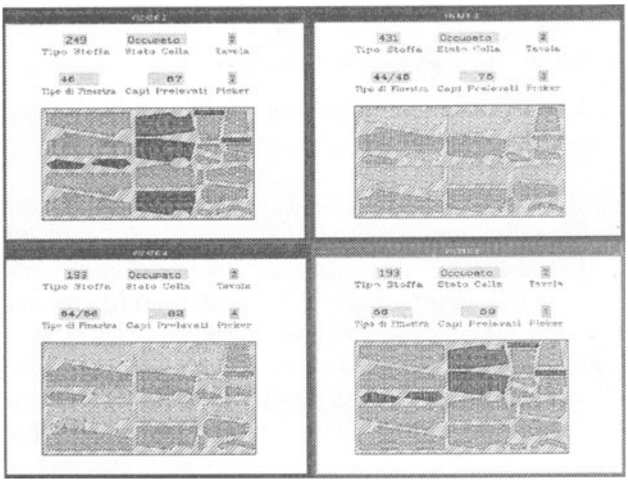

Figure 4 - Some snapshots of the cutting table

For practical reasons, the investigation is better tackled, by separately analysing the different segments of the manufacturing cycle, in order to reduce the degrees of freedom of each influence factor. The Figure 2 gives the functional model of a typical laying and cutting section, provided with the local storing for fabric rolls and two tables for the unwrapping, each one alternatively feeding a cutting head.
The batches are arranged beforehand and the material sorting and fetching is accordingly programmed; nether-the-less, additional one-of-a-kind items have to be processed, depending on customers' orders. Therefore extra locations in the local storing and on the laying table are left to accept the 'unscheduled' occurrences, once the requests are enabled. The ratio of extra-items as compared with overall batch amount is an important feature, characterising the kind of artefacts quality and the business policy, in view of the flexibility exploitation.

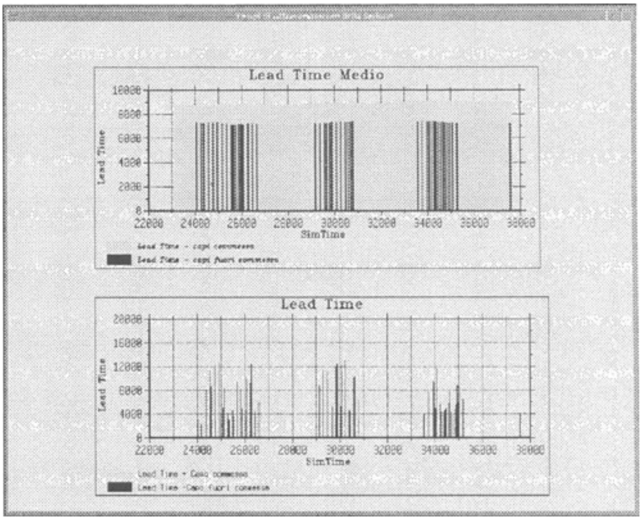

Figure 5 - Diagrams showing productivity statistical indices

By simulation, different options can be compared. The LCX-SIFIP package is oriented to a segment of the manufacturing cycle, using the interfaced information flow to rule all process. A given enterprise might include several laying and cutting sections, properly attuned for a set of subsidiary aims. The sections are fed by centralised warehouses, whose information system provides the continuously updated picture of the current situation, including, for instance, the misfits mapping of the each fabric rolls so that, during unrolling, the information is duly exploited to select the unwrapping sequences with the best exploitation of the fabric. Downstream, the sewing sections, normally, characterise by longer processing time, thus the material flow has to branch off, distributing the pieces among several parallel units. Today, this segment is concerned by different approaches, including, as said, the productive decentralisation to regions with low wages. Cost monitoring has to face: material logistics, quality control and work cycle duration, on one side; and: investments in flexible automation, on the other side, before establishing the effectiveness figures and the return perspectives of actual implementations.

3 EXAMPLE RESULTS AND CONCLUSIONS

The relational frame aiming at computer simulation includes the functional description of the material transformations with the behavioural specification of the steering logics. With manufacturing based on (large) batches, sometimes, produced one season in advance and distributed to vendors with preestablished mixes, very little is expected to be adapted on process, mainly dependent only on unwanted occurrences (resources failures, procurement troubles, etc.). Then the visibility of the facilities current behaviour and the assessment of the investments return vs. the actually enabled production programmes do not rise to the level of criticality.

Aiming at high-standing dresses with one-of-a-kind product organisation and customised satisfaction, quick-response and total quality become demanding requisites to win the competition in a world-wide market. Intelligent manufacturing rises among the options with consistent coverages and computer simulation turns to reference means for developing and acknowledging the appropriate set-ups and the effective schedules.

Few results obtained with the LCX-SIFIP package are given to exemplify the recalled proposition. The Figure 3 shows a typical display of the graphic interface of the simulator, with a window the laying situation of a table and the cutting situation of the other; different statistical indicators provide the utilisation ratios of the resources and the existing queues at the sewing and at the pressing sections.

The Figure 4 gives a view of the cutting table, with the lay-out of the items ready for the stripping and collection to sorted packages to be forwarded to the sewing sections.

The basic outputs of simulation, Figure 5, provide information on the average lead-time and on the current figures, with estimate of work-in-progress situations by respect to resources availability. The simulator, further, embeds specialised restitution blocks for investigating the influence of differently setting the resources or modifying the process programming.

Sample studies have been performed (and will be discussed in the presentation), considering, in function of the percent ratios of the single items by respect of the overall batch amount:

– the utilisation figure of the local fabric rolls storing, Figure 6.a,
– the utilisation figure of the (translating) cutting head, Figure 6.b,
– the current number of items actually laid down, Figure 6.c,

– the current number of items actually cut through, Figure 6.d,
– the overall productivity (items per hour), Figure 7,
referring the above characteristics to the number of locations of local buffers, as a total or as a reservation ratio to one-of-a-kind dresses. The investigation can be prosecuted using many other reference parameters, such as: · the length of the laying table (as a whole and as attribution to extra items); · the number of superposed fabric layers and the amount of apparel sizes allocated for each laying cycle; · and so on.

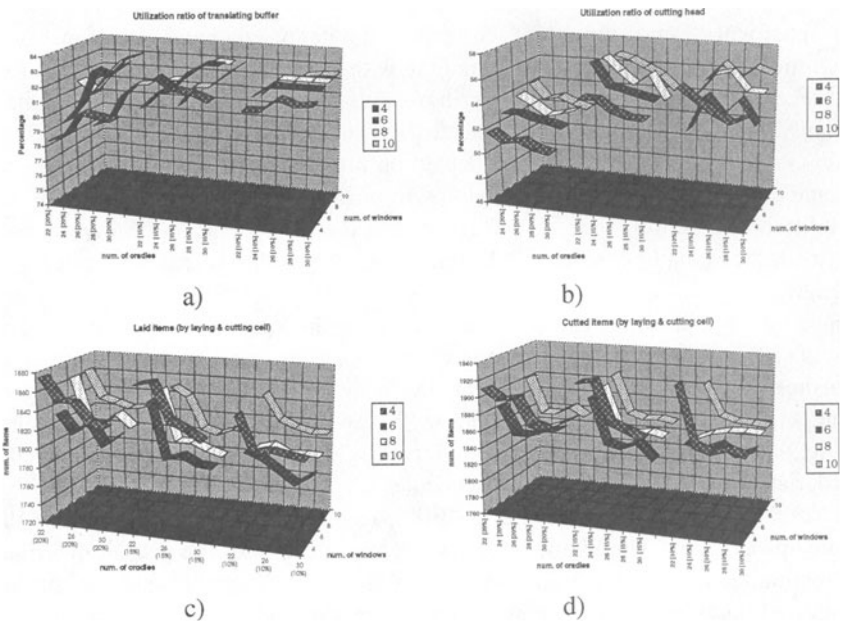

Figure 6 - Utilisation of buffer (a), cutting head (b), laid (c) and cut (d) items

The study is readily extended, for combining each *selected* behaviour of the laying and cutting section with the other sections of the plant; the build-up of the reference knowledge progresses, covering every situation of actual interest. On that background, the information gathered by simulation supplies checks about the feasibility of given enterprise's policies, assessing the effectiveness of alternative strategies with indication on the responsiveness in terms of product mixes and due dates. The potentialities of the production plans based on 'intelligent' manufacturing are accordingly ranked and the return on investment is forecast for each given enterprise policy.

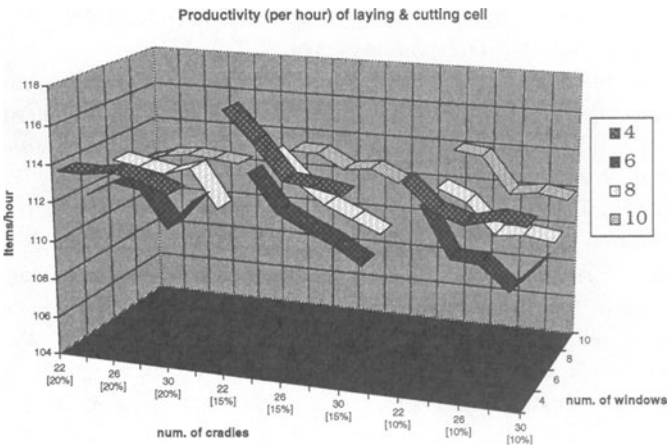

Figure 7 - Overall productivity of laying & cutting cell

The presentation is developed to introduce of the capabilities of the economy of scope, in a world-wide context where the work-division is more and more established on the objective separation according to technological range. The competition between enterprises would issue from monitoring the value added with manufacturing in connection of actually sold apparel, rather than pre-setting the production batches and running after buyers, with advertising or by lowering the selling prices. This might be insufficient for high-standing dresses, as buyers require personalised quality and quick service. The discussion offers hints to look for the integrated manufacturing approach. Whether this different set-up is accepted, the simulation aid supports rapid and virtual prototyping, involving the co-operative interest of distributed teams and of distributed manufacturing with low-cost studies and extended comparative assessments; the tool is, then, to be used for the life-long assessment of the most effective production plans and for the timely upgrading authorised by the adaptive exploitation of the flexibility on each different (strategic, tactical or execution) range.

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