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LIFE-STYLE DESIGN DRIVEN ECO-PROTECTION

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The eco-protection acts imply reorganising the manufacture business, towards product-service supply chains. The innovation can be tackled at two ranges: - the presetting of the knowledge management surroundings, to deal with the extended producers' responsibility; - the incorporation of the entrepreneurial facility/function assembly, to accomplish the product-service delivery. The paper surveys the knowledge management frame, specifying the standard PLM aids, with account of the PLM-SE and PLM-RL requirements, giving especial attention on the alternative net-concern options, from virtual, to extended enterprises infra-structures. For explanatory purposes, the study discusses example extended enterprise deployments, and related knowledge management frames, for SE applications ruled by SME contexts; and examines example virtual enterprise settings, with related information networking requirements, for RL applications, according to the EU enacted rules for the ELV recovery (reuse, recycle) domain. The developments relate the impending changes, needed by the current manufacture business, today, perhaps, too much neglected, by most industrial companies, due to incumbent economical vicissitude. The competition, however, is ceaseless spur, and the axiom innovate or perish should suggest to consider the eco-protection acts, rather than charges, the opportunity to reorganise the manufacture business, with the suited incorporation of intangible value added.

Keywords: Knowledge management. Lifestyle design. Product-service. Reverse logistics. Service engineering.

1. INTRODUCTION

The industrialised societies face greater challenges than ever, to keep the growth pace, due to globalisation (competition of lower wage countries, etc.) and to sustainable growth (exacting regulations to preserve eco-conservativeness, etc.), [Lovelock 2009], [Popov 2009], [Schmidt 2005], . For higher effectiveness, several major changes in product design are needed, with focus on lifelong properties and on recovery opportunities. These paradigm shifts modify the relative weigh of the design phase, compared to the production phase, as, in the past, return on investment was mostly won by manufacture *internalities*, once pre-set optimal off-process choices. Now, the demanding figures, linked with product on-duty and disposal features, turn the enterprise competition on the lifecycle *externalities*, so that the shop productivity is side-effect, compared to the overall supply chain effectiveness.

The ongoing trend leads to expand the manufacturers' responsibility, from the *point-of-sale*, to the *point-of-service*, to support the conformance assessment duties, as for safety and environment protection acts [Muñoz 2009], [O'Neill 2001], and to the *point-of-disposal*, to comply with the enacted recovery, recycling and reclamation duties [Wang 2006],. This means to deal with the provision of *products-services*, where the *additions* correspond to the mostly intangible frames, going together with the (material) supply chains, to warranty the scopes achievement, at clients' satisfaction and environmental safeguard, [Antonelli 1995], [Borg 2004], [Friedman 2005], [Mihailovich 2009], [Morin 1999], [Nevins 1989], [Parsaei 1998].

The design steps, then, become critical: to optimise the lifecycle performance, to increase the profitability, to enhance the delivery quality, to respond to the regulatory drivers, to satisfy customers, stakeholders and third parties, up to face the manufacturers' responsibility for the whole supply chain. This requires reconsidering the design duties, [Veleva 1996], by exploiting proper decision skills that cut across the manufacture business, to concentrate the efforts on the *additions* appearing after the *point-of-sale*, and to integrate prospects over the whole supply chain, addressing on-duty service and reverse logistic views, with full business coherence, [Leondes 2000]. The knowledge management is winning way, to improve the enterprise value chain awareness, achieving the unified accountability of the items' on-duty and end-of-life marks. The provisioning, manufacture, operation, maintenance, disposal and recovery figures are tested and assessed by virtual prototypes. As compared to the early industrial habits, when competition was won by the off-process presetting of optimal production plans, today, the decision support is required to run on-process, aiming at, [Blumberg 2004], [Michelini 2010]:

■ features-customised products, with warranted lifelong performance and acknowledged call-back;

■ total-quality manufacturing effectiveness and robustness, with minimal environment impact;

■ standard servicing for conformance-to-use, made available as voluntary agreement integration;

■ recovery (reuse, recycle) provision, when prescribed by the enacted eco-consistency regulations.

The conventional manufacturing business requires the full rethinking of the engineering paradigms, forcedly obliged to look at the on-duty performance and at the end-of-life requirements, as main features guaranteeing competitiveness, based on the service *externalities*, as compared with the old process *internalities*. The need to look at the overall supply chain follows the established trends of the economy of scope. The vertical flow-shops are replaced by horizontal job-shops, incorporating non proprietary facilities and technologies, with resort to out-sourcing and to productive break-up. The manufacturing functions (strategic positioning, market assessment, risk management, resource planning, quality deployment, engineering trimming, shop running, work-flow scheduling, factory management, productivity monitoring, performance evaluation, finance/cost managing, etc.) become interlaced worry, with commitment and liability distributed among the associated partners. The suited set-up is forcedly achieved dynamically, through co-operative efforts, and after facility choice, [Jacucci 1998], [Mo 2001], [Rautenstrauch 2001], [Sherman 2006], [Womack 1990], [Zaremba 1994].

The enterprise competitiveness will turn, from the capability of offering new products (fit-for-purpose to the *individual* necessities), to the ability of providing the added services, granting the expected functions to the buyers' satisfaction and better tangibles effectiveness (fit-for-purpose to *general* protection). The emerging knowledge management aids, now, are, [Lambert 2004], [Schoensleben 2004], [Stiglitz 2007]:

■ the presetting of *product lifecycle management*, PLM, tools, offered as standard design out-fit, [Wenzel 1997];

■ the provision of *service engineering*, SE, aids, as diagnosis, decision and maintenance support;

■ the execution of *reverse logistics*, RL, accomplishments, when requested at the items' end-of-life.

The business widening, around the lifelong performance, is sought with resort to enhanced PLM tools, with *federated* architecture, assuring unified access to the value chain issues. The integration of the lifecycle *view* (structure and function layout, fabrication process, quality certification, maintenance policy, disposal duties, etc.) into a *super-model* is competitive advantage, to upgrade the manufacture activity. These PLM tools are winning options, to fix the divide, favouring value added deliveries of high technology countries, [Best 2001], [Dreher 2008], [Forey 2004], [Steingart 2008], [Suhas 2002], [Tzafestas 1997], [Wingand 1997].

The PLM aids enable to conceive, build, deliver and support enhanced supply chains, if the knowledge flow is efficiently project tailored. The mere *problem solving* capabilities happen to be illusory, when these do not link with real market onsets and with environment needs, driven by emerging business paradigms. Focus on the value chain requires high attention, as the lifestyle design shall develop as collaborative frame, allowing the designers to work closely with suppliers, production partners, customers and conformance certifiers, to obtain valuable inputs, each time ranking the achieved issues with factual returns, [Muller 2001].

The paper directly deals with the eco-design knowledge management tools, in view to develop right lifestyle information surroundings. Indirectly, the underling entrepreneurial settings are appraised, based on assembly the needed facilities/functions, timely adapted to the current product-service provision. The net-concern help is the winning knowledge management support, distinguishing dissimilar infra-organisational options, from the *virtual* enterprise lay-out, where independent partners collaborate to the common project, to the *extended* enterprise set-up, where the leader manufacturer establishes and co-ordinates the actual supply contract. The co-operating structures are motivated by the extended producers' responsibility. The former situation is apt answer, when the eco-regulations are ruled on voluntary base. When compulsory eco-targets are required, the latter allows reaching better performance, when the design-for-service or the design-for-recovery is standard manufacturer's option, ruled by the resource manager, as current internal duty. In general, however, the two *virtual* either *extended* organisations, today, depend on how the single enterprise is aware of the changes, and is capable to incorporate the *externalities*, as necessary completion of the traditional *internalities*.

2. ECO-ENGINEERING SCOPES

The market of manufactured goods evolves towards knowledge-intensive deliveries, with largest value added in intangibles. Companies' competition establishes at the ideation/development stage, to conceive customers' tailored offers with comparatively effective performance, reached along the lifelong operation and call-back stages. Basically, the business profitability requires lifestyle knowledge orientation:

- ■ off-process decision support instruments, assuring the design and development of the deliveries;
- ■ on-process monitoring and managing aids, assuring the lifecycle and recovery prescribed charges.

Extended organisations, based on co-operative networked infrastructures, are the chief instrumental aids to rule and manage the business to manufacture and to trade the *products-services*, at on-duty and end-of-life coverage. Suitable modelling and simulation tools need to be available, backing the on-process information flow, to provide the assessment means for the operation testing, accomplished on virtual prototypes.

More specifically, addressing the product conception and acknowledgement tools as off-process decision support, we might distinguish four domains, **Fig. 1**, in-progress tackled by the basic integration steps.

■ product specification, leading to proper performance, selecting, by CAD, CAM, etc. tools, the producibility figures, operation constraints, disposal requirements, etc., of the forecast *product-service* delivery;

■ process specification, leading to improve the manufacturing effectiveness by the simultaneous engineering practice of the product-and-process mutual betterment, through pace-wise up-grading;

■ eco-consistency specification, leading to establish regulation, maintenance, restoring, etc. plans, for on-duty conformance-to-use, and to call-back and recovery plans in keeping with the enacted rules;

■ enterprise specification, leading to adapt the productive infrastructure, which support the supply chain with resort to the facility/function integration, matching the in-progress requested *externalities*.

Figure 1: Knowledge manager: basic integration steps

The outlined eco-driven innovation requires the lifestyle knowledge orientation, grounded on design supports allowing the supply chain transparency, through considerably up-dated business paradigms. The engineering paradigms do not establish as self-reference proposals, rather they develop to face current demands. The EU environmental policy, to foster more eco-conservative behaviours, is enacting series of Directives, requiring conformance-for-use assessment at the point-of-service, and mandatory recovery targets for the end-of-life products. These acts, moreover, joined to producers' *responsibility* for the free take-back of mass-produced durables (such as household appliances and cars), lead to restructuring the industrial businesses, because the competition is ruled by the *externalities*, depending on the supply chain lifecycle performance, rather than on the conventional *internalities* of the production technologies.
The innovation is dependent on the design phases and on the knowledge management for the product eco-modelling, up now still hampered by severe restrictions, such as:

■ creation of tools requires sophisticated skill and domain practice, mainly aiming at specific purposes;

■ technical aids are dealt with as problem-solving skill (with negligible cost/benefit economic concern);

■ the issues are not openly shared, rather protected as proprietary assets (out of limited side-views);

■ current modelling addresses one domain, and knowledge transfer requests engineer's intermediation;

■ complex products requires multiple models, mostly not combining together to yield integrated views;

■ the capture and reuse of a product knowledge and data require high ingenuity and oriented training;

thus, in general, little capability exists to exploit the product models to investigate the lifecycle interactions, unless for single constraints, separately acknowledged through special purpose descriptions.

2.1 The lifestyle design knowledge

The lifestyle design is critical because of the lack of univocal technical leading strings, due to the relevance of the *externalities*, having socio-political spurs. This distinguishes the concept, by respect to the traditional process- or product-innovation, when higher efficiency is achieved by scope economy grounded on technical expertise. The emerging engineering paradigms, leading to eco-design issues, are motivated by *externalities*, namely, the demands fixed by the environmental acts, and managed by the original manufacturers, after up-grading their business organisation, to incorporate every facility and function, required by the in-progress supply chain. The driving motivation, out of the *process*- or *product*-innovation, happens to be fostered by *enterprise*- or *environment*-innovation, meaning that totally new industrial settings are needed, [Allenby 1995], [Cunha 2006], [Dickhoff 2004], [Michelini 2000], [Steger 2005], [Tremonti 2008].

These innovations mean to look after eternally reconfiguring productive set-ups, to timely aim at grouping manufacture shops, followed by maintenance and service functions, to end with recovery and remediation facilities. The engineering paradigms are unifying support, assuring the overall knowledge, at the meta-level, from which the effective entrepreneurial organisation coherently follows. The *product-process* description develops, embedding all relevant modelling and simulation features, ***M&S*F**, to cover the four spheres of the product, the process, the environment and the enterprise.

The four ***M&S*F** ranges expand the conventional PLM tools reaches, to include the *service engineering*, SE, data into the PLM tools, creating SE-oriented-PLM, or PLM-SE, and to further expand the *reverse logistics*, RL, figures in the same tools, creating RL-oriented-PLM, or PLM-RL.

For the enterprise profitability, dependence on the strategic positioning in the market is standard admission, and the supply chain concept has, also, been modified into *value* chain, to join parts and materials delivery, with the related intangibles flow (*value* web), supporting a main contractor, with vital complements. Today, the expansion of off-process design tasks and connected data-bases is compelled by enacted product lifecycle regulation constraints, and is reached with existing ICT aids, once the four ***M&S*F** ranges are acknowledged, [Ito 2009], [Oesterle 2001], [Olling 1992], [Parker 2006].

The *product-process-environment-enterprise*, **2P2E**, design becomes best practice, once the all lifecycle, disposal included, duties are compulsory manufacturers' liability, [ESRC 2008]. This shows the way to the *extended* enterprises, and the ***M&S*F** description shall evolve to include the business and operation management areas, so that the supply chain *externalities* are dealt with by simultaneously adapting the enterprise data (taking in the timely useful facilities), to the environmental requests (mandatory targets or voluntary agreements). The challenge is here more problematic, since the engineering and manufacture physic-based frames are replaced by economic transactions, human and intellectual activities, social and legal constraints.

The knowledge management shall cover objects and events by texts, frames, spreadsheets or graphic trends. The model validation and simulation testing quickly lead at data reduction in terms of cost propagation and due dates. This provides effective way to acknowledge the business and operation functions, providing full visibility for reliable prediction and on-process control and steering actions. The incorporation of appropriate *extended* enterprise ***M&S*F** is domain open to new developments, where the knowledge management play the strategic role, with large resort to networked infra-structures.

At the *environment* integration step, the plain net-concern or *virtual* enterprise options, already improve the effectiveness, especially if the market of productive facilities/functions exist, and the assembling of the co-operating setting can be made. With these options, the lifestyle design and annexed knowledge management aids are open-loop enablers, assuring *product-process-environment* integration, thus leading to lawful supply chains, in front of the (previously enacted) mandatory eco-targets.

The *enterprise* integration permits closing the information loops, at the *product-service* re-design duties. The networked partners co-design abilities are, then, fully under the unifying control of the project ruler, and the **2P2E** design timely optimises the value chain, at lifestyle comprehensiveness.

2.2. PLM, PLM-SE and PLM-RL aids

The **2P2E** design means moving two steps further the simultaneous engineering *product-process* coverage, to include the supply chain specification, as necessary prerequisite for the business competition. The steps mean to include the value chain *externalities*, to deal with on-duty behaviour and end-of-life recovery, thus, to face demands out of the traditional manufacturers core competences. At the design phase, the innovation shows that the existing integration aids, such as *product lifecycle management*, PLM, need to evolve, to link the operation account and to cover the lifelong on-duty picture. The collaborative design shall enhance, with added effectiveness in modelling and simulation by enabling the reuse of already implemented and assessed virtual prototypes, and by making it easy to aim at split-level pictures.

Back to the recalled four integration steps, **Fig. 1**, along the delivery value chain, the lifestyle design strategy achieves full transparency, allowing the designers to face the demanding requests from the *externalities*, as valuable inputs, since the early conceptualisation phases, and to respond by innovative PLM aids, embedding the *super-model* with *federated* architecture. The paradigm shifts, in the product design to reach supply chain integration including the environmental constraints and entrepreneurial facilities data, can be viewed as the evolution of the scope economy tools, preserving methodologies, but with strategies covering the lifecycle performance, since the *value chain* necessarily needs to close on conformance-to-use assessments up to the *point-of-service*, and on recovery targets at the *end-of-life*.

To achieve the model federation ability, research ought to be undertaken in the model build-up, interfacing techniques and programming schemes. The challenge is manifest, listing the crucial goals and requirements, **Fig. 2**, each time tackled by the sought knowledge management tools.

The growth sustainability is recognised to promote the divide towards the last steps, moving back the natural resource restrictions into the manufacture economy, after that the industrial revolution established the divide at the *internalities* steps of the product-process integration, with the huge productivity increase, compared to the earlier handicraft economy of skill. The design for sustainability, especially, deals with the knowledge management, as support to assess on-duty lifelong properties and withdrawal tasks, by their modelling and simulation at the early design phases.

The unifying super-model, for the coherent arrangement of the whole conditioning knowledge, distinguishes because of a set specific attributes, to deal with *products-services*.

The decision support systems for product lifecycle design are recognised, once the knowledge management in the co-operating infra-structure is assessed. In the cluster, each partner is just a *node* adding his know-how to the networked business, and a *step* of the value chain. The net-concern is a *factual* alliance of companies that merge together, to share skills and competencies and to inter-link facilities and resources, responding to the business opportunities. The *virtual* enterprise is the co-ordinated net, assembled for the given *product-service* lifestyle delivering; the leadership is, mostly, turned on the *service* project, chiefly, motivated by the enacted mandatory eco-regulations. The *extended* enterprise is the coherent incorporation of the supply chain *externalities*, in the entrepreneurial mission; the leadership is, chiefly, *product*-oriented, under the principal manufacturer's direct responsibility.

In the value chain knowledge management, the real-time, on-process duties play relevant role, provided by the specialised operators/facilities, timely involved for the running and disposal duties. The technical details of the *product-service*, nonetheless, need to be already established at the design stage. In different words, the lifestyle delivering distinguishes from the earlier supply chains, due to the information content, covering the operation responsibility span up to the points-of-service and of call-back.

■ *flexible complex product representation*: to build standards and procedures that enable creating a reference model to yield complete descriptions by simple modules addition and interoperability methods;

■ *robust performance simulation environment*: to fashion procedures translating customers needs and wants, and tracking the cost sensitivity along the value chains, by means of plug-and-play blocks;

■ *flexible complex process representation*: to specify the production capacity/capability layout, including options, such as productive break-up and out-sourcing;

■ *conformance assessment simulation environment*: to verify the on-process functional requirements, impact prescriptions, amount of material reclamation, etc.;

■ *flexible complex lifecycle representation*: to describe the supplier responsibility and the service sold with the product (reprocessing and recycling included);

■ *eco-consistency assessment environment*: to define the third-party certification bodies and the reference metrics, related with the supply chain eco-impact;

■ *distributed supply chain collaboration environment*: to provide the features of the networked organisation, linking suppliers, consumers and controllers.

Figure 2: Knowledge manager: goals and requirements

The PLM technicality develops, accordingly. The basic PLM, *product lifecycle management*, is the tool to handle the product data, through the lifecycle, from materials provision, to on-duty requirements and end-of-life disposal. It includes functions such as the organization of engineering and processing data, of operation maintenance and conformance assessment, and of take-back recovery, recycling and reclamation tasks. Its completion requires embedding:

■ the *reverse logistics*, RL, the business opportunity (possibly subject to compulsory rules), for the recovery (reuse, recycle) of end-of-life items, in compliance of the enacted bylaws, with the related data monitoring and vaulting accomplishments;

■ the *service engineering*, SE, the business opportunity (mainly driven by voluntary agreements), along the product life-span, to guarantee the item enjoyment, with conformance-to-use certification, and related data monitoring and vaulting accomplishments.

The emerging specialised tools are:

■ the PLM aids carrying the RL duties, PLM-RL, the product lifecycle management *oriented to* the reverse logistics;

■ the PLM aids supporting the SE tasks, PLM-SE, the product lifecycle management *oriented to* the service engineering.

For the *extended* enterprise, the specific ***M&S*F** characteristics develop on the four data-base ranges, **Fig. 1**, to permit all the requested goals, **Fig. 2**, consistent with the *product-process-environment-enterprise*, **2P2E**, design. As compared with the old *product-process*, **2P**, design of simultaneous engineering, the practice means moving to the lifestyle *externalities*, from the economy of scope applied to the shop *internalities*. The paradigm shift aims at the lifelong supply chain, disposal included, effectiveness, to grant the eco-footprint control, with the required natural resources' transparent targets. The timely integrated productive lay-out is profitably achieved with resort to the function/facility market, to select, pick-up, negotiate, incorporate and manage the pertinent manufacture/service module, which enhances the in-progress value chain. The technical frame of the *virtual* enterprise is quite similar, due to the effective exploitation of the networked partners. The only difference, according to the definitions of the present study, is in the *enterprise* integration step. The timely requested facilities and functions are fully independent partners, and the (principal) manufacturer does not rules them, having the *product-service* re-design in the knowledge management current duties.

3. LIFESTYLE ECO-SUPPLY

The study summarises the challenges opened by the sustainable growth demands, [Kahraman 2009], and shows how innovation is strictly connected with new information flows, the PLM-SE and PLM-RL, to be established at the design phase, to make effective the service engineering, SE, possibly, expanding the business through voluntary agreements, and the reverse logistics, RL, whenever enacted through call-back requirements. In general, the emerging business lines profit of co-operative networked organisations, according to different approaches:

■ on one side, manufacturers could be spurred to keep in charge the all *service*: artefacts supply, lifecycle conformance and disposal requirements, so that the trade regulation would depend on single indentures;

■ on the other side, independent enterprises could profit by safety rules and environment acts expansion, to become *service* dealers, with technology oriented qualification and infrastructure-based organisations.

Both approaches, nevertheless, require to focus on the *design functions*, moving the enterprise profitability to be critically dependent on the initial choices of the prospected supply chain. The tuning of the PLM tools to cover all accomplishments at the *point-of-service* and at the *end-of-life* means the huge restructuring of the design tasks, since the added *functions* are totally outside the original manufacturing domains. The outlined investigation, thereafter, assumes reasonable pace-wise deployments, distinguishing:

■ the situations where the companies' core business can easily incorporate the lifestyle expansion, so that the *extended* enterprise integration is the right away opportunity;

■ the situations of very high business or entrepreneurial rigidity, forced to comply already enacted on-duty or end-of-life targets, for which the *virtual* enterprise is best choice.

The problem is discussed, accordingly, with focus on the reference knowledge frames that make *feasible* the new design tasks and efficient the *related* overall innovation, at two ranges:

■ by coherently including the all duties in *extended* enterprise settings, and offering the products' lifecycle servicing, by promoting the pertinent 'voluntary agreements' with the interested clients;

■ by forcedly enabling specialised reverse logistics rulers, assuring the end-of-life products' recovery, stated as 'mandatory targets', within the regulations enacted in view of the sustainable growth.

The discussion, for explanatory purposes, goes on referring to case examples. The *extended* enterprise setting is SMEs' challenge, offering co-operation in diagnostics decision keeping and equipment troubleshooting. The service-engineering provision ought to make a step ahead, having the distributed intelligence joined to self-sufficient on-situ equipment, able to keep in charge the operations: monitoring, diagnostics, up-keeping, repossession, certification and duty levying. The servicing applies to machinery, plants, communication and transport means, shopping centres, bank and trade appliances, entertainment and education stands, etc., and the business is progressively expanding, as the eco-protection acts ask to operate at full coverage.

The *virtual* enterprise setting is fundamental option, when the environmental acts establish compulsory eco-targets, to allow putting in the market mass-produced items. The end-of-life take-back is, now, required by the EU rules for the waste electrical-electronic equipment, WEEE, and for the end-of-life vehicles, ELV, in both cases, with the producers' responsibility of achieving suited recovery (reuse, recycle) figures. Face to the impending 'mandatory targets' of the environmental policies, most (old fashion) producers are not ready for the coherent **2P2E** achievements. Anyway, the knowledge management necessarily needs to face the split-up *environment-enterprise*, **2E**, information flow, and to deal with the fitting facility/function assembly. The set-up will, typically, resort to, [Liu 2005]:

■ the project-oriented net-concerns, gathering and interacting in the facilities/functions market;

■ the recovery rulers, for the *virtual* enterprise choice, negotiation and assembly broking operations;

■ the governmental agencies, authorised treatment facilities and certifying bodies, for tasks overseeing.

The **2P2E** (likely, the split-up **2E**) approach requires suitably powerful software enhancers, exemplified, for explanatory purposes, by the PLM-SE tools, to implement the diagnostic/maintenance frames of *extended* enterprises, and by the PLM-RL tools, to help building and managing the *virtual* enterprise set-ups, whether world-class companies are locally late or totally absent, and the reverse logistics duties ought to be fulfilled by subsidiary means.

3.1 Example SE value added options

The explanatory case is, here, the *AmIR*, *ambient intelligence ruling*, project, which deals with sets of knowledge acquisition and management modules, designed and tested in collaboration with interested end-users (chiefly SMEs). The application examples are summarised in **Fig. 3**, [Cascini 2008], [Michelini 2009].

The example *AmIR* project cases cover standard situations. The service engineering provision assumes man co-operation in decision-keeping and avails of *ambient intelligence*, AmI, friendly interfaces, **Fig. 4**, to link the involved knowledge operators.

The lifelong knowledge acquisition and management requires many forms to capture, process and store the data; special methods to support reuse and retrieve the information; and oriented ways to vault and maintain the results. The diagnoses trail standard reasoning techniques: causal and temporal chaining; deductive and probabilistic algorisms, frame-based union, case-based association, rule-driven heuristics, etc., in which the knowledge build-up and maintenance are

vital options.
The autonomic troubleshooting, mending and healing supply entails front-end resources, system-embedded and/or exo-supplied, to fulfil the regulation and reinstatement interventions. The knowledge management is performed by small enterprises, with expertise in the service engineering domains. The objective aims at the provision of *functions* (in lieu of *products*), with high AmI features, seeing the crucial competitive edge of the new opportunity. The AmI implication means, enhancing friendliness, lowering down times and cutting maintenance costs. The knowledge management modules, **Fig. 5**, exploit standard software.

■ *continuous process watching*: the everyday life is compelled to exploit entangled machinery and equipment, requiring number of built-in checks and refits, to maintain/restore the right performance; the knowledge-based analysis of the ambient data enables adjustments to be continuously made, when required (with no need to send out, each time, the field engineers);

■ i*ntelligent home-support*: the networked system deals with multi-tenancy buildings, plus professional/company offices; the AmI, through proper sensor lay-outs (video surveillance, temperature and smoke detectors, IR motion inspection, etc.), builds-up the clients specific profile, and supplies the expected security figures (with no people on-situ);

■ *remote after-sale monitors up-keeping*: the real-time business disturbances require immediate corrective actions, whose critical lag-time depends on the allocated duty (bank terminal, tele-medicine post, etc.); the effective intervention, via AmI aids, is of major relevance, to achieve the customer satisfaction and to increase his trust;

■ *centralised overseeing of technical installations*: the combined monitoring and actuation of specific facilities/fixtures (shopping centres, sport plants, etc.) is built-in option, needing, however, expertise of the attendants; the service-engineering provision by on-process AmI, allows real-time control or the immediate alert of responsible operators.

Figure 3: Applications of the SE knowledge management

The link between service-engineering and ambient-intelligence has practical relevance, permitting the quick expansion, in the lifestyle business, of advanced SMEs, offering to diversified users, the technology-oriented knowledge management. The overall architecture, **Fig. 6**, allows dealing with series of issues:

- the automation of the refitting control, by the resort to turn-key solutions, with throughout reliance on the on-process intelligence, acknowledged by the off-process confirmation;
- the security provision, with the customers trust, grounded on measurements and observations

incessantly acquired and analysed, to grant safe continuation to the local activities;
▪ the secure preservation of the real-time function-suppliers, in front of unexpected disturbances, so that the programmed supply does not cut short, avoiding any kind of operation deficiency;
▪ the remote management of the pro-active restoration of fixtures, especially, to be enjoyed by wide public, without time delay (and cost) of dispatching dedicated technical staff.

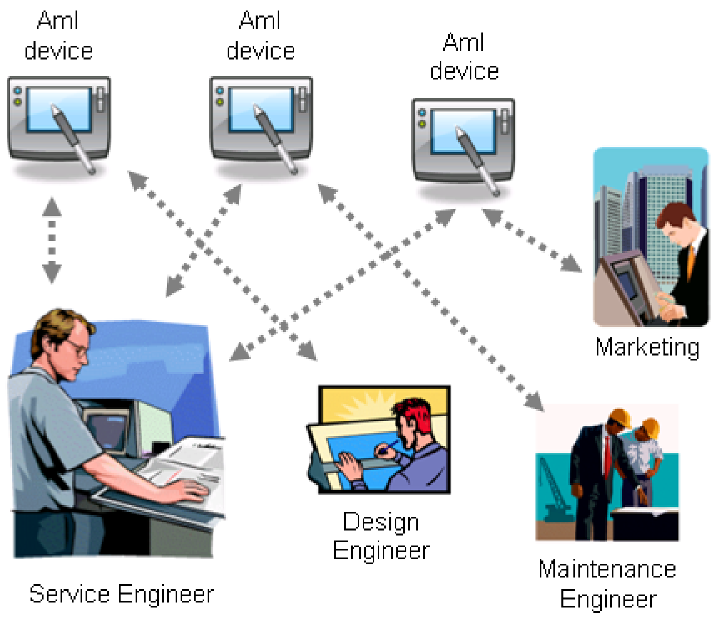

Figure 4: The PLM-SE set-up, with ambient intelligence aids

■ the shared knowledge-base, central repository of the problem-solving data, with the system characteristics, and the hypothesized and acquired know-how;

■ the customer support, personalised data-base for the specific service, with the delivery instructions and the problems-avoiding advises;

■ the AmI interface, to process the monitored data (diagnostic aids), to interact with the main/local data-bases, and to help the users;

■ the diagnostic module, to enable the devised reasoning methods, showing the problem-solving suggestions, with risk-assessments;

■ the overseeing module, to organise the data, performing the communication, up-keeping, remediation, etc. jobs, and storing the whole data-frames.

Figure 5: The modules of the *AmIR* knowledge management

The sample implementations provide clarifying hints. The number of actual cases is deemed to continuously increase, and the service-engineering field, even if now at its beginning, is expected to be growing business of the world to come, in the spirit of robot-driven falls-out.

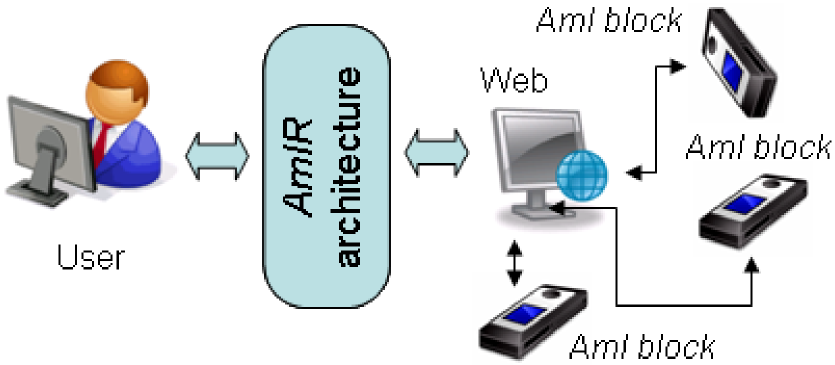

Figure 6: The *AmIR* aids functional modules in real-life missions

3.2 Example RL value added options

The automotive domain is paradigmatic case, where reverse logistics starts to turn, from opportunistic job, to universal requirement. It deals with *registered* goods, based on the affirmation of the ownership rights, and the administrative governmental recording. The ELV, end-of-life vehicle, requires the *de-registration*, with official steps, before issuing the *certificate of destruction*, *CoD*. The enacted EU regulation requests, **Fig. 7**, a series of accomplishments, with enforced eco-targets.

■ the member states need to establish collecting systems for exhausted vehicles and parts, at authorised sites, where suited treatments shall grant safe and reliable fitting out, by removing noxious and harmful parts;

■ the withdrawal needs to be accomplished without charge on the final owners (prescription fully enabled from 01.01.2007), but included in the product-service delivery, as inherent attribute;

■ the users co-responsibility could be invoked, for non-conservative behaviours, when critical pieces are damaged, removed or modified, downgrading the supply original setting;

■ the enforced recovery (reuse, recycle) targets are strict, requiring to reach 85% of the vehicle weigh, out of 5% (assimilable) fuel and 10% shredder residuals dumped to landfill (modified from 01.01.2015: 10% fuel, 5% residuals);

■ the dismantling and destruction duties ought to be certified, with assessment of reused parts, recycled materials, secondary-fuel and residuals dumping, to be notified to the EU.

Figure 7: The EU mandatory ELV reverse logistics duties

The ELV disposal is cost, as recovery does not repay the attainment of the enacted targets. The carmakers responsibility is deemed to embed the cost at the *point-of-sale*, because all marketed items shall include the ELV *free* take-back.

The *reverse logistic* activity might organise according to three schemes (*equivalent*, in the present EU spirit):

▪ *extended* enterprise, if the carmakers cover the recovery tasks, as part of the overall supply chain;

▪ *virtual* enterprise, if the recovery is ruled by a body, or business broker, organising the backward track;

▪ *net-concern*, if the recovery data-flow, centred on the ATF, usefully uses PLM-RL, for *CoD* purposes.

The first coherently embeds the externalities in the entrepreneurial value chain. The last is rough approach, when the manufacturer's effectiveness is lacking, and the knowledge frame applies as *service engineering* instance.

The explanatory reference is, here, the *RL-elv*, *reverse logistics of end-of-life vehicles*, project, developed to assess the operation effectiveness of the said three schemes, through integrated knowledge management aids, **Fig. 8**, [Michelini 2008], [Mosca 2008], [Putnik 2007], [Teuteberg 2010].

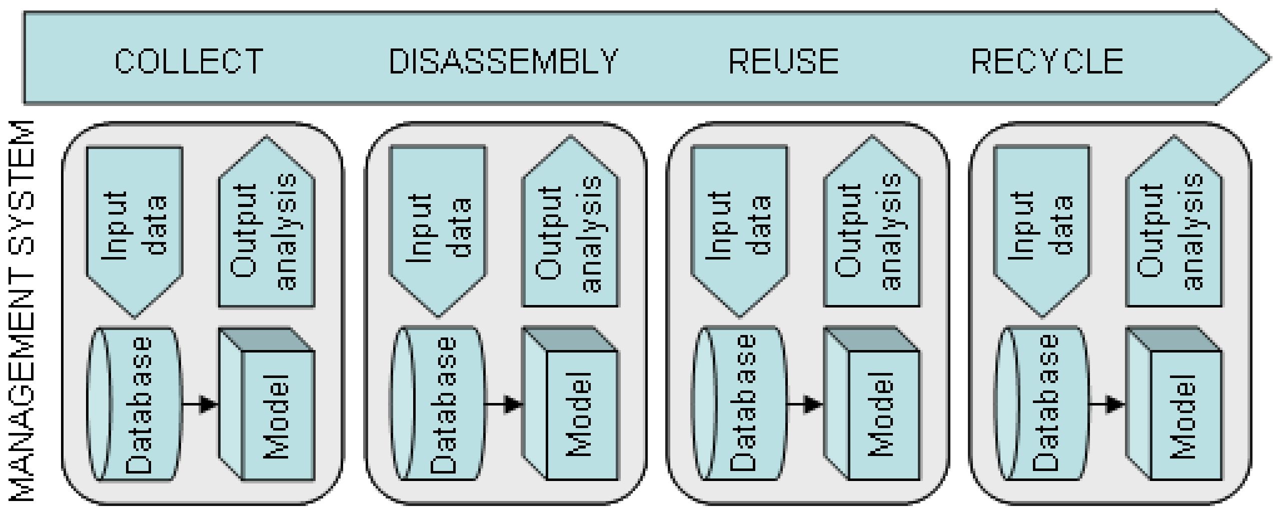

Figure 8: The knowledge build-up in the ELV reverse logistics

The *authorised treatment facility*, ATF, is the knowledge management central function, to provide the certification of:

■ the ELV pre-processing for safety setting, after removal of the polluting/dangerous parts;
■ the lawful recovery flow, by wreck splitting into: pieces for reuse, materials to recycle, etc.;
■ the administrative duties (*CoD* drawing-up, etc.), with related forms to testify the eco-targets.

The ATF number, location and capacity, thus, are fundamental choice in the reverse logistics efficiency, and, unless the free market promotes challenging competition, the Authorities ruling is the critical prerequisite of effectiveness. The foolish distribution of ATF could compromise the all backward-flow efficiency.

■ the network to collect the disposed items, with transportation, handling and storage equipment, with the related information processing and archival;

■ the allotment of *authorised treatment facilities*, ATF, strategically located, to grant efficient, safe and reliable securing of the collected wastes;

■ suited reuse flows (conditioned parts) and recycle stands (shredder, sorter, re-former, etc.), along properly specialised processing streams;

■ convenient trade lines, to support the reuse/recycle flows, provisioning the manufacture and the maintenance areas.

Figure 9: Functions/facilities needed by the backward-flow

The backward-flow, from exhausted goods, to remediation assets, **Fig. 9**, requests special purposes stands, and suited information platforms, linked to carmakers (for the PLM-RL, etc.), and supervising agencies (for the eco-target assessment, etc.). The platforms need to incorporate the ***M&SF*** of the reverse logistics, say:

■ the facility/function data, for each backward track step: collection, disassembly, reuse/recycle, secondary resources provision, etc.;

■ the relational data-base containing: references PLM-RL, car registration files, recovery process issues, facilities/functions inventory, etc.;

■ web interchange between concerned operators: carmakers, clients, authorities, recovery process partners, certifying bodies, etc.;

■ the information controller, for documentation, reporting and data archival.

The *RL-elv* project builds around the knowledge management, **Fig. 10**, creating the working structure by means of the computer simulation structure.

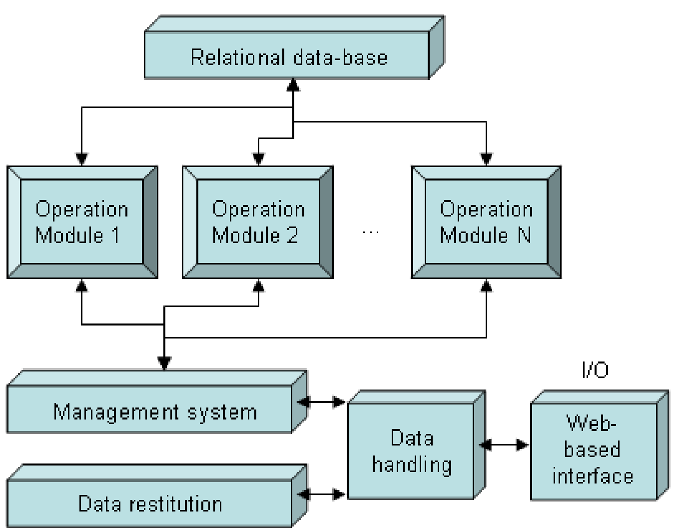

Figure 10: The knowledge manager simulation/appraisal tool

The information platforms are be permanently accessed by the heterogeneous number of parties, with different interests, liability and responsiveness. The web interchange, thereafter, accordingly is built, with barriers, for the sensible data protection (clients' privacy, producers' secrecy, etc.), warranting, nonetheless, the transparency to the EU directives regulated targets.

The knowledge manager, **Fig. 10**, sets around the relational data-base, linked to the operation modules of the networked facilities/functions. It is interfaced to the communication platform, friendly also for web applications, assuring management aids to create and to run interfaces with other languages, procedures and databases; to define interactions of blocks; to start/stop concurrent processes; to enable client/server links; to establish masks and graphic displays.

In the car dismantling/recovery, the information infra-structure plays the critical role. Our separation into the *extended* enterprise, or *virtual* organisation, or *net-concern* setting, permits comparing the value chain, when the manufacture business puts off, or not, the *externalities* to *internalities* account, in planning the company engagements. The **2P2E** approach integrates the recovery as design/redesign task, and the *extended* enterprise has full control on the embedded costs. The split **2E** approach grants visibility on the technical (dismantling, etc.), and bureaucratic (deregistration, etc.) duties, and the *virtual* organisation reaches clear-cut evidence of alternative reverse logistic settings/fittings, with related allocation of the profit/loss figures, induced by the administrative and organisation policies, each time promoted (and enacted). The costs are openly shown by *visible fee* assessments, under the autonomous body's broking/ruling. The *RL-elv* project allows to compare how the *net-concern*, out of the entrepreneurial *extended*/*virtual* organisation efficiency, distributes the charges, with, however, the opacity of the administrative levy, due to the governmental agency's direct control.

In short, the *RL-elv* project aims at the value chain appraisal of the eco-protection acts, based on the efficient exploration on integrating the related knowledge management schemes. The study is especially important, if the carmakers do not establish *extended* enterprise lay-out (e.g., German case), and the alternative *visible fee*, by *virtual* settings (e.g., Dutch case), or the *deposit*/*refund*, under governmental agency (e.g., Swedish case) shall be weighed.

4. CONCLUSION

With earlier economic systems, the wealth expansion depends on process productivity, aiming at the affluent society, based on transforming raw materials into cheap items, ceaselessly replaced by new ones better suited to users' satisfaction. The eco-conservativeness requires to lower pollution and consumption. The producers responsibility covers the full *product-service* provision, on the lifecycle span, disposal included. New set-ups need to be devised, highly affected by the supply chain *externalities*, out of the traditional manufacture steps, [Bagwati 2004], [Baskin 1999], [Weber 2004], [Wolf 1999].

The eco-protection acts are challenge to reorganise the manufacture market by knowledge entrepreneurship schemes. The new market leaders will move within this technical-scientific framework, replacing the economy of *scale*, by the economy of *scope*, with, specifically, two opportunities, [Cunha 2009], [Kovacs 2002]:

■ functions delivery and artefacts life-extension policy, with the profitability in the business of supplying *products-services*, incorporating the *externalities* of the lifestyle provisioning;

■ increased recycling efficiency, with profitability in the new businesses aiming at *reverse* logistics (from waste, to secondary 'raw' materials), according to the already enacted targets.

The two domains develop outside the factories, and the knowledge contents of the required PLM aids shall, accordingly, expand to deal with the set of scopes, with critical relevance, aiming at on-duty performance or operation reliability, and at pollution precepts or recovery effectiveness. Moreover, the PLM prerequisites (e.g., *total connectedness*) appear to be critical challenge, notably, when dealing with a net-concern, built by independent companies that focus on their core competencies and join, each other, the efforts for co-design, co-manufacture, co-marketing, co-maintain, co-servicing and co-recycle, in view to fulfil the requirement of supplying *products-services* at the clients' benefit and the environment safety, [EIPA 2008].

The *product-process-environment-enterprise*, **2P2E**, practice is deemed to broaden the *product-process*, **2P**, design of 'simultaneous engineering', focusing the value chain on lifestyle *externalities*. The new PLM tools distinguish by the lifestyle additions for on-duty service engineering, and for reverse logistics duties, with the pertinent ***M&S*F** supplements. Actually, the design-for-manufacturing, *DfM*, design-for-assembly, *DfA*, etc., scopes shall expand over the *new* design-for-disassembly, *DfD*, design-for-recovery, *DfR*, etc., ones, which need to establish since the early product ideation steps. The business paradigms will include recovery, reuse and recycle of products, parts and materials, to minimise the tangible resources spoil and to maximise the whole supply chain performance. The full ***M&S*F** identification shall enable the designers to explore and to analyse the reverse logistics as worthy option, to enhance the tangibles productivity and the environmental sensitivity, enabling the company effectiveness and profitability. The issue brings to the *extended* enterprise organisation, properly specialised in *product-service* provision. Today, the EU eco-regulation has enacted mandatory recovery (reuse, recycle) targets within the extended manufacturers' responsibility. These rules apply to the automotive industry, but not all carmakers have the *extended* enterprise goal in mind. In default, the *virtual* enterprise goal might result effective, specialising the *environment-enterprise*, **2E**, design whether the proper PLM-RL aids allow the «business ruler» brokerage to integrate the right functions/facilities. Once again, the product lifestyle design is the enabling option, supporting the innovation.

In general, the proper exploitation of ***M&S*F** description will be the way of improving the effectiveness of the manufacture businesses, to reach the best balance of all the constraints in designing, developing, producing, supporting, servicing, recovering and recycling products. Cost and time compression, customer satisfaction, lifecycle responsibility, environmental protection and resources conservativeness have to be part of relational models, with algorithmic and heuristic modules, balanced by the captured knowledge, virtual tests, on-line analyses and designer's decision making. The ICT aids shall support the best practice, from concept creation, through artefacts operation and call-back, up to waste handling and remediation; every requirement will be known by the users, and transparent to the authorities, so to assess the resource productivity. The federated modelling approach becomes dynamic, with learning a bit from each accomplishment and training the design teams to combine views and to integrate functions.

The paper outlines the expected evolution in the manufacturing business, purposely focusing the attention on the knowledge management surroundings, because of their critical nature in the restructuring to come.

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