Integrated Logistic Support Concept in Aviation Engineering

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To the modern philosophy of logistic processes improvement belongs concept of Integrated Logistic Support (ILS) that was mostly developed in aircraft industry and other branches of production, and also at exploitation of Complicated Technical Systems (CTS). ILS originates from Computer Aided Acquisition and Logistic Support (CALS) initiative and it has importance of continual acquisition and products life cycle (LC) support in the present time. The main tool of ILS is Logistic Support Analysis (LSA). LSA utilizes synergetic effect of technical disciplines that use uniform special data base (DB LSA), with aim to shorten duration of technological processes, starting from research, continuing to project proposal, production, up to maintenance and complex Life Cycle Support (LCS) of CTS. In the aircraft engineering it enables to project and plan production and logistic support in real time, higher competitiveness, reengineering of company processes at research, production and working of high-tech products. Control and establishment of flexible global logistic networks, with their huge communication and coordination needs, makes assumptions of their future intensive development.

Keywords: Integrated Logistic Support, Computer Aided Acquisition and Logistic Support, Logistic Support Analysis, logistics of production, logistic management, simultaneous engineering.

1. INTRODUCTION

Aircraft and rocket techniques belong to the most complicated technical systems and they therefore need completely new approach to the logistic support. Modern airplanes are composed of avionic systems, electronic, mechanic, hydraulic and pneumatic subsystems, with the newest technologies and materials application. Complicated technical systems need synergy of costs decreasing and safety increasing. Very expensive products evoke economic return problem, what cause LC prolongation needs, and total costs of exploitation decreasing during life of the system. It needs continual modernization of subsystems, modular system of final products, integrated logistic support and ensuring ability to stay in duty for longer time. Long duration of life cycle of expensive CTS in aviation and defense systems enforces continual and fast solving of economically pretentious actualizations, modernizations and innovations. It also requires new and revolutionary scientific knowledge and technologies increasingly, fast growth of computers utilization, and using new information and testing technologies. Computer systems implementation in logistics is seriously needed for nowadays trends in army and industry. It is mainly for reaching the higher complex quality from system parameters point of view (readiness, availability, power, reliability, safety, manufacturability, maintainability, supportability, partial and total modernization, recirculation, etc...), and also from used methods point of view (simultaneous engineering, limitation of production variability etc.). CALS initiative – acquisition and LS with computer utilization raised in the year 1985, and from the year 1994 it has the new meaning of Continuous Acquisition and Life-cycle Support, as mean ILS of CTS [1].

2. COMPUTER SYSTEMS IMPLEMENTATION IN THE LOGISTICS

Information technologies utilization analysis in aviation industry shows that one of their development direction is wide use aviation

production life cycle at all stages of and its logistic support within common information environment. Complex of the most modern technologies aimed at Life Cycle Costs (LCC) and as low as possible CTS is defined as Integrated Logistic Support. Result of utilization of these CALS technologies is establishment, maintenance and development of Technical Operation Systems (TOS), which attributes are consistent with CTS design. CALS technologies were originally intended only for logistic information support. By continual development, mainly by growing power of computers, CALS has been transformed in to the means of informational support of research – development – production – use and modern logistic support of CTS in all stages of product LC, starting from marketing and ending by abolition. CTS projecting interconnection with production supported by computers, i.e. Computer Aided Design (CAD), with Computer Aided Manufacturing (CAM), is influenced by fast modernization changes, what needs again and again to completely rework processes and activities connected with acquisition logistics and logistic support. The basis of quality control of CTS is logistic management of acquisition disciplines, aimed at all stages of LC. This complex effort named Integrated Logistic Support (ILS) continually defines, designs, states and ensures complex support of CTS readiness during whole life cycle [2]. CALS goal is revolutionary change in field of acquiring, archiving and transfering digital data and information, as well as testing technologies unification. Projecting and production supported by computers enable to produce data, instead of mechanical drawings and copies, modeling new future product as integrated database that enables to project and plan production and also logistic support in the real time with production teams utilization, next suppliers and sub-suppliers. So, by this, Integrated Product Team (IPT) arises. This approach is known as simultaneous engineering (or Concurrent Engineering – CE). CALS in praxis involves organization of common information space, supported by automated systems designated for engineering effective problem solving and plant sources planning, and also for production planning and control, information remote access and on-line solution of supplier-customer relations, evolution prognosis and predictive solutions. Common integrated database has the same and standard rules for generation, re-cording, actualization, searching and transfer of information. Data administration of common database is ensured by Product Life Cycle Management (PLM) system, either as completely automated systems collection CAE /CAD/ CAM/PMD and ERP/CRM/SCM for development, projecting and integrated logistic support of CTS, or it is only as supporting informational system of plant for interaction with different producers.

PLM system – shown in the Fig. 1, is the basis for information space integration of industrial products and on the basis of ILS it enables interaction of wide spectrum of producers utilizing automated and information systems.

Legend to the figure: PLM – Product Life Cycle Management, PDM – Product Data Management, CAD – design, CAE – engineering, CAM – technologies and production, CRM – data base of customers, SCADA – Supervisory Control and Data Acquisition Software, MES – Manufacturin Execution Systems is interconnection between plant information system

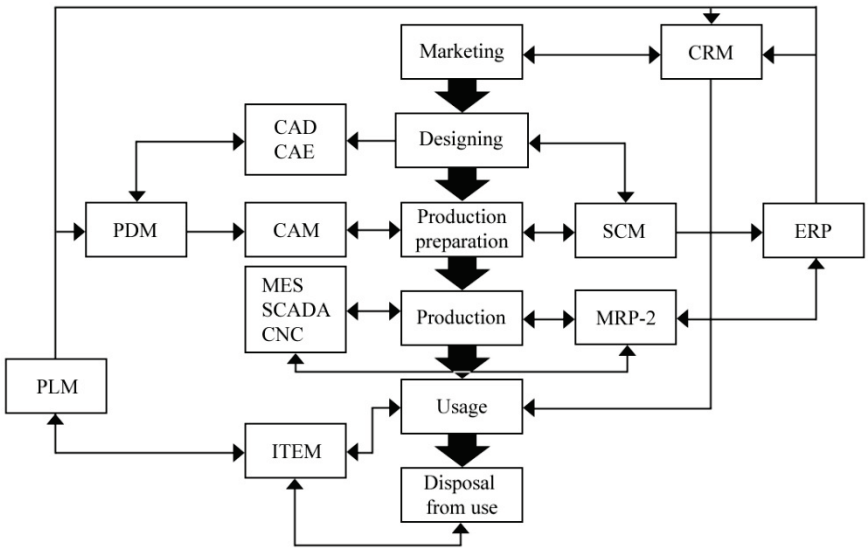

Fig. 1 Industrial production life cycle and information systems used.

and plant production automation system, SCM – Supply Chain Management, ERP – plant information system (control of plant), CNC – computer supported production means, MRP-2 – production sources planning, ITEM – Interactive Electronic Manuals.

Market success of CTS without CALS technology would be impossible today. Standardized data formats of network servers enable fast transfer of modern design solutions and they „do not find out, yet found". This modern design and production approach of high-tech products is based on:

- computers and modern information technologies used in all phases of product life cycle,
- providing uniform methods of management processes,
- all attendants cooperation (producers, suppliers, operators) in accordance with international standards requirements, stating rules of interaction (electronic data exchange).

ILS implementation would be involved at producer, supplier and customer into agreement requirements about CTS delivery. Higher stage of information integration is Joint CALS and Joint Engineering Data Management and Information Control System – JEDMICS. They are evolutionary programs identifying a lot of functional requirements for logistic processes of CTS, for example:

- Logistic Support Analysis (LSA),
- Logistic Support Analysis Record/report (LSAR), etc...

and supporting spare parts supply function for repair processes of machines, respectively.

3. PRODUCTION AND OPERATION OF COMPLICATED TECHNICAL SYSTEM

The key meaning of CALS establishment for production and logistics is in working with the only integrated database suitable for suppliers, developers, technical manuals, trainers and also for logistics specialists. More databases will be developed and maintained by producers, or suppliers/customers, what evokes need of standardization and cooperation. Then both parts of logistics, acquisition and maintenance merge into one integrated logistics that starts before research and ends by equipment abolition. Most of life cycle phases, starting with raw materials and components suppliers choice, up to product selling needs for logistic support, e.g. supplying chain control for products, added value increasing, material pretension decreasing and waiting time on final product decreasing. Procedure of „Make or Buy" is used increasingly, mainly at limited production capabilities, or if there is advantage when the part is completed from standard components. Many companies develop specialized software and hardware for electronic business (e-commerce), and either provide or utilize common information space for providing or doing variable services, operations of design, production and supplement of ordered articles [3]. CTS projecting and production directly on order with pre-defined parameters and specification, at using CALS technologies, enables to minimize time and costs of supply. Work coordination of many partnership companies that utilize internet and electronic business (electronic data exchange), known as data management system (CPC) of integrated information space thus enables repetitive utilization of the same project documents in common projects, what significantly decreases development time of a new product, decreases cost of whole design and production cycle and simplifies systems existence – see Fig. 2.

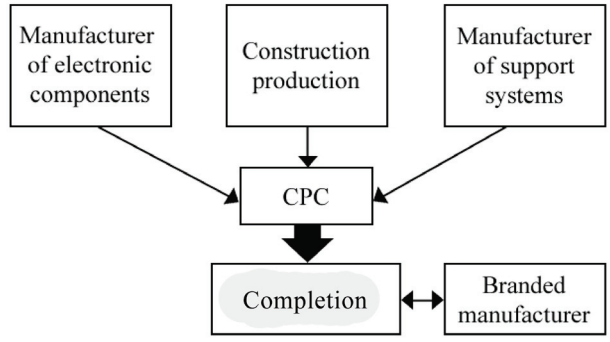

Fig. 2 Company virtual interaction with suppliers

A modern logistic system based on CALS vision will be a system continually updated and standardized. Standards have to be used in all participating companies that solve development, research and production of CTS, on basis of internationally agreed documents for Integrated Logistic Support. Synergetic effect of CALS implementation is huge and some sources feature:

- 30-40% implementation acceleration of science and research,
- up to 30% costs decrease on new CTS acquisition,
- for 20% time shortening for purchasing spare parts,
- up to 9 times shorter time for projects adaptation.

In terms of production, frequently it comes to significant increase of production quality, moreover it comes to 50% shorter development time and production preparation, productivity increase by about 75%, savings in ware-houses about 60%, return on investment in-crease by about 70%, and up to 50% servicing and stock reduction [4]. Presented savings can be even higher after planned CALS extension by maintenance function and its sub-function of testing, measurement and diagnostics (TDM – Test Measurement Diagnostic), what enables change of time scheduled maintenance to on condition maintenance. Moreover, CALS provides CTS research and development acceleration from 6-10 years to 4 years and fast implementation of high technologies to the production processes. Research centers of CALS technologies – 'Applied logistics' are in economically developed countries (USA, France, Germany, Russia, Great Britain, etc.) intensively dealing by research and implementation of software solutions for high-tech products and their informational provision. Logistic service provision for solutions implementation depends on common approach of participated companies, at integrated information products and modern technologic approaches creating. Integrated Logistic Support is ensured by set of technologies aimed on operational and technical parameters of products improvement, and on LCC decreasing.

4. INTEGRATED LOGISTIC SUPPORT

The main tool of ILS is Logistic Support Analysis (LSA) that utilizes synergetic effect of technical disciplines that use uniform special database (DB LSA) containing input data and example solutions results. The aim of DB LSA is to shorten technologic processes starting from research, project proposal, production, up to service maintenance and complex Life Cycle Support (LCS) of final products with as low costs as possible.

To the ILS belong:

- CTS and its subsystems technical condition treatment planning,
- material and technical support of final product operation,
- statement of requirements on size, specialization and training of technical personnel, including system of retraining and periodic testing,
- digitalization of technical description and operation manuals,
- special methodic and algorithms development (software) for condition monitoring and continual tracking of equipment operational parameters and their statistic processing for no-failure operation and safety increasing needs.

ILS according to British standard 00-600, JSP 886, head 7, Part 2 is defined as organized approach that influences design and development of product, its support solution during life cycle and costs optimization for CTS sustainability. ILS ensures continual optimization of total CTS LCC, including modifications, changed operation conditions at permanent support. ILS of industrial systems/devices is sum of different kinds of engineering activities realized by control engineering and informational technologies, oriented on devices high readiness provision, e.g. no-failure operation, long life, reparability, etc., at simultaneous cost decreasing on operation and maintenance [5].

All activities (basic processes and their interconnection) at ILS are introduced in the Figure 3.

ILS contains:

- Logistic Support Analysis (LSA),
- planning and control of maintenance and repair of products (technical service – TS),
- planning and control of Material-Technical Support (MTS),
- development and innovation of operation and maintenance manuals,
- equipment for operation, maintenance and repairs of product provision,
- planning of packing, loading and transferring processes of devices,
- infrastructure of technical operation systems elaboration,
- software support and information technologies provision,
- condition monitoring of equipments, operation and maintenance processes,
- planning and organizing of disposal/re-circulation of devices.

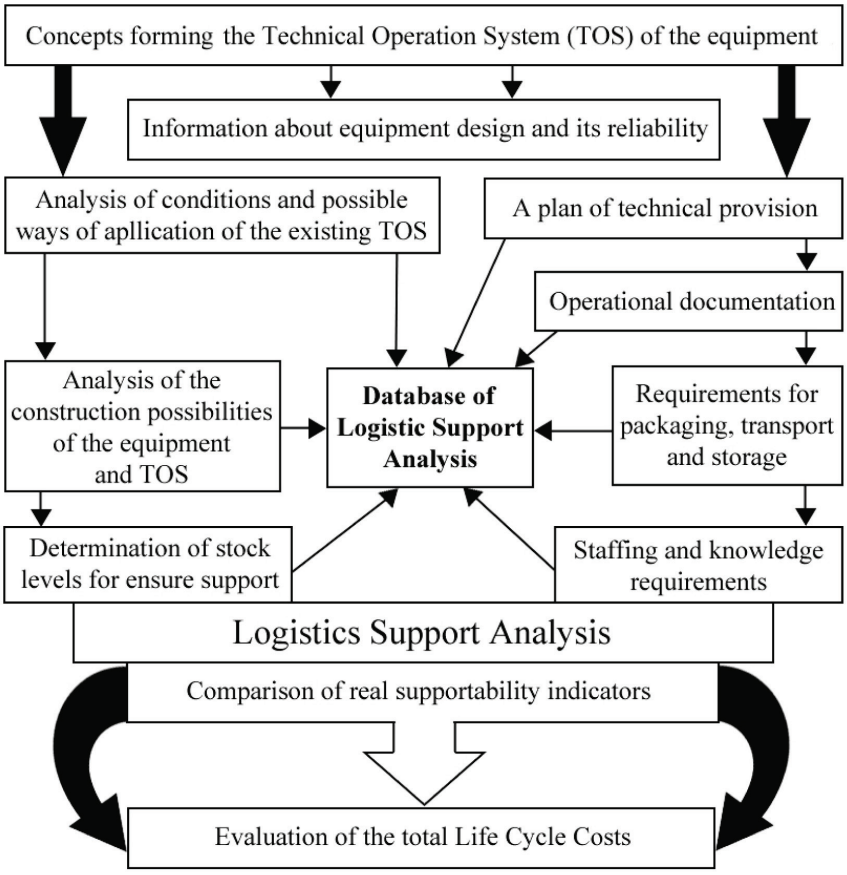

Fig. 3 Basic ILS processes and their interconnection

5. LOGISTIC SUPPORT ANALYSIS

LSA is the key tool for most ILS tasks solutions. LSA includes:

- conditions and possible devices operational scenario analysis,
- current Systems of Technical Operation (STO) analysis,
- variants of devices design and their STO analysis,
- the best operation combination,
- maintenance executing analysis, including methods and working technologies chosen, with evaluation of their complexity, time consumption, financial, personal and material difficulty,
- changes in actual STO analysis, resulting into concept proposal of a new final product,
- statement of form, range and conditions of permanent technical support including after-market service,
- system of data acquisition development with aim to ensure feedback from consumers (monitoring) and information about failures, problems and proposals for improvement and design modification, performance, material changes at new pro-ducts,
- evaluation of STO effectiveness, coefficient of technical readiness increasing possibility, costs of TS and downtime decreasing.

For logistic support tasks solution is in LSA – Suite [5] used 6 basic and 3 auxiliary modules: – Logistic Structure of Instrument (LSI), failure types, consequences, seriousness analysis (AMICA), maintenance, spares, documentation, and operational costs. Functional possibilities are ensured by auxiliary modules: – lists and classifiers, project manager, messages.

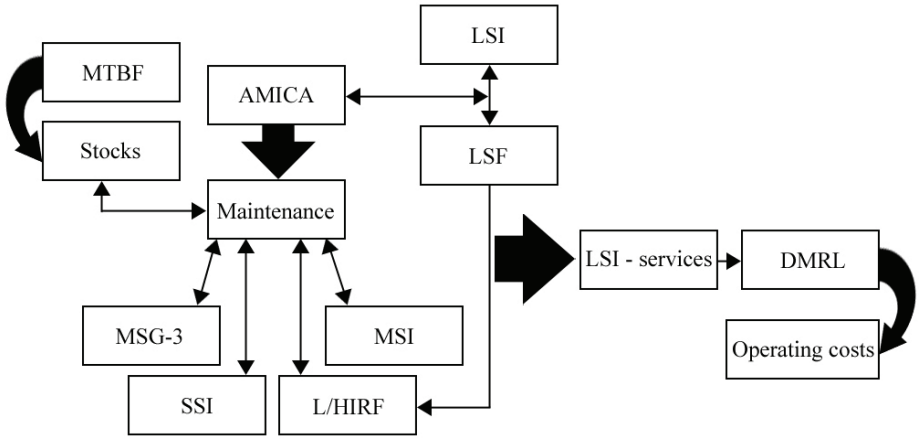

Fig. 4 Application of modules at LSA

At CTS Logistic Support Analysis it is necessary to do:

- system logistic structure analysis – LSI,
- function analysis of product – LSF,
- failure types and their seriousness analysis – AMICA,
- compensation and corrective actions identification (maintenance/repair) –MSG3.

LSA results are recorded in BD LSA database in the standardized format and they are continuously used for innovation, or new product preparation. The aim of the analysis is:

- clarification of requirements on technical service (TS),
- TS costs estimation,
- obtaining new requirements from customers, definition on product parameters, structure, design and characteristics of devices.

Thus for CTS producer within LSA has to state/define:

- recommended procedures of product and subsystems TS,
- TS organization description (manuals),
- periodicity, means for TS and needed qualification skills of operation and service personnel,
- kinds of logistic stores for TS,
- certificated spare parts suppliers,
- technologic procedures for different levels of maintenance (LOM),
- kinds of documentation, records and their standardization.

Planning of operation, maintenance and repairs of CTS enables statement of rational amounts of needed material sources (spare parts and consumables), but also financial, personal and time consumption needs due to financial outgoings minimization during LC of device [6]. Thus planning involves stating of:

- items (components) of MTS, e.g. spare parts as component part of product, or provisioning,
- their codification (cataloging),
- ways of logistic support (replenishment, ordering ...),
- financial difficulty of acquisition,
- time progression and needed amounts of orders,
- components and subsystems reliability, including service (changing) intervals.

At CTS composed from huge amount of components, there is very important their cataloging that enables:

- common system of classification and identification of components,
- minimization of purchasing of duplicate components,
- centralized statement of requirements /needs and amount of purchasing,
- possibility of public procurement of components, and purchasing costs lowering.

Cataloging enables to decrease costs of spare parts, and therefore also decreases total LCC of a product. It is a source of information for effective controlling of sub-suppliers and it is part of ILS concept. In the conditions of globalization a common language within international cooperation of worldwide producers in the given area is required.

6. ILS AND COMPETITIVENESS

It is apparent that kinds of activities related to ILS concept are very different and they largely depend on product life cycle. Common goal is decreasing of total costs of LC, so not only costs at the first CTS acquisition, but also for many year of operation, unavoidable maintenance and repairs of devices, up to their abolition. ILS goal is also increasing operational-technical characteristics of a product, and downtime decreasing at exploitation and maintenance /repairs. Operational-technical characteristics level/rate is evaluated by a so-called coefficient of technical readiness K_{TP}, as a ratio of device functional state duration T_{FS} to total duration of product duty T_{CU}, that is composed from T_{FS} and downtime T_P due to failure, repair, check, etc. Then can be written relation (1) that:

$$K_{TP} = \frac{T_{FS}}{T_{CU}} = \frac{T_{FS}}{T_{FS} + T_P} \tag{1}$$

It is actually probability that product will be in operational state in any time, except planned downtime. The smaller failure and repair rate, the nearer probability of operational state to the 1.

Efficiency criterion of ILS is product retention as long as possible in operational (failure free) state. CTS sustainability in operational state and criterion that this approves is the complex parameter dependent on:

- CTS and its components faultless probability (Mean Time Between Failures – MTBF),
- time duration of repair (Mean Time of Repair – MTR),
- total time for Operational State Renewing (RST),
- Mean Time Between Maintenance (MTBMA),
- Mean Time Between Replacement of parts and subsystems (MTBR).

The aim of ILS task is:

- LCC minimalization at stated value of readiness coefficient K_{TP},
- maximalization of readiness coefficient K_{TP} at defined LCC.

K_{TP} is within reason measure of the quality of product (a benchmark) what has influence on competitiveness. Then rate of competitiveness (MCS) can be expressed as ratio of quality and price [7], what can be expressed by ratio of technical readiness coefficient K_{TP} and price of operation /utilization organization, maintenance and repairs C_{PUO}, what can be written in the form (2):

$$MKS = \frac{K_{TP}}{C_{PUO}} \tag{2}$$

ILS concept of high-tech products has goal to reach higher total (complex) quality of CTS from their characteristics and competitiveness increasing point of view. Thus, for example „Tupolev“ by processing operational documentation of Tu-204/214 according to international standard ASD S 1000 D requirements, solves aftermarket service and competitiveness increasing. The key part of this technology of condition monitoring is creation and keeping of airplane electronic formular, automatic data processing, using RFID components, etc. what in final consequence renders exceptional reliability of produced airplanes and passengers safety. The first Russian airplane designed by new CALS technologies including LSA is SSJ – 100, which has been completely designed in digital environment, with huge utilization of CAD a PDM technologies.

7. CONCLUSION

Systematic approach to integrated information systems creation/processing for high-tech products and CTS support during whole LC needs unceasingly improved conceptions, deep study and CALS technologies development. Top products and CALS procedures knowledge enable fast configuration of CTS, integrated logistic support and its analysis in all stages of product LC, reengineering of company processes at research, production and operation of high-tech products. System of data management (PDM) has main role in integrated information environment and renders, collects/preserve rationaly structured data for product design, technologies, production and operation, as well as realization of modern logistic support of complicated technical systems. Already now is in preparation and elaboration of a new standard ASD S 3000 L [8] with participation of worldwide leaders in technologies research.

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