INTEGRATED LOGISTICS SUPPORT (ILS) OVERVIEW; by Chuck Sproull 7/97

5. DEFINITIONS OF INTEGRATED LOGISTICS SUPPORT

DoDD 5000.39 Acquisition and management -- A disciplined, iterative and unified approach to the management of technical activities needed to DEFINE, DESIGN, ACQUIRE and PROVIDE SUPPORT during operational phase, at minimum cost.

A composite of all support considerations (planning and resources) needed to assure the effective and economical support of a system for its full life cycle (concept, production, use/support, disposal). Integral part of all other aspects of system acquisition and operation. ILS characterized by harmony and coherence among all ILS elements.

All arrangements for getting right item to the right place to the right person at the right time, so it is always ready for use. (cbs)

The DoD definitions indicate that planning for support should to be finished before the operational phase.

6. INTEGRATED LOGISTICS SUPPORT PLANNING

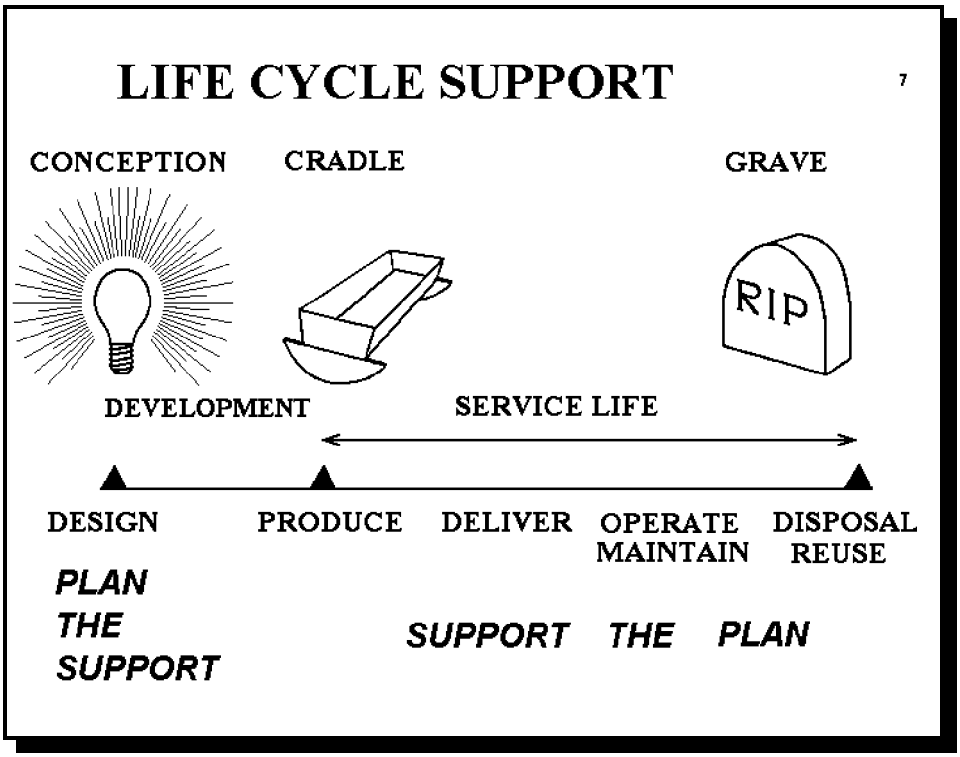
Identifies all support elements required for new equipment, and influences its design before production, so that after production it can be operated and maintained more effectively.

The International Society of Logistics (SOLE) defines LOGISTICS as the art and science of management, engineering and technical activities concerned with defining [end user] requirements; and designing, maintaining and supplying resources to support ... operations.

LOGISTICS ENGINEERING seeks to:
- design supportable prime mission equipment,
- design and acquire optimum support capability for the prime equipment.

Complete LIFE CYCLE management consists of;
- design engineering for performance,
- support engineering for readiness, funding, and schedule.

7. Some people consider Life Cycle as "cradle to grave." But the cradle is only where support begins; cradle time is too late to begin planning for support. Support planning should begin long before that; as soon as possible after program initiation (conception), and continue through product design development phases. Jesus taught an important business principle concerning Life Cycle Cost. "Which of you, intending to build a tower, sits not down first and counts the cost, whether he has sufficient to finish it?" (Luke 14:28). The majority of money spent on most products is spent during their operations and maintenance phase. This makes up-front financial planning even more important.



In the natural family situation, for example, when do mom and dad begin planning for support of their child? Very soon after conception, when she finds out she is pregnant, they begin planning and acquiring child support elements: (supportability has already designed into children, all parents need to do is plan ahead and provide adequate support resources). So the definition of Life Cycle should be expanded backwards to include the full scope of planning and providing support "conception to grave." More about this later. Here are two lists of support elements.

At the highest level, logistic consists of four main concerns: All products cost money, require time to deliver, take up space in trucks, storage areas and in user locations, and have weight that is handled either by people or support equipment.

ILS ELEMENTS OF EQUIPMENT ILS: 8

- **DESIGN INTERFACE (DI)**
- **MAINTENANCE PLANNING (MP)**
- **SUPPLY SUPPORT (SS)**
- **SUPPORT EQUIPMENT (SE)**
- **PACKAGING, HANDLING, STORAGE AND TRANSPORTATION (PHS&T)**
- **TECHNICAL DATA (TD)**
- **FACILITIES (FAC)**
- **MANPOWER & PERSONNEL (M&P)**
- **TRAINING & TRAINING SUPPORT (TTS)**
- **COMPUTER RESOURCES SUPPORT (CRS)**
- **DISPOSAL / REUSE / RECYCLE**

8. Here is a list of the 10 formally recognized Integrated Logistics Support elements, plus an 11th or final element that considers what happens after the system service life:

9. Planning for Design Interface considers mechanical and electrical interfaces such as size and shape of new equipment relative to the spaces available at the user installation site, physical interfaces between the equipment and operation and maintenance personnel and electrical attachments to power and test equipment. It translates such basic logistics concepts as reliability, maintainability and availability (RM&A) into impacts of new equipment support requirements on existing and available support resources, organization and program cost.

DESIGN INTERFACE 9

- **RELATION OF SUPPORT-RELATED DESIGN**
  - **-PARAMETERS (R, M, A, QA) TO READINESS AND SUPPORT REQUIREMENTS.**
- **EXPRESSED IN OPERATIONAL TERMS,**
  - **-READINESS OBJECTIVES,**
  - **-EFFECTS ON SYSTEM SUPPORT COSTS**
- **MAKES DESIGNERS MORE CONSCIOUS OF**
  - **-EQUIPMENT DEMANDS ON SUPPORT SYSTEM RATHER THAN JUST MATHEMATICAL MTBF, MTTR**
- **PRODUCT SPECIFICATION - SYSTEM**
  - **-PERFORMANCE INCLUDES METRICS FOR MEASURING DEMANDS ON LOGISTICS SUPPORT SYSTEM**
- **CAN INCLUDE OTHER INTERFACES:**
  - **-(Internal, External)**
  - **-MECHANICAL**
  - **-ELECTRICAL**
  - **-HUMAN**

10. Mission Reliability is the probability that a system will operate as specified during a specified period of time in its intended environment. One way of measuring Hardware reliability for repairable equipment is Mean Time Between Failures (MTBF). This is the average number of hours between failures (or some other measure of performance like miles for cars, or bullets for guns). One of the first cars I owned (67 Dodge Dart) was very reliable. I drove it 84,000 miles in 4 years, with normal upkeep like oil changes and tune-ups, before it needed any corrective maintenance.

RELIABILITY

10

$$R = MTBF = \frac{1}{\text{Failure Rate}} \qquad FR = \frac{1}{MTBF}$$

MTBF = 250 Hours:

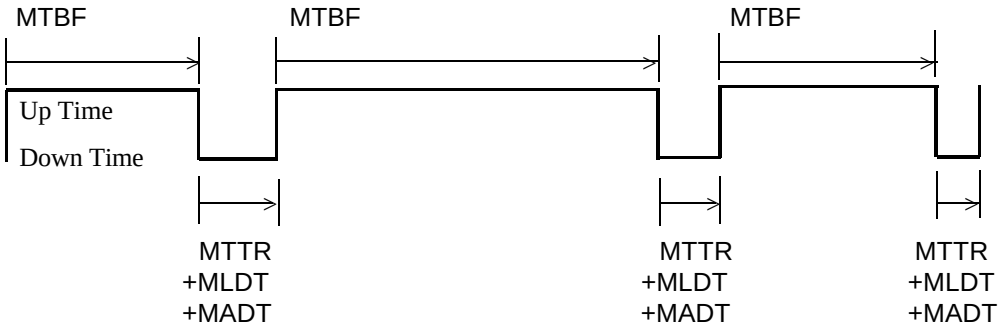
FR = (1 / 250) = .004 FPH or

FR = (1 / 250) x 1,000,000 = <u>4000</u> Fail / 1,000,000 Hour

MTBF = 250 Hours:

FR = (1 / 6000) = .000167 FPH or

FR = (1 / 6000) x 1,000,000 = <u>167</u> Fail / 1,000,000 Hour



SERIES: FR (Total) = FR1 + FR2 + FR3 + ... + FRn

PARALLEL: FR (Total) = 1 / (1/FR1) + (1/FR2) + (1/FR3) + ... + (1/FRn)

<u>Hardware Reliability</u> is the reciprocal of failure rate. If an item fails once every 250 hours, its failure rate is 1/250 = .004 FPH. A standard military and commercial way of expressing this is failure rate per million hours. In this example, FR = 4,000 failures per million hours. If a more reliable part fails about once every 6,000 hours, its FR is only 167 FPMH. Reliability for a system can be calculated by combining the individual failure rates of its parts and components using the following formulas: For parts in series, total FR = the sum of the individual FR. For parts in parallel, total FR = the reciprocal of the sums of the reciprocals of the individual failure rates.

<u>Maintainability</u> is the measure of how well an item can be restored to its original operational condition. Maintainability can be expressed as <u>mean time to repair (MTTR)</u>, or average time to remove the broken or failed item (like a flat tire, a frozen water pump on a car engine, or a crashed hard drive in a computer), and replace it with a good one. This is also referred to as "<u>down time</u>," or the time that the equipment is <u>not ready</u> for operation. And it includes the time it takes to obtain and install a replacement item.

OPERATIONAL AVAILABILITY

11

$$Ao = \frac{\text{Up Time}}{\text{Total Time}} = \frac{MTBF}{MTBF + MTTR + [MLDT+MADT]}$$

$$Ao = \frac{\text{Up Time}}{\text{Total Time}} = \frac{500}{500 + 1.5 + 10} = \frac{500}{511.5} = .9775 \text{ (Good)}$$

$$Ao = \frac{\text{Up Time}}{\text{Total Time}} = \frac{500}{500 + 1.5 + 1} = \frac{500}{502.5} = .995 \text{ (Better)}$$

The equivalent measure of MTBF, for throw-away items and non-repairable equipment is <u>Mean Time to Failure (MTTF)</u>. Down time for these can be shorter than for repairable equipment, depending on access to failed part and availability of replacements. It is usually most cost effective for expensive equipment to be repairable and for throw-aways and non-repairables to be inexpensive.

11. Ao, Operational Availability is the ratio of up time to total time, or the amount of time the equipment is available and ready for operation. Ao = Up Time divided by Total Time, or MTBF / MTBF + MTTR + logistics and administrative delay times.

If a system has a MTBF of 500 hours and it normally takes 1.5 hours to repair, but it takes about 10 hours to obtain the parts from a warehouse across town and do the administrative paper work, then Ao = 500 / (500+1.5+10) = .9775. A higher Ao of .995 could be achieved by using more reliable parts or stocking spare parts locally (for less than 1 hour logistics delay).

12. To acquaint you with some more support-related concepts, here are some statistics on my 1976 Dart. Use conditions included highway to jeep trail, temperatures of -40 to 120 deg F, elevation 0 to 7,000 ft above sea level; load up to 1,500 lbs people plus luggage; operating environments included sun, night, fog, salt spray, rain, mud, snow, ice.

USE STUDY

12

1967 DODGE DART, 84,000 MILES / 4 YEARS

80% highway	20% city	
7,200 miles	15,800 miles	
50 mph avg	20 mph avg	
1,244 hr +	840 hr	= 22,184 hr / 4 yr
		= 546 hr / yr
Utilization rate	546 hr / 8766 hr / yr	= **6% or 1.5 hr / day** (variation: 5 min - 20 hr)

OWNERSHIP COSTS

OPERATION

84,000 miles @ 20 mpg = 4,200 gal gas @30 ¢/gal = $1,260

PREVENTATIVE (scheduled) MAINTENANCE

84,000 miles x 1 / 3,000 mile oil changes	= 28 changes	
28 x 6 qt oil = 168 qt x $1.00/qt	= $168	
28 x $2.50/filter	= $ 70	
3 x 30,000 mile tune ups	= $100	
other	= $ 62	= $ 400

CORRECTIVE (unscheduled) MAINTENANCE

4 tires + 1 = 5 tires @ $40/tire	= $200	
replace brake shoes	= $ 20	= $ 220
Total		$1,880

Op-Maint Cost = $1,880/84,000 miles = **2.2 ¢/mile**

PURCHASE (approx) = $5,000

Total $6,880

Op-Maint Cost = $6,880/84,000 miles = **8.2 ¢/mile**

MAINTENANCE PLANNING

13

EVOLUTIONARY PROCESS TO DEVELOP AND ESTABLISH MAINTENANCE CONCEPTS THAT WILL BE IN EFFECT FOR THE COMPLETE SYSTEM / EQUIPMENT DURING THE USE PHASE (BETWEEN PRODUCTION AND DISPOSAL).

- **TYPES:** PREVENTATIVE (Scheduled)
  CORRECTIVE (Unscheduled)
- **LEVELS**: ORGANIZATIONAL (USER)
  INTERMEDIATE (SHORE, AFLOAT)
  DEPOT or OEM
- **BASED ON AVAILABILITY & EXPENSE** OF:
  PARTS,
  TEST EQUIPMENT
  MAINTENANCE PERSONNEL
  TRAINING FOR REPAIR SKILLS

If 80% of those miles were highway driving at an average rate of 50 MPH (40-75), and 20% were city driving at an average of 20 MPH (1-40), then the car was used about 2,184 hours in 4 years, or 546 hours per year. The utilization rate was about 6% or about 1.5 hours per day; the average between some all day business and vacation trips and many shorter trips to work, the store...etc. If its gas mileage rate was 20 mi/gallon, the operating cost at 30 ¢/gallon was $1,260. Cost of upkeep (28 oil changes at 3,000 mile intervals) and two minor tune-ups is about $300, for a total operation and maintenance cost of $1,880. This works out to be only about 2.2 ¢/ mile. If the purchase price was $5,000, total ownership cost was about $6,880, or $1,715 per year, or 8.2 ¢/ mile.

13. Maintenance Planning begins with defining the maintenance concept. This concept describes how much and what type of maintenance (preventative, corrective) and what maintenance actions (remove, replace, repair, throw away) will be done at each maintenance level, to provide the most effective and

affordable maintenance for the system during its entire life cycle. Examples of maintenance levels are:

ORGANIZATIONAL (0-Level) many user locations,
staffed by user technicians,
INTERMEDIATE (I-Level) staffed by skilled
technicians, with more resources, and
DEPOT (D-Level) which corresponds to original
manufacturer (OEM).

This is the highest maintenance level; it is normally staffed by the highest skilled specialists and has the most expensive tools and test equipment. Some systems have only two maintenance levels (I and D) and some have four or more. The maintenance concept is strongly influenced by how much money the program sponsor/manager can afford to pay for preventative and corrective maintenance of the new system. This in turn depends on the cost and distribution of tools, test equipment, spare and repair parts, facilities, skilled personnel and transportation from user to maintenance facilities.

SUPPLY SUPPORT ----> *THE PIPELINE* ----> [14]
ALL MANAGEMENT ACTIONS,
PROCEDURES AND TECHNIQUES USED TO:
• DETERMINE REQUIREMENTS TO:
- ACQUIRE,
- CATALOG,
- RECEIVE,
- STORE,
- TRANSFER,
- ISSUE AND
- DISPOSE OF SECONDARY ITEMS:
(SPARES, REPAIR PARTS, AND
CONSUMEABLES USED IN PM AND CM)
• PROVISIONING AND INITIAL SUPPORT OF
REPAIRABLE SYSTEM
• INITIAL AND SUSTAINED SUPPORT, AND
REPLENISHMENT OF EXPENDIBLES

It may be more economical, for example, to outfit many O-level repair facilities with low cost test equipment, low salary technicians who can only perform easy maintenance tasks (like remove and replace failed parts) and with storage for many inexpensive parts; and have one depot facility containing the more expensive test equipment and highly-skilled, high-salary technicians who can perform more complex repair tasks, with low quantity high cost assemblies of the system. Conversely, it may be desirable to equip many O-Level locations with expensive test equipment, staff them with highly trained and skilled technicians and stocked with expensive repair parts. This could increase the Ao, but would it be affordable?

14. Supply Support: For equipment that is to be maintained, a "pipeline" is set up in advance for maintenance items like spare parts, consumeables and expendibles which are required to sustain equipment maintenance actions; which in turn support equipment operations. System design and support engineering process includes determining what assemblies and parts are expected to break, burn out or otherwise fail, their historical or predicted failure rate and their estimated replacement rate, determining requirements for secondary items like spares and repair parts, and disposal of failed or broken items.

Provisioning is the process of examining engineering drawings or actual hardware assemblies to determine family or indenture relationships between repairable assemblies and the replaceable/throw-away subassemblies or components needed to repair those assemblies. Also considered is the attaching hardware removed to get to the failed items, and which are needed to put the equipment back together. Listed in a Maintenance Manual are correct part numbers of parts that need to be stocked in order to repair failed equipment, and tools and test equipment needed for maintenance actions. Provisioning includes plans to acquire, catalog, receive, store, transfer and issue good parts.

For expendable equipment that is either cheap enough to throw away if it fails or is useable only once and

cannot be recovered (like bullets, type writer ribbons and some sonobuoys), supply support plans for a constant supply, storage and use of these items. There is a growing trend to use Commercial Off-the-Shelf (COTS) subassemblies to make and repair equipment. Inexpensive COTS items may be treated as extendible if failed assemblies are replaced and then discarded rather than repaired.

15. Packaging, Handling, Storage and Transportation: After a piece of equipment is produced, it is packaged and distributed to various user locations or to storage facilities. During the handling and transportation phases of physical distribution, equipment is sometimes exposed to treatment that is rougher than at any other phase of use or maintenance. Therefore it is important to protect it to retain the reliability and quality that was designed into it. Planning ahead for PHS&T during the design phase includes:

a. Choosing appropriately rugged parts, mounting them so they won't shake loose, and designing shock mounts to reduce mechanical stress;

b. Packaging and preservation - Selecting appropriate materials for wrapping or coating the equipment. This is used to seal, pad and protect equipment from extreme environmental factors such as temperature, pressure, salt water, electromagnetic radiation and the shocks and vibrations that it will experience during transportation, storage and use;

c. Either designing and buying a new outer package to fit the new equipment (additional program expense), or influencing the equipment design to fit standard packaging (usually the less expensive alternative);

d. Plans on how many units will fit onto a pallet, and how high can the pallets be stacked. Also considered is age dated materials and the need for first-in-first-out (FIFO) method of inventory management;

e. Planning for unit of issue and considering the possible economy of packaging several units together for efficient loading in trucks, rail cars, aircraft, ships and storage locations.

f. Staying informed about transportation priorities and noting the tightest or weakest places that big or heavy equipment is likely to pass through or over during distribution, such as bridges, tunnels, overpasses, wearhouse doors ... etc.

PACKAGING, HANDLING, STORAGE and TRANSPORTATION 15

- RESOURCES, PROCEDURES, METHODS
- DESIGN CONSIDERATIONS:
  - PACKAGING, STACKING - FORM, FIT
  - TRANSPORTABILITY
- ROUTING FROM MFR. TO USER
- PRESERVATION RQMTS FOR STORAGE (SHORT AND LONG TERM)
- ENSURE SYSTEM AND SUPPORT ITEMS ARE PROPERLY PRESERVED, PACKED, PALLETIZED, HANDLED, TRANSPORTED, AND STORED:
- TO MAINTAIN BUILT IN RELIABILITY.
- ENVIRONMENTAL CONSIDERATIONS (SHELF LIFE, FIRE FIGHTING)

g. Equipment that contains high security items or hazardous materials would be limited in the kinds of facilities they could be stored in, and their storage facilities would need special security or fire fighting equipment.

h. Warehousing is the ability to keep items in stock while supplying them to users at various rates. This is a very sophisticated science, and is included in the subject of operations analysis. Some basic warehousing formulae are:

FILL PIPELINE = Mean Demand x Repair Time, STOCK LEVEL = On Hand + In Repair or On Order - Back Order

A technique called "just in time inventory" or "just in time manufacturing" JITM, reduces the expense of storage by extending the warehousing concept back to the manufacturer's assembly lines. Instead of making occasional large production runs and storing the products in expensive facilities until people buy them, and gradually deplete the supply, JITM attempts to satisfy user demands by a production rate based more on consumer rate. This, of course, can fail if there is a sudden, unexpected increase in demand rate. So there may need to be a balance between storage and JITM.

PHS&T planning considers for the best transportation routing of equipment via air, sea or land (rail or truck) from manufacturer to user locations. It also considers the routing and transportation of packaging materials back to the equipment manufacturer for re-use.

Here are some accounts of interesting transportation problems. Several years ago Crane was given two stainless steel tanks 16' diameter 47' long, having 11"-17" wall thickness and weighing almost 500 tons each. These were originally constructed as nuclear reactors, and Crane was going to reuse these as hydroacoustic test tanks to test sonar traducers under 2,500 psi (simulating ocean pressure about 1 mile deep). The only problem was these tanks were located in Mississippi. They had to be moved by barge up the Ohio River, by rail car from Jeffersonville Ky across the river to Crane In, and then by a special semi-trailer to the test facility. A trial run was made along the railroad using a special "template railcar." This car had 16' measuring "whiskers" radiating out in all directions to determine if there was enough clearance through tunnels and underpasses, and past road cuts and buildings. Some rock walls had to be excavated, the railroad bed had to be lowered under I-65, and one corner of a restaurant had to be cut off to prepare the way. The tanks were loaded on special 22-axil rail cars with end braces that distributed the weight of each tank over the space of three rail cars and finally transported to Crane.

Another PHS&T story is about a trucker who was used to delivering torpedoes using a highway with overpasses that gave his truck only a couple of inches of clearance. One day the highway surface was raised with 4" of new asphalt. Because no one had thought to update the clearance information on the sign 1/4 mile before the overpass, on his next trip, the top layer of torpedoes was sheared off by the overpass.

SUPPORT & TEST EQUIPMENT (S&TE) 16

- ALL EQUIPMENT REQUIRED TO MOVE, OPERATE AND MAINTAIN SYSTEM
- COMMON (STANDARD) AND PECULIAR
- GROUND SUPPORT (YELLOW)
- TEST EQUIPMENT: ELECTRONIC AND AUTOMATED
- TOOLS
- METROLOGY AND CALIBRATION
- ACQUISITION, LOGISTICS SUPPORT OF S.E.

16. Support and Test Equipment: Support equipment includes weight handling equipment like frames with handles, cranes, fork lifts, chain hoists, hooks, slings, and test fixtures unique to that new equipment. For smaller, light weight items that can normally be handled by personnel, no advance planning is required for handling equipment. But, for heavier and bulky items, standard or peculiar weight handling equipment may be needed to carry it from a truck and install at the location where it will be used or repaired. Planning ahead for handling equipment may either influence the prime equipment design to include lift eye bolts, or to design special adapters that allow the equipment to fit onto standard transporter carts.

Test equipment includes multimeters or other electronic and mechanical test meters used for localizing failures before repair and verifying correct operation after repair. Planning ahead for testing may include use of embedded computers to do built in test (BIT), installing easy to access test points, maintaining the operation and accuracy of test equipment, ease of prime equipment assembly and disassembly, and

choosing attaching hardware (bolts, nuts) of subassemblies to make the most economical use of standard tools. Support Equipment items can have their own ILS programs.

Along with the hardware aspects of ST&E is the need for metrology and calibration, which enables test equipment to measure accurately and precisely, according to U.S. or world standards. Some people think of standards as restrictive of their freedom. But in fact standards contribute to maintenance of freedom and peace by enabling agreement and communication among different people, companies and nations.

TECHNICAL DATA 17

- RECORDS & INFORMATION (MANUALS AND DRAWINGS)
- OPERATIONS AND MAINTENANCE
- COMPUTER S/W DOCUMENTATION (NOT ACTUAL PROGRAM OR S/W)
- FINANCIAL AND CONTRACT ADMIN.

17. Technical Data: Includes all printed or digital technical and scientific data. Operators need operator's manuals in order to learn how to use the new equipment, maintenance personnel need maintenance manuals to learn how to fix it, supply personnel need provisioning lists to know what items to stock, so maintenance personnel can obtain spare and repair parts; therefore accurate engineering drawings, and accurate, well illustrated manuals and provisioning lists are among the important technical data that is delivered with new equipment. Computer programs and financial and contract data are not included in this element.

FACILITIES 18

- REAL ESTATE (LAND & BUILDINGS)
- REQUIRED FOR FULL LIFE CYCLE SUPPORT OF SYSTEM,
- INCLUDES STUDIES TO DETERMINE: REQUIRED TYPES, AVAILABILITY, IMPROVEMENTS (NEW, MODIFIED)
- SPACE, ENVIRONMENT, POWER, S.E. FLOOR STRENGTH, SMOOTHNESS,

18. Facilities: Facilities are used for storage, training, operations and maintenance. Personnel involved in planning for storage facilities first examine existing facilities for good location, adequate floor space and strength, availability of support equipment, environmental conditions and fire fighting equipment; and would compare their existing capacities with total expected volume and weight requirements of the new equipment as it is distributed to various storage and user locations. For maintenance, operations and training facilities, power requirements are also considered. If existing facilities are not adequate, plans need to be made many years in advance to fund the modification of existing facilities or buy land and build new facilities to fulfill new requirements. At the acoustic test facility mentioned earlier, they had to construct a foundation that would support the weight of the both tanks filled with water, total weight of 1,500 tons. In storage facilities having 30' high shelves, using high fork lifts that travel 20 mph between aisles, it is important for the floor to be smoothed to within 10 thousandths of an inch to prevent dangerous swaying of a loaded forklift.

19. Manpower and Personnel: Planning for most effective operation and maintenance of new equipment includes planning for the people who will be operating and maintaining it. Questions that need to be answered are:

a. How many hours per day or per week will the new equipment be in use, and are there enough personnel available to operate it in

MANPOWER & PERSONNEL 19

- IDENTIFY AND ACQUIRE (HIRE) PERSONNEL - MILITARY, CIVILIAN
- WITH APPROPRIATE GRADES, SKILLS
- TO OPERATE AND MAINTAIN SYSTEM
- AT PEACE TIME AND WAR TIME RATES
- RELATED PROGRAM:
  - HUMAN FACTORS

addition to their present duties? or does it replace older equipment so that dedicated personnel will work full time with the new equipment?

b. What is the mean time between failures (MTBF) and the mean time to repair (MTTR)? How much additional time demands would new prime equipment maintenance tasks make on existing maintenance personnel?

TRAINING & TRAINING SUPPORT 20

- PROCESSES, PROCEDURES, TECHNIQUES, DEVICES AND EQUIPMENT TO TRAIN:
- MILITARY (Active, Reserve), CIVILIAN
- OPERATIONAL AND SUPPORT SYSTEM
- INDIVIDUAL AND CREW TRAINING
- FORMAL AND OJT
- NEW EQUIPMENT AND REFRESHER
- ILS PLANNING AND ACQUISITION OF

c. What are the peace time and war time demands for operation and maintenance?

d. What types of personnel (military, civil service, civilian, contractor) and what grades, skills and skill levels will personnel need in order to operate and maintain the new equipment? How much additional training will they need?

e. If additional personnel need to be hired, more money needs to be budgeted for additional salaries; and additional administrative personnel may be needed.

20. Training and Training Support: Planning in this element considers all the types of training available (civilian and military colleges, short term classes, refresher courses, OJT, individual and crew) to the all the different types of personnel involved with operating and maintaining the new equipment; curriculum development, instructor training, training materials (books, videos), tests and training equipment (such as simulators). Also, like Support Equipment, Training Equipment sometimes needs an ILS program and Maintenance Plan

COMPUTER RESOURCES SUPPORT 21

- ALL RESOURCES REQUIRED TO OPERATE AND SUPPORT
- EMBEDDED COMPUTERS WITHIN SYSTEMS AND EQUIPMENT
- RESOURCES INCLUDE:
  - HARDWARE
  - SOFTWARE
  - DOCUMENTATION
  - PERSONNEL (NUMBERS, SKILLS)

21. Computer Resources: includes support of hardware, software and documentation used in Built in Test (BIT) modules and tactical computers embedded within a weapon system. New cars have embedded programmable computer resources that requires specialized support if they fail.

22. Software Logistics Support: Planning ahead for effective

S/W support is concerned mainly with debugging and updates of S/W programs, supply and reliability of various media (plastic with bar code, magnetic tape and diskettes, optical disks, chips and EPROMs) on which programs are stored, and documentation.

SOFTWARE ILS SUPPORT 22

MAINTENANCE
- FAULT DETECT/ISOLATE S/W IN H/W
- SOLVING USER PROBLEMS
- DEBUGGING, UPDATES

SUPPLY SUPPORT
- ADEQUATE SUPPLY OF MEDIA
  - MAG TAPE
  - MAG AND OPTICAL DISKS
  - CHIPS, EPROM
  - PAPER
- RIGHT FORMAT

PHS&T
- PROTECTION IN ENVIRONMENT
- SHELF/SERVICE LIFE

PERSONNEL & TRAINING

TECH. DOCUMENTATION

23. Disposal/Re-use is not always formally recognized as an Integrated Logistics Support element; but, because of its importance as final phase in life cycle, it is described here as an element. Planning ahead for disposal/reuse includes planning for ease of disassembly and separation of parts, metals and materials that can be sold and used over again, or disposed of in sanitary land fill; this includes isolation and neutralization of hazardous materials. Planning ahead for disposal considers the placement and method of attachment of subassemblies containing hazardous materials, ease of separation from chassis, neutralization and disposal/re-reuse of hazardous materials, and reclamation of precious metals. Precious metals include silver, platinum and gold plating on electrical contacts. Other recyclable metals and materials include aluminum, iron, steel, chrome, brass, copper wiring, subassemblies and chips from older computers, wood and packing materials.

DISPOSAL / REUSE 23
- PLAN FOR CONSERVATIVE USE OF MATERIALS
- HAZARDOUS MATERIALS
  - TRANSPORTATION
  - ACCESS TO MATERIALS IN EQUIPMENT
  - CONTAINERIZE
  - NEUTRALIZE
  - DISPOSAL METHOD
    - = INCINERATE OR EXPLODE
    - = SANITARY LANDFILL (LOCATION)
- REPROCESS / RECYCLE (CLEANERS, PAINTS, OILS)
- PRECIOUS METALS, BEARINGS AND JEWELS (GOLD, SILVER, PLATINUM)
- OTHER METALS (IRON, STEEL, TIN, COPPER, ALUMINUM, BRASS ...)
- OTHER MATERIALS (PLASTICS, WOOD, PAPER/CARDBOARD, GLASS, PACKING

PHS&T planning needs to be done all over again for disposal and reuse of equipment and materials. The packaging materials and pallets can also be reused. This requires planning ahead and funding for transportation modes and routes back to the manufacturer or to facilities that specialize in recycling those materials. This logistics element is receiving increased emphasis lately because, with the PHS&T element, recycle and reuse are becoming a large scale redistribution effort.

24. Below is an outline of disposal/reuse options that can be used for items containing recyclable and hazardous materials:

DISPOSAL / REUTILIZATION OPTIONS

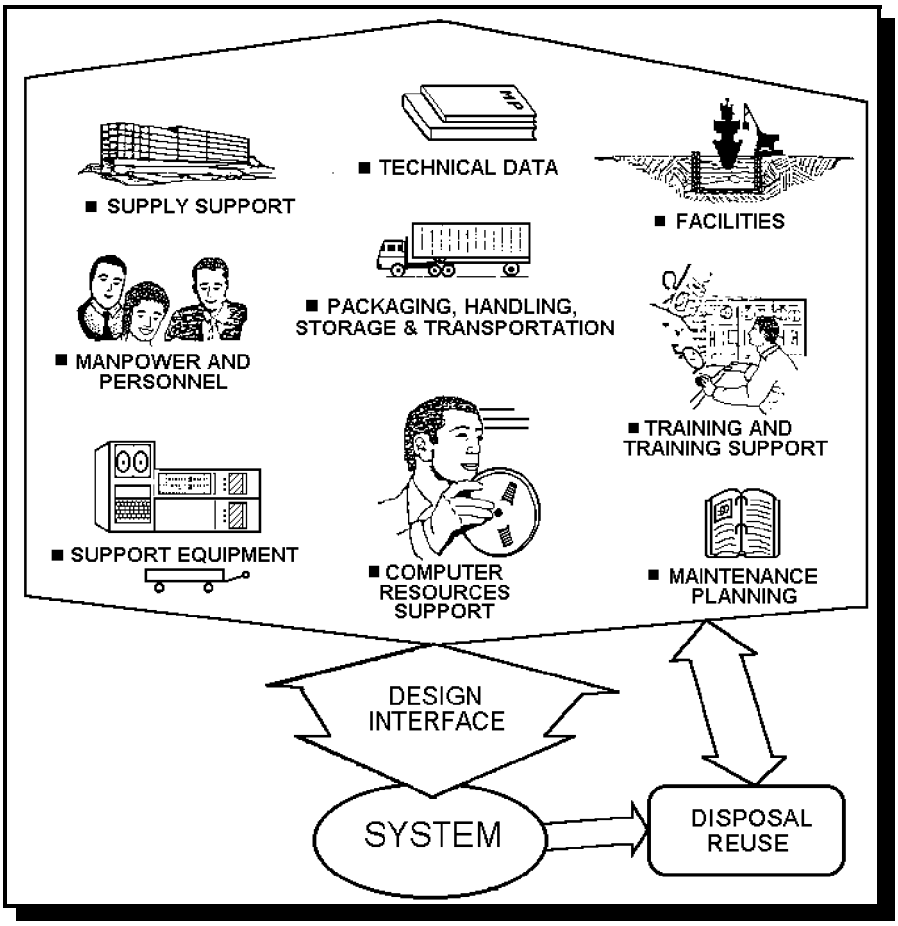
1. REUSE
   a. Within DoD
   b. Foreign Military Sales
   c. Transfer to other Federal Agencies
   d. Donate to State or Public Agencies and Institutions

2. SALE

a. To Persons or Companies and Reused in Originally Intended Application
b. To other Military Activities of County Facilities for Ultimate Disposal

3. RECYCLE AND REPROCESS
a. To Persons or Companies for Separation, Reprocessing and New Applications

4. ULTIMATE DISPOSAL
a. Landfill
(1) Open Dumps and General and Special Purpose Landfills
(2) Sanitary Landfill
(3) Secure Landfill
(4) Modifications
b. Incineration or Detonation by Explosive
c. Other
(1) Open Ocean Dumping
(2) Disposal Ponds and Lagoons
(3) Opening and Neutralization



25. Here is a conceptual diagram that shows an overall relationship of support elements to the system and support environment.

26. Following is a practical and very familiar situation best handled by a family logistics manager (Husband) and production engineer (Wife) working together with love, advance planning and with other support personnel, called CHILD SUPPORT. This includes all phases of the child's life cycle, from conception to cradle, to deployment (maturity, employment and preparation for next generation support). For example:

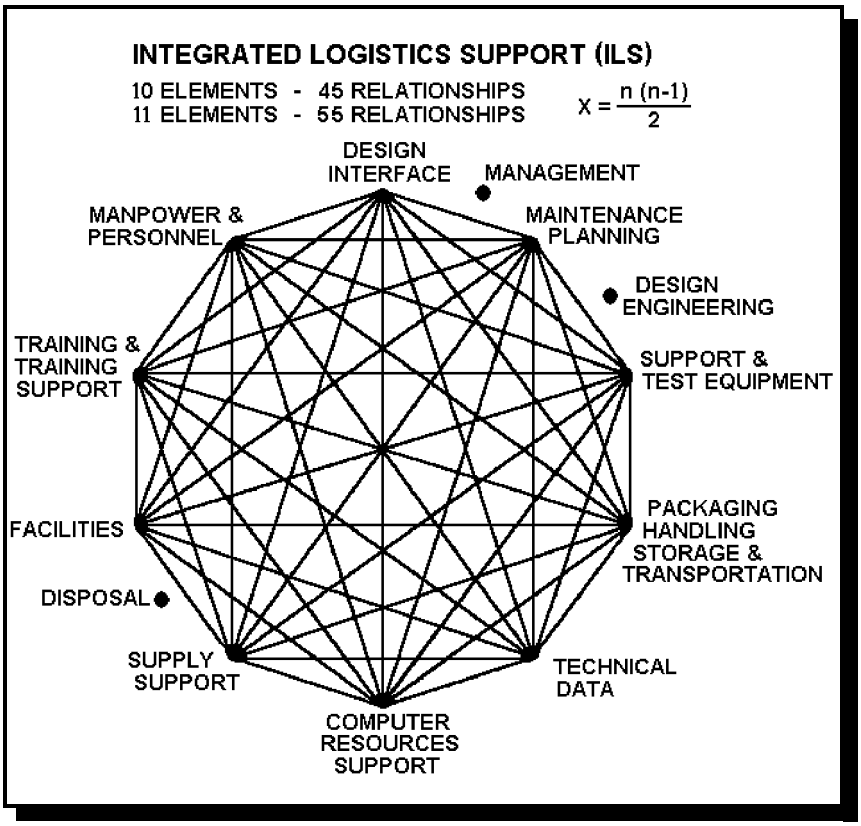
Facilities: - production (hospital delivery room), Operation and maintenance (kid's bed room, home environment - these can be a long lead items), Church (spiritual support and guidance), School (academic and character development);

Manpower and Personnel - How many people will be needed to care for this new child? Parents, doctors and brothers, sisters, grand parents, baby sitters.

Design Interface - impacts on family activities, locks on medicine cabinets laps and cradling in arms, clothing sizes.
Maintenance Planning - Life (Operations and PM) - - - Health (PM/CM)
Organizational - - - - Pantry, refrigerator, garden - - Home remedies
Intermediate - - - - - Convenience store - - - - - - - - Doctor's office
Depot - - - - - - - - - Grocery store - - - - - - - - - - - Hospital
Supply Support - Consumeables: milk, food, diapers, wipes, soap, bibs, clothes,

Support Equipment - Changing table, bath tub, high chair or booster seat, baby bottles or mom, dishes and utensils,
other furniture ...
Test Equipment - Thermometer, scales, tape measure.
Packaging, Handling, Storage and Transportation - crib, car seat, parent's laps, coat, stroller, shoes, diaper bag
Technical Data - Birth Certificate, Baby Book, camera and film, The Bible, books like "How To Raise Good Kids,"
list of boys and girls names, UYK stickers on hazardous material containers like Chlorox and Ammonia.
Training and Training Equipment - Parents need training in order to raise kids, kids need educational toys, games,
books, a training potty, and may even need an instrument of correction (board of education).
Computer Resources Support - program the embedded computer (the child's mind and heart) with nurture and
admonition and good examples that will prepare him or her to live a life of good quality, maximize "up time" and
readiness to earn a living, raise a family, and use talents to add value to various aspects of society.
LRFP - all of these support resources require new line items in the family budget.
So, you see, studying ILS elements can be very practical and fun, and can be applied to all areas of life. For example, what are the elements of support for a house, heating with a wood stove, managing a school, a hospital, a factory, a garden or a garden tractor, a car, hunting and fishing? The basic elements of support are all about the same, just different resources within each element.

The emphasis will now be shifted to INTEGRATED Logistics Support. Integration is the most important part of any effective customer and product support effort. Even the best planned and funded logistics support program will fail miserably if the elements are not integrated. Integration of logistics support elements depends on effective communication among personnel involved in each of the elements, as well as with design engineers and the program manager.



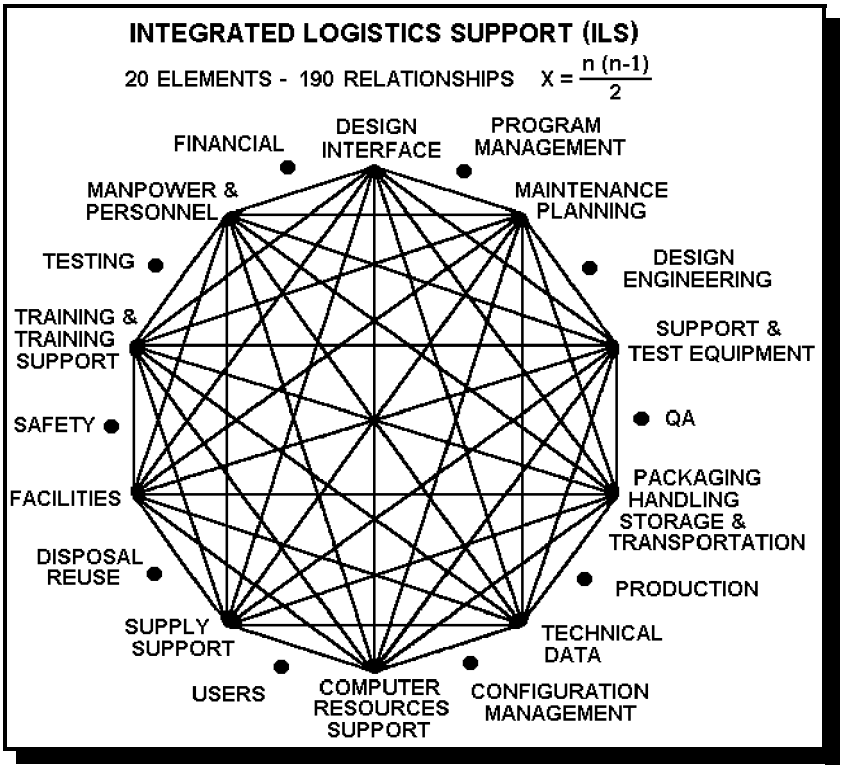
27. This diagram shows the importance of integration. The dots represent individual members. The lines represent the relationships between all the members and have the effect of "holding" them within an effective pattern. This is a practical application of a principle of group effectiveness found in the Bible, in Ephesians 4:15-16. "...By [the head], the whole body fitly framed together and compacted by that which every joint supplies." "Joints" here are not the members, but are the connective strength and functional relationships among the members, which are the bones and muscles.

The effectiveness of a body does not depend on just the existence of enough individual bones and muscles to do a job. Because you could have a complete set of human bones and muscles, with all the other necessary organs, all neatly organized on the floor, plus a chart showing how they all should fit together,

but not have a body. In order for there to be a functioning body, you need sinues to connect the bones together the right way, tendons to connect the muscles to the correct bones, cartilage material in the midst of the joints to help the bones work smoothly together, and there needs to be something inside the head bone that knows the purpose of the body and can communicate that purpose to all its members. There also needs to be a skin that defines the inside and outside of the body, a name for that body, and something to give it life. Likewise, the effectiveness of a group of people does not depend only on the existence of the members, nor on how well each member is trained, nor how well each can accomplish his or her individual part of the effort, nor on how neat the organizational chart appears. But it depends most of all on how close and how strong the "joints" (working relationships) are between the members, and how accountable they all are to the head.

The number of relationships in a group can be determined by the following formula: X = 1/2 * [n * (n-1)]; where "n" is the number of elements and "X" is the number of relationships (or maximum number of straight lines connecting a given number of points in a pattern). Or subtract 1 from n, divide the even number (either n or n-1) by 2 and multiply by the odd number. For large groups, the number of relationships approaches 1/2 "n" squared. For example, a family of Mom and Dad and 5 kids (like ours) has 7 members; but in reality it has much more than 7 members it has (7*6)/2 or 21 relationships ("joints"). In order for that family to function best, Mom and Dad (right and left side of the head) need to work at maintaining a good relationship with each other and with each of their kids, and the kids need to learn to maintain reasonably good relationships with the parents and each other. Just like in a human body, where one weak or painful joint can greatly reduce the effectiveness of that body, so one bad relation between any 2 members, or one member who can't maintain a right relation with other members, can greatly reduce the effectiveness of the whole group.

In the DoD, for example, we have 10 logistics elements, so there are 1/2 [10*(10-1)] or 9*5 or 45 relationships among them. Including ILS Management in the organization adds only 1 member. But this one member adds 10 more relationships to maintain. Adding Design Engineering, Production and User Community to the ILSMT organization adds only 3 more members, for a total of 14, but this adds up to 7*13 or 91 relationships, double the original size.



28. Looking at a bigger picture, suppose a corporation has 20 members in management, engineering, logistics and related fields, double the size of the ILS Team, it would have 190 or almost 4 times the number of relationships to maintain. If any of these relationships are missing or bad, or any elements are developed independently from each other or separate from the prime equipment during design and development, things will go wrong with the support during the deployment phase. The bottom line is this: merely assigning engineering and logistics tasks to people in a program organization, even if it is well organized and the members are well trained, that does not guarantee the program will accomplish its purpose, but it also requires close integration among the team players. Let's look at some of these relationships.

The relation between Manpower & Personnel and Training is fairly obvious, because it is the personnel who are trained.

But what about the relation between Manpower and Facilities? If people will be working 8-10 hours a day in a new storage or maintenance facility, there needs to be plans for proper temperature control, ventilation, rest rooms, lighting, maybe a canteen area ... etc. Such concerns are included in a program called Human Engineering.

What about Supply Support, Training and Technical Documentation? Supply Support plans for the repair parts, tools and test equipment that are needed to maintain the system. Maintenance Manuals contain repair procedures and lists of those repair parts, tools and test equipment. Training materials for Maintenance personnel normally include the Maintenance Manual. If three different personnel are involved in planning in these three elements, they better communicate frequently enough to assure they have the same and correct information.

The relation between Maintenance Planning and Supply Support is easy to see. Even though different personnel are involved in these for different purposes, the information will ultimately converge again at the user, because the same parts and part numbers are included in both elements and in the actual equipment. The relation between PHS&T and Disposal/Reuse/Recycle is important due to the increased demand on transportation and storage during the redistribution of end-of-life-cycle materials.

But let's look at an example of dis-integrated logistics support. Let's say an engineering technician who works with the design engineer in one field activity is tasked to write the maintenance plan and the technical manual for a new amphibious combat vehicle engine, having a planned 20 year service life. And a loggie in another activity is tasked to develop the provisioning list of spare and repair parts for that engine. The engineer and loggie initially receive the same information from the program manager; but for some reason they fail to communicate with each other afterwards.

The engineer changes the design to incorporate more reliable parts (like a more efficient carburetor, which happens to have a different mounting bolt pattern), and tells the technician who quickly changes the maintenance manual, but for some reason fails to tell the loggie. The loggie very professionally provisions the engine with the original carburetor and sends his spare parts list to the item manager, who in turn quickly procures a sufficient quantity for 20 years supply of spare parts. The older carburetors are stored in the supply warehouse, and their part numbers are entered into the supply system database. Next year the vehicle with that new engine is delivered to the user.

Another year later the carburetor fails during a critical mission and needs to be replaced quickly. The repair technician looks in the engine maintenance manual, finds the procedure for replacing the new carburetor, finds the new carburetor part number, and orders it from supply. He is notified that the new part number does not exist in the supply data base and no new carburetors were procured; and he is sent the older model carburetor that was listed for that engine. He tries to mount it to the engine block but the mounting holes don't line up. So, the engine, and therefore the vehicle, are not ready for the mission, and the whole in-service program experiences costly delays until additional quantities of the new carburetor are procured.

Is this a logistics problem? Not exactly. The logistics support elements and organization were there. But this is an integration problem - a breakdown in the relationships between engineering and logistics and between two ILS elements (Maintenance Planning and Supply Support) and a related program, Configuration Management, which is supposed to keep track of all the changes. Next comes finger pointing and bad feelings, and the already massive list of lessons learned grows longer. So, maintenance of professional relationships is important, even more important than personal feelings and prejudices.

In general, integration begins by methodically considering each element in relation to all of the others, and is accomplished by managers, engineers and technical personnel in each element, along with the users, communicating and coordinating with each other about their decisions, funding, schedules and needs. Teamwork works best when each member works to maintain good professional relations and communications with all the other members.