

# Importance of Spare Parts Supplies in Air Transport

Ślusarczyk Beata and Kot Sebastian

**Abstract**—Article focuses on the issue of supply management of spare parts for passenger aircraft. Meeting the needs of the aviation associated with rapid time delivery and high level of security of supply. Such a system, however, requires proper optimization of inventory management at every level, in such a way that on the one hand ensure the highest quality of service, on the other hand minimize logistics costs. The case study presented in the content describes of the complexity of the problem and possible solutions that can be used in supply management in relation to various aviation spare parts types.

**Index Terms**—Spare parts, supply, air transportation.

## I. INTRODUCTION

In present times, the issue of supply is considered in a particular ways, not only traditionally - through purchases transactions, but mostly through the supply chains and occurring processes and relationships between suppliers and customers. The procurement process is continuously subject to significant changes, focusing not only on the subject of supply, but having more and more suppliers opportunities. Purchasing becomes more proactive, setting networks, managing them, and the processes. The nature of modern supply is the results of:

- Interorganizational dependencies;
- Use of suppliers resources;
- Use by suppliers the development studies;
- Costs Management;
- Logistic of joining and transformation processes [1].

Kennedy, Patterson and Fredendall described that spare parts inventories differences from other manufacturing inventories [2]. First, the functions are different. The function of spare parts inventories, however, is to assist a maintenance staff in keeping equipment in operating condition. Spare parts are not intermediate or final products to be sold to a customer. Second, the policies that govern spare parts inventories are different. Spare parts inventory levels, however, are largely a function of how equipment is used and how it is maintained. Maintenance which requires a given kind of part can sometimes be postponed or avoided, and the choice of a maintenance action can have an immediate impact upon the relevant spare parts inventories.

Romeijnders, Teunter and van Jaarsveld proposed a new, so-called two-step forecasting method that does take the additional repair information into account [3]. In the first step they forecast, for each type of component, the number of repairs per time unit of that component and the number of

spare parts (of the type under consideration) needed per repair of that component. In the second step, these forecasts are combined to forecast total demand for a spare part. The rationale behind this method is that the ability to recognize what causes a change in the demand for spare parts, contrary to existing methods, should lead to better demand forecasts. One of the main tasks of supply shall be deemed to ensuring that the materials needed to operations will be provided when they just be needed. In air transport, this issue is extremely important, because in case of any delays in the necessary components supply, aircraft parking costs amount to tens of thousands dollars. In the case of high capital intensity of air transport, the extremely important seems to be to ensure the reliability technical and technology aircraft equipment, which is mainly ensured by the spare parts availability [4]. The issue of inventory management of spare parts take is very common topics in scientific deliberations, among others Z. Sarjusz-Wolski and Cz. Skowronek, who correctly pointed out that the supply of critical parts can often redundant, but its absence in case of failure can cause a major financial consequences, than the cost of long-term warehousing of items [5].

In air transport, prices of spare parts, repair, its maintenance, and storage costs are so high that it is impossible to ensure that the warehouse has all spare parts for aircraft, which can be reported demand. Additionally, purchase volume too much overtime spare parts to the warehouse generates costs in terms of capital freezing in parts, inventory costs and the probability of loss of spare part due to the economic inventory aging [6].

The relationship between mean demand and flying hours/landings was considered by Ghobbar and Friend [7]. Firstly, it is not at all clear that flying hours/landings are an appropriate “clock”; e.g., for landing gear, what matters is not how long the aircraft is in the air, but how often it lands; also, some radar parts spend substantial amounts of time switched on and running while the aircraft is on the ground, so that flying hours understate the actual intensity of use. Secondly, there is no particular reason to assume that the relationship between flying hours and mean demand goes through the origin. Even if the aircraft simply sits in a hangar, some failures would inevitably occur. In this study we investigate the sources of demand lumpiness based on factors relating to the nature of airline operations that may have certain effects on the rate of demand for parts. Airline operators are constantly faced with irregular operational problems that develop from severe weather patterns and unexpected aircraft or airport failures. This may result in the need to reschedule flight services or reroute aircraft

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## II. SPARE PARTS SUPPLY FOR AIR TRANSPORT

Nowadays aviation is one of the safest branches of transport. It results above all from the fact that airships must be at the most failure-free. Very frequent technical inspections, strict rules as well as a periodic replacement of components are condition to fulfill it.

Planes consist of many million parts made of various materials, from plastic and leather, through aluminium and alloys of different kind, uranium and titan. All air parts are characterized by an excellent quality, standardization, certification as well as high price. They are not also readily available, they can be purchased by special subjects and the entire market are subject to regulations, through which the sale e.g. to embargoed countries is not possible. Airlines have special privileges thanks to which they can purchase parts directly at producers, however very often they are not dealing with supplying all of the parts.

They are divided into a few groups [8]:

- Expendable – they are chemicals of different kind, plastic or metal elements having usually a little value and one-time application e.g., screws, greases, seals etc. Parts of this type are usually being purchased through maintenance providers i.e. companies dealing with the technical support. Carriers rarely have such a service, because it involves a separate character of activity and separate approvals by the Office of the Civil Aviation - Part 145 [9]. Possession of expendable parts due to their amount and diversity could cause the decrease of the efficiency of the chain supply, as well an increase of costs.
- Consumable – also disposable parts, however more valuable than expandable ones. Only in very few exceptional cases, there is a possibility of their repair. They are plastic elements of different kind or panels. They can be purchased by service stations or the carrier (in case of seats, kitchen, cargo). Repairs of some elements can be made both by producers as well as specialized and certificated repair shops.
- Repairable – it is a category of parts, which are not components of rotatable type, however they have special directives of producers about their repair. Repairs take place at producers or in workshops having suitable entitlements. As an example it is possible to give door locks or engine pipes. Repairable type parts are being practically purchased exclusively by carriers because of their high prices. The problem in case of parts of this type is also their repair, because the number of repair stations is strictly reduced and they are largely located in the United States and it involves transport costs as well as customs-legal formalities. In addition it is estimated that as far as about 50% of components after the preliminary inspection is recognized as BER-beyond economical repair-so the repair exceeds 60% of the value of the new component and in this case the part is being qualified for scrapping.
- Rotatable – most important and at the same time the most expensive kind of components. It is a majority of elements installed on the plane from wheels, engines parts, avionics computers, skin modules up to engines. For every kind of rotatable type parts a possibility of repair exists and the

history of using them is being precisely monitored, thanks to what the number of working hours of these parts is well-known. They are exchanged as a result of defects or after the specific number of hours or cycles of use. Majority of these components is being exchanged after 15 thousand hours. Defects are also happen very often and although the majority of systems is being duplicated for security reasons, such a component must be immediately exchanged and sent for repair. Supplying of rotatable parts belongs to the haulier, however on account of the high price of components only small airlines are making up their mind for the purchase, most often used parts.

## III. IMPLEMENTATION OF THE „JUST IN TIME” CONCEPT

Aviation is a peculiar industry, in which every carrier bear enormous financial outlays. So planes need to be in move to bring profits. Because of very strict air rules even the smallest defect can cause ground the plane and that means losses. It is estimated that a stop of the plane lasting an hour costs the carrier about 5000 EUR. So, in case of functioning of every airline a key element is the efficient process of supplying parts and components essential for the constant airworthiness.

Rotatable type elements are most frequently undergoing defects, in particular that ones, which have a status of critical components - they are a part of the engine, manoeuvring or the chassis and have a direct impact on the safety. On account of their high price, majority of carriers while purchasing them, decide on agreements of the pool type [10]. There are several dozen companies dealing with activity of this type, so-called pool providers, in Europe the biggest subjects of this type are Lufthansa Technik and AJ Walters. Pool agreement consists in purchasing components both new as well as from the secondary market and for making them available to the specific group of airlines, as well as repair of dismantled components. These companies are supposed to ensure the availability, depending on the agreement, from one part to a few pieces of a given part in the any time and place for a commission.

Following priorities of orders of components of pool type can be enlisted on the example of Lufthansa Technik company:

- Replenishment – order being aimed at supplementing inventory balances. The company has 7 days for providing the component and its transport takes place mainly via motor transport,
- Critical B – the company has 4 days for providing the component, depending on the location its transport takes place mainly via motor transport,
- Critical A – is about components, exchange of each can cause possible grounding. In this case the time of the realization of the order is only 24 hours. Most often parcels are being sent as air cargoes. When t is about parcels of bigger sizes the company uses special couriers offering door to door service.
- AOG – Aircraft On the Ground is about grounded planes. After placing an order it is carried out with immediate effect. Depending on the location parts are being sent as air cargoes or by special couriers. In extreme accidents

parts are being sent by special chartered planes or by the worker of a company (On Board Courier), which is being sent directly to the client on board of a regular plane and have to deliver the parcel directly to the client.

The next way which airlines apply is loan—which is lending of the component. It is applicable in case of big and expensive skin elements or also expensive parts not included in pool agreement. The price of lending has a daily rate and takes as a rule 1/365 of the value of the part for one day. After lending the efficient part is provided to the haulier and installed on the plane, the dismantled component finds its way to repair. This termination is equally costly but essential in case of having an aircraft in working order.

In case of standard consumable parts supplies in just in time system are also possible. However the majority of large distributors and producers has own AOG branches, however in the most of cases the costs of transports are higher than the value of a very part, additionally in case of orders in AOG mode extra fees are included.

Much worse a JiT application looks in case of the seats part or the kitchen since these parts are largely produced exclusively for a specific airline. The lead time in this case takes out from 45 up to 90 days. During this period it happens very often that the number of parts ordered is being increased sometimes repeatedly and a next order is needed.

Parts of expendable type are being delivered in the vast majority by companies dealing with the technical support. In case of main bases they have the minimal number of part, which consumption is the greatest. In case of smaller bases they are being delivered appropriately to planned repair or service works.

#### IV. IMPLEMENTATION OF „JUST IN TIME” IN AIR TRANSPORT COMPANY

A process of supplying in case of sudden ordering of the parts in case of the lack on the inventory balance is the first process. In the result of the JiT application it is a very frequent case. Since straight majority of defects affecting the airworthiness have rotatable type components let us trace individual stages of the process of ordering the component having the high priority to the main base:

- Detecting the defect is a first phase. Every day upon completion of the last flight on the given aircraft a service takes place. In case of detecting the defect or reporting it by the crew, opening the formal freelance agreement takes place - work order.
- The next stage it implementing such an order into the system and informing a supplies department. At first inventory balances are being checked, since very often happens that given parts have substitutes. If there are no such a part on a magazine, checking the existence of it in the pool agreement and placing an order takes place. If the given component is not contained in the agreement, seeking on the global market and the contact with other suppliers take place. Search engines having data about inventory balances of distributors and enabling a direct contact with them are very helpful, one of the biggest is ILS [11].

- In case of existence of the component in the pool agreement placing an order takes place. For the sudden demand the order gets AOG or Critical A priority. At this moment expendable type parts are also being ordered, since often happens, that they are not available in the service station.
- High priority orders are being processed almost immediately. They are being coordinated by AOG branch but next sent to the logistic department dealing with the dispatch. Preparation time for the dispatch in case of the availability of the component and additional parts along with the loading and preparing transit documentation in case of parcels of the immediate priority is about 2 hours.
- After preparing the parcel its transport takes place. The supplier owns 3 main branches in FRA-Frankfurt, MUC-Munich, HAM-Hamburg. All bases are being located within or next to airfields, which at most simplifies logistic processes connected with air transport. In case of large parcels and some of dangerous materials direct ground transport is being use.
- After the deliverance of the component receiving inspection takes place, during which technical documentation and certification is being checked. Than the part is being given to be installed in the plane. Technical documentation is being filled and after tests the plane is again completely operational and ready for a flight.

In the studied airline, supplying with the spare parts took place in Just in Time system. Total number of orders, as well as of these ones of critical character, presents Table I.

TABLE I: TYPE AND PERCENTAGE SHARE OF ORDERS IN JIT SYSTEM

Type	Number	Percentage share	Critical parts	Percentage share
Engine	190	21,11%	145	34,20%
Hydraulics	42	4,67%	28	6,60%
Avionics	86	9,56%	74	17,45%
Seats	296	32,89%	-	-
Kitchen	3	0,33%	-	-
Safety	106	11,78%	82	19,34%
Cargo	80	8,89%	45	10,61%
Chassis	69	7,67%	50	11,79%
Cosmetics	28	3,11%	-	-
<b>Total</b>	<b>900</b>	<b>100,00%</b>	<b>424</b>	<b>100,00%</b>

Source: Own study based on internal data

It results from above data that very large percentage of parts ordered in Just in Time procedure constituted seats parts, together with cosmetic and kitchen parts (33.63%). These parts did not have critical character, however supplies of these components were not being made in the company. Straight majority in case of seats, cosmetic and kitchen parts constitute consumable elements (Table II), that is parts of relatively minimum value, in case of which, leaving Just in Time concept would let great savings in transport costs.

The share of critical parts, in case of which the order with immediate effect is necessary amounts to as many as 424 positions. In the analysis of the consumption of parts, an average consumption for individual groups was being determined, as well as the total number of pieces, which were ordered under the critical procedure.

TABLE II: DIVISION OF ORDERED PARTS ACCORDING TO THEIR TYPES

Type	Number	Percentage share	Sort of parts			
			Rotable	Repairable	Consumable	Expendable
Engine	190	21,11%	97	24	68	1
Hydraulics	42	4,67%	28	2	10	2
Avionics	86	9,56%	62	16	8	0
Seats	296	32,89%	5	0	291	0
Kitchen	3	0,33%	1	0	2	0
Safety	106	11,78%	34	11	61	0
Cargo	80	8,89%	5	3	72	0
Chassis	69	7,67%	33	4	31	1
Cosmetics	28	3,11%	0	0	18	10
<b>Total</b>	<b>900</b>	<b>100,00%</b>	<b>265</b>	<b>60</b>	<b>561</b>	<b>14</b>

Most often exchanged elements were cargo area parts. It results from the fact of very frequent damage caused by the loading and the unloading of luggage. However the largest group, because as many as 34.2 %, constitute engine parts.

Amongst 1518 ordered critical parts, the most numerous group were these of rotatable character (68%). These elements in some cases are being characterized by great dimensions and weight, what considerably affects the rise in transport costs. In terms of the size of orders the next group of parts are consumable ones (27%). Much smaller participation in supplies have repairable parts with appropriately 4% participation, however the number of expendable parts does not constitute even 1% of the total of ordered elements.

The number of ordered critical parts is not identical with the number of shipments. In the result of an analysis of inclusions to the system it was established 32.4% of parts was being transported along with other parts. It results from the fact, that in case of orders of rotatable parts, consumable ones, essential for the exchange of parts, are very often being also ordered. In some cases an order on two or more part was being placed. And so the total number of critical orders and transports amounted 1026.

## V. SUMMARY

Applying Just in Time concept considerably improves a process of supplying with spare parts in the air transport. It gains a special significance in the situation of arising defects and the need of ordering elements needed, mainly of these ones of critical character. Ordering the spare parts in Just in Time mode is burdened with many problems, which efficient solving influences the speed of providing with essential elements and their efficient assembly [12]-[14]. Main factors, jeopardizing the efficient course of the process of supplying are:

- lack of parts on the inventory balance at distributors and components factories, in occasional cases even such great distributors as Lufthansa Technik do not have a given component. Then acquiring ordered elements from other branches or from the secondary market is necessary,
- errors in the order picking: lack of checking parts before leaving the magazine; quantitative gaps or wrong sending other component,
- errors associated with the certification of parts, what depending on the type of the spare element can be corrected via e-mail (for consumable and expendable parts), or however in case of rotatable and repairable parts the certificate must be original, i.e. personally signed by

the person taking out and copies are inadmissible,

- mistakes made by the those responsible for the installation of the element, e.g. mechanical damages of the exchanged part, what results in the need to place a next order and to repeat the process of the dispatch.

All exchanged factors considerably determine the time and the efficiency of the order processing. In a case, when problems occur, the process of the delivery can be much extended, and hence transport costs will rise [15]. But if ordered elements have critical character, the airline will incur extra costs associated with grounding planes.

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