# An Activity Analysis of Project Scheduling Problem: A Case Study

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Abstract- Maintenance and servicing of aircraft is costly and time consuming process. Aviation industry requires servicing of aircraft with in specified period and minimum cost with maximum effectiveness and efficiency. In this paper study of scheduling of activities, major activities involved in aircraft maintenance (Hindustan Aeronautics Limited, Agra) is done which consume more time. Study of activities have been done in different phases such as brainstorming, workshop, nominal group technique etc. We have also drawn flow diagram, cause and effect diagram to explain the internal details of activities and found, time and cost can be reduced by detailed analytical study. The results on the real data show that significant benefit regarding maintenance, scheduling, and time cost trade off analysis can be obtained from the proposed case study.

Keywords- Time Cost Trade Off, Project Scheduling, Aircraft maintenance

## I. INTRODUCTION

In real life activities are performed using different resources in a regular manner. The combination of all activities form project and arrange the project activities according to project requirement in optimum way are known as project scheduling [3]. For scheduling of project two criteria are very important first is time and second is cost. Project planner use different methods with utilization of different sources to complete the project in shortest time with minimum expense of cost. To compress the project time project manager have to accelerate some activities at an additional expense During project scheduling different decisions are taken regarding time and cost of each activity for overall network, the set of decisions that resulting desirable time cost realization constitutes time cost trade off problem [2]. This tradeoff between time and cost gives project planners both challenges and opportunities to work out the best plan that optimizes time and cost to complete a project and is therefore of considerable economic importance.

Developing technologies to transform material without emission of green house gases, use of nonrenewable or toxic material or generation of waste is termed as sustainable manufacturing. Many industries have started to use ec-innovation to describe their contribution to sustainable development. For getting economical and environmental effects some steps needs to be taken regarding process modification, product design, alternative business model and creation of new procedures and organizational arrangements. Some industries are focusing on technological product and process advances for example collaboration of vehicle designer and steel makers.

There are hundreds or even thousands of activities with in real life project, it is almost impossible to enumerate all possible combinations to identify the best decision for completing a project in the shortest time and minimum cost. The problem gets future complicated due to presence of many uncertain variables such as weather condition, labor skill, managerial experience and weather condition etc, which dynamically effect both the project direction and cost, during its implementations [5].In TCT analysis project manager has to schedule project completion time with minimization of total project cost. For specified budget he has to reduce project time by hiring more workers or extra resources due to which direct and indirect cost of project is affected [1].

Now days aviation has become competitive field of business all around the world. Aircraft is being used in different field such as civil and military areas. Many factors are required to be in competition such as maintainability, reliability, cost etc. Maintenance cost greatly affect from buyer point of view [4]. Maintenance of aircraft is complex and time consuming process and requires scheduling of different activities involved in maintenance. Maintenance involves repairing, replacing, inspecting different components of aircraft. Maintenance of aircraft consists of number of small projects which is to be scheduled in minimum time and specified budget. Maintenance of aircraft is divided into number of trades: airframe, engine, electrical, avionics, instrument, structure. Every trade is divided into number of activities which takes different time and cost. Every trade has its own specialists. Some time two or three trade work simultaneously.

### **II.LITERATURE REVIEW**

Scheduling of aircraft maintenance is vast area. For scheduling of maintenance of aircraft numbers of methods and techniques have been developed. Different exact and heuristic techniques are also used to solve tome cost trade-off problems. Pour et. al developed a model of discrete time cost trade-off problems by using weight relative deviation after solving multi-objective optimization problem[1]. Piotr et. al explained about scheduling of complex construction project by using evolutionary algorithm[10]. Ahmed et. al presented a computerized system for scheduling and cost optimization of non-serial projects with application of genetic algorithm[9]. Mohammadi developed genetic algorithm pareto front approach (multi-objective genetic algorithm) for solving time cost trade off problems and minimize project time and cost in an efficient way [8]. Xiaoyu et. al studied of scheduling of airport ground handling services by multi-agent systems and focused decentralized multi-project under uncertainty [6]. Shouman et. al used mixed integer linear programming and formed critical path network for scheduling natural gas projects by replacing use of petroleum gas bottles[7]. Mohammad et. al used scatter search algorithm to minimize weighted earliness tardiness penalty cost, which is applied if finish time of each activity is not equal to due date of resource constrained project scheduling problems[11]. Bokor et. al explained drawback of traditional technique such as Gantt Chart and network modeling[12]. Wei-Neng et. al used critical path method and PERT technique for scheduling in agriculture field such as grape garden stabilization[13].

Authors presented discrete production planning models as pollution prevention models under uncertainty to solve economic and environmental problems. Maria presented a framework to insert sustainable manufacturing concept into current industrial engineering curriculum to address current unsustainable practices in industry and society. Kopac focused on sustainable machining in comparison to conventional machining and showed cooling/lubrication can provide improved overall machining performance with satisfying different parameters in terms of enhanced machining surface quality, tool life, chip breakability, power consumption and increasing productivity. Vishesh et. al focused on vehicle design changes to reduce the environmental impact of automotive industry and found replacing steel with aluminum or composite material not only increases fuel economy but also reduces the overall life cycle emissions and energy consumptions. Degrates et al proposed a framework for application of system dynamics to sustainable manufacturing. The framework formed relevant factors in four domains such as manufacturing, environmental, social and financial to develop model components and analyze sustainable manufacturing.

Orhan et. al proposed concurrent daily aircraft maintenance and route planning approach to minimize maintenance cost up to 18-37% of direct operating cost[14]. Massoud et. al developed computerized simulation model for aircraft line maintenance department at continental activities[15]. Yufeng et. al formed model that allows scheduling of operation level whenever an unscheduled maintenance event occurs[16]. Raju et. al presented different level involved in aircraft maintenance and find, higher the D level maintenance efficiency increase the availability of aircraft at operational time[17]. Shangyao et. al used network simplex method to solve pure network flow problems and developed Lagrangian reliasation based algorithm to solve multi- commodity network flow problems[18]. Hesham studied about aircraft maintenance labor scheduling to find growing labor requirements with minimum cost and found seven day workweek eliminates the increasing weekend demands with reducing the cost [19].

## III. Hindustan Aeronautics Limited Agra, a Case Study

A small unit of HAL is situated in Agra where maintenance of aircraft id done. We visited different section of HAL unit and make contact with number of person. Maintenance of aircraft is complex and time-consuming process. In HAL, maintenance of AN-32 is done, it requires 1800hrs for complete servicing. Maintenance of aircraft is divided into different trades whish are as follows: 1. Airframe 2. Engine, 3. Electrical, 4.Avionics, 5.Instrument, 6.Structure.

Every trade is related to different field and has its own specialists. Work of every trade is divided in number of activities which have different time and cost. Each activity of maintenance can be depending upon on one trade or more trades. We made contact with head of maintenance department; he provided me lot of information regarding servicing of aircraft. Maintenance of aircraft consists of 130 activities. Every activity is completed using one or more trade and have different time. Initially general inspection of aircraft is done and rough idea is made about external repairing and replacements of parts. We have done case study in different steps which are as follows.

1. Brainstorming-In this stage we formed five groups of people working in HAL.1.Low Skill Worker 2. High Skill Worker 3.Supervisor 4.Engineers 5.Top Level Management. We have done discussion with these groups regarding maintenance of aircraft which includes following points:

(i) Repairing ,replacement and inspection of different components of aircraft

- (ii) Scheduling of different activities
- (iii) Reduction of time of different activities
- (iv) Reduction of cost occurring in maintenance
- (v) Control of uncertainties occurring during maintenance regarding labor skill, managerial experience
- (vi) Control of delays i.e. unavailability of parts, external labor requirement etc.

All groups provided lots of information and found nearly 130 activities are required to complete the whole maintenance of aircraft AN-32. Different group give different suggestion for reducing time and cost of different activities. We collected 20 activities from each group, out of which 10 activities were common for all groups. We will work on those 10 activities which can reduce time and cost effectively, they are as follows

S.NO	ACTIVITIES
1)	Carry out Flight Testing, Repair All Rotables
2)	Servicing of Windows (Cockpit/ Cargo) And Replacement
3)	Remove Elevator Undertake Servicing As Per Task Card
4)	Flushing of different hydraulic systems
5)	Remove to facilitate condola seal change.
6)	Retraction test complete hyd. Oil report
7)	Physical checks of rotables
8)	First attend ground run
9)	Induction ground run, preservation
10)	Preparation of air test and delivery there after

Table 1 Major activities involved in aircraft maintenance

2. Workshop –After brainstorming session we have visited workshop and hangers where servicing of aircraft is done. In workshop there are heavy equipments and machineries for servicing of different parts. In one hanger servicing of three to four aircraft can be done simultaneously. In workshop we consulted with number of workers and supervisors, they provided detailed information about major activities which occurs in servicing of aircraft. In workshop generally all trade work simultaneously but major work is done by avionics and engine trades. Workers do some major activities in workshop such as servicing of engine, apply the coating in internal engine parts, inspection of all hydraulic, braking and priming systems, carry out spark test on engine etc. After collecting major activities we edited, coded and key worded them.

3. Idea generation- After long discussion with workers, engineers, supervisors of different trades we found some activities consume more time and due to which cost also increases. These activities consume more time due to different uncertainties such as unavailability of labour skill, weather condition, managerial experience, testing of different parts in lab, unavailability of different parts in store, unavailability of replaced parts, unavailability of heavy equipments/machineries etc. We found that we can work on different uncertainties and can reduce time and cost of whole maintenance. We found some problem also occur during ground run after servicing and also consume much time to remove problems, we will concentrate on those activities.

4 Nominal Group Technique- We have done NGT test after the different session and asked to the different members to give two problems for each activity so that time and cost could be minimized. We summarized working of different activities by using flow diagrams

5. Need Statement- In aircraft maintenance main aim is servicing of aircraft in given time and minimum cost with providing maximum efficiency and effectiveness. Since aircraft maintenance is time consuming and complicated

task so this area has great scope for doing work. It consist of number of activities and consume time which can be reduced by extra effort or applying some analytical techniques. The uncertainties occur during servicing may be eliminated by taking predetermined decision.

	Inspection of flight	4				
	Inspect rotable items	4		Inspect the window for any crazing, cracks, nicks	1	
$\bigcirc$	Unmount the rotable parts	16	$\overline{\frown}$		1	
$\rightarrow$	Bring the parts to lab	4	$\bigcirc$	Remove window fairing	1	
$\bigcirc$	Clear the parts	4	$\bigcirc$	Remove clamps	1	
	Check insulation	8	X	Remove glass	2	
	Check water and oil level	8	$\bigcirc$	, in the second s		
$\bigcirc$	Brush change	16	$\square$	Clean space	1	
$\bigcirc$	Brush bedding	56	$\bigvee$	Bring new glass	1	
$\Box$	Inspect rpm	8	$ \Box $	0		
$\bigcirc$	Servicing of lighting parts	6	$\bigcirc$	Attach window with sealing	2	
	Check noise	4	X			
<b>L</b>	Check errors	10	$\bigcirc$	Attach clamps and apply proper tension	1	
$\bigcirc$	Oiling and greasing	12	$\cap$	here a life i de a	2	
$\square$	Assemble the components	16	$\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{$	Install fairing	2	
$\downarrow$	Bring the parts to aircraft	4		Inspect for recurring and mounting	2	
$\bigcirc$	Mount the parts	16		mounting		
	Inspect the flight	4	Activity- S	ervicing of Window Cockpit Carg	o and	
Activity- Carry out Flight Testing, Repair All Rotables(160)						

Figure 2

Figure 1

	Insp
$\bigcirc$	Ren
X	Ren
$\bigcirc$	posi
	Brin
$\bigcirc$	Ren
$\bigcirc$	Disc
$\bigcirc$	Disc
$\bigcirc$	Blan
Ŏ	Ren
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$\diamond$	Ren
$\bigcirc$	Past
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$\bigcirc$	Con
$\mathcal{Q}$	Con
$\mathcal{Q}$	Μοι
$\bigcirc$	Inst
	Fina

spect engine		$\bigcap$	Position the aircraft on	6	
emove spinner		$\bigvee$	jacks		
emove propeller and osition on stands	16	$\bigcirc$	Attach the HST	3	
ring the crane		$\gamma$	Check/flush different		
emove propeller by crane	10		hydraulic system	4	
isconnect oil pipes	7		Check/flush different	4	
isconnect a/c pipelines	7		braking and priming system	4	
lank all disconnected open	8	$\bigcirc$	Do the patch test	6	
pes	0	$\bigvee$	Send the sample to lab for		
emove the condola	8	$\Rightarrow$	testing	3	
spect the condola	2	Ď	Wait the results of samples	8	
lean the condola	8	LT_	Take the comple of UCT oil	4	
emove rotten (broken) seal	8	Ц.		4	
acta tha anal	6	$\Box$	Wait the results of samples	5	
aste the seal	0		Carryout system checks of	c	
ait for sticking			interrelated functions	6	
lount the condola			Check all overriding systems	6	
onnect AC lines	7		check an overhang systems	U	
4 - 11 - 14	7		Check leakage of hydraulic	4	
onnect on pipes	0		pipelines if any	83 <b>1</b> .9	
onnect disconnected loops	0				
lount the propeller	15	()	Proper lubrication and	2	
stall spinner	8	$\gamma$	greasing is done	2	
inal Inspection	6		Final inspection	2	
<b>Activity</b> – Flushing of different hydraulic					
seal change (154)		system(63)			

Activity -R seal change (154)

Figure 4

Figure 3

$\bigcirc$	Remove elevator hinge points access covers	1
$\int$	Remove split pin of all detachable	1
$\mathcal{O}$	Remove elevator moving shaft from joint	1
$\bigcirc$	remove elevator trim tab shaft	1
$\overline{\bigcirc}$	Remove all 3 elevator mountings	2
Ŏ	Clean the surface thoroughly with cleansing agent	1
$\square$	Wait for dry the surface	1
$\bigcirc$	Apply Primer on shining surface	1
$\square$	Wait for dry the surface	1
	Paste fabric cloth	2
Ď	Wait for dry the surface	1
T	Apply coats of paint	1
6	carry out oiling and greasing of all movable parts/joints	2
$\bigcirc$	Resplit pinning of all mountings	1
$\overline{\bigcirc}$	Mounting of elevator	2
Ŏ	Connecting of elevator shafts, turn tab shaft	1
	Check operation	1

Activity- Remove Elevator Undertake Servicing As Per Task Card (21)

Figure 5



Figure 6 Cause And Effect Diagram

# **IV.CONCLUSIONS**

We studied about number of activities involved in aircraft maintenance and found some activities that have scope of reducing time and cost. By analysis we found some results they are as follows

- Repair of rotables (inverter, generators)takes 160 hrs which can be reduced up to 154hrs
- Change of condola's seal takes 154 hrs which can be reduced up to 148hrs.
- Flushing if hydraulic system takes 63 hrs which can be reduced up to 55hrs.
- Repair of elevators takes 21hrs which can be reduced up to 18hrs

Similarly we found that time can be reduced by great extent of whole aircraft maintenance

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