MAINTENANCE BUDGET

REV4 - 27/05/2024

Sapienza Università di Roma

M.Sc. in Aeronautical Engineering

Aircraft Flight Operations and Maintenance

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0. INTRODUCTION

INTRODUCTION

- As the CAMO team of an Airline operating 5 Embraer 170, our mission is to ensure the continuous airworthiness, reliability, and availability of the new Airbus A320 fleet that our airline intends to operate.
- We intend to debut by operating two leased Airbus A320s, facilitating connectivity between **Fiumicino Airport ←→ London Luton Airport**
- To achieve this, we have developed a comprehensive maintenance strategy and detailed a budget proposal for the first year of operation, along with a forecast of maintenance costs for the next five years, with targeted actions for their reduction.
- Responsible for overseeing technical operations to ensure efficiency and regulatory compliance, devising a strategy for in-house or outsourced maintenance to maintain airworthiness and operational efficiency and establishing and managing the maintenance budget.

1. AIRCRAFT PHASE IN

AIRCRAFT PHASE IN (1/5)

In this phase, the CAMO must **outline** and **strategize** the necessary maintenance activities to obtain the Certificate of Airworthiness (CoA) and put the aircraft into service and ensure readiness for operation by the designated project date, which is **January 1st, 2025**.

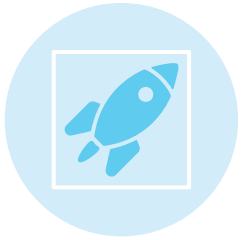
GANTT CHART IS NECESSARY

AIRCRAFT PHASE IN (2/5)

Assumptions for the GANTT Chart (1/2)

The A and C checks for the A320s will commence just prior to aircraft delivery, with the aircraft inspection conducted during this period.

An external consultant has been engaged to assist the Operator throughout the entire process;



The start of operations is planned for January 1st, 2025, while the initiation of the business setup is scheduled for May 13th, 2024;

The training of the CAMO staff is structured into four sessions to ensure that the workload is manageable and operations continue smoothly.

AIRCRAFT PHASE IN (3/5)

Assumptions for the GANTT Chart (2/2)

The consultant will start working on the Maintenance Program and will initiate the inspection of the aircraft's technical records immediately following the acquisition of Technical Publications from the OEM. Once the training is completed, they will receive support from the CAMO staff.

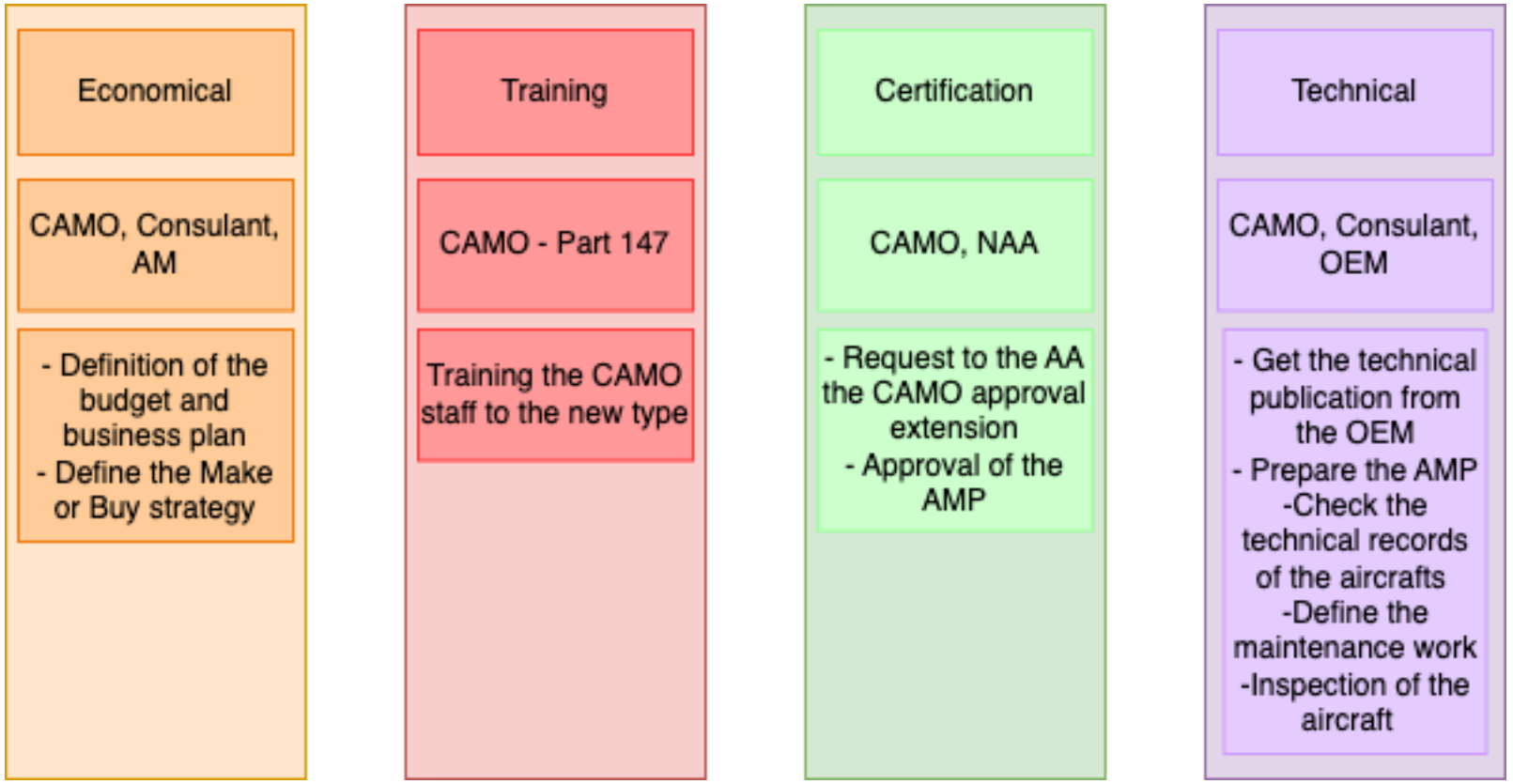
The procedure for extending CAMO approval with the National Aviation Authority (NAA) will start after the completion of the first session of training.

The definition of maintenance tasks will begin concurrently with the development of the budget and the business plan.

Upon approval of the extension and finalization of the Aircraft Maintenance Program (AMP), the application for its approval will be submitted.

AIRCRAFT PHASE IN (4/5)

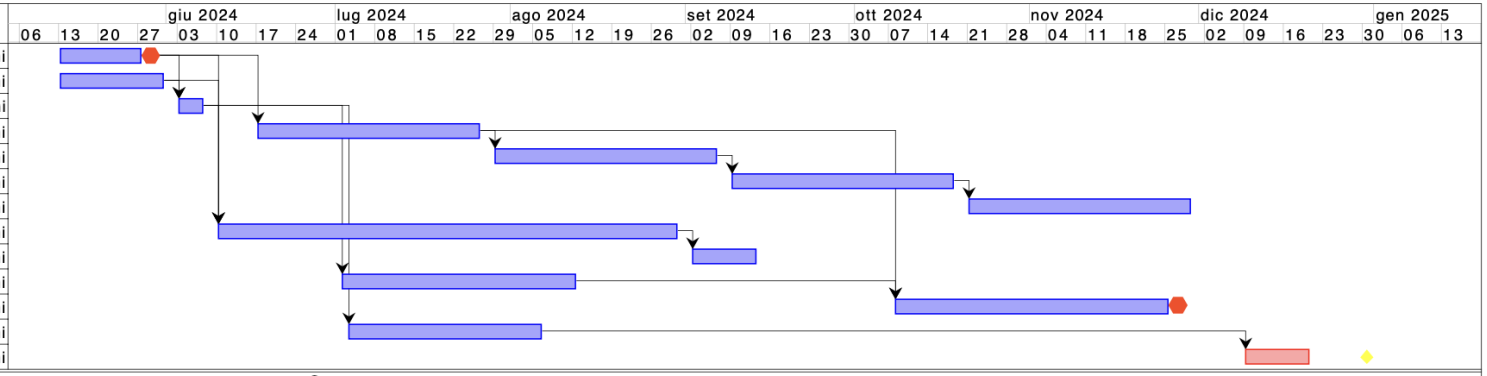
New Business Launch: Considered Activities Areas and main Accountabilities



AIRCRAFT PHASE IN (5/5)

Gantt

	Nome	Durata
1	Preliminary budget and business plan preparation	11 giorni
2	Define the maintenance works necessary and make or buy strategy	15 giorni
3	Get the technical pubblication from the OEM	5 giorni
4	Training of the CAMO staff (first session)	30 giorni
5	Training of the CAMO staff (second session)	30 giorni
6	Training of the CAMO staff (third session)	30 giorni
7	Training of the CAMO staff (fourth session)	30 giorni
8	Contract negoziation	60 giorni
9	Budget review	10 giorni
10	Preparation of the AMP	30 giorni
11	Requests to the AA the CAMO approval extension to the new model and obtain..	35 giorni
12	Checking the technical records of the aircraft	25 giorni
13	Perform the inspections of the aircraft	10 giorni



Gantt

2. REQUIRED MAINTENANCE

REQUIRED MAINTENANCE (1/8)

Maintenance works On-aircraft and Off-aircraft

- Task "**On-Aircraft**" (On the aircraft):
  1. Light maintenance checks (**Check A, Check C**).
  2. Line checks (**daily checks, weekly checks, unscheduled line maintenance events**).
- Task "**Off-Aircraft**" (Off the aircraft)

  Involves comprehensive servicing of aircraft components (APU, landing gear, exterior aircraft parts), ranging from routine cleaning, testing, and adjustment to potential complete overhauls as necessary; usually conducted while the aircraft is out of service, this entails component removal, replacement by maintenance staff, and reinstallation or storage for future use.

REQUIRED MAINTENANCE (2/8)

Assumptions for the required maintenance (1/2)

Schedule: **4 flights** per day of **2.5 hours each aircraft**

No major maintenance event expected in the **5 years** period

Aircraft out of warranty

Aircraft shall be returned fresh from A and C check

Line checks
Daily: to be performed every 24 h (preferably at night) 2 Manhours (Mh) of Licensed Mechanic (LM),
Weekly : every 7 days 2 Mh of LM
Unscheduled line maintenance events: 2 Mh of LM per day

REQUIRED MAINTENANCE (3/8)

Assumptions for the required maintenance (2/2)

Aircraft Availability (scheduled and unscheduled maintenance): **90%** (0.9)

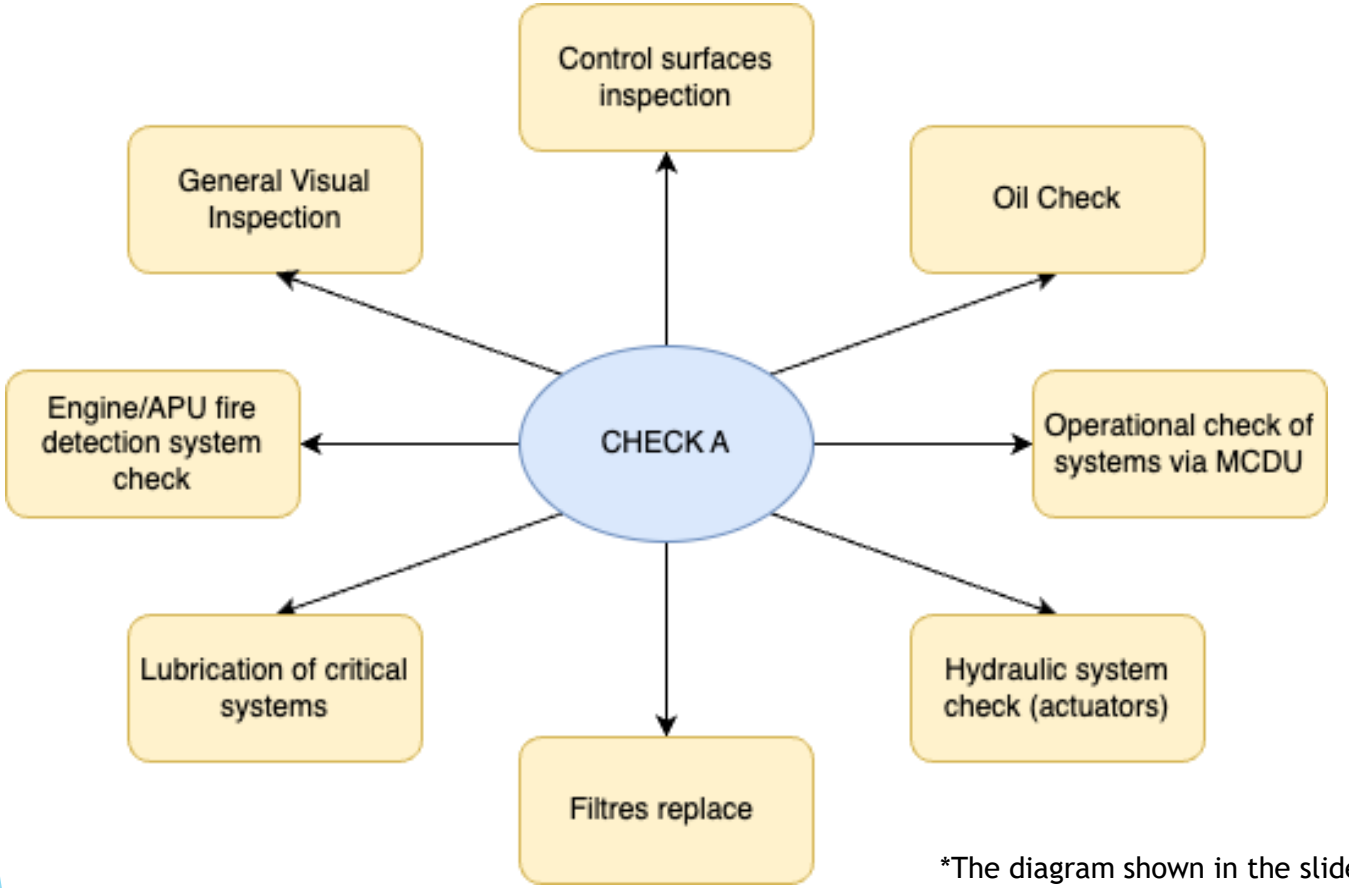
Check A : every **750 Flight Hours** (FHs)
Check C: every **24 Months**

The **last A check** before the return is **anticipated of 75 FHs.**
To evaluate how much we need to advance the check the following calculation was performed:

$$750 - (365 \times 0.9 \times 5 \times 4 \times 2.5 - 750 \times floor\left(\frac{365 \times 0.9 \times 5 \times 4 \times 2.5}{750}\right)) = 75\ FHs$$

REQUIRED MAINTENANCE (4/8)

Check A

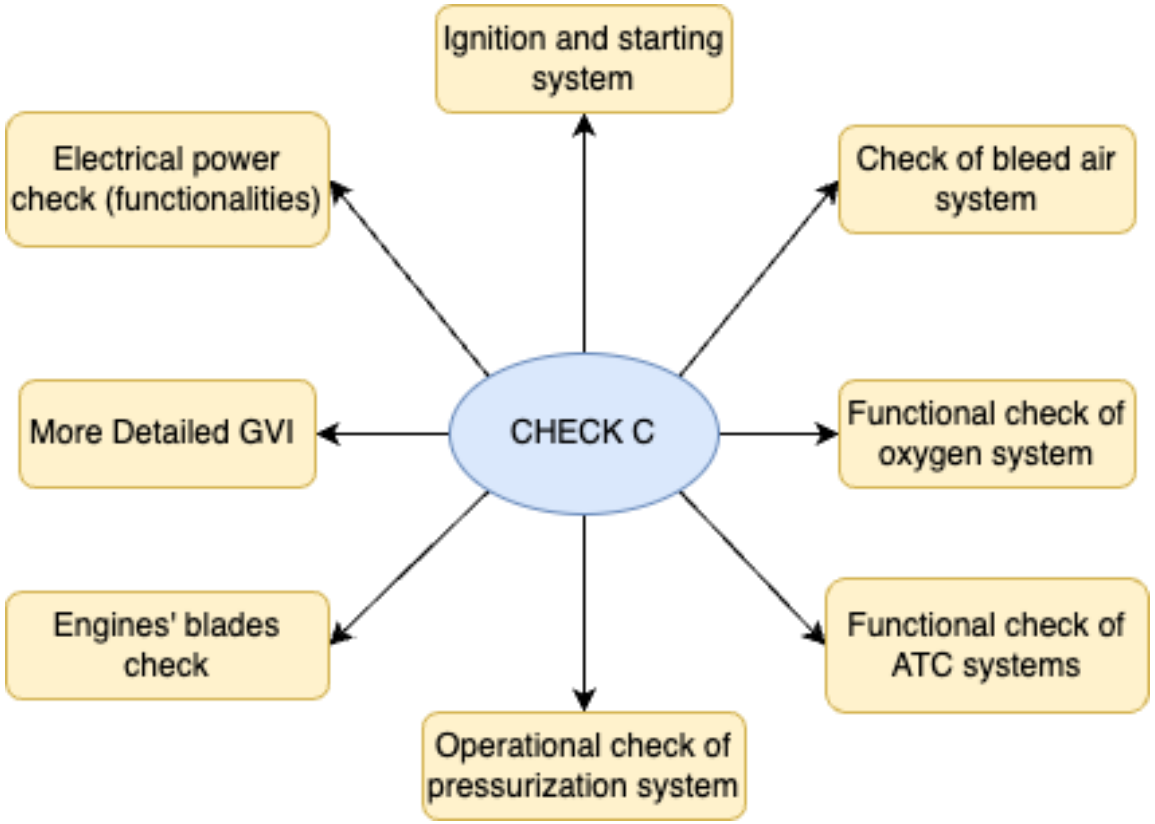


Generally, off-aircraft maintenance isn't required, but if a part is damaged, it might become necessary!

*The diagram shown in the slide outlines some of the activities relevant to the check under review.

REQUIRED MAINTENANCE (5/8)

Check C



A more detailed inspection increases the likelihood of identifying damaged parts, thus non-functioning, consequently raising the probability of resorting to off-aircraft maintenance!

*The diagram shown in the slide outlines some of the activities relevant to the check under review.

REQUIRED MAINTENANCE (6/8)

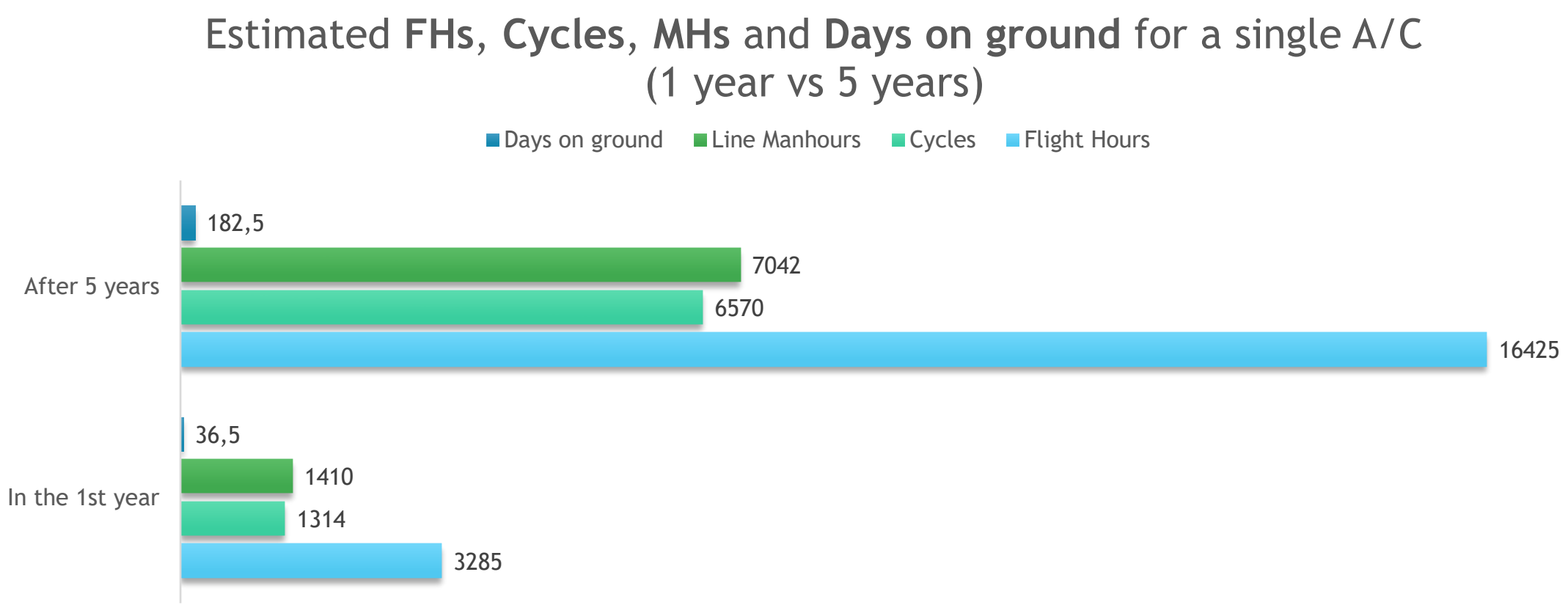
Maintenance check (On aircraft)

MAINTENANCE CHECKS (LIGHT)	*TIME INTERVAL*
A Check	750 FH
C check	24 Months

MAINTENANCE CHECKS (LINE)	*TIME INTERVAL*	*MANHOURS*
Daily	Every 24 hours	2
Weekly	Every 7 days	2
Unscheduled	Daily	2

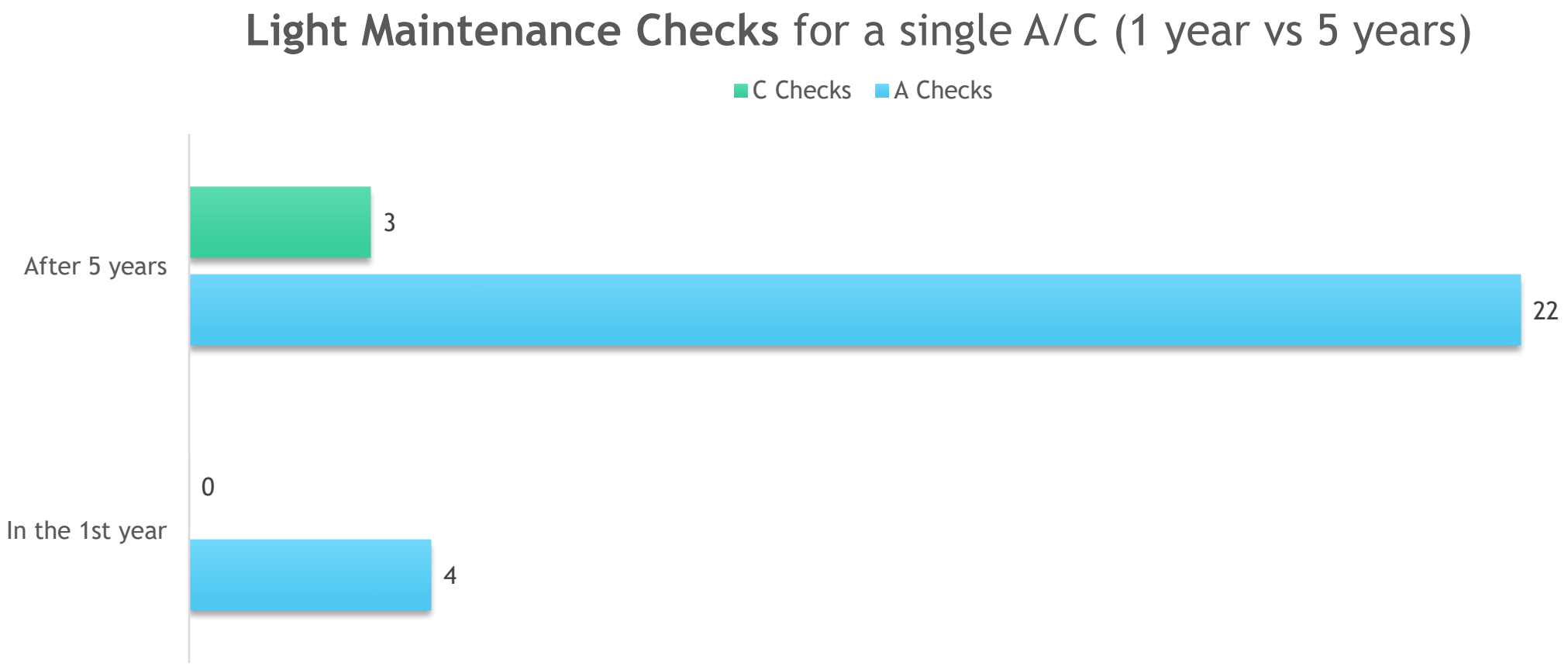
REQUIRED MAINTENANCE (7/8)

Some calculations



REQUIRED MAINTENANCE (8/8)

Some calculations



3. MAINTENANCE MAKE OR BUY ANALYSIS AND DECISION

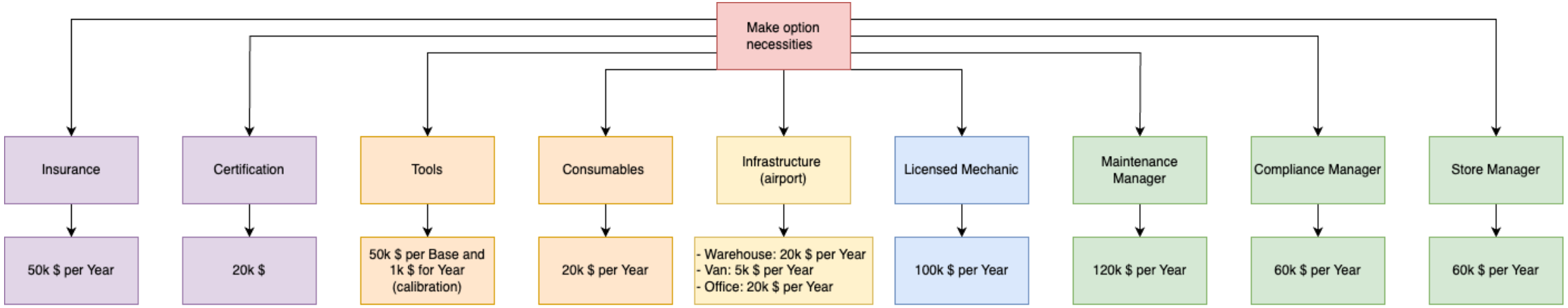
LINE MAINTENANCE – BUY SOLUTION

- Considering that:
  - A single A/C requires 1410 MHs/year;
  - There are 2 leased A/Cs (A320);
  - The operating period is 5 years;
  - The cost of the consumables is 20K $ per year but we consider only an additional cost equal to 10% of 20K $,because an administrative fee must be paid due to the need to advance the money and manage the inventory;
  - Line maintenance work is priced at $100 per hour.

- The total cost over 5 years is:

$$(1410 MHs/y \times 5y \times 2 \times 100) + (2K \times 5y \times 2) = 1,43M\ \$$$

LINE MAINTENANCE – MAKE SOLUTION



Hp:

- Managers and infrastructures are paid six months prior to the start of operations.
- Licensed mechanics are paid three months prior to the start of operations.

TOTAL COSTS

Some calculations

Base	*Tools*	*Infrastructure*	*Certification*	*Insurance*	*Consumables*	*Licensed Mechanics (6* x base)*	*Compliance Manager*	*Maintenance Manager*	*Store Manager*
ROME FCO	55K $	247,5K $	20K $	250K $	100K $	3,15M $	330K $	660K $	330K $
LONDON LTN	55K $	247,5K $	20K $	250K $	100K $	3,15M $			

TOTAL LINE MAINTENANCE COSTS (5 YEARS): 8,965M $

*For calculating the number of licensed mechanics, we assume a standard work schedule of 7 days a week and 24 hours a day. Specifically, we presume that a single technician works a total of 1600 hours annually, with the year 2025 composed of 52 weeks.

$$\left\lceil \frac{24 \times 7}{\frac{1600}{52}} \right\rceil = 6$$

BUY VS MAKE SOLUTION

BUY

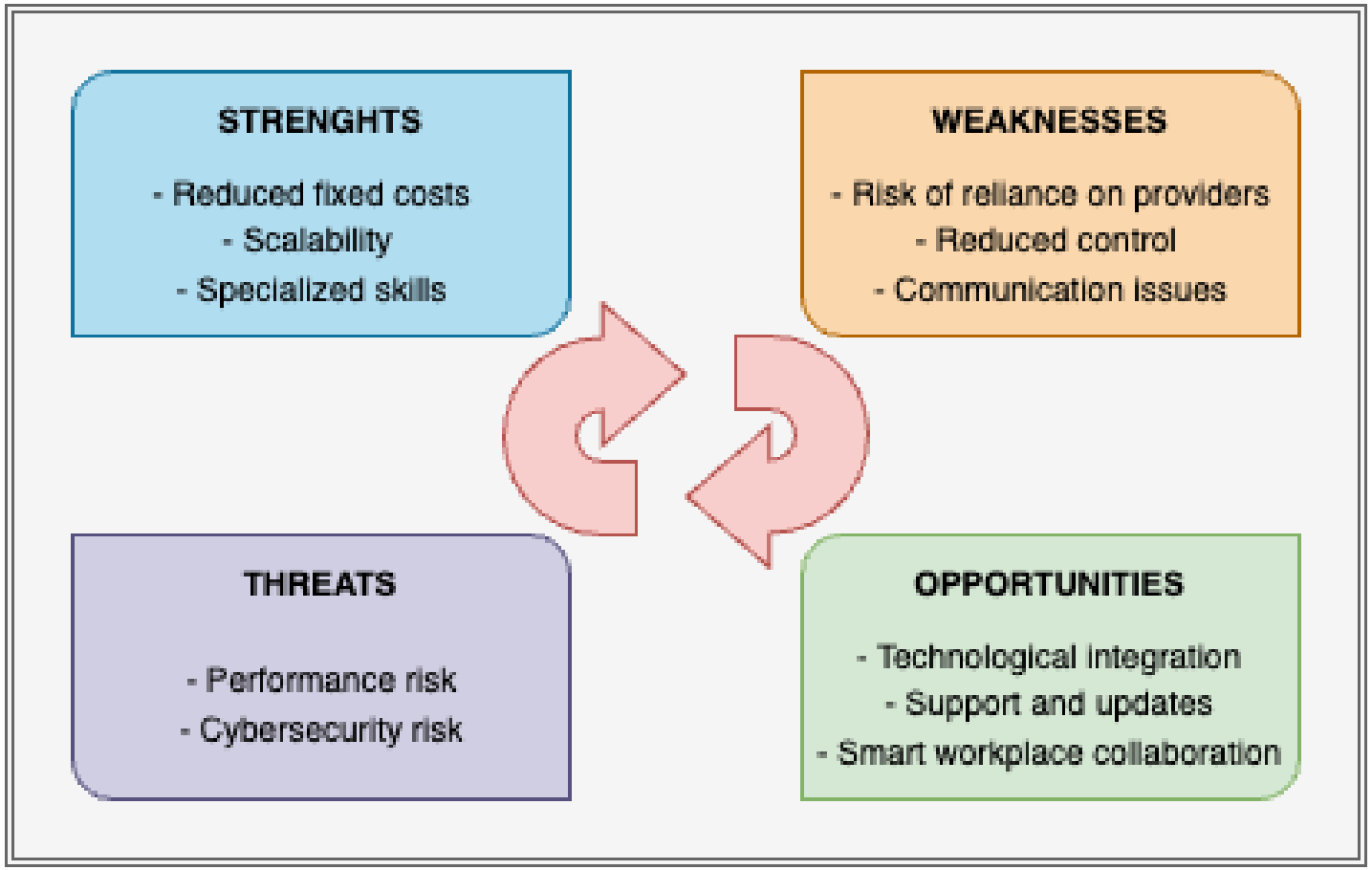
1,43M $

MAKE

8,965M $

Given the "make costs", it is appropriate to purchase line maintenance. Additionally, since any other maintenance activities (components, engines availability, landing gears, A and C checks) require additional investments, personnel, and infrastructure, the decision to follow the **buy solution for all mainteinance activities** is further justified.

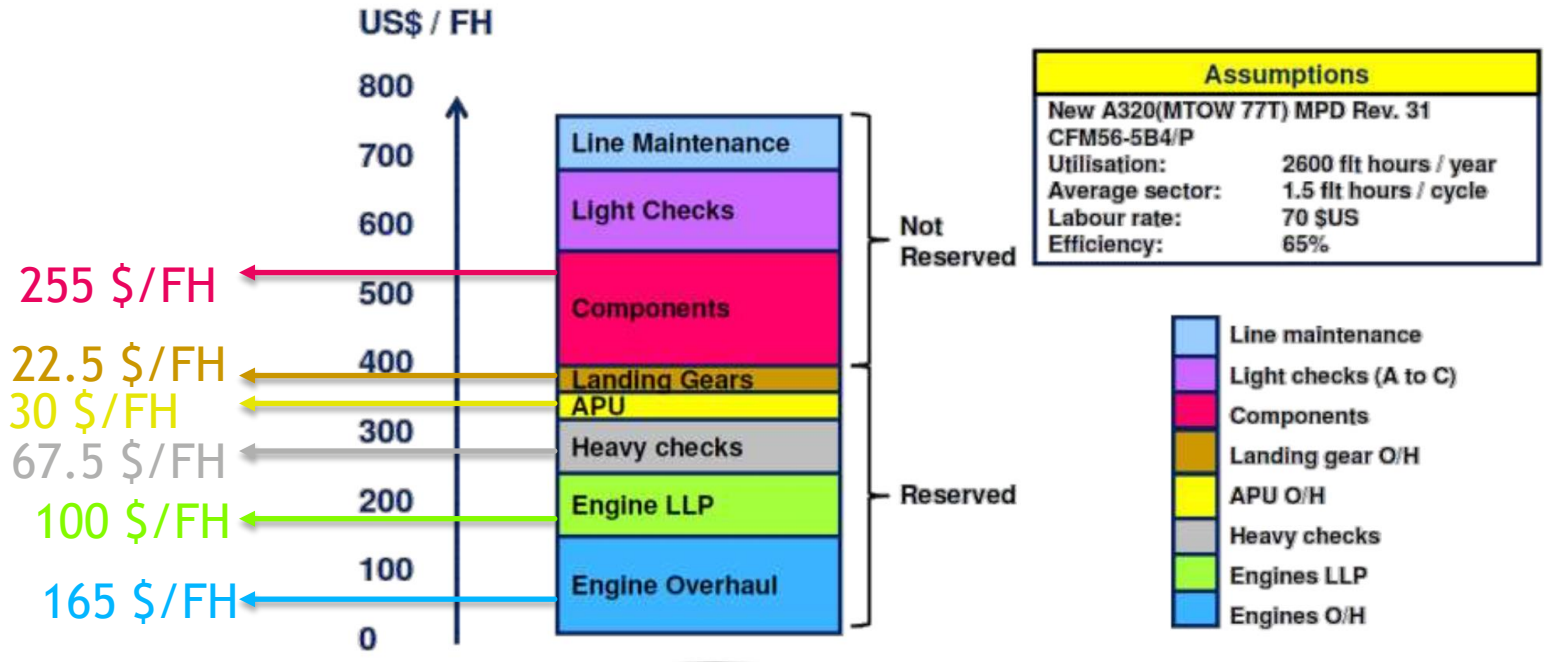
SWOT ANALYSIS – BUY SOLUTION



4. MAINTENANCE BUDGET

MAINTENANCE COSTS

This figure shows the costs of each aspect of maintenance. The costs related to Line Maintenance and Light Checks are provided, while the remaining costs have been estimated by **increasing the average values provided by Airbus by 50%.**



ON AIRCRAFT VS OFF AIRCRAFT

ON AIRCRAFT

LINE MAINTENANCE	100 $/MH
A CHECK	15.000 $
C CHECK	150.000 $
HEAVY CHECK RESERVES	67.5 $/FH

OFF AIRCRAFT

COMPONENTS	255 $/FH
LANDING GEARS	22.5 $/FH
APU	30 $/FH
ENGINE	265 $/FH

TOTAL COSTS

spreadsheet

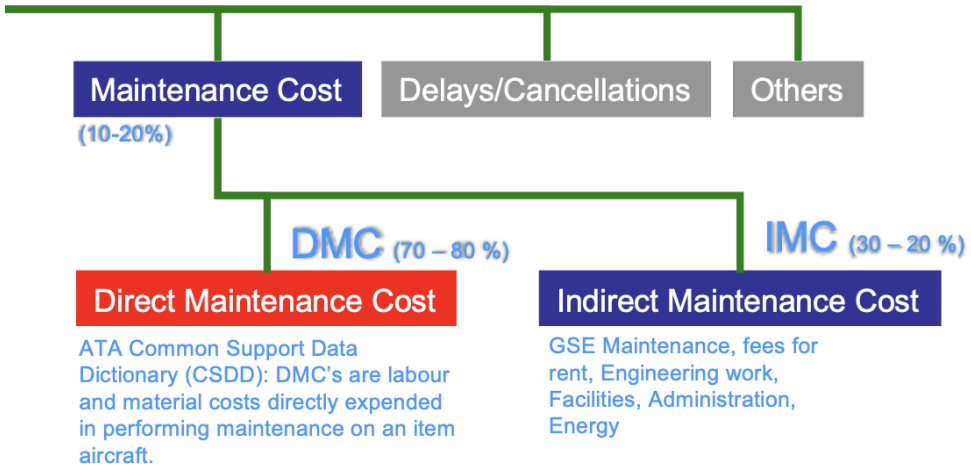
			MONTHLY PAYMENT	YEARLY COST	COST (5 YEARS)
RESERVED	ON AIRCRAFT	LINE MAINTENANCE		$282.000	$1.408.400
		A CHECK		$120.000	$660.000
		C CHECK		$0	$900.000
		HEAVY MAINTENANCE	$36.956	$443.475	$2.217.375
	OFF AIRCRAFT	COMPONENTS	$139.613	$1.675.350	$8.376.750
		ENGINES	$145.088	$1.741.050	$8.705.250
		LANDING GEARS	$12.319	$147.825	$739.125
		APU	$16.425	$197.100	$985.500
		TOTAL RESERVED		$4.204.800	$21.024.000
		TOTAL		$4.606.800	$23.992.400

DIRECT AND INDIRECT COST

spreadsheet

The following table presents the total maintenance cost divided into direct and indirect costs.

	DIRECT 75%	INDIRECT 25%	TOTAL COSTS
1 YEAR	$3.455.100	$1.151.700	$4.606.800
5 YEARS	$17.994.300	$5.998.100	$23.992.400



CONSEQUENTIAL MAINTENANCE COSTS

spreadsheet

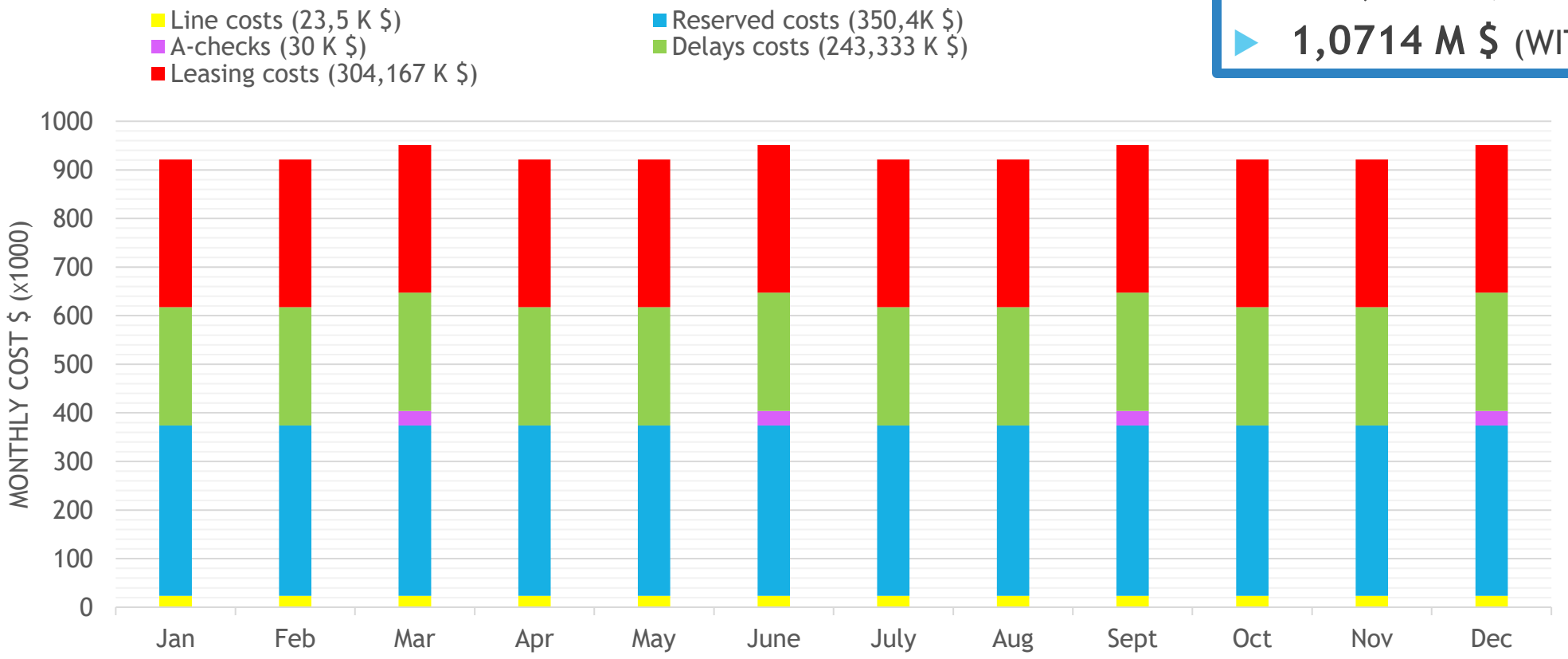
This slide illustrates the consequential maintenance costs, encompassing both unscheduled and scheduled maintenance activities that can lead to mission delays and aircraft unavailability. Grounding an aircraft for either type of maintenance results in additional expenses for the operator, potentially requiring the lease or standby availability of another aircraft to meet operational demands.

	CYCLES	FHs	N° DELAYS (95% DR)	LEASING FHs (10% AV)
1 YEAR	2920	7300	146	730
5 YEARS	14600	36500	730	3650

	COSTS OF DELAYS	COSTS OF LEASING
1 YEAR	2.920.000 $	3.650.000 $
5 YEARS	14.600.000 $	18.250.000 $

- Average cost for a delay: 20.000 $/delay
- Cost for an A320 replacement a/c: 5.000 $/FH

MONTHLY COSTS FOR FIRST YEAR FOR 2 A/C



spreadsheet

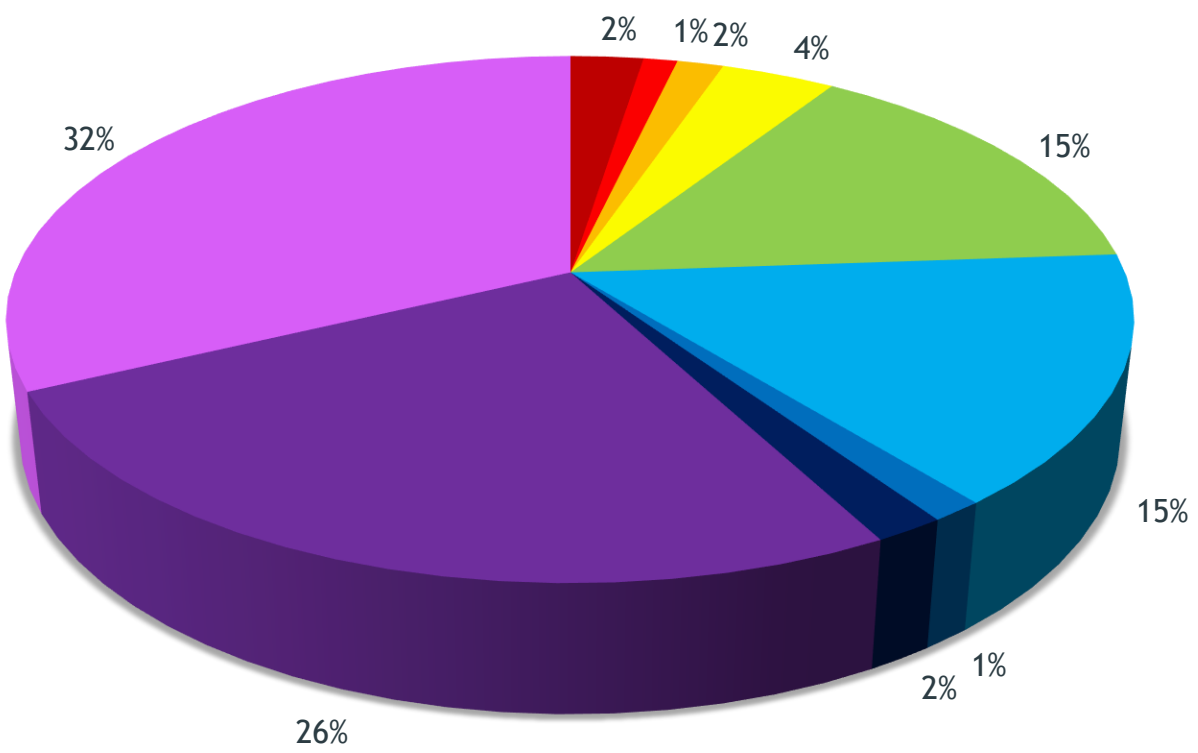
MONTHLY COSTS:

- **951,4 K $** (WITH A-CHECK)
- **921,4 K $** (BASE)
- **1,0714 M $** (WITH C-CHECK*)

*C checks for the two aircraft are performed in different months

TOTAL COSTS

spreadsheet



The figure represents, in a pie chart, the percentage breakdown of the total maintenance cost (direct, indirect, and consequential).

TOTAL COSTS (5 YEARS and 2 a/c) = DIRECT AND INDIRECT COSTS + CONSEQUENTIAL COSTS
= 23.992.400 $ + 32.850.000 $ = 56.842.400 $

PROPOSES FOR THE CEO

Strategies to Reduce Maintenance Costs

Financial Arrangements with Lessors: Establish financial agreements with lessors to pay only 55% for the last C check, spreading costs effectively over the lease term.

OEM Remote Monitoring System: Obtain the manufacturer's aircraft remote monitoring system to collect real-time data on aircraft performance and reliability. This system can identify potential issues early, allowing for timely preventive maintenance actions.

OEM Modifications: Procure upgrades directly from the aircraft manufacturer to enhance performance and reduce maintenance needs. For instance, investing in new corrosion-resistant coatings to decrease the frequency of preventive maintenance

Negotiate Discounts with AMO: Negotiate discounts with the Approved Maintenance Organization (AMO) for scheduled maintenance tasks. For example, securing a 10% discount on the total cost of a D-check by pre-booking and pre-paying for multiple D-checks in advance.

Efficient Shift Pattern and Coverage: Implementing an efficient shift pattern and coverage strategy is crucial for optimizing maintenance operations. For instance, one could opt for negotiation of contracts to ensure that Check A is performed during Line maintenance overnight.

TOTAL COSTS (30 YEARS LIFE CYCLE) spreadsheet

ASSUMPTIONS:

- The only additional cost is the leasing of A320s due to scheduled D-checks;
- D-check costs are already accounted for in the maintenance reserves;
- Every aircraft has 5 D-checks spread over 30 years, with each check happening every 6 years.

Total Maintenance Costs for a 30 year maintenance programme (1 a/c):
177.527.200 $

A320 PRICE (70% list price): 0,7 x 105.000.000 $ =
73.500.000 $

FINAL CONSIDERATIONS

- A carefully planned and strategically managed maintenance program is vital for ensuring the safety, reliability, and efficiency of aircraft operations.
- By focusing on proactive and preventive maintenance, resource optimization, and stringent safety standards, airlines can achieve significant cost savings and operational benefits.
- This approach not only enhances the performance and reliability of the fleet but also supports the financial sustainability and growth of the airline, making it a critical component of overall business strategy.
- Maintenance over 30 years significantly impacts aircraft expenses, exceeding the purchasing cost. When drafting a business plan, choosing the right aircraft type based on its maintenance costs throughout its lifespan is crucial. Analysis should include factors like technology, materials, and regulatory compliance to optimize operational efficiency and cost-effectiveness.
- Considering external factors such as geographical operating area, the availability of certified AMOs, and the spares market is essential for maintaining seamless and cost-effective operations, making these considerations an integral part of the overall maintenance strategy.


Andrea Morello
Giada Rinaldi
Matteo Scafoni
Lorenzo Tasciotti
Thank You For Your Attention!