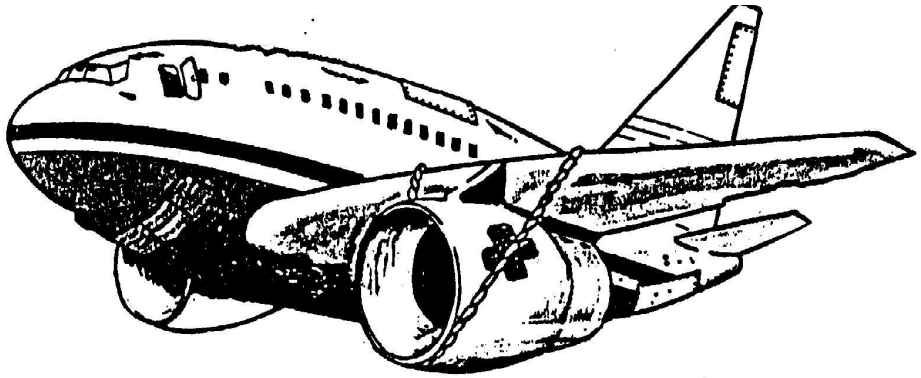
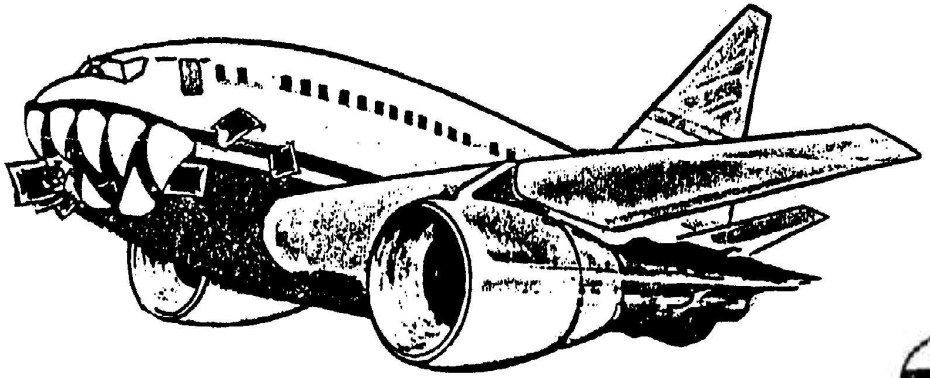
Stomphorst & Partners
- Aviation Industry Experts -

Aircraft Maintenance



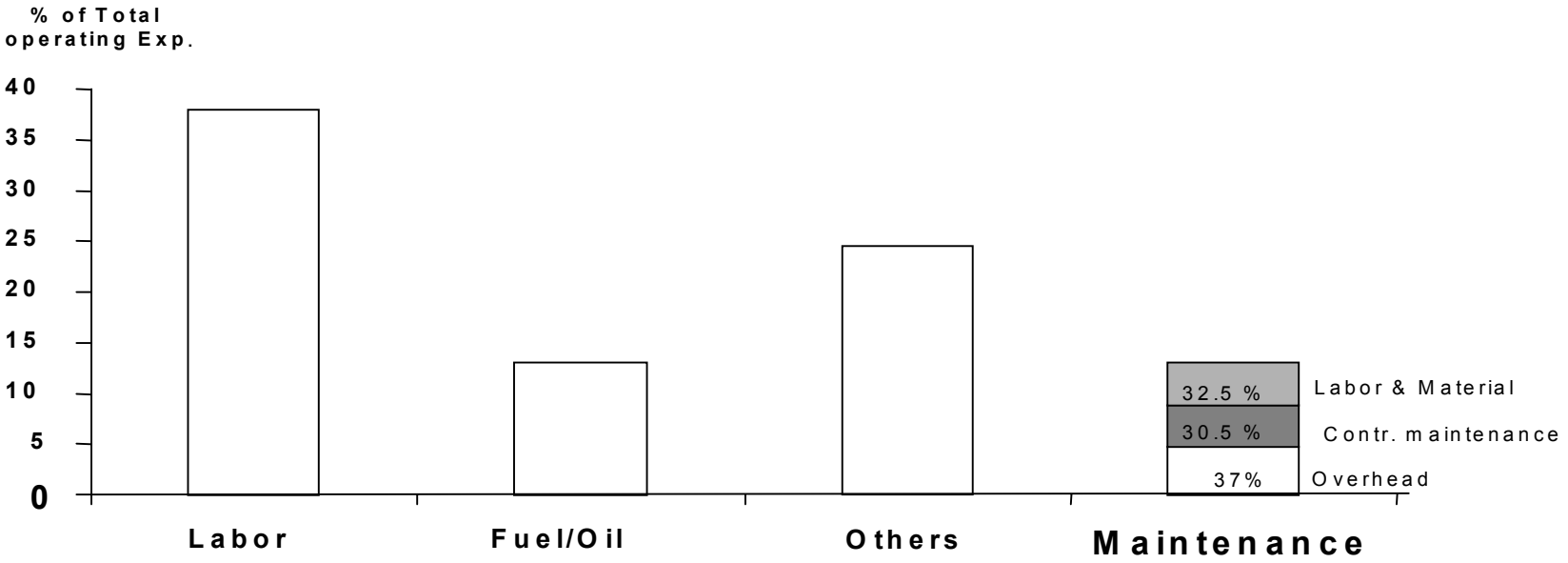


Aircraft Maintenance

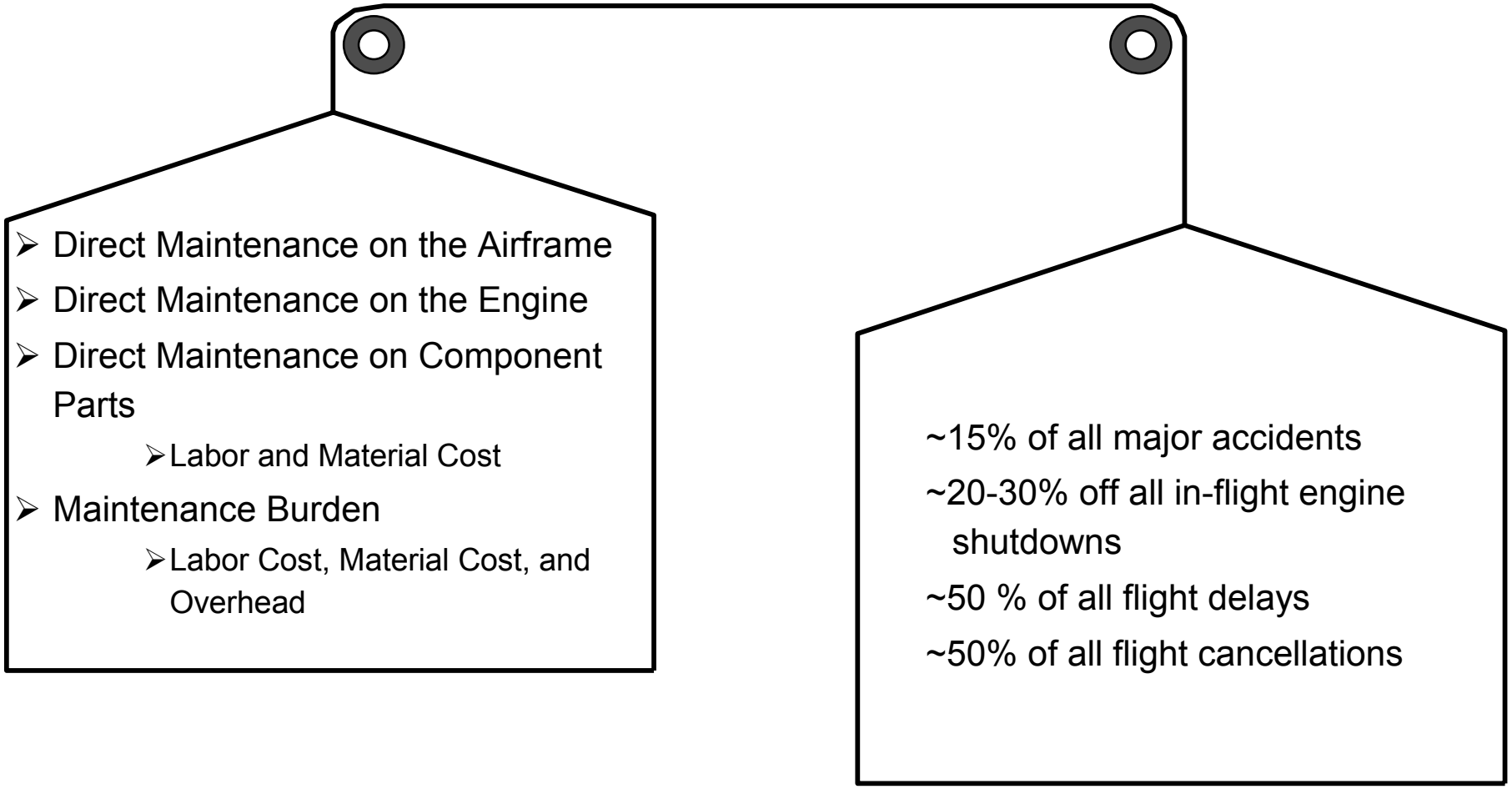
Total expenditures of roughly $ 9 billion for aircraft maintenance activities indicate that maintenance is a major expense driver

- Since the 1990s airlines have been able to reduce total operating costs by as much as 15 percent per ASM.
- The maintenance costs have been reduced, in that same period, by an average of only 6 to 9 percent.

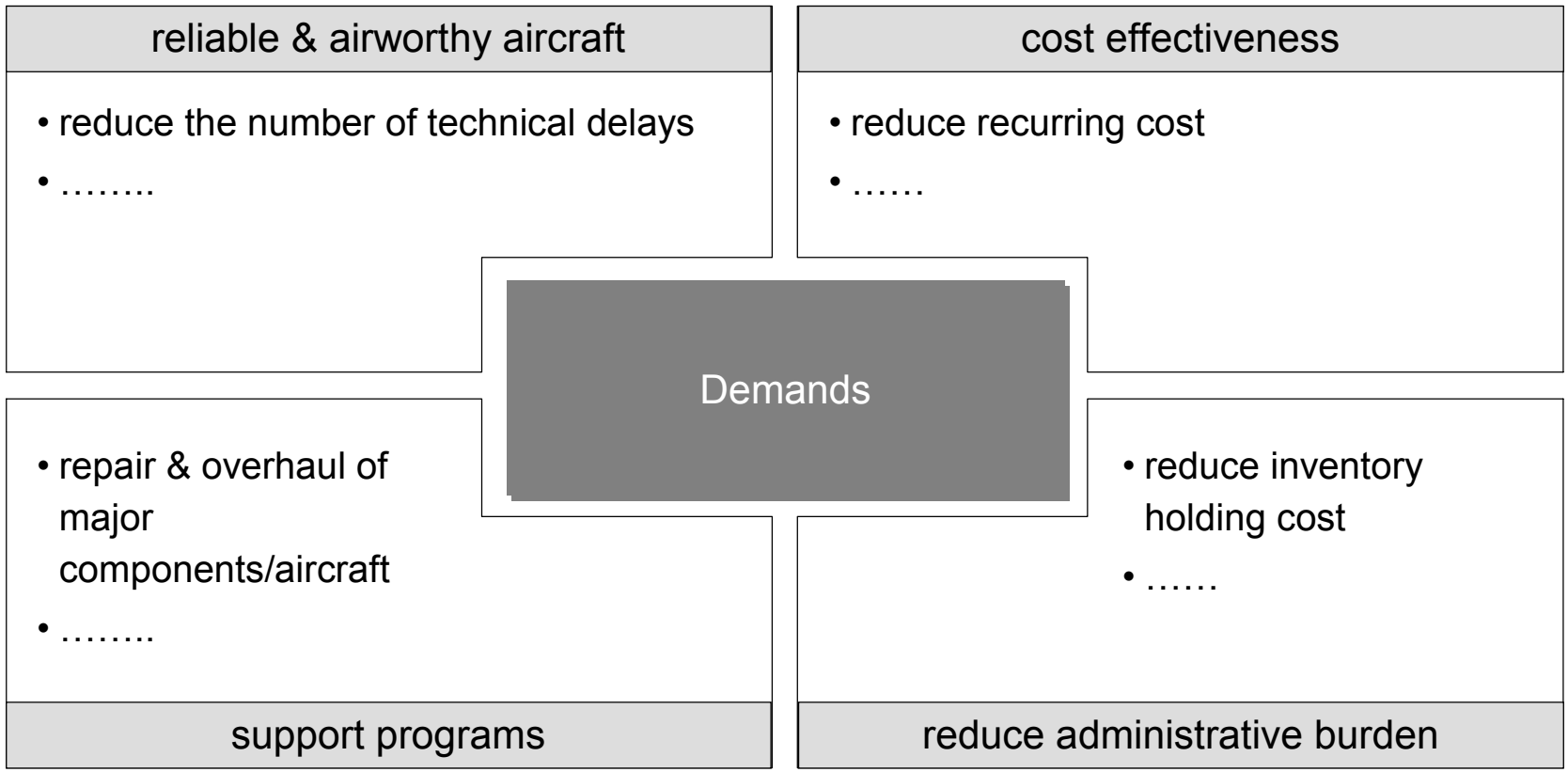
Systemwide Expenses



Different types of costs are incurred and various risks must be management



Aircraft Maintenance



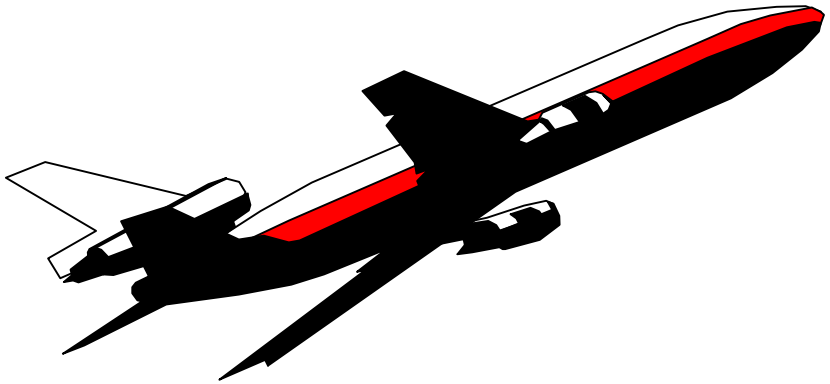
Functions and tasks of maintenance organizations are varied but necessary to comply with international regulations.

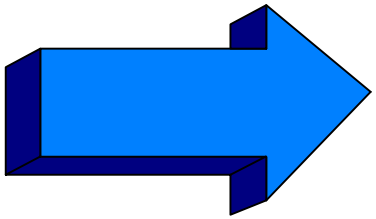
1. Production Engineering
   - Skilled manpower
   - Appropriate tooling

2. Supplies
   - Spare parts

3. Technical Services
   - Engineering assessments
   - Drawings

4. Quality Assurance
   - Regulatory demand
   - Safety and quality

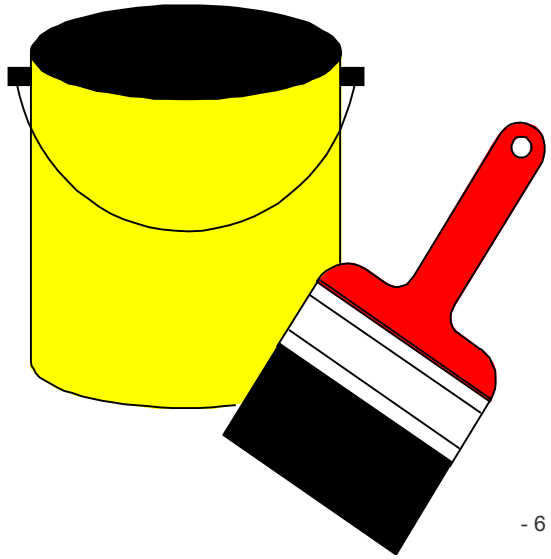




All is needed to ensure minimum down time and allow for maximum utilization of aircraft, while achieving high degree of safety

Ensuring optimum reliability requires competencies for three maintenance activities at differeing intervals

1. Line Maintenance
   - During turnaround
   - Overnight (max. 48 hrs interval)
     - En-route service,
     - terminating and pre-flight checks,
     - service checks
     - ‘A’ check roughly every 350 Flight hours
2. Base Maintenance
   - Fixed Interval
     - Maintenance check and overhaul
     - C checks every 18 months or ca: 4000 flight hours
       - Cycle is C1, C2, C3, C4 etc.
     - Engine changes
     - Major modifications
     - Major repairs
3. Unscheduled Maintenance
   - Defect rectification (Line-& Base maintenance)
   - Airworthiness Directives (AD’s)/ Lufttuchtigkeits Anweisungen(LTA’s)
   - Incorporation of Service Bulletins
   - Alert notices
   - Configuration changes
   - Engineering orders
   - Refurbishment



The Joint Aviation Authorities of Europe regulate and administer air transportation in Europe

- Aviation Safety
  - Requirements for
    - Airworthiness
    - Operation
    - Licensing
- Joint Certification
  - Harmonisation

The Joint Aviation Authorities requirements apply to five different areas

- Airworthiness

  JAR-1, 21, 22, 23, 25, 26, 27,29, E, P, APU, TSO, VLA, AWO

- Operations

  JAR-OPS, STD 1A, STD 3A

- Licensing

  JAR-FCL (Part 1,2 & 3)

- Environment

  JAR-36

- Maintenance

  JAR-145, 66, 147

  Published on 30 July 1991

  A requirement to qualify an organization to carry out maintenance on an aircraft operated for commercial air transportation

  Effective since 1 January 1992

Aircraft Maintenance

To account for increases in experience, better testing procedures and technological advances, maintenance policies have varied over time and continue to do so.

- Maintenance Steering Group (MSG) establishes maintenance policies.
- Three different eras in the development of maintenance policies have been observed

‘till late 60’s

- Hard time maintenance and overhaul intervals were established (Time Between Overhaul), based on flight hours and cycles.
- Block Checks (A, B, C & D) were established and carried out accordingly
  - C check 3’000 flight hours, D check 20’000 flight hours.

‘till mid 80’s

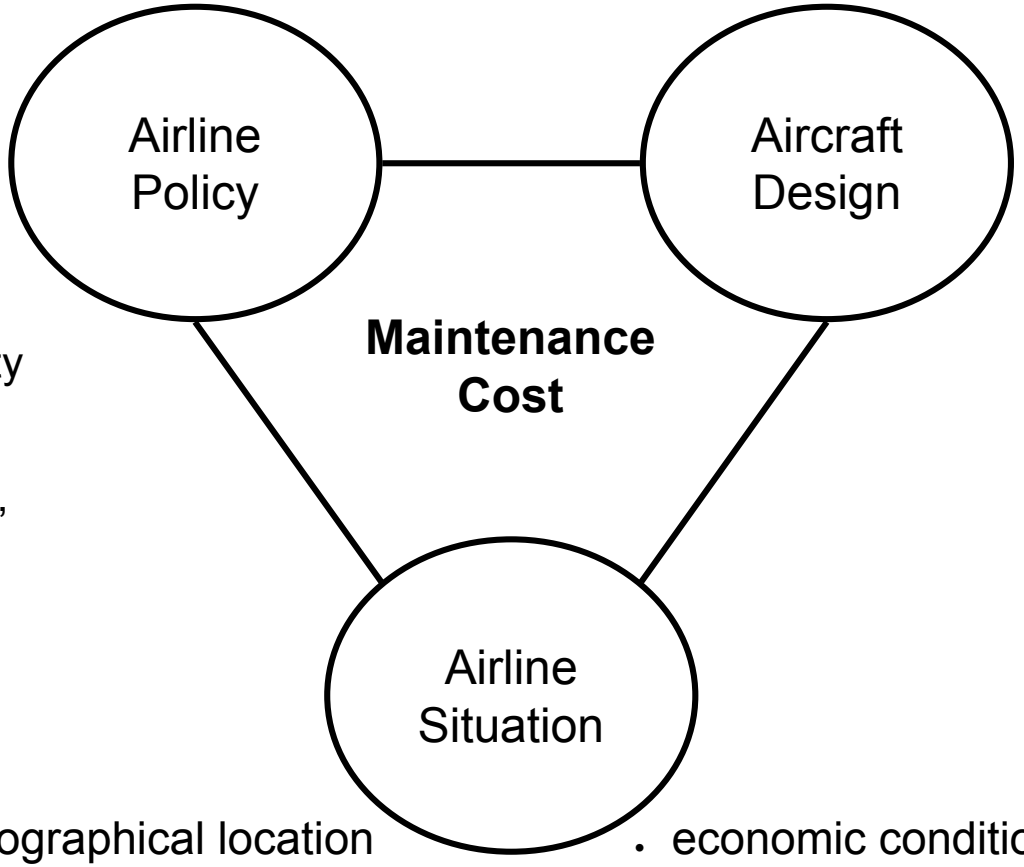
- MSG 2; on-condition maintenance (OC) and condition-monitoring (CM) philosophy were established.
- Reliability statistics and reporting used with corrective actions to be taken when alert levels were exceeded.
- Life limited parts (LLP) identified.
- Maintenance checks on calendar time, with a cap on the flight hours.
- Block Checks extended:

  C check 15 months or 3’500 flight hours, D check 6 years or 24’000 flight hours.

Today

- MSG 3; policies for reliability reporting, structural inspections, LLP’s, and individual maintenance tasks intervals.
- Operator can, based on capacity and flight schedule, compose individual checks.
  - C checks every 18 months or ca: 4’000 flight hours, varies for long-range operation (LR)
- aging aircraft
- ETOPS

A large number of factors exert pressure on the cost function of an individual airline.



What the airline decides on:

- labor rate
- maintenance schedules
- spare/skill availability
- labor efficiency
- policies on cleaning, servicing, painting, and refurbishing
- accounting practice

What the manufacturer can do

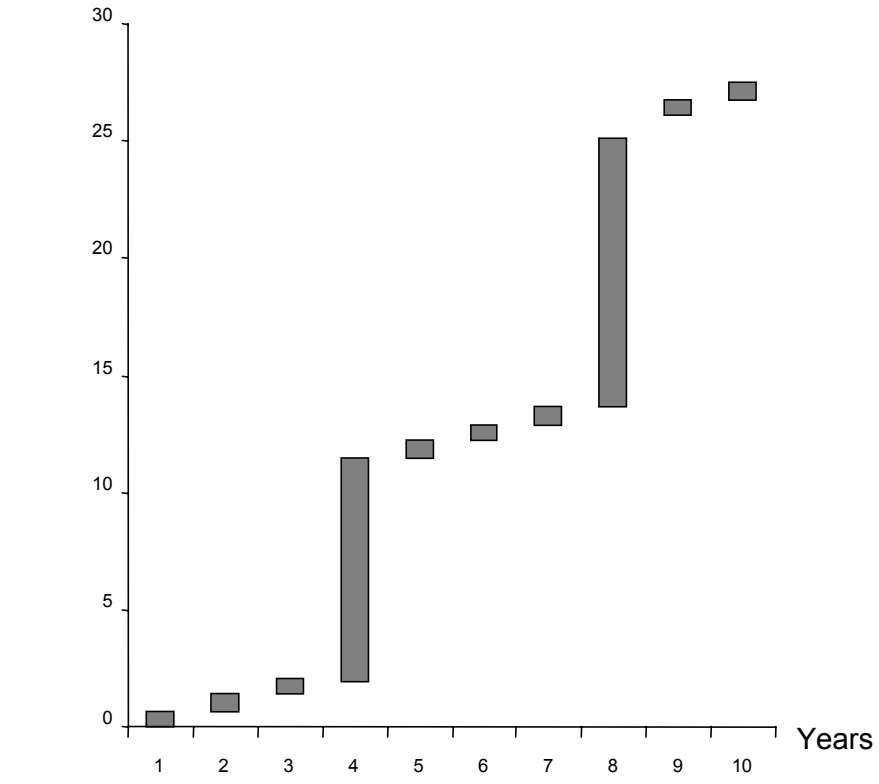
- maintainability
- reliability
- skill level needed for repair
- nominal sector length
- aircraft age behavior
- quality of technical documentation

- geographical location
- market and competition
- climate (corrosion and engine rating)

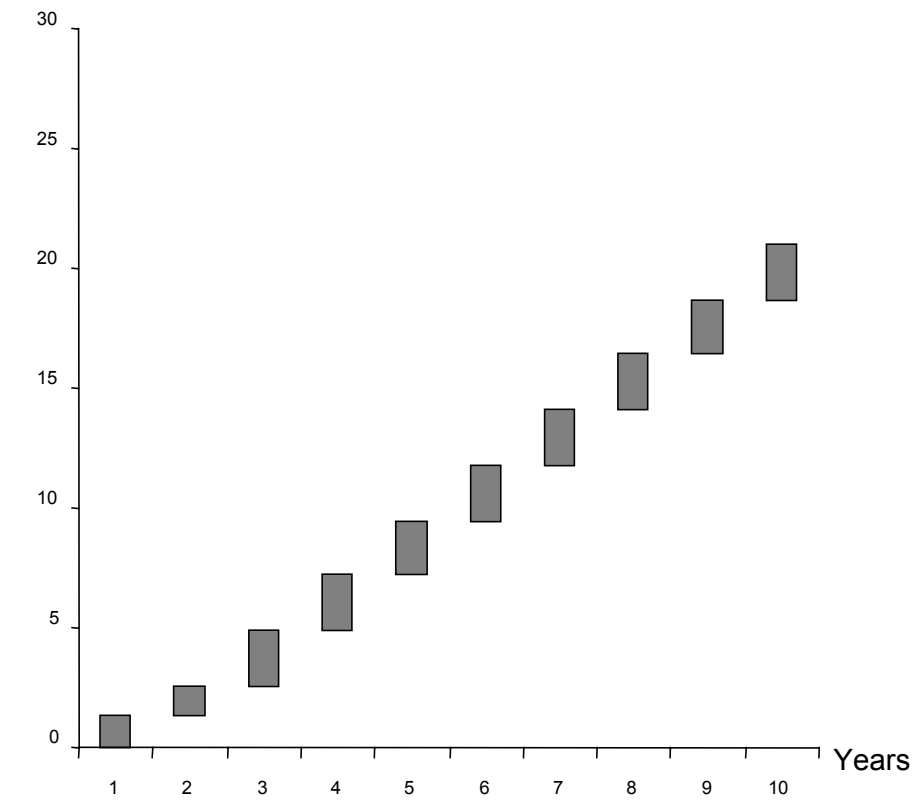
- economic conditions for spare parts
- location of maintenance bases and out stations

Obviously, the choice of the right maintenance strategy has a strong influence on costs and thus on market value; yet not every strategy can be implemented by any airlines.

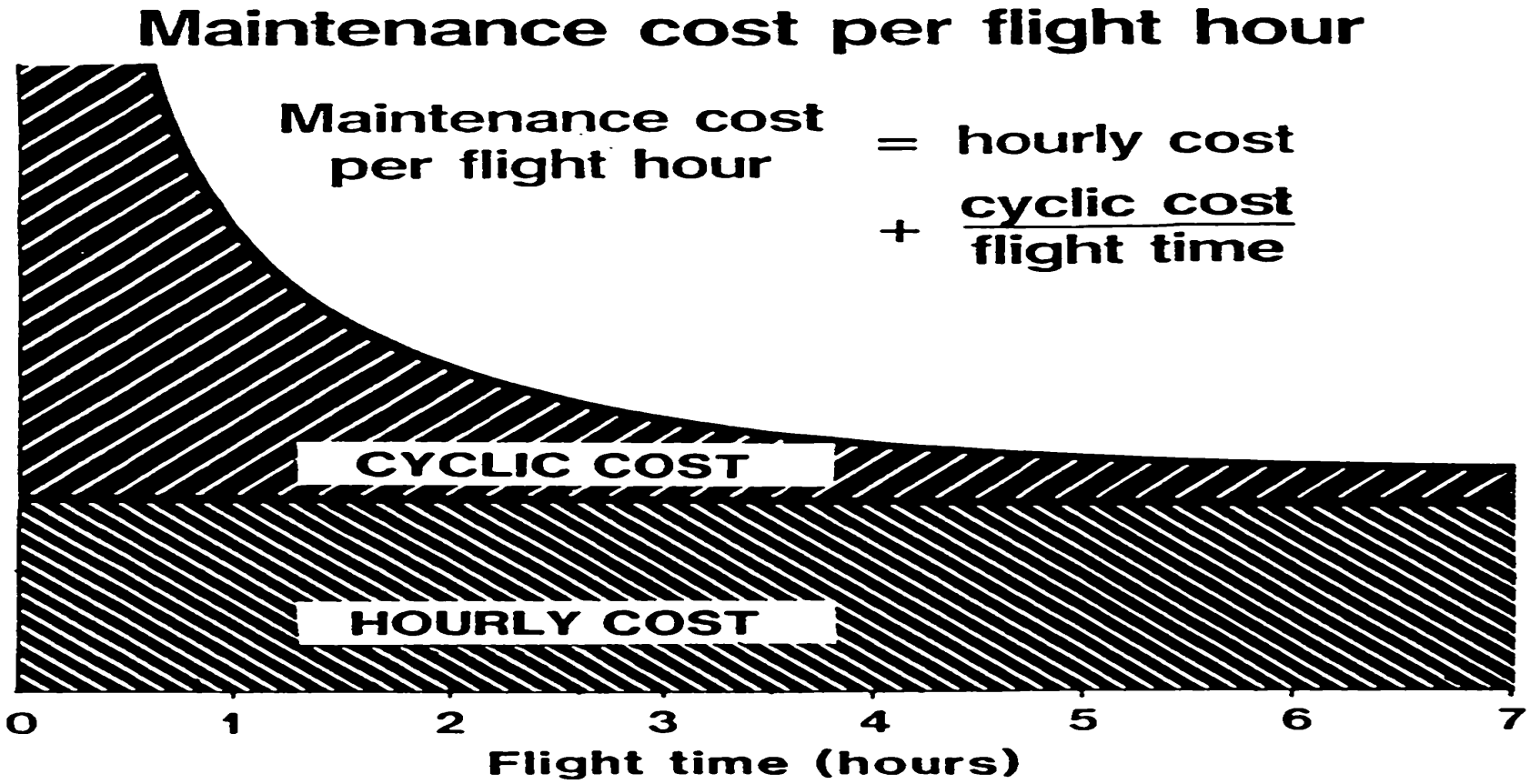
“Heavy Maintenance” strategy



“Continuous Maintenance” strategy

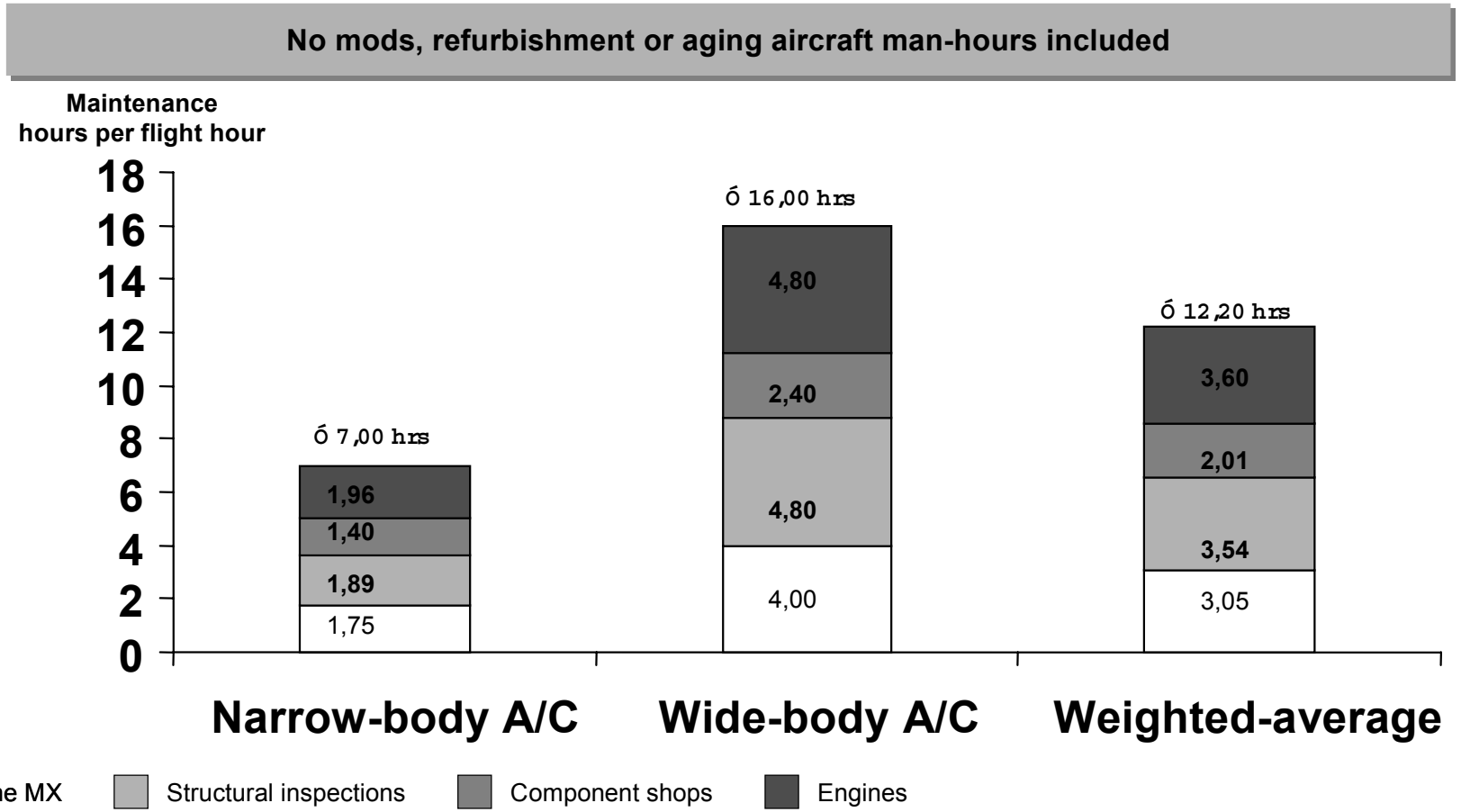


Obviously, the strategic direction has a great impact on how maintenance costs behave



Strategic direction dictates labor intensiveness of maintenance activities; which is one of the main culprits to effective control of maintenance expenditures.

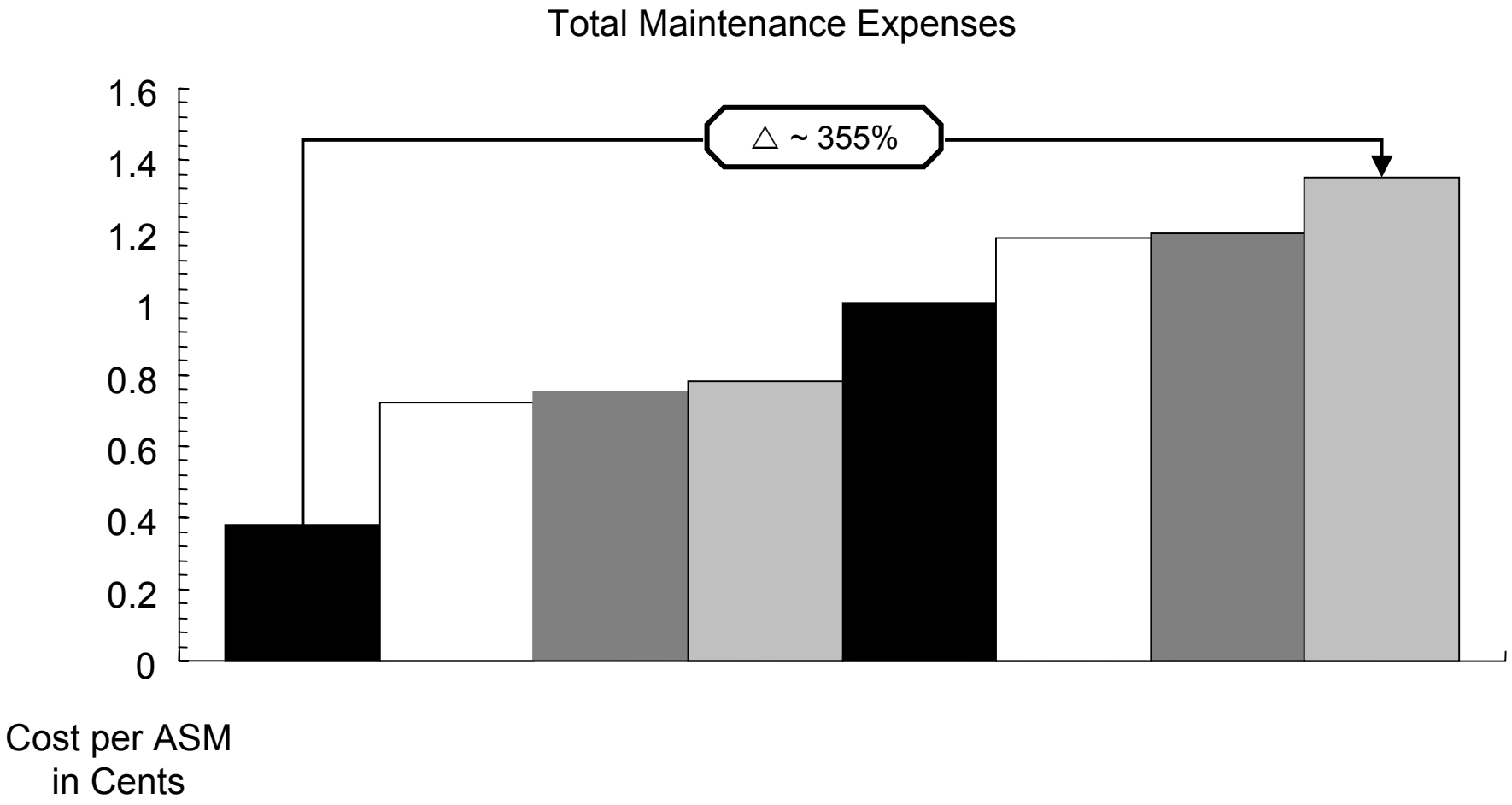
US airline maintenance man-hours breakdown



Strategic direction and airline situation dictate necessity for carrying out maintenance tasks.

Recommended initial intervals (flight hours)					Worlds weigthed fleet average intervals (flight hours)			
A	B	C	D / SI	Aircraft	A	B	C	D / SI
125	750	3,000	20,000	737-100, -200	175	705	2,965	21,050
200	---	3,200	22,400	737-300,-400,-500	225	---	3,355	22,385
300	---	3,600	25,000	747-100,-200,-300	485	---	4,975	25,100
500	---	5,000	25,000	747-400	650	---	5,750	26,550

Taken all factors together there is a significant discrepancy in observed maintenance expenses per ASM.



A variety of reasons exist for inflated costs

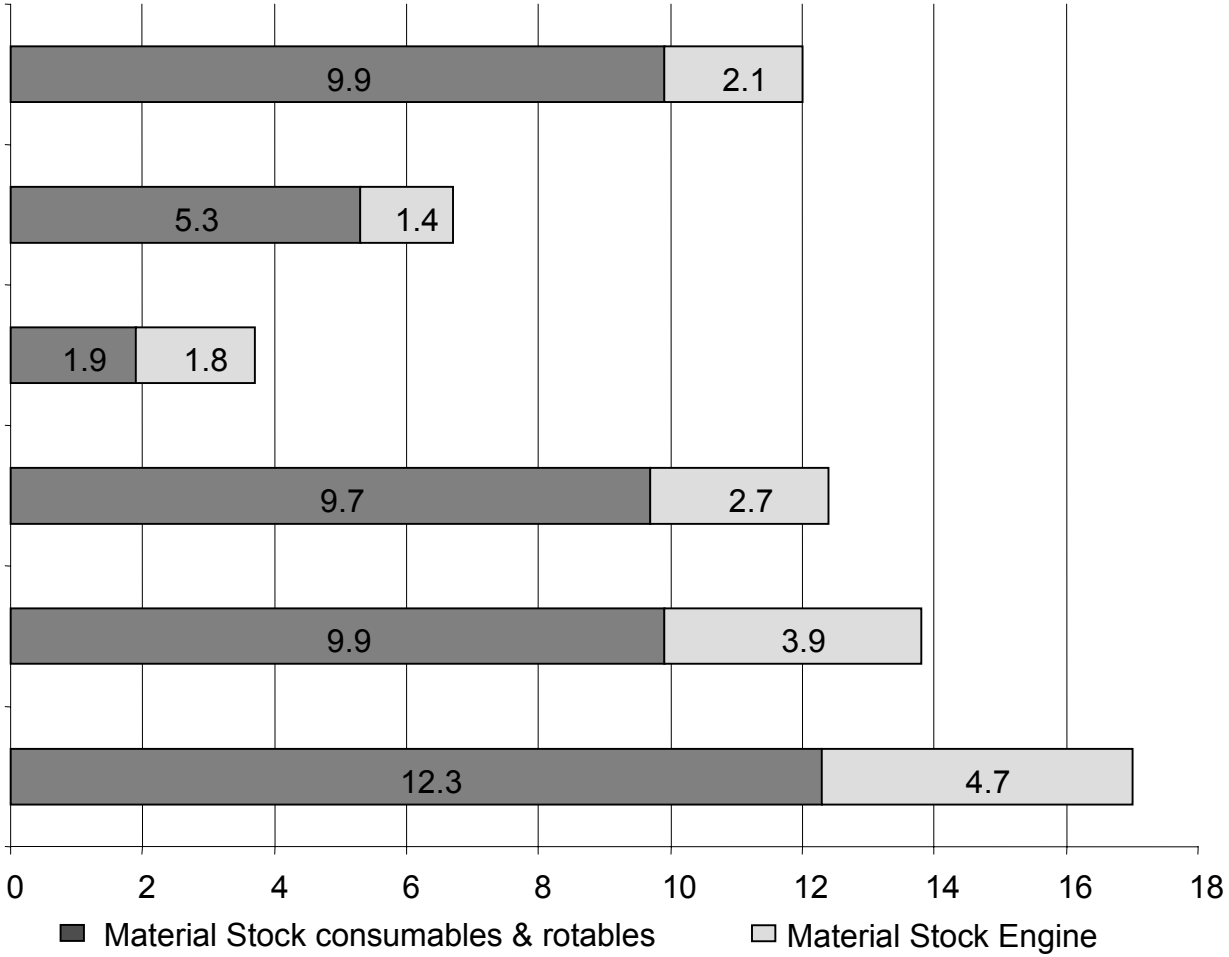
Massive spare parts build-up worth $45 billion

Inventory Costs are $8 billion a year

Labor Intensive

Differences in maintenance philosophies, management experience and productivity determine observed ratios between stock holdings value and fleet value.

Stock holdings value as a percentage of fleet value

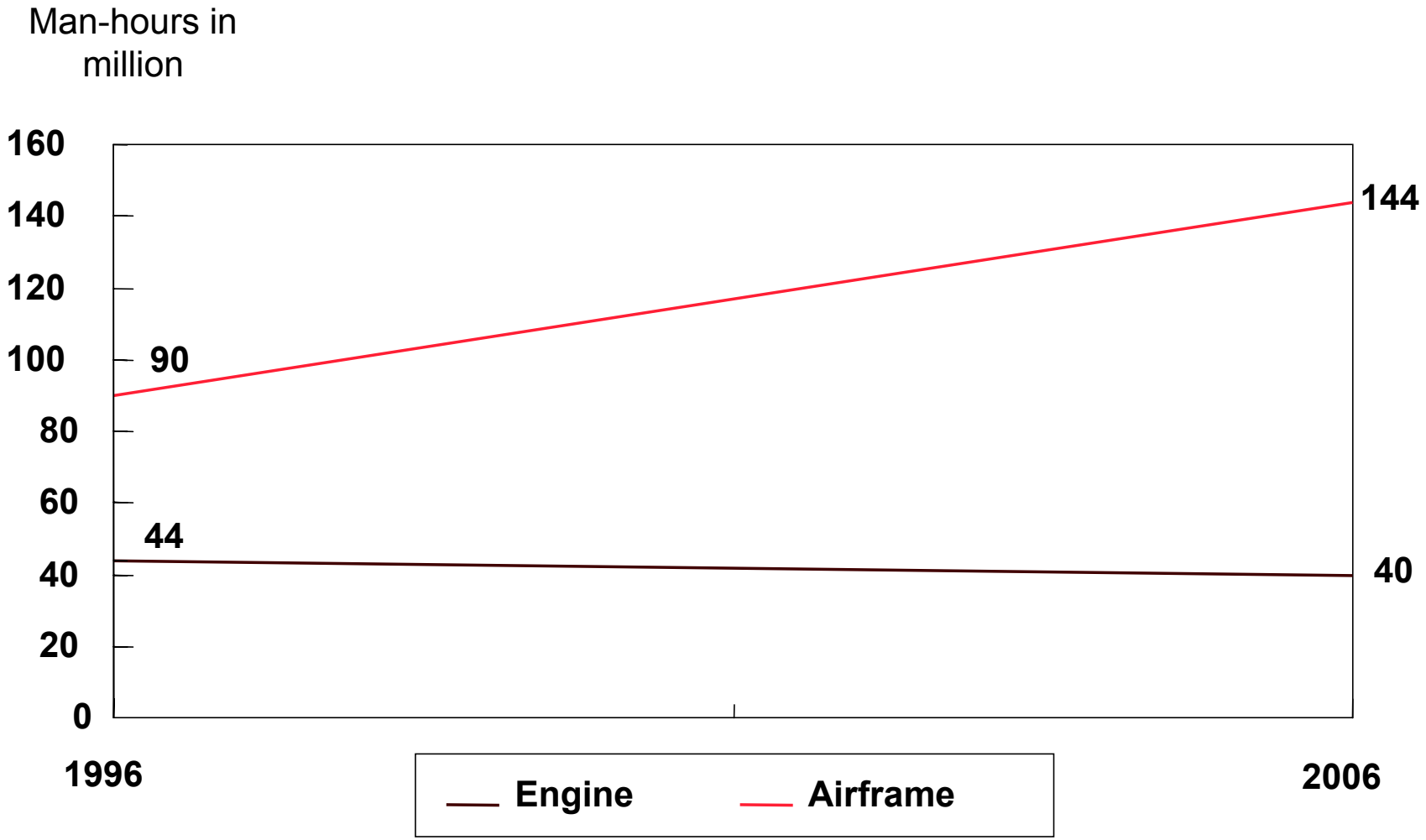


- ✓$20 billion high value rotables
- ✓$25 billion non-rotables

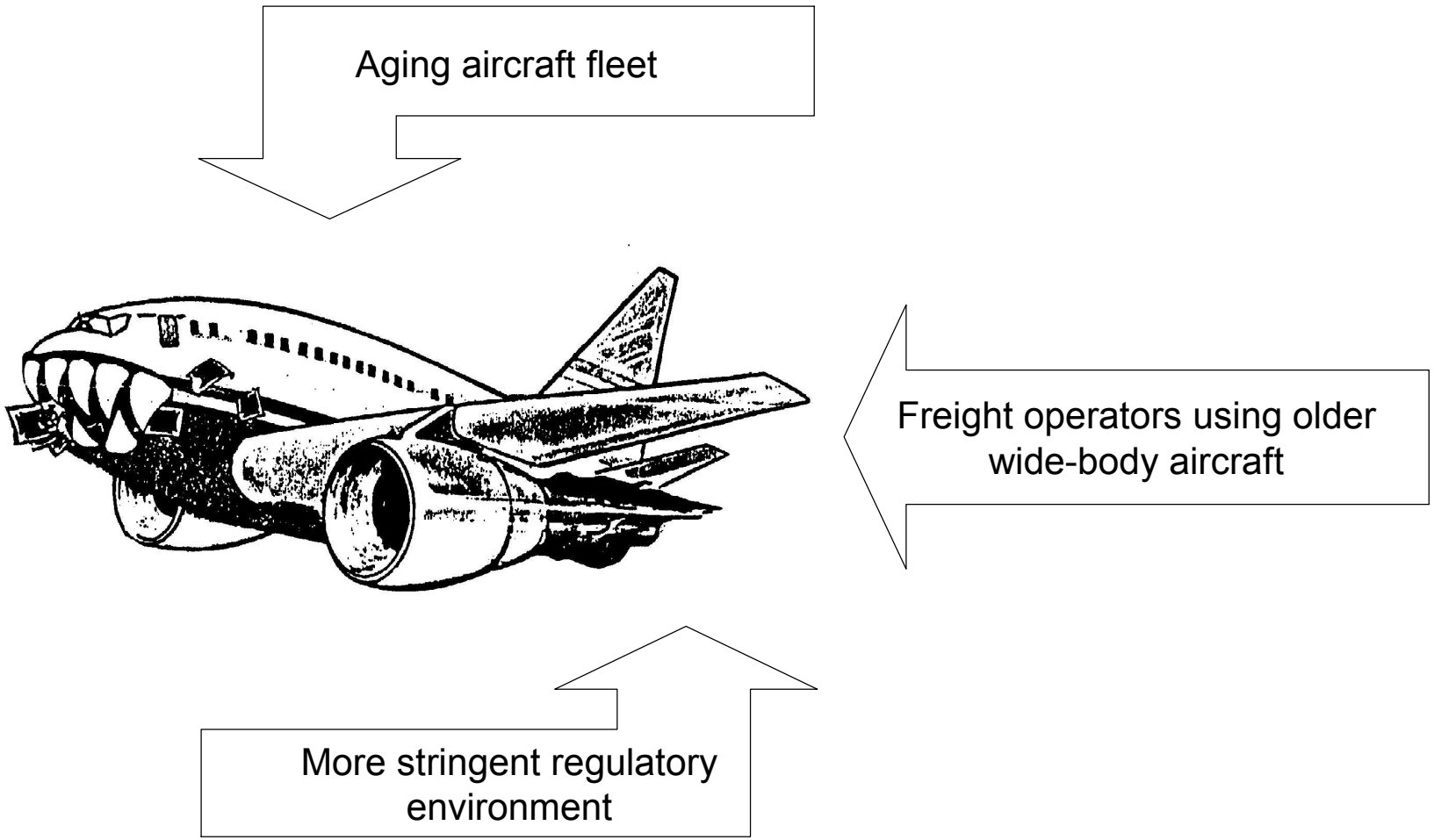
Sufficient for 4 years of support

33% are the true 'No-Go-Parts'

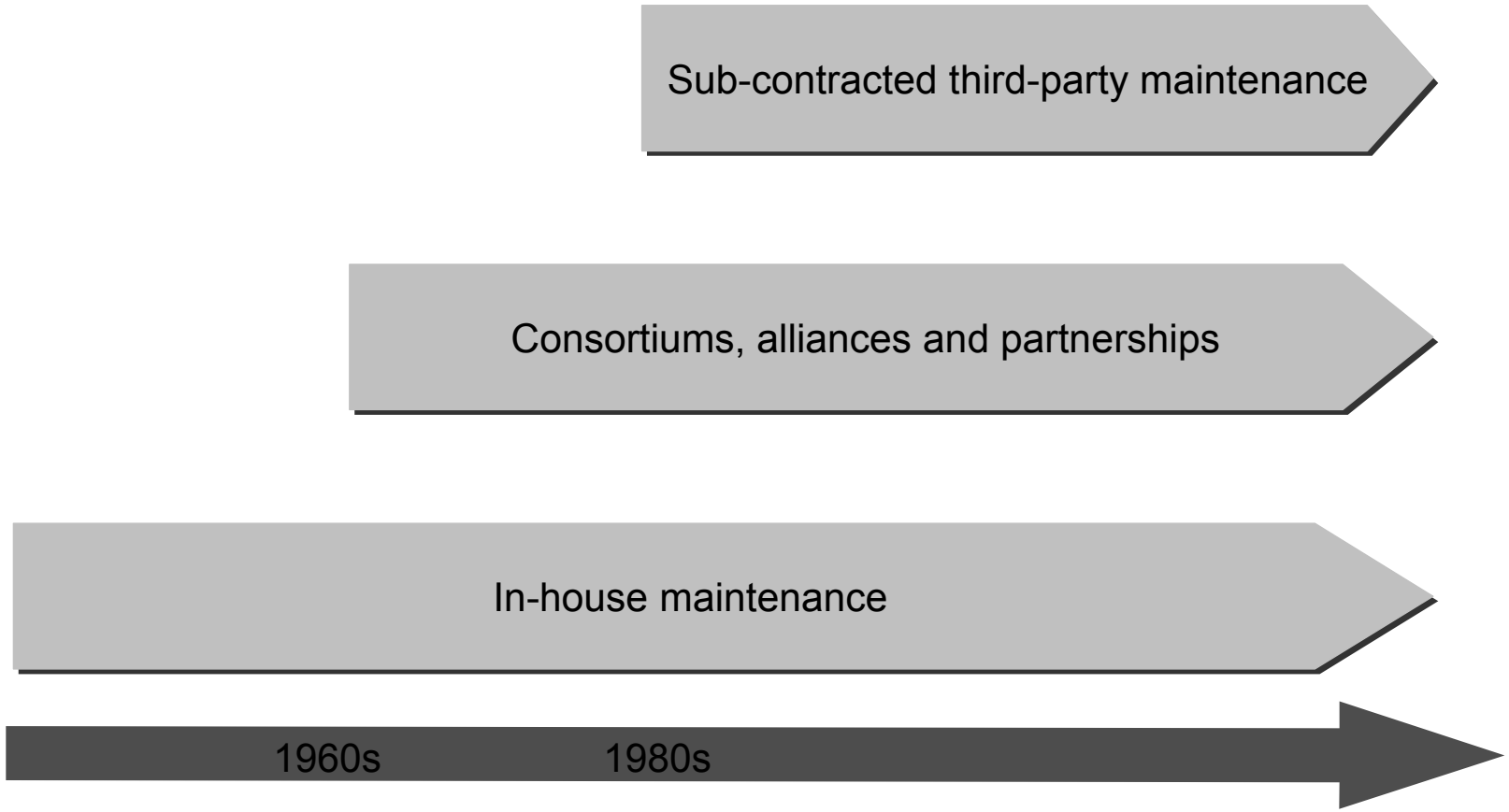
The composition of the projected airline fleets demand more intensive maintenance checks



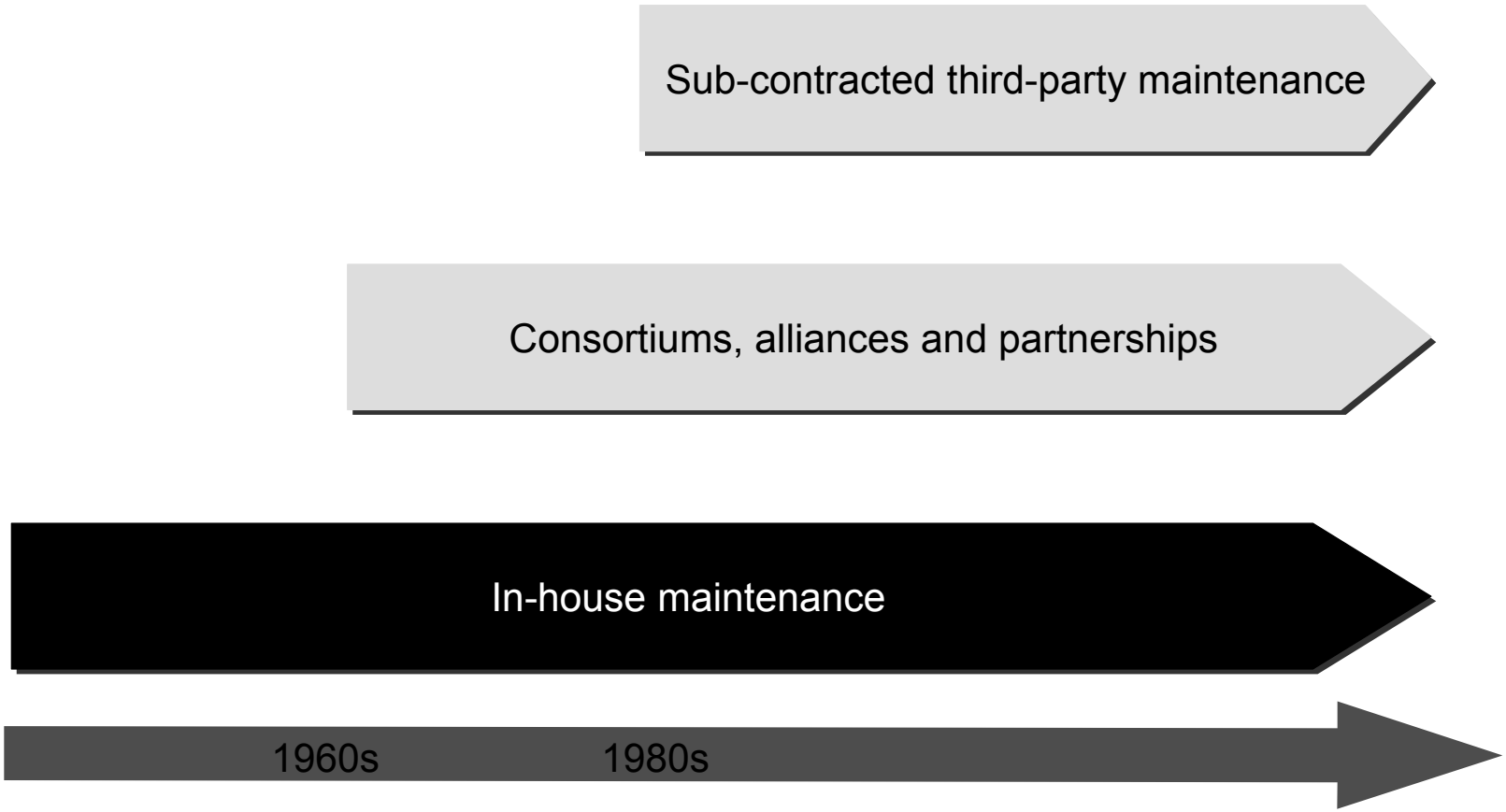
Factors anticipated to negatively influence the development towards more expensive maintenance activities



Throughout the life-span of the airline industry various proactive approaches to aircraft maintenance have been explored.



Aircraft Maintenance



Establishment of in-house maintenance facilities as cost centres was a natural result of the predictability an inexperience.

Operationally and economically feasible given a relatively small fleet and a regulated industry.

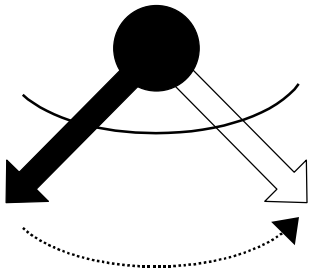
As the industry grew there was no need to change this policy, new technology aircraft introduced required fewer intervals between heavy maintenance.

- Allow managers to control operations and forecast future demands
- Keep ground time to a minimum and revenue flying time to a maximum.
- Extensive in-house engineering for absolute quality assurance.
- Directly manage rotable inventories

Today, competitive pressures make executives rethink the cost equation realising that pure in-house facilities - cost centers - are no longer acceptable.

- High inventory requirement
- Extended maintenance training
- High costs for land, buildings, and equipment

- 25 wide-body aircraft
- 40 small-body aircraft
- 50 engines per year
- 8% the world airlines have a fleet size that begins to reach a critical level



Expand in-house capabilities

Reduce in-house capabilities

When expanding your in-house capability, focusing on 5 key issues offers the greatest potential for improvement.

Activities

Clear-cut definition of scope and objectives of technical support to support own fleet (maximum reliability and dispatch rate)

Labor Costs

Cut direct labor cost and improve personnel productivity

Processes

Redesign of planning and dispatch processes and adaptation of IT-support in order to cut administrative cost and fully utilize available resources

Develop specialized and focused bases to which direct specific jobs

Material Costs

Cut material procurement cost and effectively control stocks

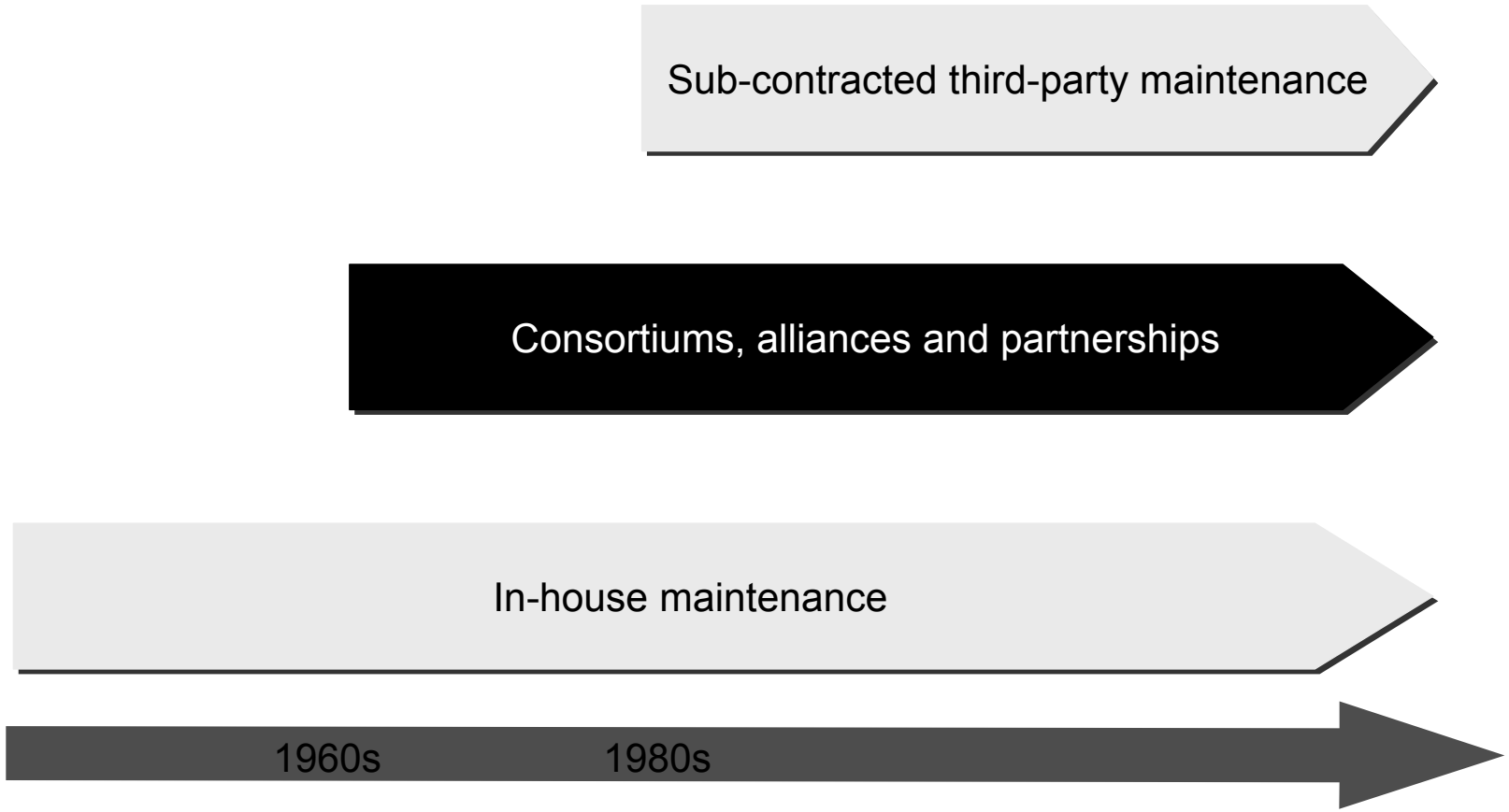
Organisation

Redesign of management organisation to ensure transparency and accountability and allow effective cost and quality control

When reducing your in-house capability, particular attention must be given to decision making factors.

- Is the cost information pertinent, accurate, timely, and adequate.
- Will the airline avoid a major capital investment in tooling and training or will it waste assets in which it already invested
- Can people and equipment, freed up when work is contracted out, be redeployed to speed up and reduce the cost of other maintenance activities.
- Will use of outside vendors provide enough savings to offset the cost of terminating workers whose jobs are eliminated by the move.
- Can carriers keep up a free flow of communication and information exchange between the specialized maintenance bases and the airline’s scheduling group.
- Can carriers maintain the maintenance unit’s ability to respond to sudden in- creases in demand for its services, such as compliance with service bulletins and ADs, if a large portion of the group’s work is handled by a third party.

Aircraft Maintenance



The concept of a consortium - an agreement between competing airlines to specialize in specific aviation repairs- was tried first after the introduction of jet aircraft.

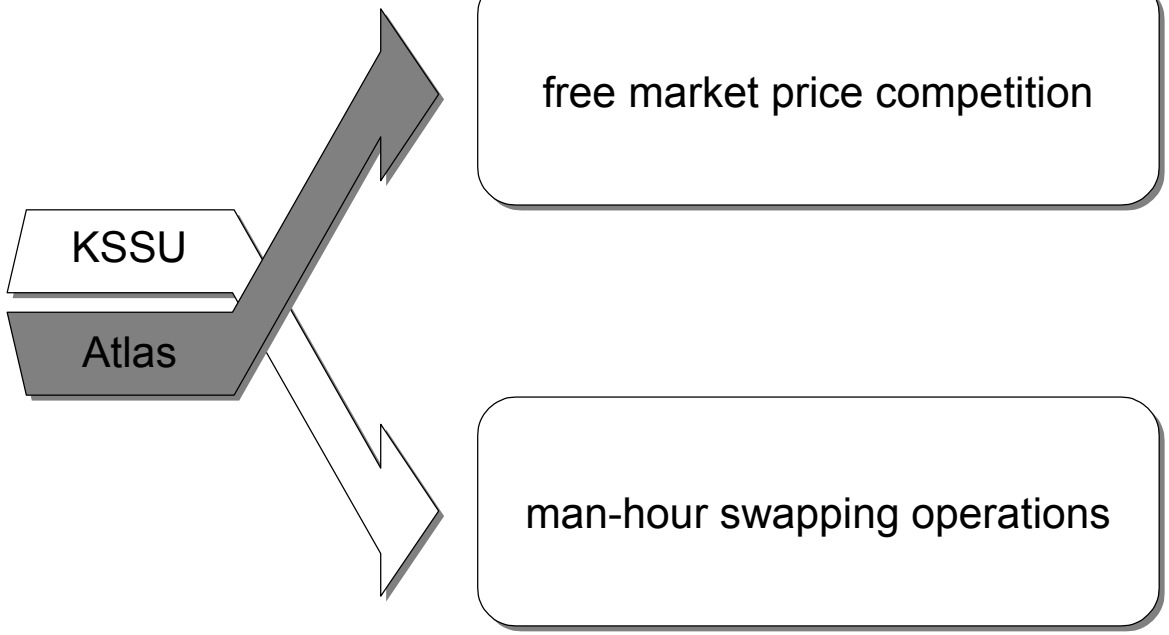
	ATLAS	KSSU
Founded	1969	1971
Members	Air France, France Alitalia, Italy Iberia, Spain Lufthansa, Germany Sabena, Belgium	KLM, Netherlands SAS, Scandinavia Swissair, Switzerland UTA, France

While most partnerships focus on similar activities to gain cost savings, there are contrasting philosophies on how to award work.

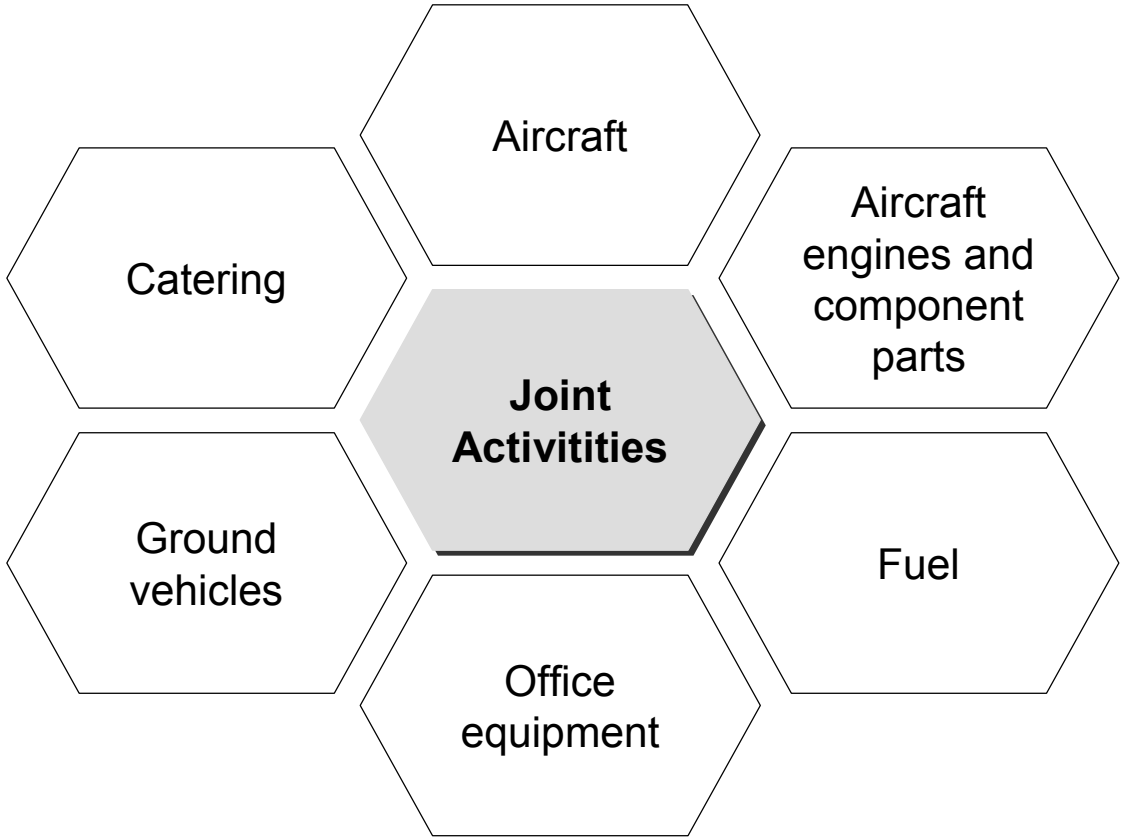
Project Engineering
- Setting standards and specifications for new integrated aircraft.

Production
- Overhaul airframes, engines, components, material provisioning, and shop engineering.

Flight Operations
- Simulator training and route documentation



Joining alliances can be used to leverage collective bargianing power to create economies of scale effects in different areas as well.



The advantages of creating pool agreements are overwhelming – not only financial but also from a reliability stand-point.

	Year 1		Year 2		Year 3	
	Pool	Air X	Pool	Air X	Pool	Air X
Fleet Size (a/c)	20	2	21	3	21	3
Stock Investment/Fleet Investment (approximation)	4,5%	8%	5%	12%	6,5%	17,5%
Stock Investment excluding Spare Engine (Mio US-Dollar)	100	18	115	40	132	58
Stock Items (different P/Ns)	39,500	30,000	40,000	40,000	48,000	48,000
Items on 160 Line Station World Wide	3,000	-----	3,000	-----	3,000	-----
Service Level	> 97%	90%	> 97%	90%	> 97%	90%
Technical irregularities caused by missing parts	1%	-----	1%	-----	1%	-----
Average Workshop Time of Components (days):						
High Price-Avionics	7-10	30	7-10	30	7-10	30
Medium Price Avionics	10-15	30-40	10-15	30-40	10-15	30-40
Mechanical LRU's	15-30	30-40	15-30	30-40	15-30	30-40

Productivity within partnerships greatly depends on the fleet strategy and how resources can be shared most effectively.

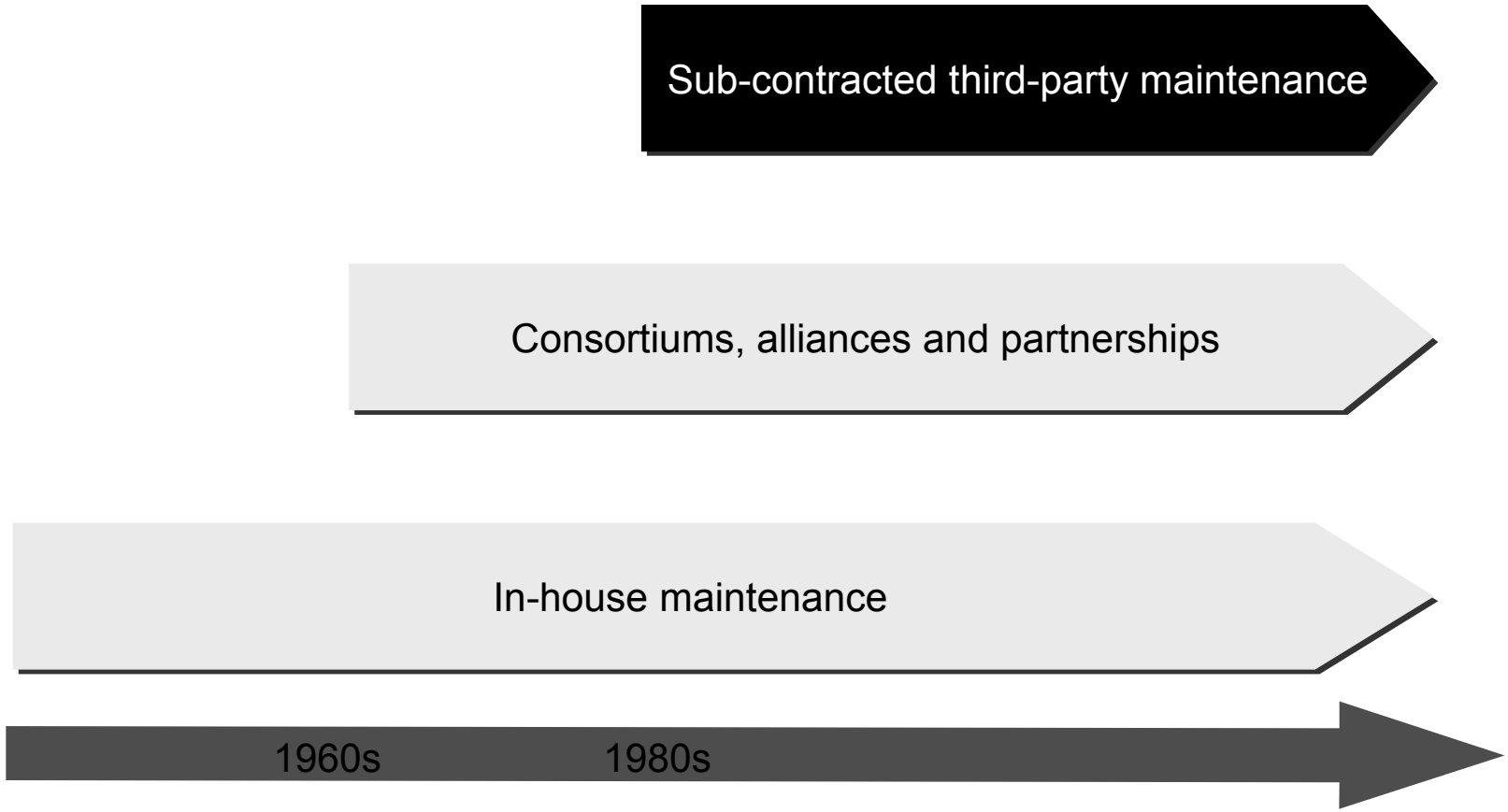
Resources	L-1011	B 757	B 767	MD 11	A 330
Administrative	**********	**********	**********	**********	**********
Mechanics		**********	**********		
Engines	**********	**********	**********		
Avionics		**********	**********	**********	
Computer Information System	**********	**********	**********	**********	**********
Inventory/Distribution	**********	**********	**********	**********	**********

To achieve maximum benefit 90 per cent of the critical parts (engines, avionics, and cockpit configuration) should share a commonality.

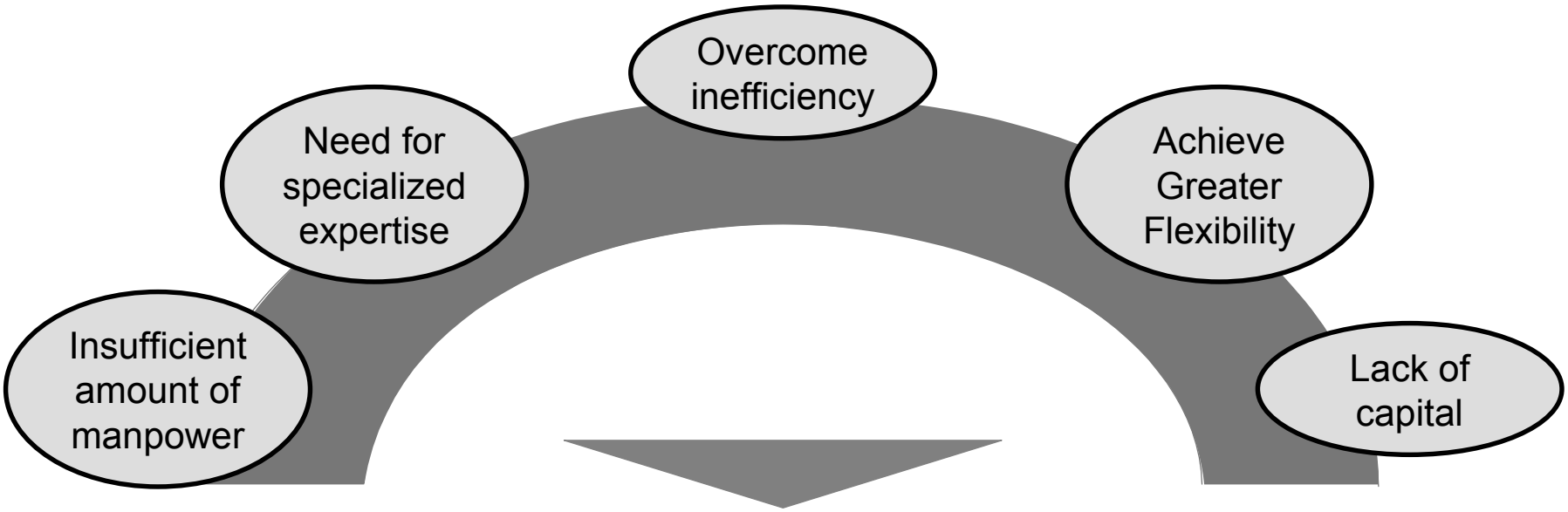
The concept of partnerships seems feasible for all the world's airlines but benefits must be evenly distributed while the need for harmonization puts great strains on any relationship.

Economic gains	Reduction of extensive inventories Reduction of training costs Achieving the Economies of Scale Operations Learning curve
Safety gains	Sharing information and facts about equipment failures aids in the prevention of further major safety problems Using only established expertise

Aircraft Maintenance

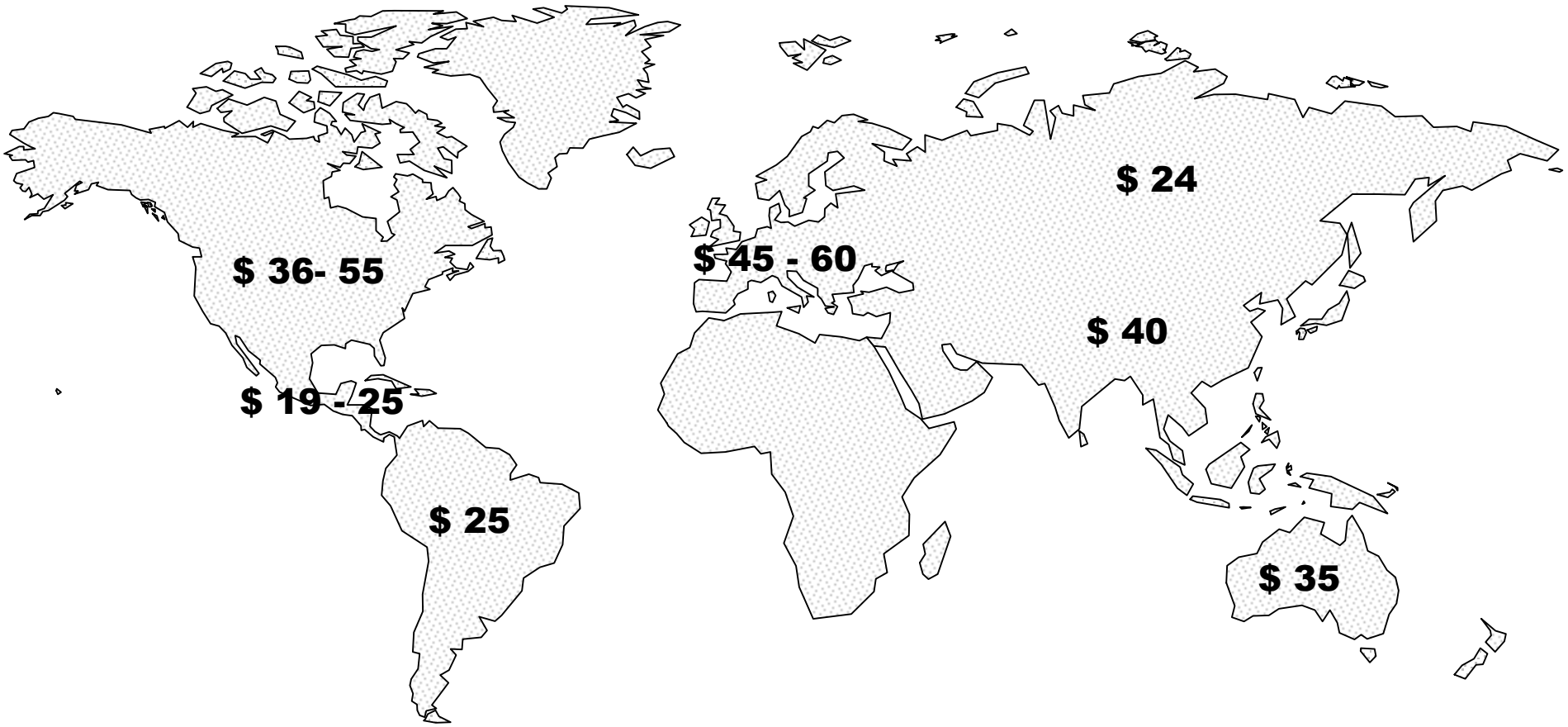


Airline costs can be reduced when contracting out lower value activities by using third party maintenance providers.



Current Land, Buildings and some equipment can be sold off, infusing more investment capital for the airlines to use in acquiring more aircraft, etc.

Price differentials regarding labor rates in the supplier market of third-party maintenance highlights the potential gain.



But at the price of operational reliability - all factors must be blended into a right combination that provides for quality, reliability, cost, and technical expertise.

- Is the aircraft repaired properly and put back in the air without undue delay?
- Is the supplier approaching each job with the intention to maximize the amount of man-hours?
- Is the supplier inclined to replace every old part with a new one by simply citing quality issues as the determinant.

Time, money and resources must be spent to ensure that the airline is on an equal footing with the supplier and the supplier choice

Which is the best? - Evaluating obstacles and strengths within its peculiar environment each airline must set out to discover its optimal solution.

Rely on information available:

- **Fleet mix**
- **City pair markets**
- **Geographical locations**
- **Organization structure**
- **Cost structure**
- **Technical capabilities, engineering expertise**
- **Necessary capital for building and equipment**

The trend appears to be toward outsourcing for the purpose of obtaining some measures of economies of scale