FEEG 2006 Engineering Management and Law
Introduction to costing and resources

Dr Roy Edwards

Why?

- The engineering professions want engagement with business and management.
- You will have to deal with business and/or organisation.
- Engineering technology and products do not just drop fully formed from the bench, lab or factory.
- They require organisation.

What interest you about engineering?

- As we go through the content I will ask you about your favourite technology.
- What is it? What product or project fascinates you, inspires you?
- How is it made? Who by? Who invented it? (loan inventor rare!)
- How is it organised?
- How was it….. Importance of engineering history.

Note

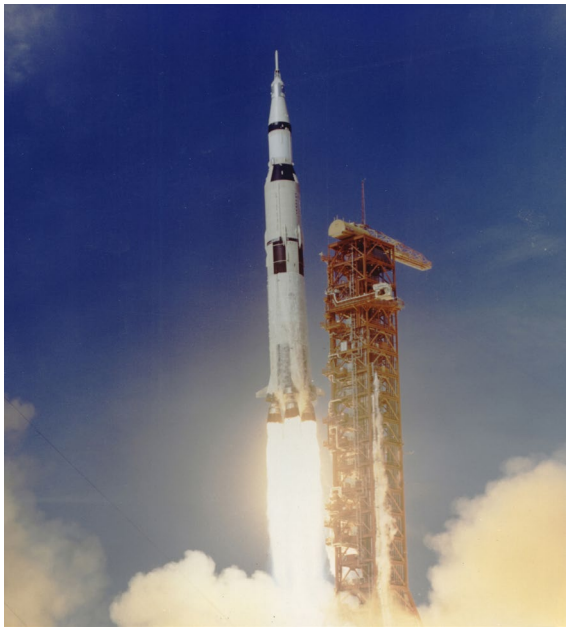
- I will now refer to product/project/service as product – but be aware that it means all of these!
- Also be aware that often products are developed within both business and charitable setting. The principles are the same. Someone – the customer – has to use your product. You ALWAYS need to remember this.

Think about any component of a product or a process.

- You are engineers – you have an understanding of this.
- A wing, a pump, a transistor, a plate, a screw.
- You might also think about – mass production, welding, grinding, flexible production.
- Even a modelling process – writing software, writing instructions, delivering research.
- All these need organising and finding resources. This is what FEEG 2006 is about. It is not separate to your maths, physics, materials, design etc – but yet another element of the same body of knowledge.

Mine…

But is it this….



Or this?

Could also be this…

Or this….

Or even one of these…. (ugh)

This is better…… But not as good as these…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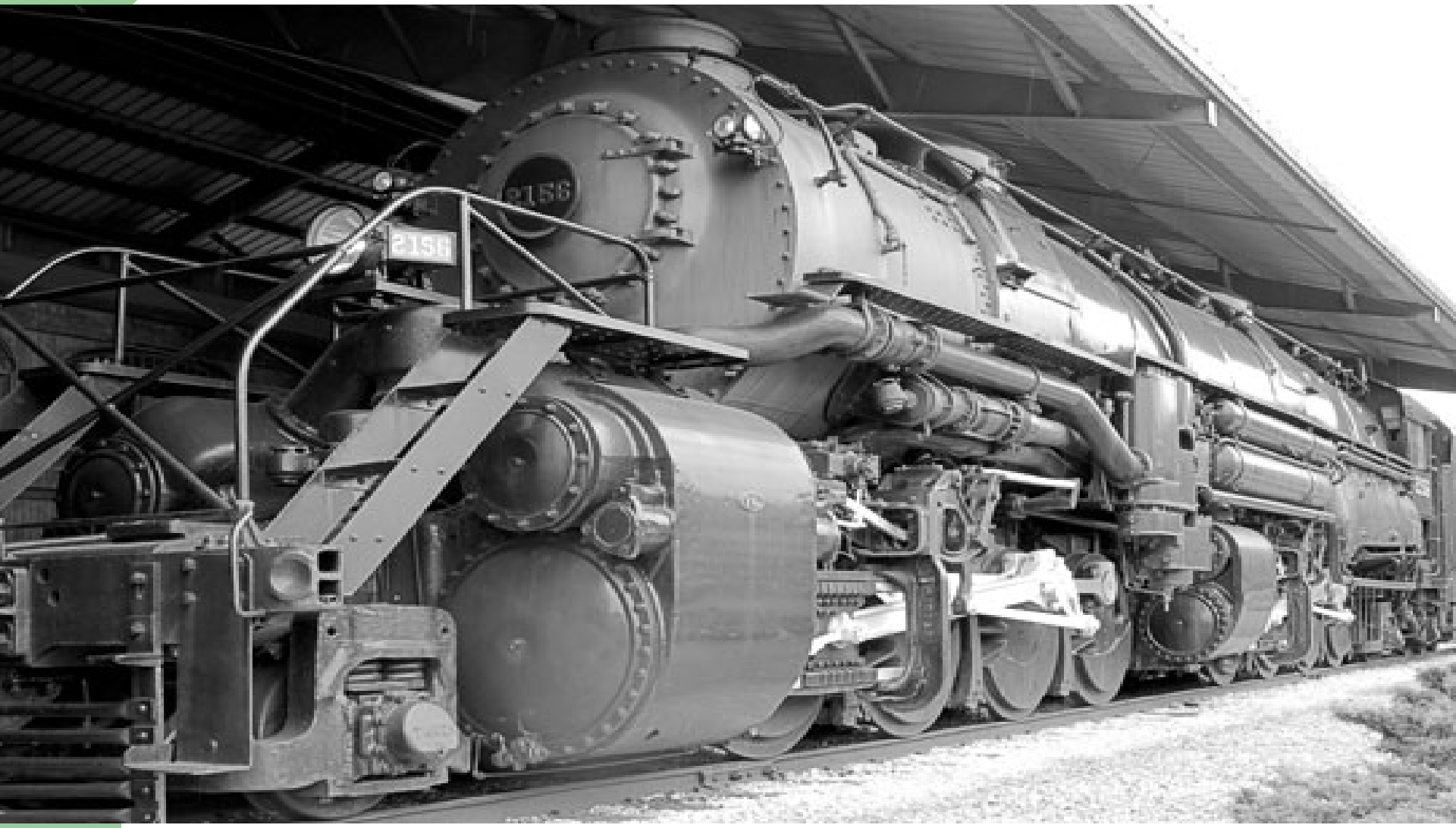
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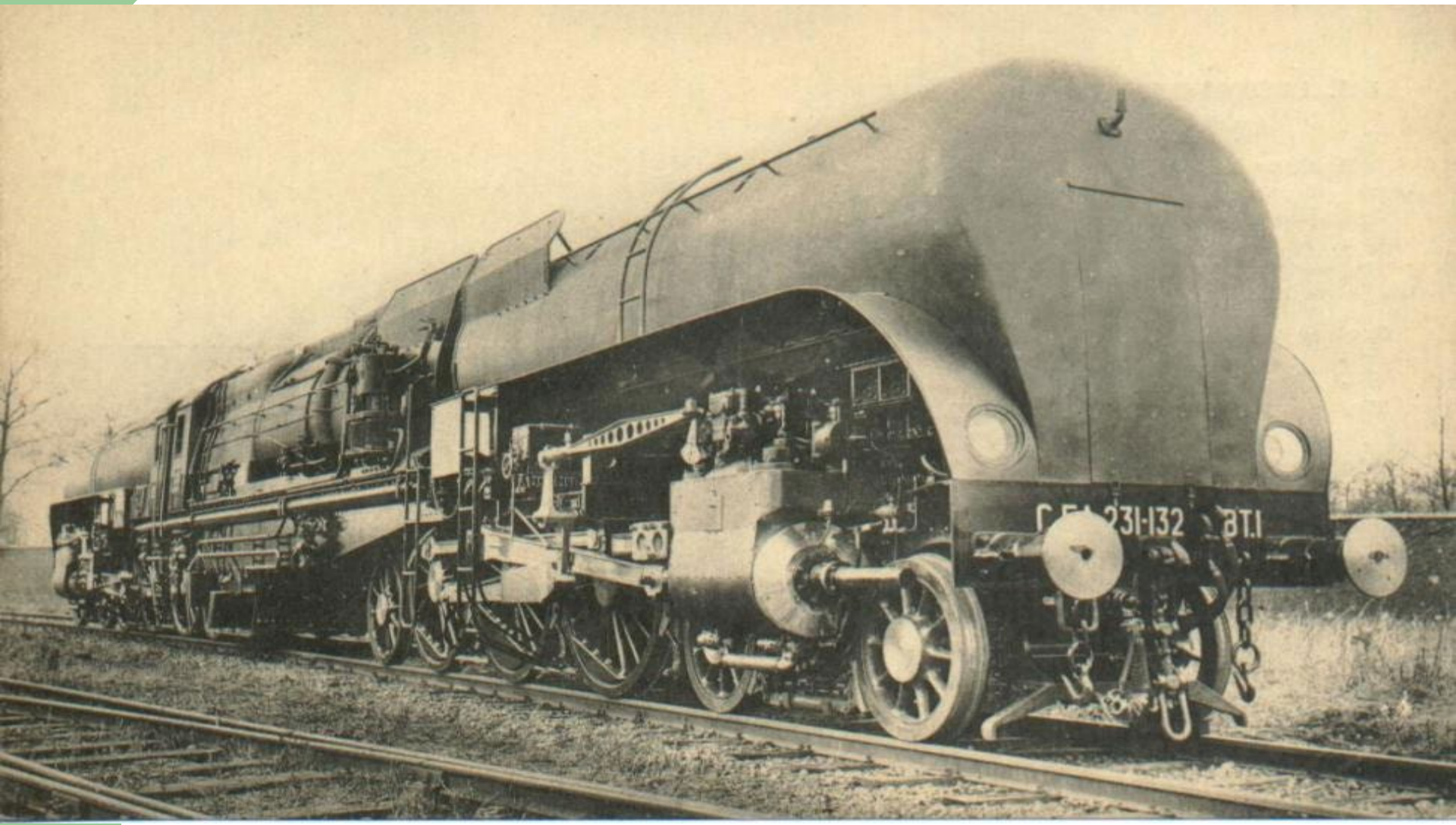

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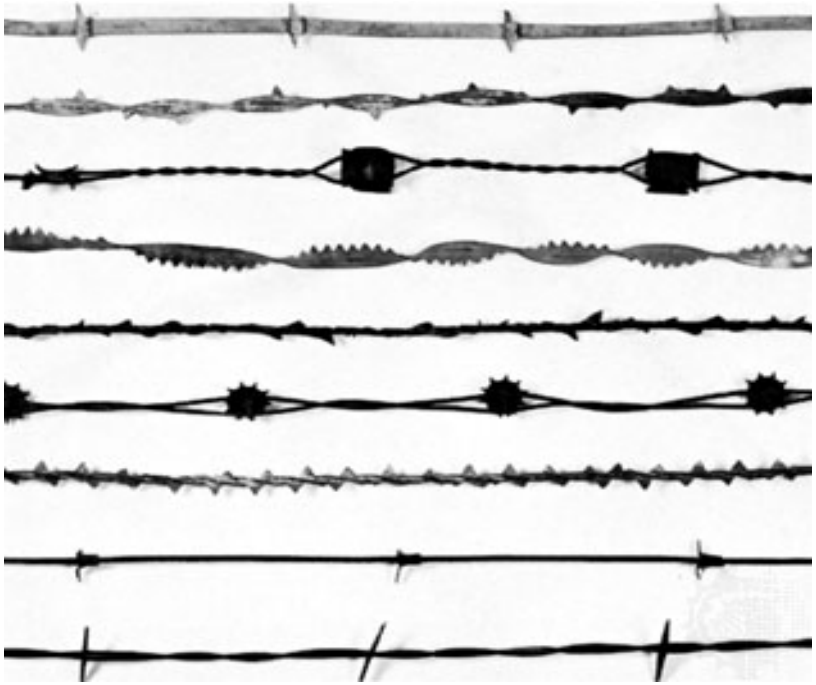
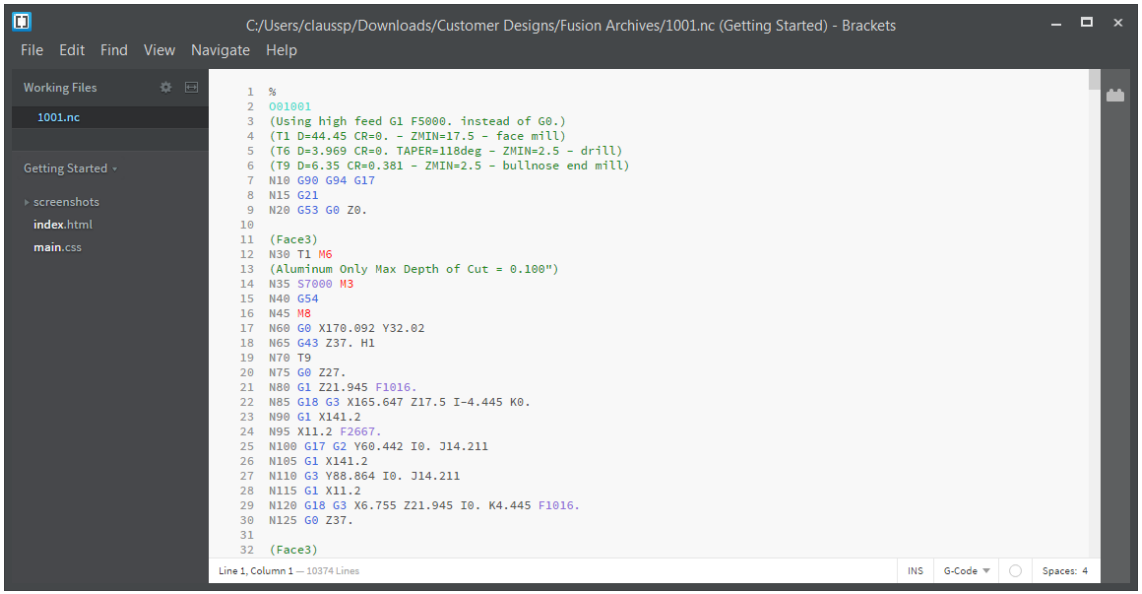


Or this….G – Code (for CNC)

https://www.autodesk.com/products/fusion-360/blog/cnc-programming-fundamentals-g-code/



What is yours?

Think about this and ask your colleagues what they have chosen?

- Why have you chosen this? What is interesting about it?
- You might also think about where the product fits within system or project?

Now think – and this is critical:

- what resources are involved in this technology?
- How is it organised – what is the business model – we will cover this later?
- The point is – technology needs designing, making, and organising.

Video

- Have a look at these two videos. They give a good idea of strategy and technology development.
- You should look at them in order:
- https://www.bloomberg.com/news/videos/2020-11-17/flight-of-the-new-concordes-video
- https://www.bloomberg.com/news/videos/2020-10-06/the-first-look-at-boom-s-supersonic-plane-video

Video

- https://www.youtube.com/watch?v=VlbZTyBuFlQ
- https://www.bloomberg.com/news/videos/2021-06-17/growing-the-space-economy-video
- https://www.youtube.com/watch?v=ZIzPzgpbHe8
- Follow the link below for four on the business of space
  https://www.bloomberg.com/qt/series/giant-leap

Accounting is part of the engineering story

- “Doing for £ what any fool can do for £10”.
- The companies that make things matter.
- They organise engineering. Accounting helps to position the resources used by accounting. Mess up the accounting – no engineering. RB-211.

Accounting.

- Accounting tells the story of a product, a process, an organisation.
- You need to understand accounting because it is the language of business and financial planning.
- Some of it is common sense – in which case it still needs to be engaged with.
- Some of it is not.

Financial Statements

- **P & L (Income Statement)**
- Records performance over a time period providing the calculations to indicate a profit or loss. This end figure is transferred to the Balance Sheet…
- **Balance Sheet (Statement of Financial Position)**
- Records the assets, liability and funding of a business at a point in time – a snapshot.

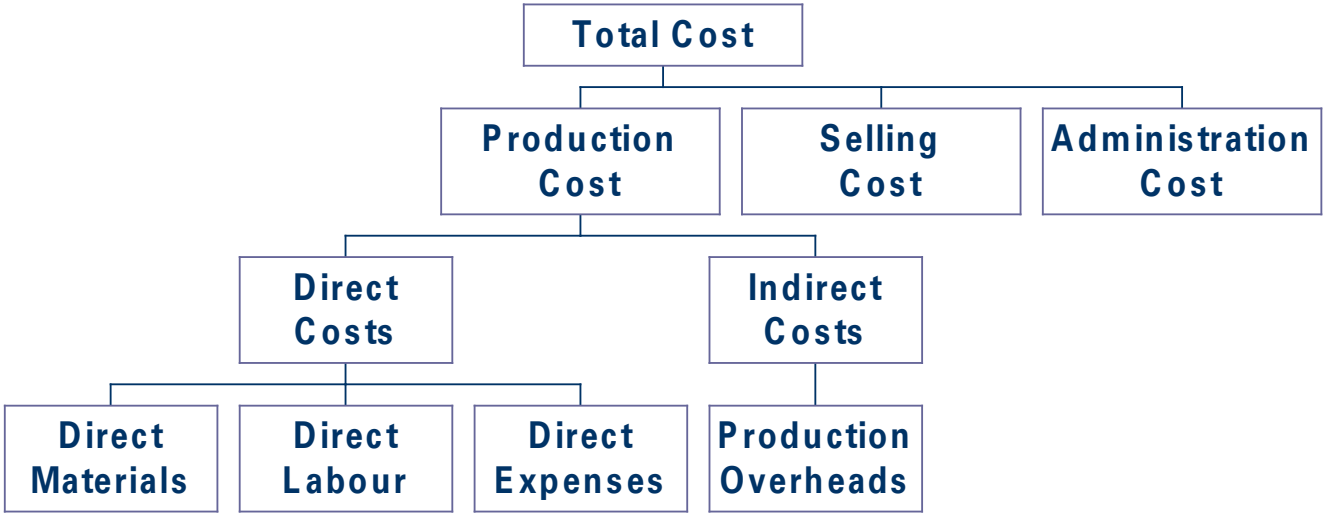
Financial Statements:

P & L (Income Statement)	Balance Sheet (Statement of Financial Position)
	Non Current Asset
Sales	Current Asset
(COS)	Current Liability
Gross Profit	Non current Liability
Expense	
Net Profit	Equity.
	Reserves.

What is Cost information used for?

- To help in determining the selling price:
  - “cost-plus” pricing;
  - can product be made and sold profitably?
- To aid decision making
- To measure and value within the financial statements for reporting purposes.
- Cost information gives us an understanding of what resources might be needed.

THE ELEMENTS OF TOTAL COST



DIRECT COSTS

Direct costs are those costs that can be directly related to a specific product or service:

- Materials: specifically used in manufacturing a product or providing a service.
- Labour: identifiable with the work involved in manufacturing a product or providing a service.
- Expenses: specifically identifiable with manufacturing a product or providing a service.

INDIRECT COSTS

Indirect costs are those costs that cannot be directly attributed to a specific product or service. They can be classified into:

- production overhead
- selling & distribution overhead
- administration overhead

EXAMPLES OF PRODUCTION OVERHEADS

- Cost of factory building (rent, maintenance, security, insurance, heat and light)
- Pay of supervisory staff
- Works canteen
- Research, development and design
- Maintenance and depreciation of machinery
- Cost of purchasing department
- Cost of receiving and storing raw materials and components
- Cost of moving work in progress around factory

FIXED COSTS

- Tend to be unaffected by fluctuations in the level of output or turnover.
- Are usually related to a period of time.

Examples: Rent and insurance of factory
Salaries of supervisory staff

NOTE: costs are deemed to be fixed by reference to the period about which we are interested: in the long run, all costs vary to some extent.

VARIABLE COSTS

Tend to follow (in the short term) the level of activity of the organisation.

Examples: Materials

Labour directly employed on production

Directly identifiable expenses such as power used to drive machines

Variable costs and direct costs are generally different names for the same items.

PROBLEMS WITH FIXED/VARIABLE DISTINCTION

- In the very short term, many “variable” costs may be effectively fixed:
  - for example, production workers may be paid weekly wages or monthly salaries that do not depend on the volume of production, and it is difficult to increase or decrease number of workers in the short term.
- Variable costs may not be linearly associated with volume:
  - discounts may be available for large volumes of inputs.
- Some costs have both fixed and variable aspects:
  - Periodic charge for rental plus charge for usage

COST UNITS

- To define cost we need to relate them to activities of the firm.
- A COST UNIT is any separately identifiable output for which a cost may be estimated or measured.
- Appropriate cost units depend on the nature of the industry/activity, for example:
  - Aircraft manufacturing: each aeroplane would be a separate cost unit
  - Electronic components: each separate component, or each separate batch of a given component
  - Construction: each separate job
  - Hospital: “patient-day”
  - University: degree programme or course?

WHERE DO COSTS ARISE? COST CENTRES

- A cost centre is an identifiable part of an organisation for which costs can be collected.
- In a manufacturing setting, a cost centre could be:
  - a single factory;
  - a particular department or activity (e.g. assembly, foundry, inspection)
  - a machine or group of machines
  - an individual or group of individuals
- Cost centres can usually be identified where:
  - many costs can be allocated to specific parts of the organisation
  - someone has responsibility for that part of the organisation

STANDARD COSTS

- Used when many identical units of a particular product/service are supplied.
- Standard cost per unit is estimated based on standard quantities of inputs and standard prices per unit of input:
  - ideal standard: can be attained only under the most favourable working conditions. May be used to motivate managers to achieve greatest possible efficiency.
  - normal standard: can be attained if work is carried out efficiently under average conditions. Allows for typical levels of machine breakdown, material wastage and worker fatigue.

How to estimate cost?

- Need to estimate quantity of inputs:
  - Materials:
    - Raw materials
    - Components
    - Sub-assemblies
  - Labour:
    - Specialist labour
    - General (unskilled) labour
  - Other inputs:
    - Machine time
    - Process time
    - Power, specific direct expenses
- Need to estimate COST per unit of input

3 Main approaches

- Parametric costing
- Costing by Analogy
- Engineering

Cost estimating relationship: Parametric Costing

- Engineers – often in conjunction with accountants - conduct detailed technical analysis of the design, development and manufacturing process.
- This involves establishing a cost estimating relationship for each product that forms the first analysis of resource use.
- In the context of FEEG 2006 we only need for you to think about how the engineering activities and cost classifications might be used in a parametric model. You are NOT required to develop one.

Parametric Costing

- “Parametric estimating is a technique that develops cost estimates based upon the examination and validation of the relationships which exist between a project's technical, programmatic, and cost characteristics as well as the resources consumed during its development, manufacture, maintenance, and/or modification”. Int. Soc. Parametric Analysis *Parametric Estimating Handbook* (2008, p2).
- This involves developing statistical models using cost data against a variety of variables – including function and performance.

Analogy

- Using evidence from past experience as an analogy for the current product design, adjusted by scaling for current design and manufacturing conditions.
- Most new products drawing upon existing products and components.
- Useful as a starting point for developing a more detailed technical specification.

Engineering estimate

- Costs determined through a bottom-up analysis of constituent parts. – materials, labour and any overheads.
- Sources of information: drawings, engineering and trade standards.
- Construction of prototype: cost as well as engineering discovery.

Using cost

- We can use costs as a basis for analysis to understand how profit and costs relate to each other.
- We have to think about direct and indirect costs – and what this means for the performance of our product.

Simple use of costs: Contribution

- **CONTRIBUTION per unit is the difference between the unit selling price and the unit variable costs.**
- **Example:**

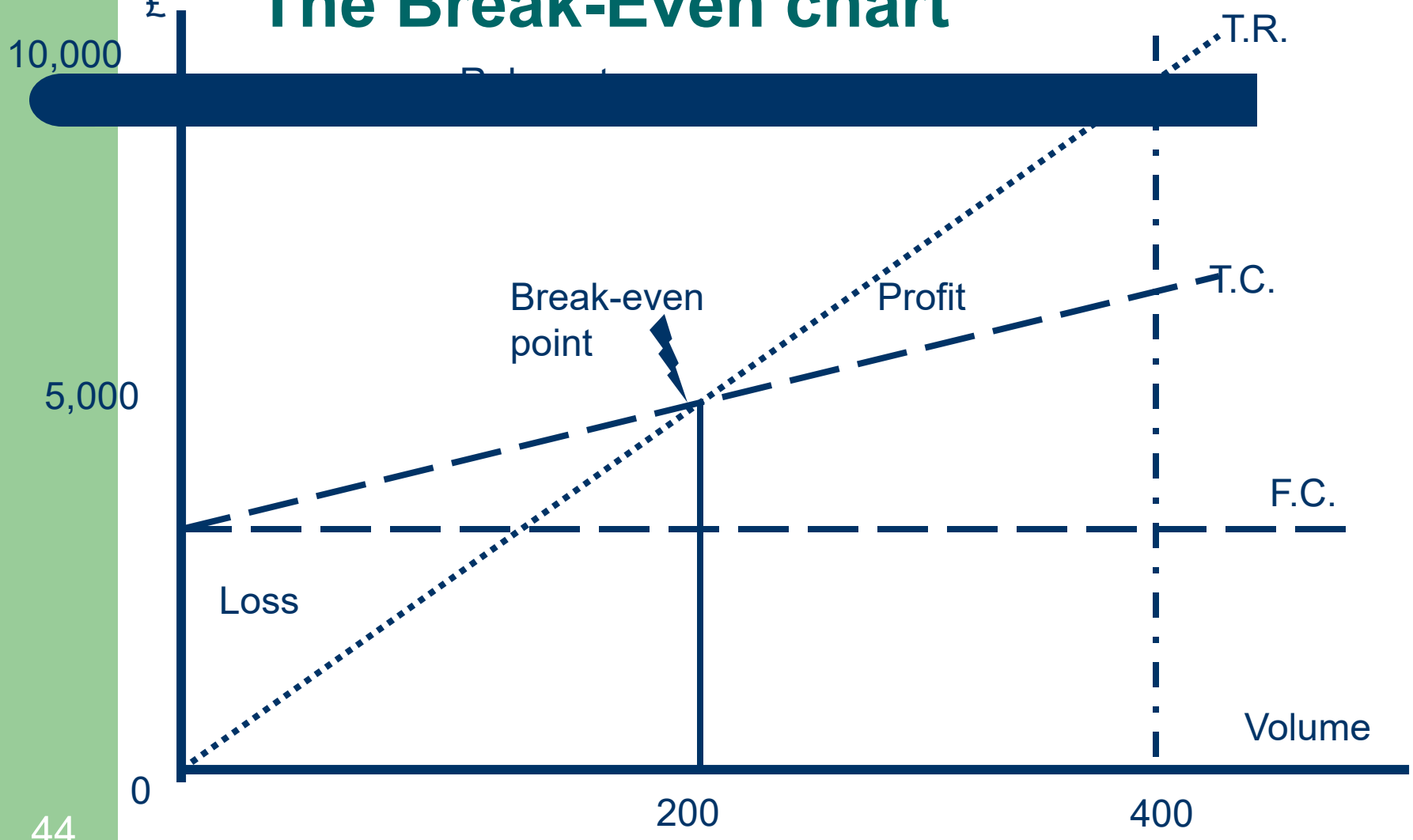
Unit selling price		£100
Direct material cost	£30	
Direct labour cost	20	
Direct expenses	10	
		60
CONTRIBUTION		£40

- **Total contribution must be enough to pay for indirect costs and give a profit. It is generally not sensible to make and sell products that produce a negative contribution.**

The Break-Even chart: data

- Fixed Costs are £3,000 per month.
- Variable Costs are £10 per unit.
- Sales Price is £25 per unit.
- Maximum production is 400 units per month.
- So FC /(Price – VC) gives us 200 units where we will have covered our variable costs plus overhead.

The Break-Even chart



Costing for product/process/service.

- Direct and indirect are the key classifications.

It is critical to think about the underlying activities and the resources needed in any engineering project as this generates the cost – direct and indirect.

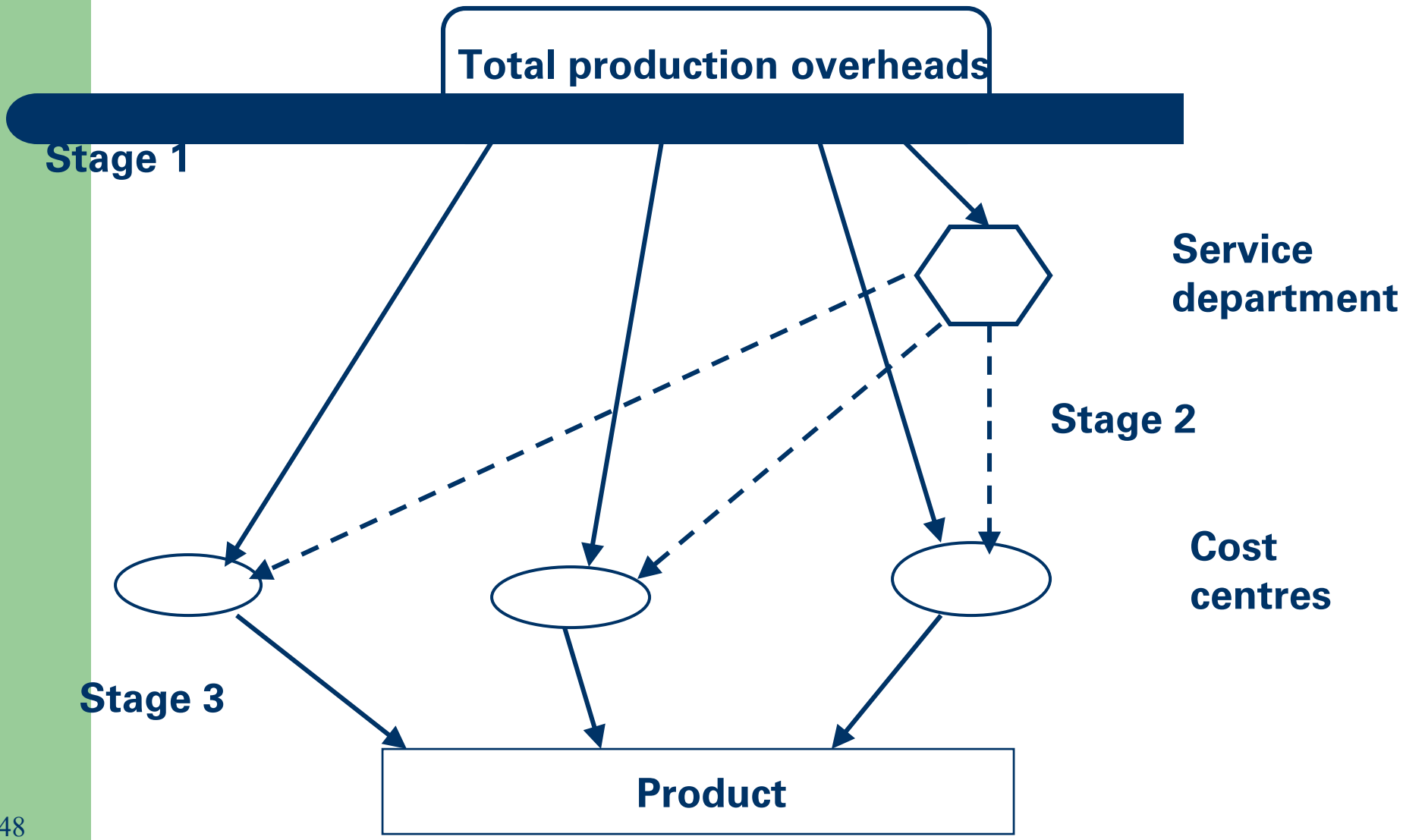
Ok…

- Ok – we have looked at direct costs but now we need to think about overheads and what to do with them?
- We need a way of allocating them to the product. This is the point at which we have to think about what drives the consumption of resources.
- This is where accounting gets a bit tricky…..

NOW INDIRECT COSTS: WHY ALLOCATE OVERHEADS?

- **PRICING:**
  - "cost-plus" pricing: need to estimate total cost
  - comparison with current market price
- **CONTROL:**
  - monitoring costs
  - monitoring usage of resources
- **ACCOUNTING:**
  - current accounting rules require businesses to record stocks and work-in-progress, including all production overheads.

OVERHEAD ALLOCATION PROCESS



OVERHEAD ALLOCATION: STAGE 1

- **Costs are ATTRIBUTED to cost centres.**
- **This may be done:**
  - **DIRECTLY**
    - costs that can be associated entirely with a single cost centre, e.g.:
      - wages of cost centre supervisor
      - costs of machine used solely in cost centre
  - **Through APPORTIONMENT**
    - costs that are associated with several cost centres

OVERHEAD ALLOCATION: STAGE 2

- Costs relating to “non-productive” service departments are reapportioned to the “productive” cost centres
- “Non-productive” service departments might include:
  - general maintenance and security
  - purchasing
  - stores and material handling
  - HR
  - research and development

OVERHEAD ALLOCATION: STAGE 3

- At this stage, all production overheads have been attributed to the “productive” cost centres.
- In each cost centre, an overhead absorption rate is calculated, based on the total overheads in the cost centre and the estimated volume of some relevant factor.
- Overheads are allocated to individual units of product by determining the number of units of the relevant factor used on the product in each cost centre and multiplying by the overhead absorption rate for that cost centre.

APPORTIONMENT BASES

- The aim is to use a “rational” basis for apportioning overheads to cost centres, so apportionment basis depends on the specific cost being apportioned.
- Examples:
  - rent of factory: floor space occupied by each cost centre
  - HR: number of workers in each cost centre
  - maintenance of equipment: value of machinery in each cost centre
- Often, apportionment of overheads is arbitrary.

OVERHEAD ABSORPTION BASES

- For each cost centre, some relevant factor will be identified, which is intended to be a good indication of how costs are likely to vary in the cost centre.
- Relevant factor will reflect nature of cost centre:
  - MACHINE HOURS: used for production departments/ processes that are highly capital intensive
  - RAW MATERIAL COST: used for processes involving handling of high-value materials
  - LABOUR HOURS: used for production departments/ processes that are highly labour intensive
  - LABOUR COST: used where labour is highly specialised and expensive.

PROBLEM OF OVERHEAD ABSORPTION

- Assuming that all costs in a cost centre vary according to a single factor is almost certainly incorrect.
- Relevant factor is often chosen because it is easily measured rather than because of its relevance.
- Some businesses use a crude absorption basis for all production overheads (for example, labour cost).
- The choice of absorption basis can have a significant impact on the calculation of total product cost.

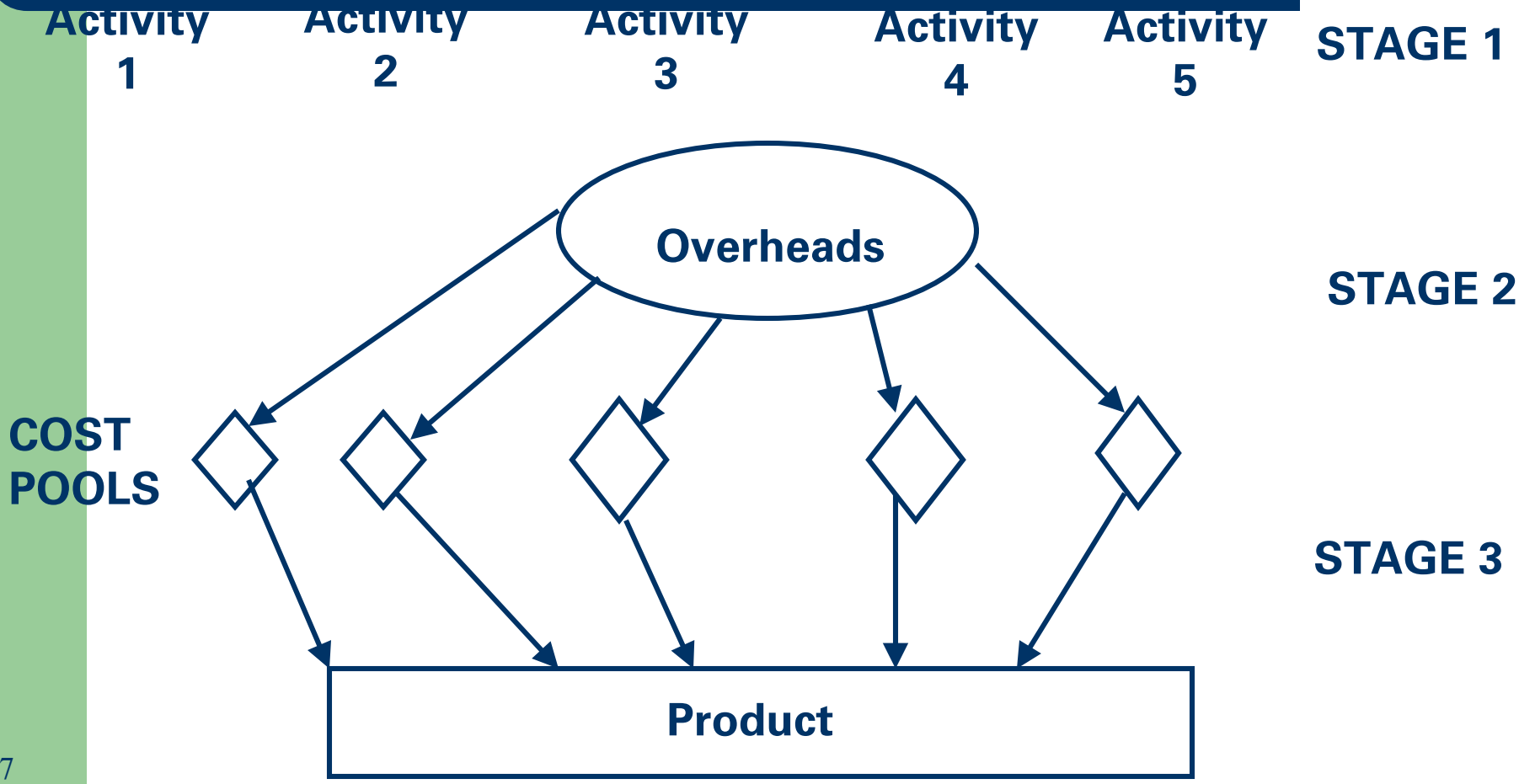
IS TRADITIONAL OVERHEAD ALLOCATION OUT OF DATE?

- Crude use of labour as main allocation basis less relevant in low-labour manufacturing.
- Distinction between production and other overheads losing relevance in customer-oriented business.
- Focus is on measuring costs, not managing costs.

ACTIVITY-BASED COSTING (ABC)

- What activities is the business doing when it incurs overheads?
- Activities need not be confined to single cost centres: they cut across traditional departmental borders.
- Traditional overhead allocation shifts responsibility for overheads to cost centres, hence those incurring overheads have no incentive to control costs.

THE ABC PROCESS



THE ABC PROCESS: STAGE 1

IDENTIFY ACTIVITIES

- These can be anything where overheads are incurred and costs can be allocated easily.
- Activities might be (small selection!):
  - Production-related:
    - Design
    - Machine set-up
    - Material handling
    - Purchasing
    - Inspection
    - Remedial work
  - Sales-related:
    - Order negotiation
    - After-sales service
    - Warranty repairs

Note:

- The notion of what constitutes an activity is important.
- Activities form how a product is made – the equipment and labour is combined in various ways to manufacture products. Engineering activities might be mechanical handling, machining, designing etc.
- You will need to think about what constitutes activities in more detail.

THE ABC PROCESS: STAGE 2

Allocate costs relating to each activity to a cost pool:
Some costs are directly attributable, e.g.:

- Labour
- Materials used in activity
- Other costs may need to be apportioned, eg:
- rent of space occupied by activity

Apportionment should be kept to a minimum, and general overheads (such as overall management costs) should not be artificially apportioned.

THE ABC PROCESS: STAGE 3

1. Identify the cost driver for each cost pool:

   The cost driver is the underlying cause of the costs associated with the activity to which the cost pool relates.

2. Calculate an absorption rate for each cost pool.

3. Allocate costs from each cost pool to products:

   The amount allocated is found by multiplying the absorption rate by the number of units of cost driver relating to the product.

Example

- LECTURE EXAMPLE
- Performance Parts Limited, produce high value engineering components. While the company has allocated overheads on the basis of direct labour hours, the majority of costs incurred are more closely related to machine hours. The company has therefore redesigned its cost system, recovering overheads by using volume related bases: machine hours and a materials handling rate for overheads incurred in the receiving department.
- Both the current and past accounting systems have reported low profit margins for product X7, the highest selling product. As a response to this, the managing director, has called a conference to discuss the cost structure of the companies products.
- You have the following information:

Lecture Example

	Product serial number			
	X7	Y7	Z 7	Total
PRODUCTION & SALES	30,000	20,000	8,000	
RAW MATERIALS USAGE	5	5	11	
DIRECT MATERIALS COST	£25	£20	£11	£1238000
DIRECT LABOUR HOURS	1,1/3	2	1	88000
MACINE HOURS	1,1/3	1	2	76000
DIRECT LABOUR COST	£8	£12	£6	

				Total
NO. OF PRODUCTION RUNS	3	7	20	30
NO. OF DELIVERIES	9	3	20	32
NO. OF RECEIPTS	15	35	220	270
NO. OF PRODUCTION ORDERS	15	10	25	50

Using Direct Labour hours

a) Direct Labour Hours computation of product costs:
Direct Labour Overhead Rate = Total Overhead/Total Direct labour hrs.
= £1,848,000/£88,000 = £21 per direct labour hour.
Therefore product costs (in £) are:

	X7	Y7	Z7
Direct Labour	8	12	6
Direct Materials	25	20	11
Overhead	28	42	21
Total Cost	61	74	38

Overhead calculated using X7 = 1,1/3 hrs. x £21
Y7 = 2 hrs. x £21
Z7 = 1 hr. x £21

Overheads requiring allocation

OVERHEADS (in £) and associated with a given Activity:

Set-up	30,000
Machines	760,000
Receiving	435,000
Packing	250,000
Engineering	373,000
Total O/head	£1,848,000

Material handling

Using material handling:

Overhead Rate = receiving dept. overheads/direct material cost x 100.

= £435,000/£1,238,000 x 100 = 35.14% of direct material cost

Machine hr. overhead rate = other overheads/machine hours.

= £1,413,000/76,000 = £18.59.

[the other overheads are £1,848,000 - £435,000 = £1,413,000]

Cost using material handling and then machine hours for the remainder.

This gives product cost:

Product	X7	Y7	Z7
Direct Labour	8.00	12.00	6.00
Direct Materials	25.00	20.00	11.00
Mat. Handling o/h.	8.78	7.03	3.87
Other o/h (m/h hrs)	24.79	18.59	37.18
Total Cost	66.57	57.62	58.05

Calculations

Notes:

Material handling:

X7 £25 x 35.14% = £8.78

Y7 £20 x 35.14% = £ 7.03

Z7 £11 x 35.14% = £ 3.87

Total Overhead:

X7 = 1 1/3 x £18.59 = £24.79

Y7 = 1 x £18.59 = £18.59

Z7 = 2 x £18.59 = £37.18

Under ABC

Cost per activity:

Set ups:

set up cost/no. of production runs

= £30,000/30 = £1,000.

Receiving:

cost per receiving order = receiving cost/no. of orders

= £435,000/270 = £1611

Packing:

cost per packing order = packing cost/no. of orders

= £250,000/32 = £7812

Engineering:

cost per production order = engineering cost/no. of production orders:

= £373,000/50 = £7460

Therefore, total unit cost, in £, under ABC:

Final figures for cost under ABC

	X7	Y7	Z7
Direct Labour	8.00	12.00	6.00
Direct Materials	25.00	20.00	11.00
Machine o/h	13.33	10.00	20.00
Set-up costs	0.10	0.35	2.50
Receiving	0.81	2.82	44.30
Packing	2.34	1.17	19.53
Engineering	3.73	3.73	23.31
Total Costs	53.31	50.07	126.64

For set-up cost allocation:

- £1000 rate for set-up cost calculated above means we can now calculate the overhead consumed per unit for each product. X7 uses three production runs so 3 x £1000/ 30,000 gives us the per unit rate of £0.1.
- Y7 7 production runs so 1000 x 7/20,000 gives us £0.35.
- Z7 20 production runs so 1000 x 20/8,000 gives us £2.5.

Calculations

Machine Overhead:
£760,000/76,000
Receiving
X7 = (£1611 x 15)/30,000
Y7 = (£1611 x 35)/20,000
Z7 = (£1611 x 220)/8,000
Packing
X7 = (£7812 x 9)/30,000
Y7 = (£7812 x 3)/20,000
Z7 = (£7812 x 20)/8,000
Engineering
X7 = (£7460 x 15)/30,000
Y7 = (£7460 x 10)/20,000
Z7 = (£7460 x 25)/8,000

Look at the difference

- This is just by allocating the overhead by different absorption bases. This is a result of the arithmetic – what we need to do is think about the functional logic behind any allocation and stress test each to see which one gives a realistic answer.
- a function of averaging rather than accounting fraud!
- The danger is – as in all walks of life – people sometimes do not like the answer they get.
- This can distort decision and lead to punishment in the market – for example, your price is set too high.
- It may also lead to organisational conflict.

IMPORTANT NOTE:

- The notion of activities will need to be used in the assignment. You will need to define what activities are being defined as part of product manufacture. You will need to identify whether the cost would be direct or indirect.
- Good reports will also identify what base will be used to allocate these costs – what measures as per the ABC example above.

So

- We know have to classify cost.
- Next we need to consider how resources link to the business model of the firm making a product.