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Driving cost down in train refurbishment projects

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Railway Interiors Expo Amsterdam RAI,
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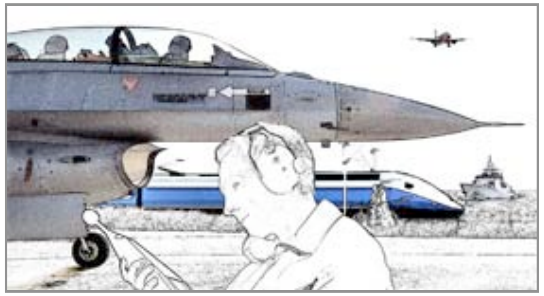

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Agenda

Current situation in the refurbishment market

Refurbishment cost drivers

How to reduce cost?:
- **Modularity and interface improvements**
- **Implement aerospace & automotive best practices**
- **Develop competences**

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Situation in the refurbishment market

- **Train bodies and bogies have a much longer economic life than the interior and related systems**

- **Train operating companies want to upgrade services, thus rolling stock interiors**

  – Trains up for refurbishment are commonly 15 to 20 years old

  – Refurbishment is a viable option if 15-20 years of additional life can be added at a competitive price

V.S.

Refurbishment cost drivers

- **Non-modular design of trains requiring refurbishment**
  - Complicated, non standard interfaces
  - Configuration Control lost over the years
- **Inaccuracy of interfaces / no interchangeability**
  - Unknown and wide variation in dimensions
  - Repairs of structural damage
- **Large number of variants within train families**
  - $1^{st}/2^{nd}$ class
  - Different lay outs
- **Limited number trains allowed by TOC's to be 'withdrawn from service'**
- **MRO companies are mainly focused on maintenance and repair and not creating a new product**

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Modularity and interface improvements

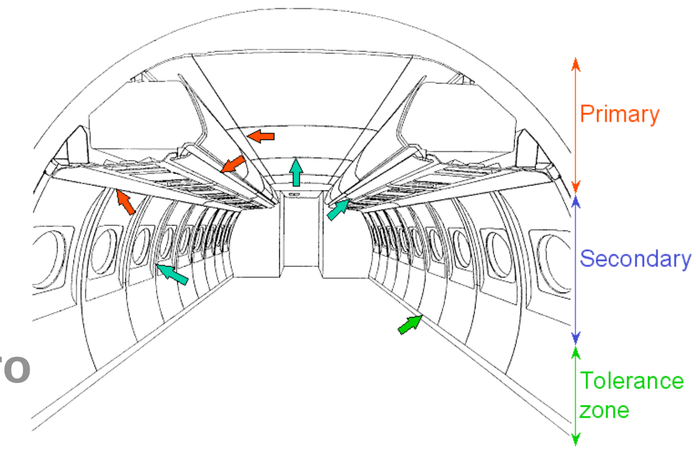
- **Modular design (tube in tube)**
  - Modules built by suppliers / at other sites
  - Standard mounting of panels and racks
  - Integrated system installation instead of loose parts and components
- **Improvement of interfaces**
  - Robust design
  - Variation management

Example: Tube in tube

The objective of the tube in tube concept is:
To limit influence of adjacent systems on the interior system

Efficient & effective interface-management

- **Combine functions at interfaces**
  - Limit system interfaces
  - Limit manufacturing logistical interfaces
  - Clear authorisation & responsibilities



Characteristics

- **Reduce trim and adjust to fit effort to zero**
- **Design for assembly**
- **Maximise parallel working**
- **Integrate functions on interface**
- **Minimise parts count, maximise repeatability**

Example: Interface management

Interface management with N²-diagram

- **Identify and structure all interfaces**
  - Smart clustering to reduce complexity
  - Supports clear requirements allocation
  - Analysing design change impact

PBS item	item 1	item 2	item 3	item 4	item 5	item 6	item 7	item 8	item 9	item 10
item 1					M	M	M			
item 2										
item 3								M		
item 4									M	M
item 5	M						O	M	E	E
item 6	M						M,N			
item 7	M				O	M,N				
item 8			M		M					
item 9				M	E					E
item 10				M	E				E	

Interfaces:

M: mechanical

O: optical

E: electrical

N: environmental

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How to reduce cost?:

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- Adopt aerospace & automotive best practices
- Develop competences

Aerospace & automotive best practices

Aerospace and automotive based production processes

- Line production & takt time

- Learning curve management

Example: Line production

Line production to:

- Enhance visibility of problems in the line
- Reduce tooling cost
- Simplify the logistical process
- Keep pressure on the project

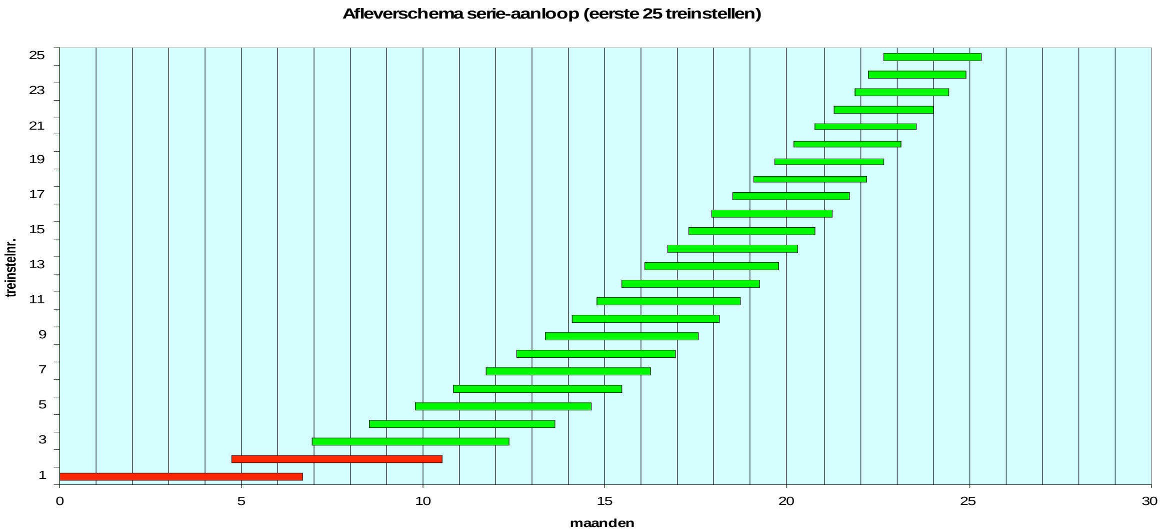
Line production volume determines takt time:

- Takt time equals frequency of delivery to customer
- Number of stations is determined by the amount of work

Example: Learning curve management

Typical learning curve contribution:

• Materials on time	35%
• Shop floor workers learning	25%
• Technical improvements	20%
• Management	10%
• Planning/line loading	10%



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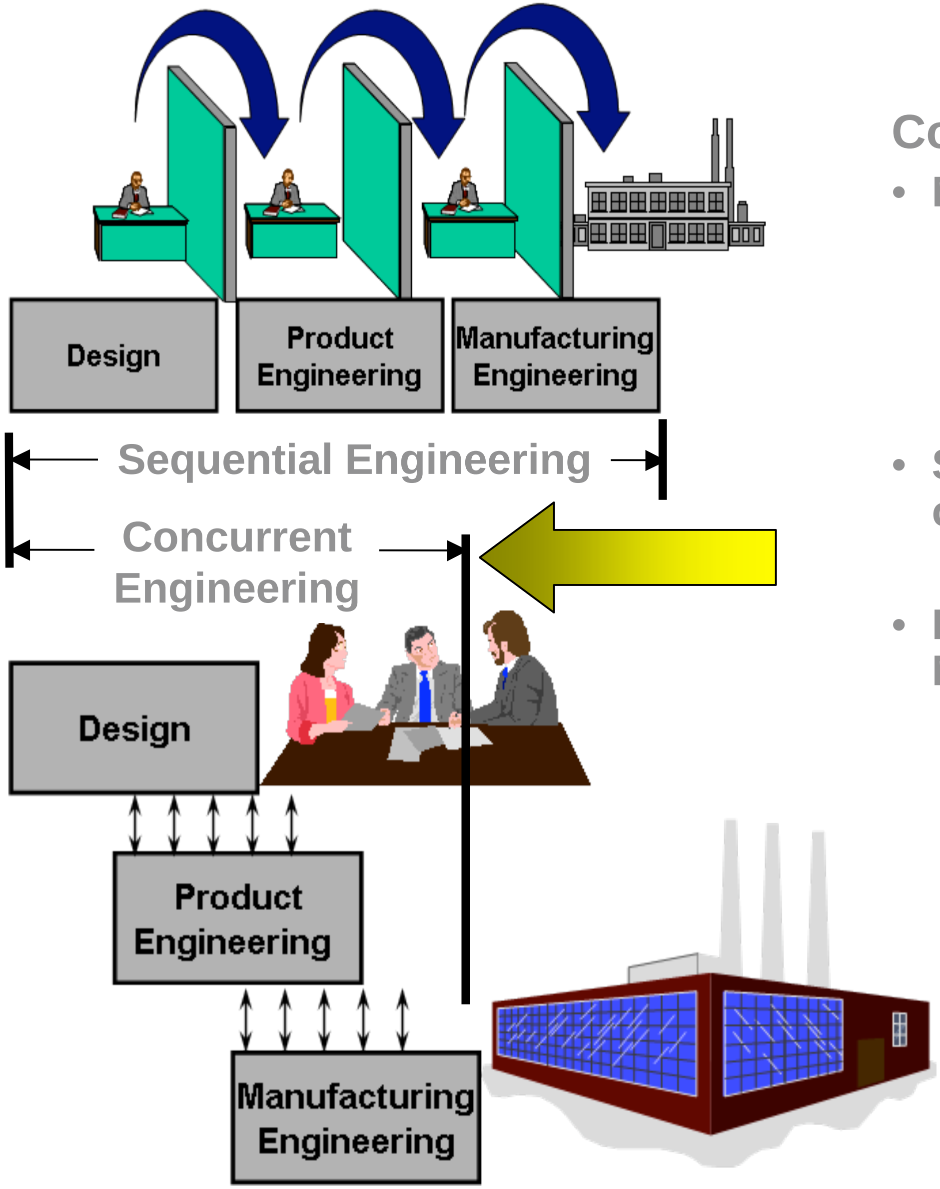
- Implement aerospace & automotive best practices
- **Develop competences**

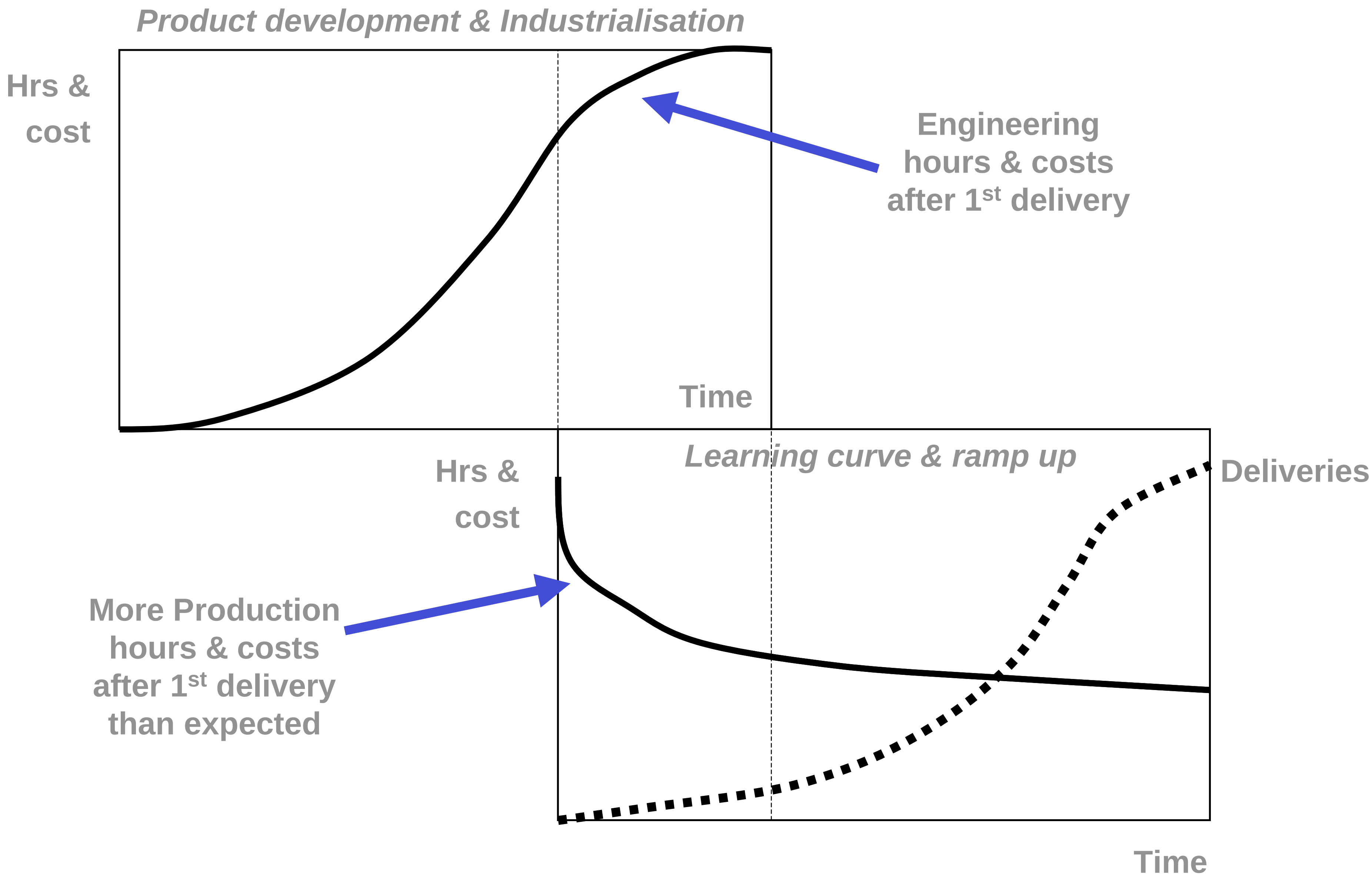
Build competences



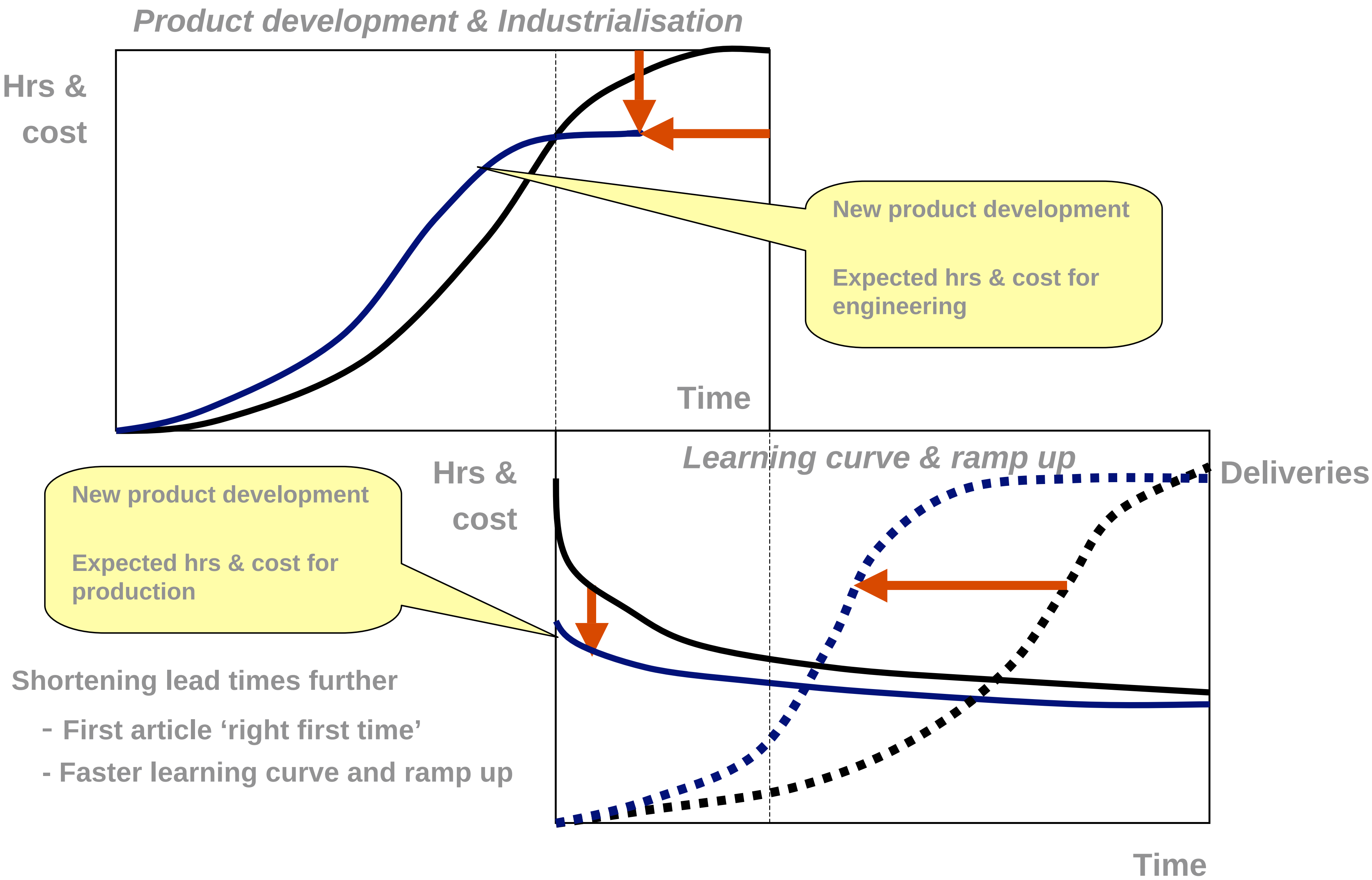
Concurrent engineering:

- **Multidisciplinary approach**
  - Integrated Product Team (IPT)
  - Tight links with Project Management
- **Shortening lead times/reducing cost**
- **Basis for Design for Manufacturing & Assembly**

Concurrent engineering



Concurrent engineering



Shortening lead times further

- First article 'right first time'
- Faster learning curve and ramp up

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Build competences

- **Improve the production planning and the production management:**
  - Lean manufacturing
  - Direct supply
  - In process control (EN/AS9100 rather than ISO9000)
  - Continuous improvement program (quality, cost, lead times)

- **Improve supplier management**
  - Supplier Quality Assurance (SQA) based on
    - upfront capability assessments,
    - monitoring through audits/visits,
    - co-development in partnership
  - Call for and support supplier development
    - Flow down of measures given above