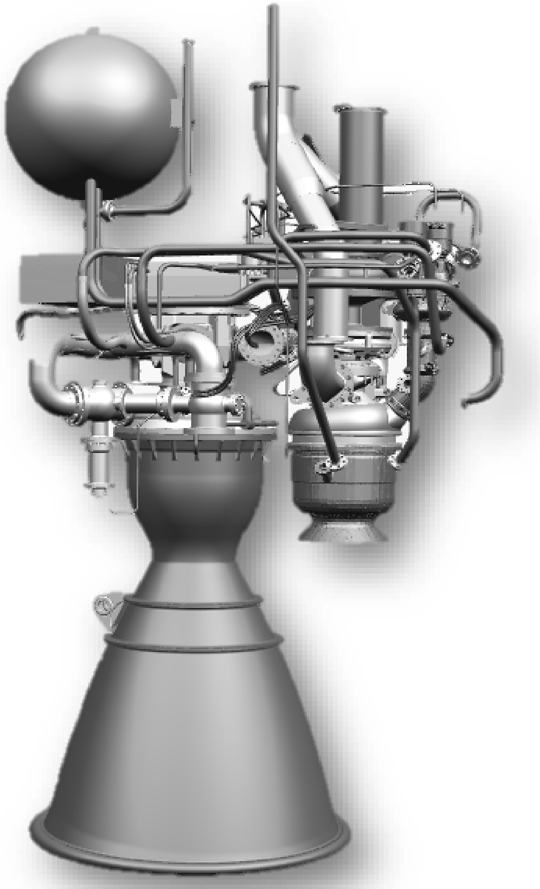
# DESIGN TO COST
# PROMETHEUS : PRECURSOR OF NEW LOW-COST ROCKET ENGINE

Pierrick BEAU – *Prometheus Cost Leader,* ARIANEGROUP -

# PROMETHEUS ROCKET ENGINE

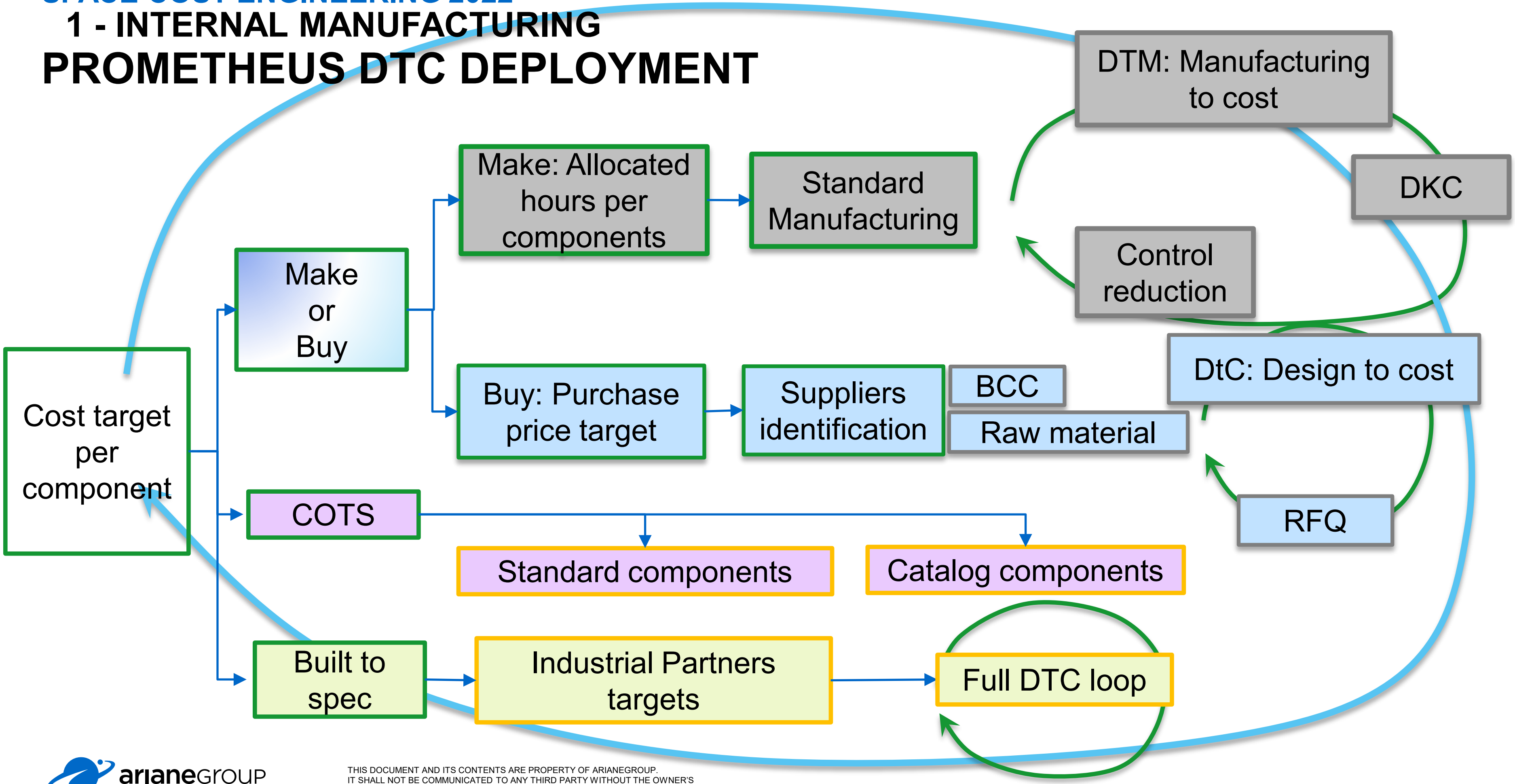
- **1M€ R**ecurrent **C**ost to be competitive
- Thrust of **1000KN** as the result for rationalization
- **Liquid** methane & oxygen
- **Reusability** for launch service flexibility
- **Precursor** of a flexible engine family concept



Project, initiated by CNES and Ariane Group and developed in the frame of the ESA Future Launchers Preparatory Programme since 2016.

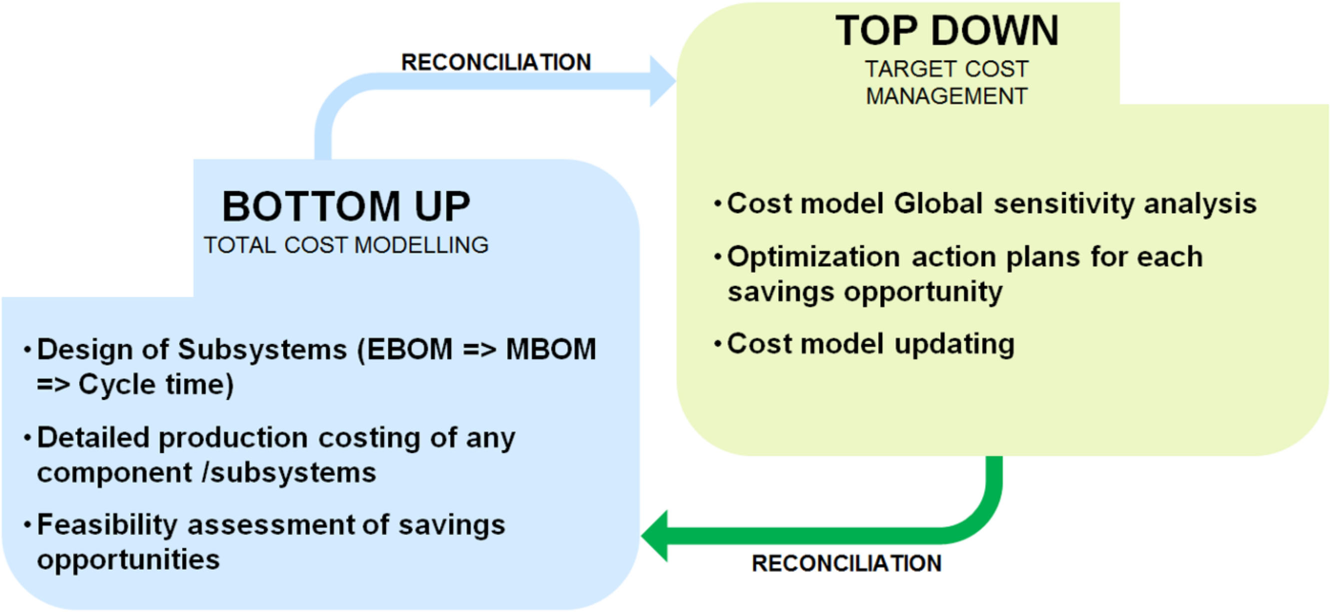
## 1 - INTERNAL MANUFACTURING

# PROMETHEUS DTC DEPLOYMENT



# 1 - INTERNAL PRODUCTION

- **Top down**: assesses product RC, identifies production cost drivers (sensitivity analysis) & production savings action plan
- **Bottom up**: provides production costs, identifies main cost generators & products savings action plan



# 1 - INTERNAL PRODUCTION

## A/ COST MODEL BUILD UP

# 1 - INTERNAL MANUFACTURING – A/ COST MODEL BUILD UP

### Engineering Bill Of Materials

Define the BOM for the elements constituting the sub-system

Manufactured parts, bought components, nuts and bolts etc…

### Manufacturing Bill Of Materials

Reorganize the BOM in a realistic assembly logic per level

Define the masses and materials for material procurement

### Process time

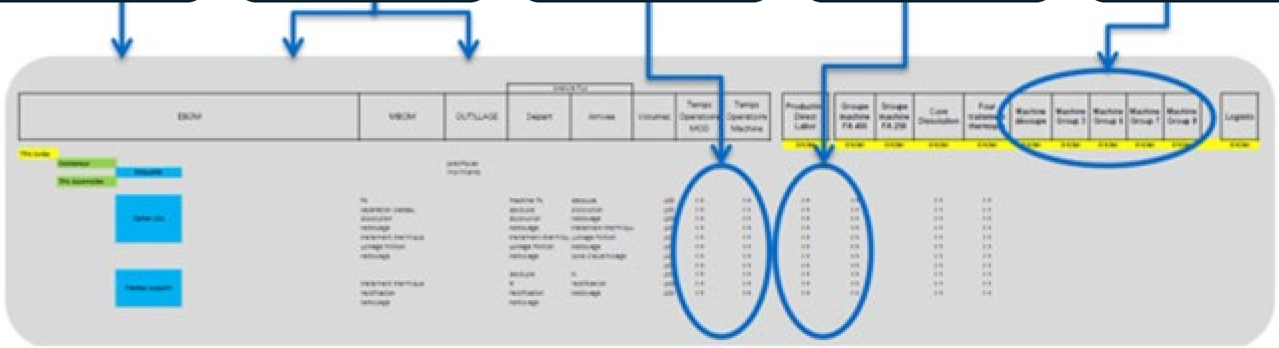
Using manufacturing standard times and flow calculations, determine preparation and production lead time for each component process sheet

### Resource needs

Identify Direct and Indirect Labour needs, production machines and means from the valorised process sheets

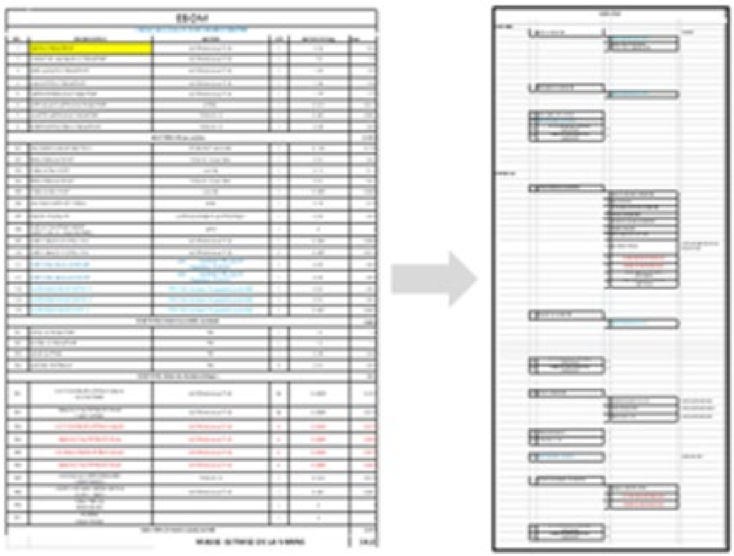
### Greenfield factory

Build the Greenfield factory : building and means definition, positioning of the machines, general fees calculation



# 1 - INTERNAL MANUFACTURING – A/ COST MODEL BUILD UP

- **BILL OF MATERIALS**



**EBOM (Engineering Bill Of Materials)** : BOM per system or sub-system with quantities and masses

**MBOM** : EBOM + realistic process and assembly sheets organized per level

- Gather process and assembly hypotheses and data for analytical costing
- Rapid monitoring of cost modification impact from design alternatives
- Compare easily different design proposals and their cost

- **Determination of the required labour/machines resources**
- **Mandatory for the Greenfield factory definition**

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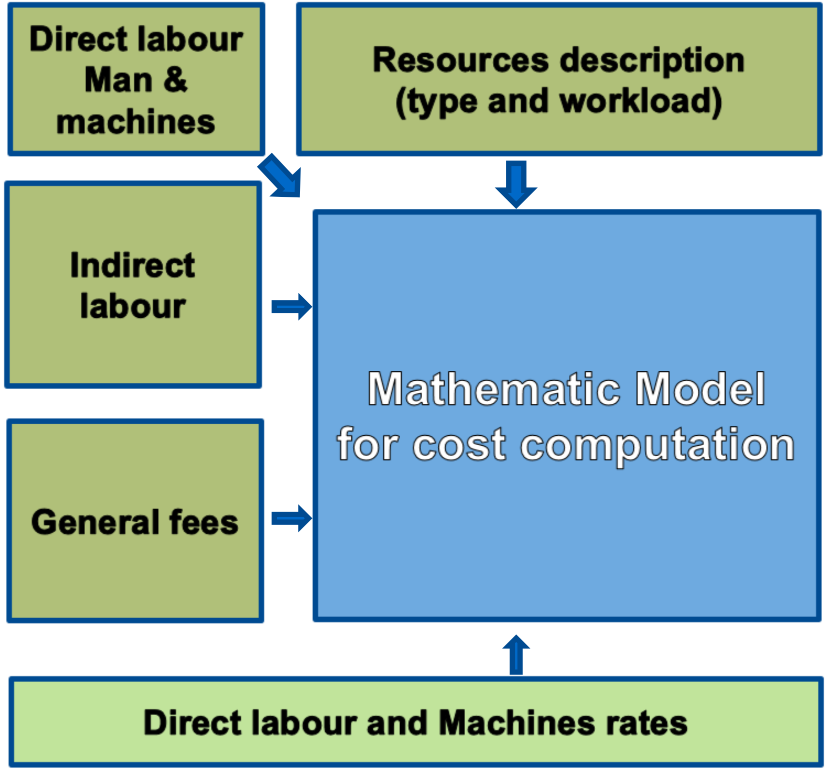
# 1 - INTERNAL MANUFACTURING – A/ COST MODEL BUILD UP

- **COST MODEL PERIMETER**




**MBOM** defines direct labour hours, machines, lead production time

**Direct labour hours + machines** define factory workload and Indirect labour:

- Production, Lab, Method, Quality
- Purchase, maintenance, supply chain
- HR, Accounting, controlling

- Surfaces (rent or depreciation)
- Machines depreciation
- Energy
- Telephone, consumables, supplies
- Gardening, IT cost, travel cost
- …

**Rates** = Labour annual cost / hours
**Component cost** = rates x process hours

# 1 - INTERNAL MANUFACTURING

## B/ « TOP-DOWN » COSTING STEPS

# 1 - INTERNAL MANUFACTURING – B/ « TOP-DOWN » COSTING STEPS

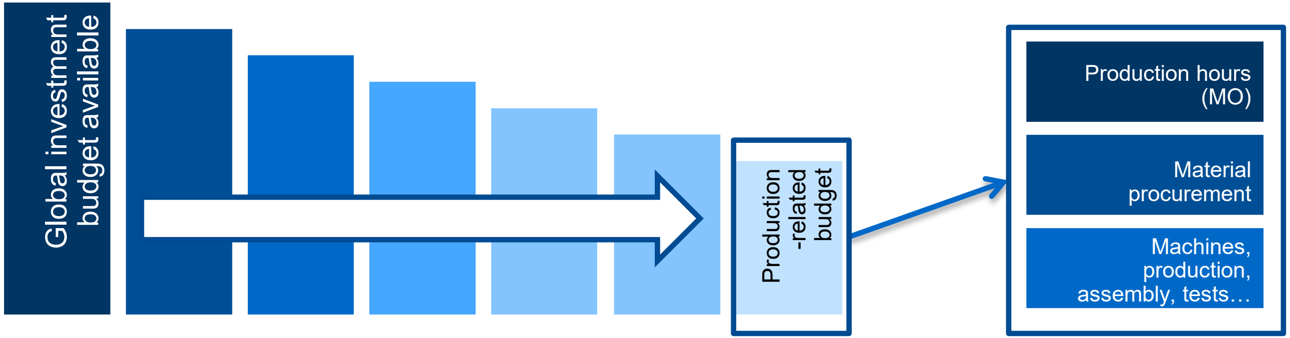
Objective : **Estimate and optimize resources available for production from the initial investment** *(e.g. : 100M€ with a production rate of 100/year for 1M€ in RC)* **:**

1) Estimate and remove from the global investment any fees that are not production-related
   **=> Production budget**

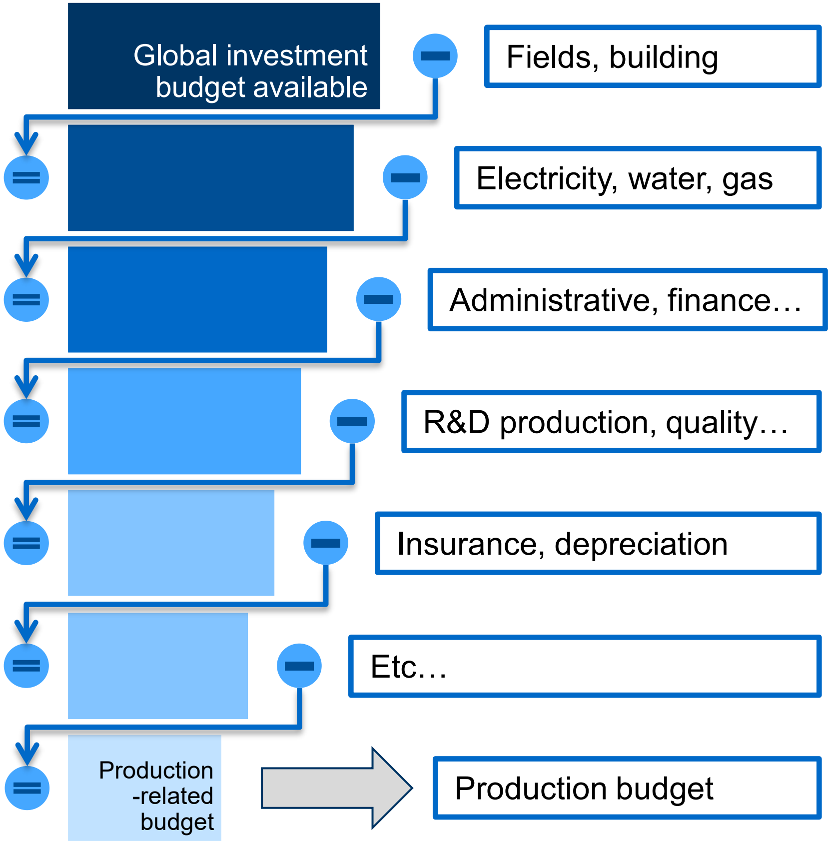
2) Break up the production budget per category (direct / indirect workforce, material procurement, machines…)
   **=> *Cost/ time target* per sub-system**

3) Distribute the budget to provide each sub-systems a *cost target (or time target) to* reach

4) Optimize budgets allocated to general fees or indirect production aspects to gain budget for production needs



# 1 - INTERNAL MANUFACTURING – B/ « TOP-DOWN » COSTING STEPS




**Actions :**

- Identify all the general fees to be taken into account in the Greenfield factory
- Apply metrics based on internal industrial data to estimate percentages to be removed per each general fee
- Use the target cost pareto to allocate the final budget to each engine sub-system
- Propose a production budget per sub-system and per category (labour, means…)

➡ *Gives an first budget for the support functions in the production factory*

➡ *Helps targeting the general and production fees to optimize*

# 1 - INTERNAL MANUFACTURING – B/ « TOP-DOWN » COSTING STEPS

Global investment budget available

Production -related budget

Production hours (MO)

Material Procurement

Machines, production, assembly, tests…

Production ressources

Evolvable – To be determined from MBOM

**Budget repartition:**

- **MOD/MOI hours :** estimated / derived by analogy with existing system / product
- **Material Procurement :** Determined from the mass data provided in the MBOM
- **Machines, assembly, tests :** Allocated from the calculated production lead times or by analogy with existing system / product

# 1 - INTERNAL MANUFACTURING

## C/ « BOTTOM-UP » RESSOURCES ESTIMATION AND CONSOLIDATION

# 1 - INTERNAL MANUFACTURING – C/ « BOTTOM-UP »

Iterative procedure by alternative conception proposals

The alternative solution is evaluated and becomes the reference if satisfactory.

**Objective**
- ➡ **Reach the cost target**
- ➡ **Try to go beyond the target**

**Alternative cost delta**

### Alternative design proposal sheet
- Proposal for a design alternative (material, assembly, process etc…) on a part or a sub-system

### Solution cost and technical validation
- Discussion between Methods, R&D and pertinent authorities to validate the feasibility of the design alternative

### Go / No Go on the alternative solution
- Validation (or not) of the alternative proposal by all the project responsible (project, costing, buyers, industrialization)

### Reference MBOM definition
- Definition of a reference MBOM used to calculate cost deltas and add alternative design solutions

### Integration of alternative solution in MBOM
- Integration of the solution and calculation of the resources variations at each level (labour, machines, material, tooling etc…)

### Optimal solution application
- Application of the consequences of the new MBOM in the Greenfield factory and new MBOM considered as reference

**MBOM updated version**

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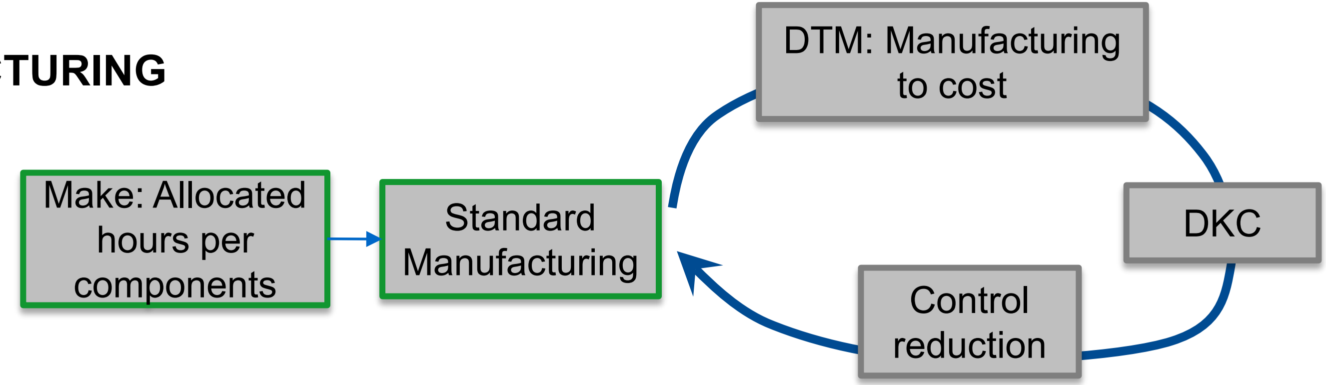
# 1 - INTERNAL MANUFACTURING




- Convergence loops between D/O, methods, programming, process experts, control
- Define standard manufacturing constraints: machines, tolerances, tools, design rules, closed door machining
- Capitalization: analyze first jobs & operators feedbacks, implement & check PLM & ERP data as soon as possible
- Define precise targets: cost allocation → man & machine hours, consumables
- Anticipate production phase, clearly dissociate specific prototype & development needs
- Key Characteristics: every control must be challenges & justified, remove redundancies. Better to control at the end of manufacturing process
- Key Characteristics: complex design features must be challenged & justified
- Modelling: manufacturing & assembly shops to identify wastes, optimum workshop management, assy schedule, kitting, parts flows

# 2 – DIRECT PURCHASE AND INDUSTRIAL PARTNERS

# CUSTOMERS ↔ SUPPLIERS

Reach the cost target

**Open the books : speak in hours, processes**

« Win-Win » position : share the earning, define the margin in the contract

**We are all someone's customer or supplier**

DTC collaboration at the initiative of the customer or the supplier

Find the optimal supplier

Design to value

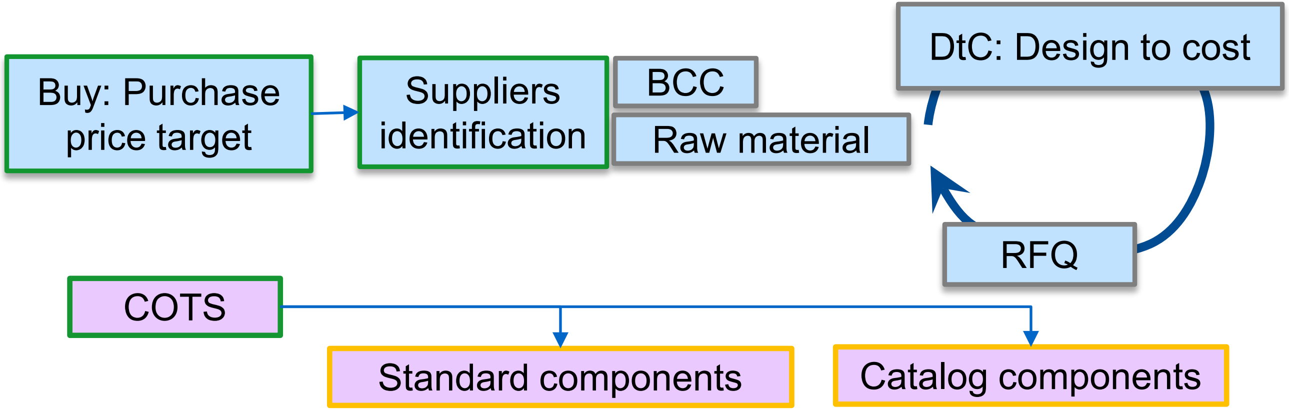
Study the Make or Buy very early

Define a contractual framework allowing a flexible work perimeter

Embedded decision makers (or top management)

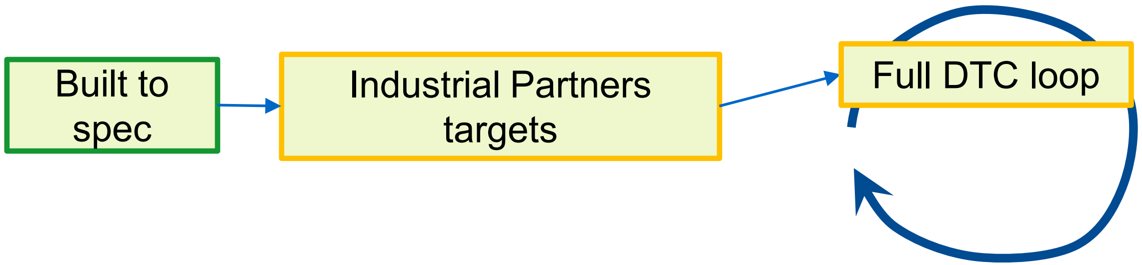
Define the industrial scheme

# DIRECT PURCHASE




- Look for new technologies to be tested on prototype phase
- Use of COTS with associated qualification and reception logics wherever it is possible
- Challenge company list of suppliers
- Co-working sessions with suppliers, knowledge of suppliers industrial means to reach the optimum cost VS design. There is also value in the voice of the suppliers (e.g. ALM)
- Specify the right level of quality for raw materials
- Rationalize the “standard” components at system level

# INDUSTRIAL PARTNERS

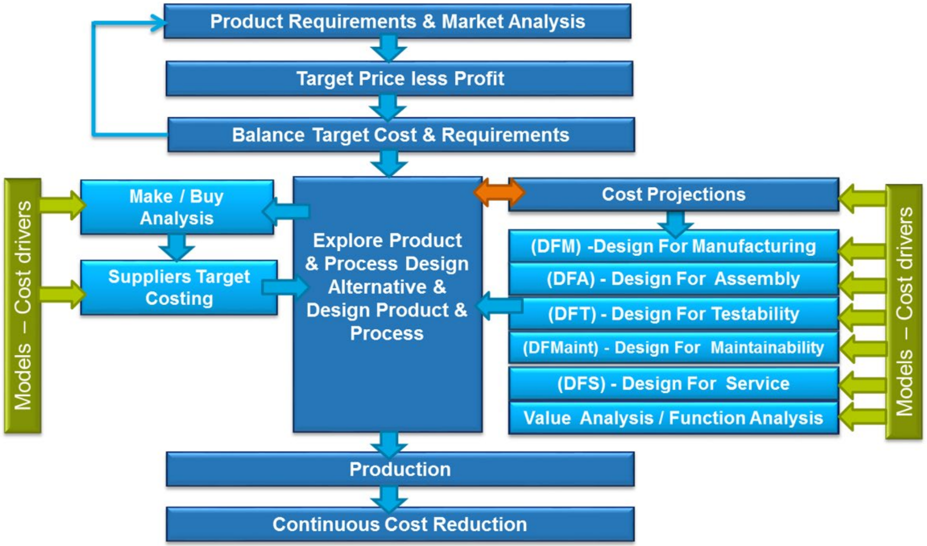



- DTC with parners can be challenging as two different company cultures meet
- Contractual frame and definition of targets can also be challenging to fully apply the DTC between 2 partner companies
- Costs are generally considered sensible information, especially when information goes out of a company
- Communication & messages are extremely important. The final goal is to maximise the value of the products, ensuring a « win win » result at every step of the technical & industrial chain

# 3 – KEY SUCCESS FACTORS

# SUCCESS FACTORS

**« Design to Cost » development process starts as EARLY as possible**




## When?

- Early design phase to maximize benefits & design freeze
- Global optimum of all product domains (MATMS)
- DTC must be associated with VA & FA as they complement
- **Too often is DTC engaged at a late stage where the majority (i.e. 80%) of costs are engaged**

## How?

- Applies to all item & level of the BOM
- Continuous & dynamic process
- Scope must be defined by FA & VA to focus on:
    - Big improvement areas
    - Risked areas
- Continual challenge of product needs, functions and specifications
- Cost estimations can be made by analogy, by parametric models or analytically, depending on the costed item & maturity of the project

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# SUCCESS FACTORS

- **Cost engineer** must be at the **center** of the project team
- DTC requires the **collaboration of all stakeholders** as well as **high transparency**.
- **Costs** must **guide** design choices
- **Both technical** and **economic** aspects of the system are optimized
- The goal is to **maximize** the **value** of the product

**Design to Cost ↔ Design to Value**