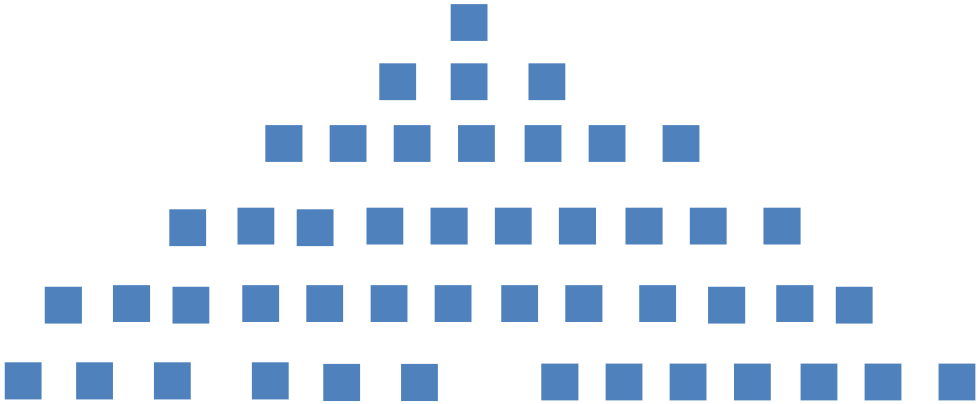
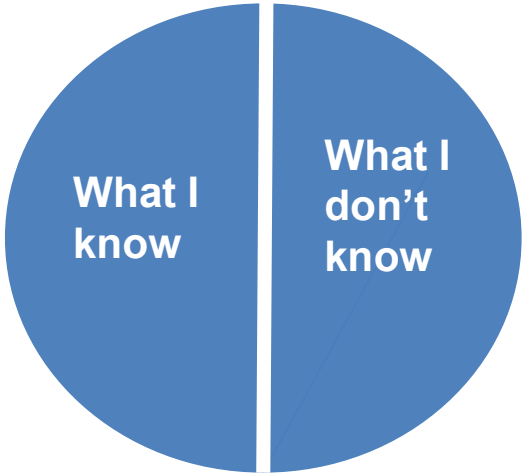
Automotive Manufacturing Evolution Summary

12/6/2024

The knowledge



The structure of information



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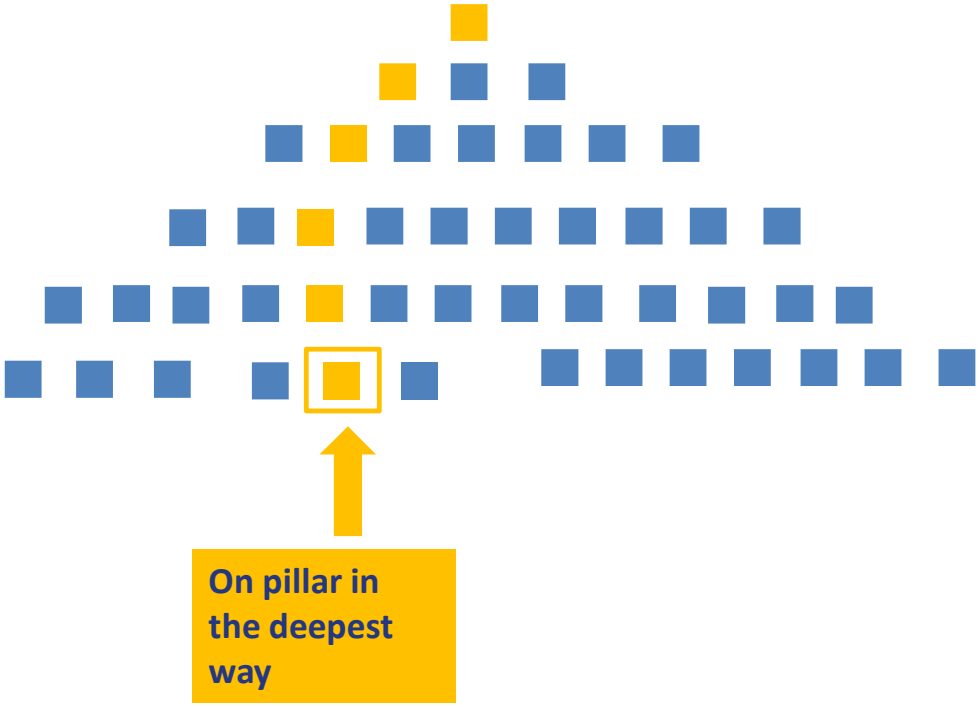

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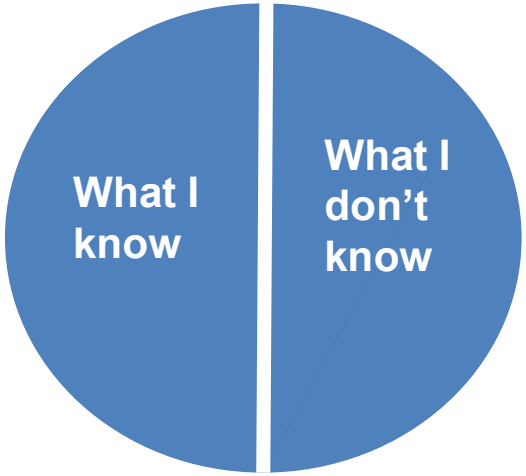
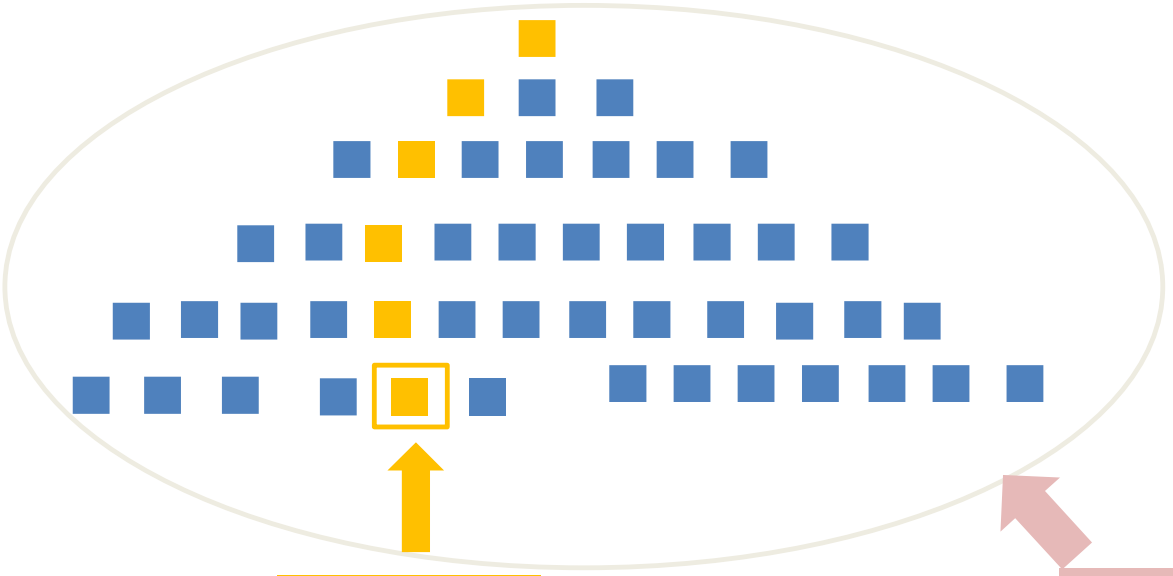
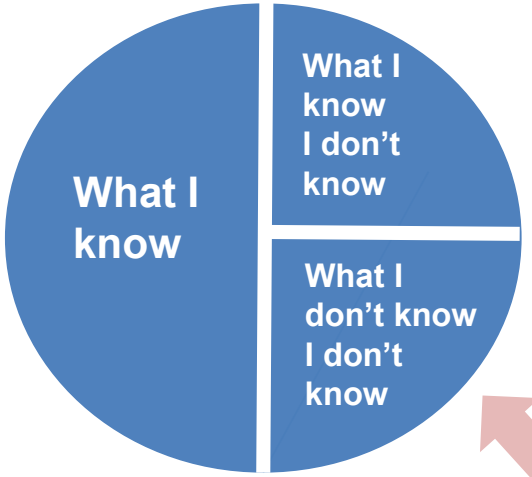


The knowledge

The structure of information



On pillar in the deepest way



To get the global view

To minimize

Automotive evolution: drivers

Historical evolution

- Taylor and the principle of scientific management
- Gantt and program management
- Ford and mass production
- Crisis of industry due to social issues- Olivetti and Fanuc case study
- The flexibility – premium production
- The machine that changed the world- Japanese production system
- The world is flat- globalization
- The electric transition

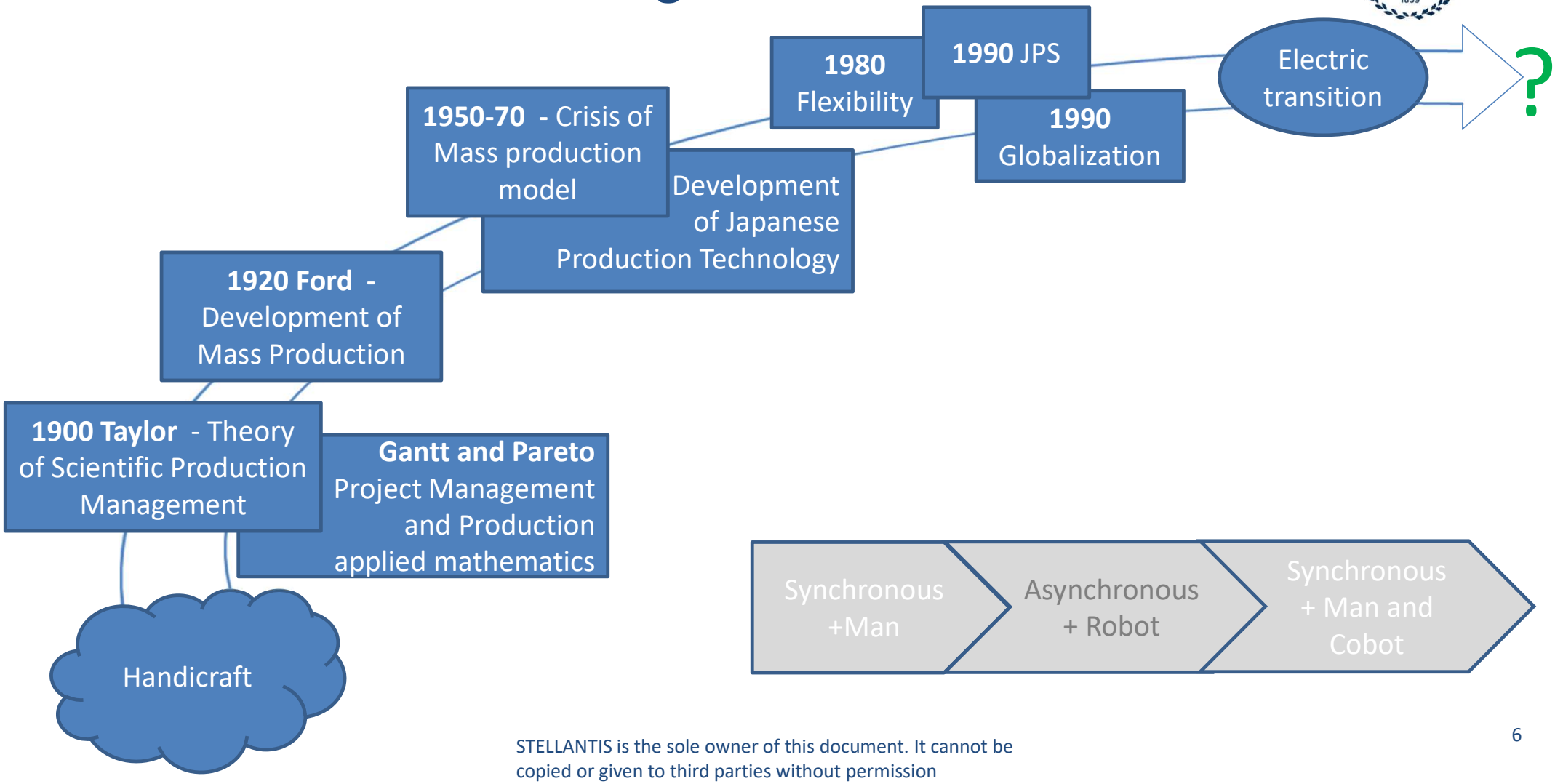
Production basics

- Process cycle definition
- Capacity/efficiency
- Assembly technology
- Machining
- Parallel vs series
- Queuing theory
- Planning/scheduling
- ABC approach in logistics
- Business cases
- Production management
- Footprint management

Automotive processes

- Product development process
- Engine production: cyl. block, cyl. head, crankshaft
- Transmission production: Assembly, gears and shafts
- EDM production(reducer, e-motor)
- Battery cell production
- Battery pack assembly
- Vehicle production: welding. painting, stamping
- Vehicle Assembly

Automotive Manufacturing evolution



Historical evolution - Highlights

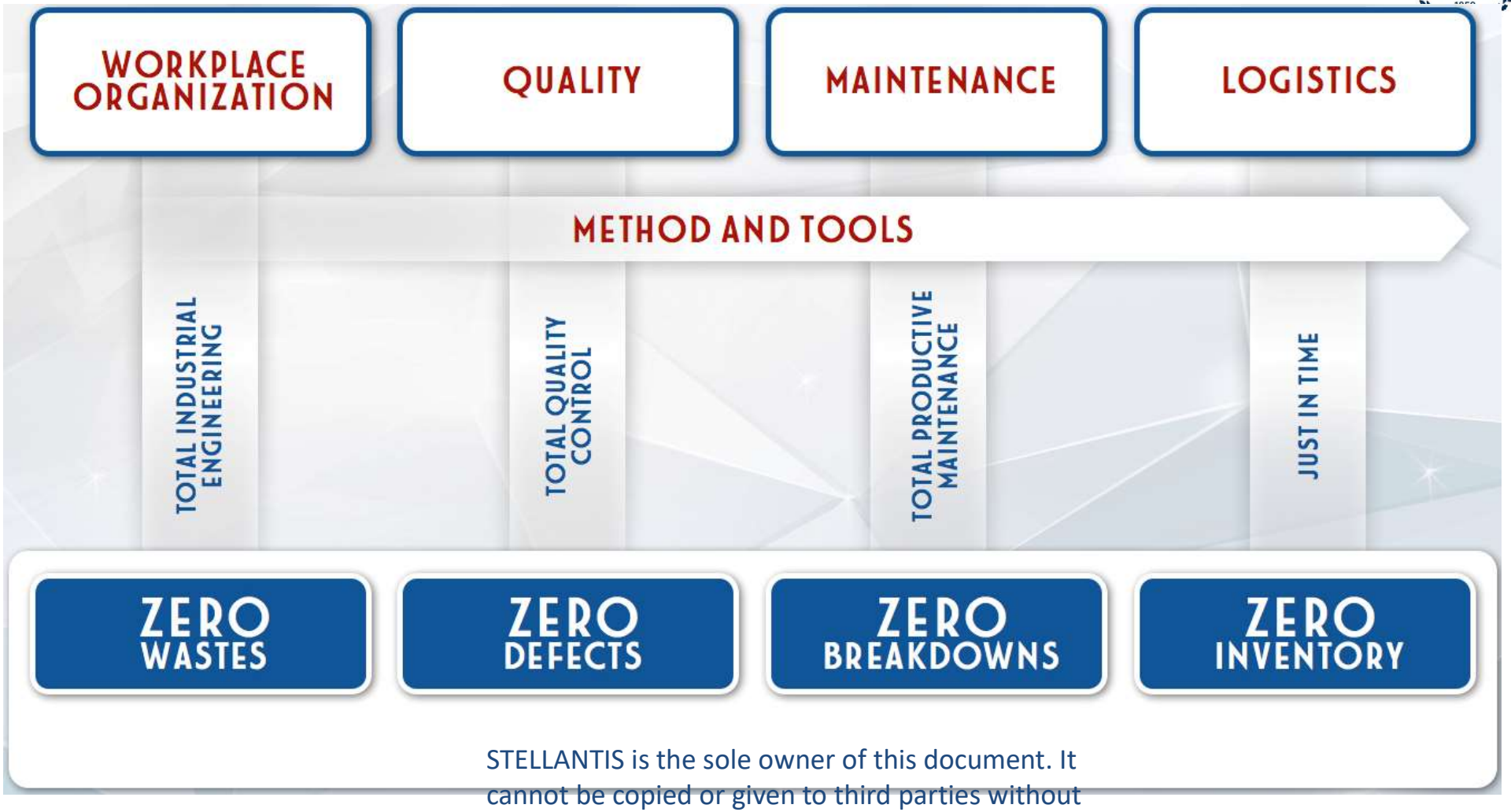
- Taylor and the principle of scientific management – **Rationale behind process cycle definition**
- Gantt and program management **– Gantt diagram construction and automotive program milestones**
- Ford and mass production – **Transfer line/Synchronous line structure**
- Crisis of industry due to social issues- **Asynchronous group structure**
- The flexibility – premium production – Impacts on production
- The machine that changed the world-Japanese production system – **The elements of lean manufacturing**
- WCM as reference for continuous improvements methods - main pillar knowledge
- The world is flat- globalization – **Information on the 10 strenghts**
- The electric transition – Emission regulation highlights, **classes and structure of electrical vehicles**

Elements of Lean Manufacturing

- Once the ideas behind the Lean Manufacturing have been explained it is time to go through the practical elements:
    - Batch reduction (from EoQ to Batch=1)
    - Total quality control
    - JIT: pull system

- The guidelines given by another important author, **R.J. Schonberger** with his book **“Japanese Manufacturing techniques”** , issued in **1982** so much earlier than “The machine that changed the world” was published, will be used as reference for the matter.

Summary of World Class Manufacturing

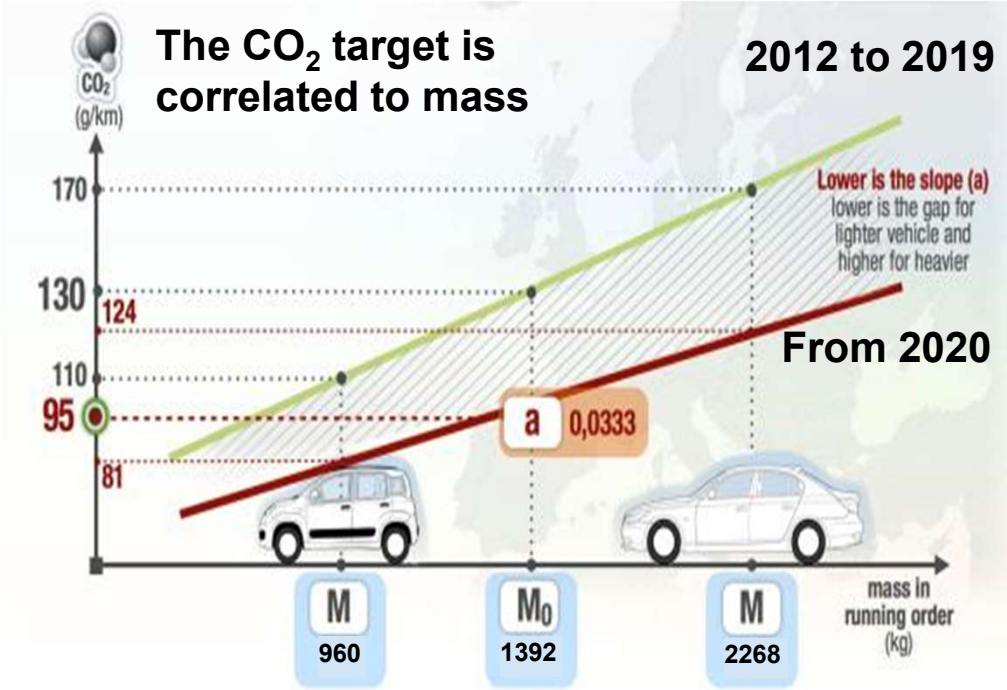


WCM Methodology

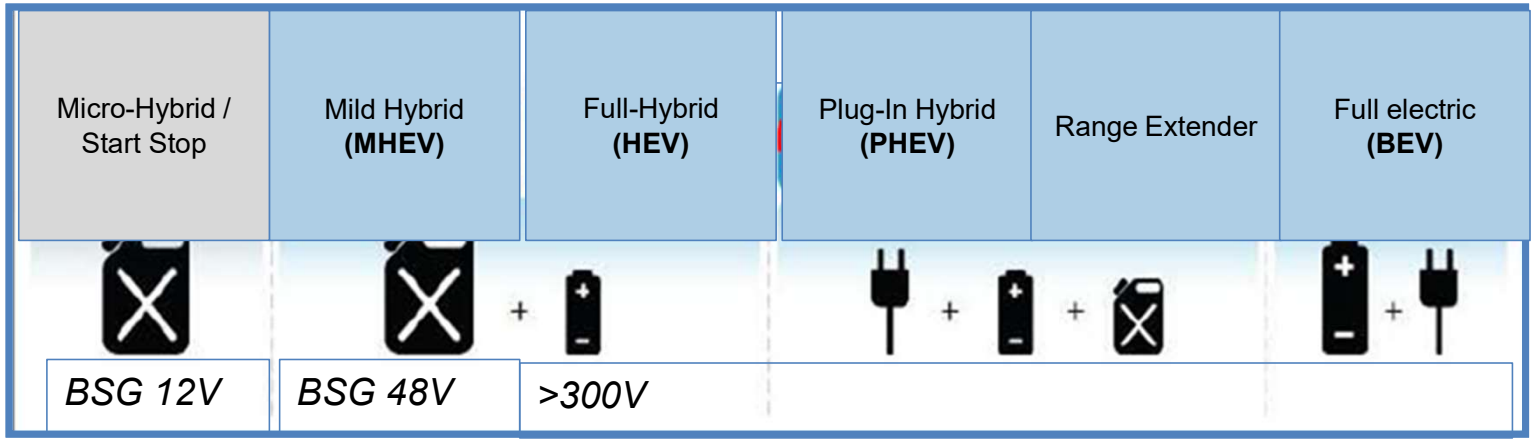
EUROPE: Emissions requirements from 2020

MAIN RULES

- Average target CO_2 emissions defined for new passenger car registrations is based on average mass: **95 gCO_2/km: from 2020 on**
- CO_2 target for each manufacturer is based on its own fleet **«average mass»**



Electric vehicle glossary



CRITERIA OF CLASSIFICATION

- **Voltage**: range of autonomy is proportional to voltage level
  - Losses proportional to electrical current ***P*** $= RI^2$ ***squared***
  - To generate the same power current decrease while the tension increase ***P= VI***
  - ***Ex.: 140HP = 100Kw***
    - *High tension 340V → I = 100k/340= 300A*
    - *Low tension 48V → I = 100k/48= 2000A (6,6 times higher, losses are* $6,6^2$ *→ 45 higher)*
- **External charging:** plug in system allows a clean recharge
- **Structure of electrical motor and traditional engine**: parallel/series

Process basics – Highlights

- Process cycle definition – **Capacity to develop a simple assembly process**
- Capacity/efficiency –**Passage from yearly capacity to cycle time and to average efficiency**
- Assembly technology – **Torque/angle technology**
- Machining – **Basics of cutting technology- Main processes**
- Parallel vs series – **Evaluation of efficiency**
- Queuing theory – **Little's law**
- Planning/scheduling –Information: Hierarchical control –Linear programming - **Mixed model algorithm**
- ABC approach – **Pareto law and application in logistics and quality - Kitting**
- Business cases – **Evaluation of break even point and profitability with WACC- Excel program use**
- Production management – Information: Budget flex analysis and sensitivity
- Footprint management – Information: Phase in phase out concept

The Little’s law

In mathematics Queuing theory Little's law is a theorem by John Little which states that the average number W of customers in a stationary system is equal to the average effective arrival rate P multiplied by the average time T that a customer spends in the system. Expressed algebraically the law is:

$$\mathbf{P} = \frac{\mathbf{W}}{\boldsymbol{T}}$$

The relationship is not influenced by the arrival process distribution, the service distribution, the service order, or practically anything else. In most queuing systems, service time is the bottleneck that creates the queue.

The result applies to any system, and particularly, it applies to systems within systems.

In manufacturing P is the throughput, production per time unit. W the Work in progress, the number of parts in the systems, and T the time to go through the system.

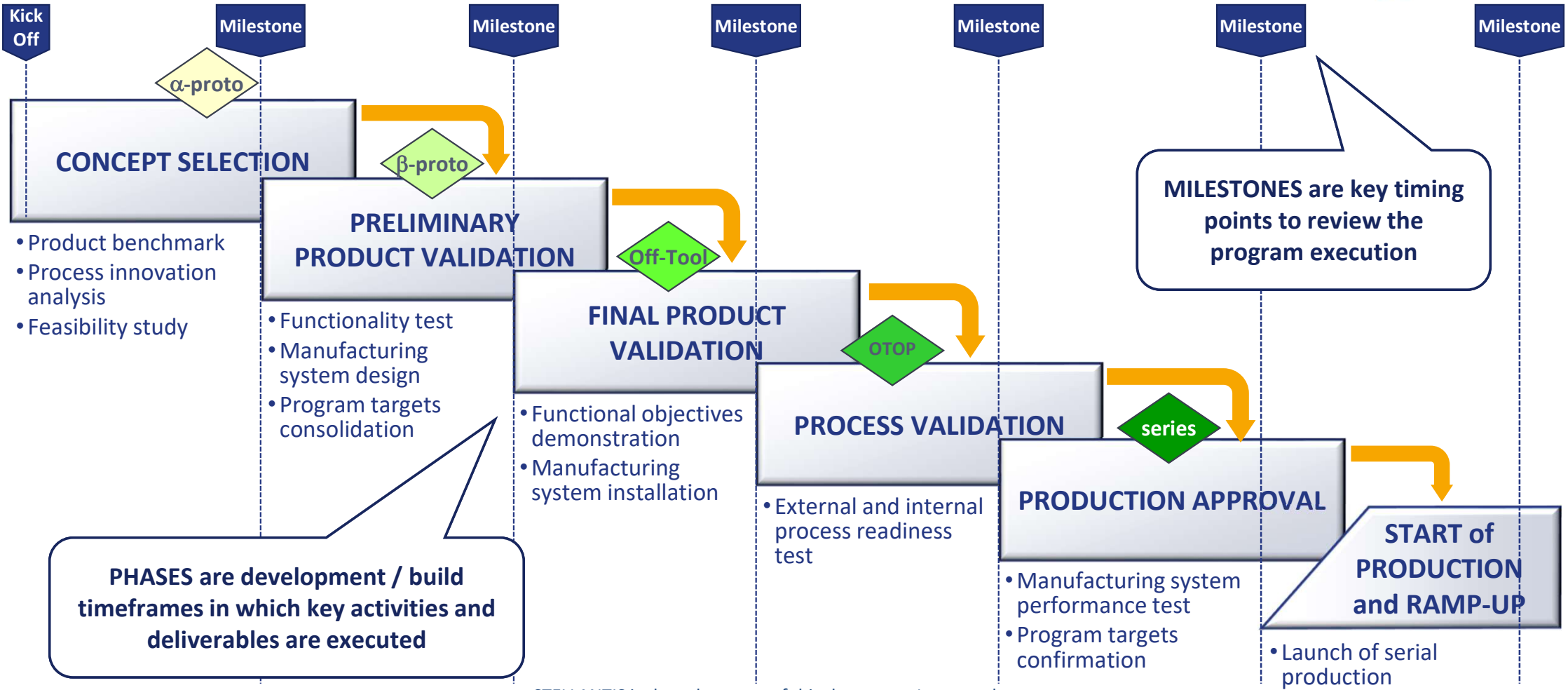
Automotive processes - Highlights

- Automotive Manufacturing engineering complete study: **sequence of steps**
- Product development process - **Milestones**
- Engine production block diagram: **Assembly, cyl. block (bore), cyl. head, crankshaft**
- Transmission production block diagram: **Assembly, gears and shafts**
- EDM production(reducer, e-motor): **block diagram**
- Battery cell production: **block diagram**
- Vehicle production: **welding, painting, stamping block diagram**
- **Vehicle Assembly block diagram**

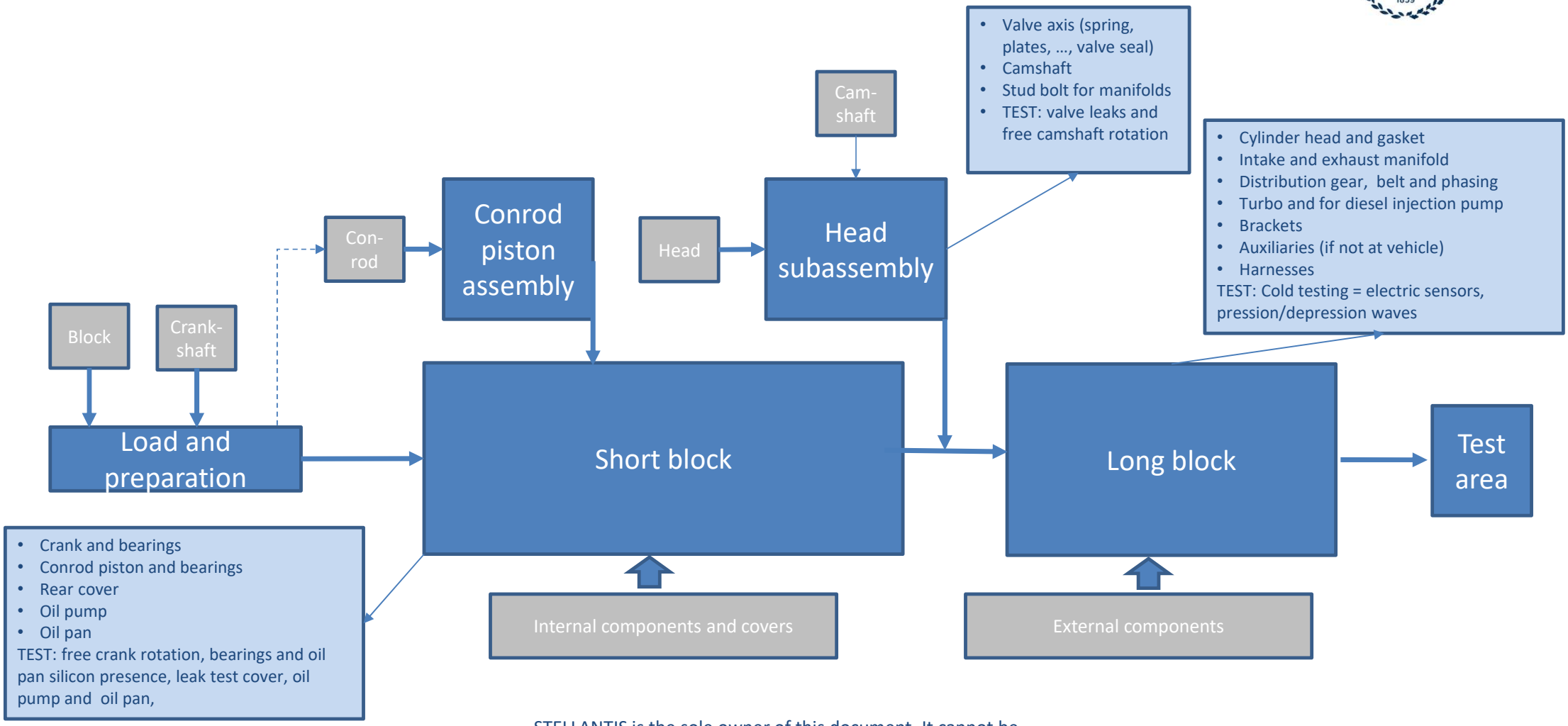
Product development process - highlights

1. The fundamental “pillars” of the Product Development Process (PDP) are risk management, definition of rules and roles, iterative breakdown of process steps, program status assessment
2. The key appointments in the Product Development Process (PDP) are the program milestones: timing points to review the program execution
3. The managerial methodology for monitoring program progress inside the Product Development Process (PDP) is to hold milestones review, focusing on program targets assessment vs. expectations

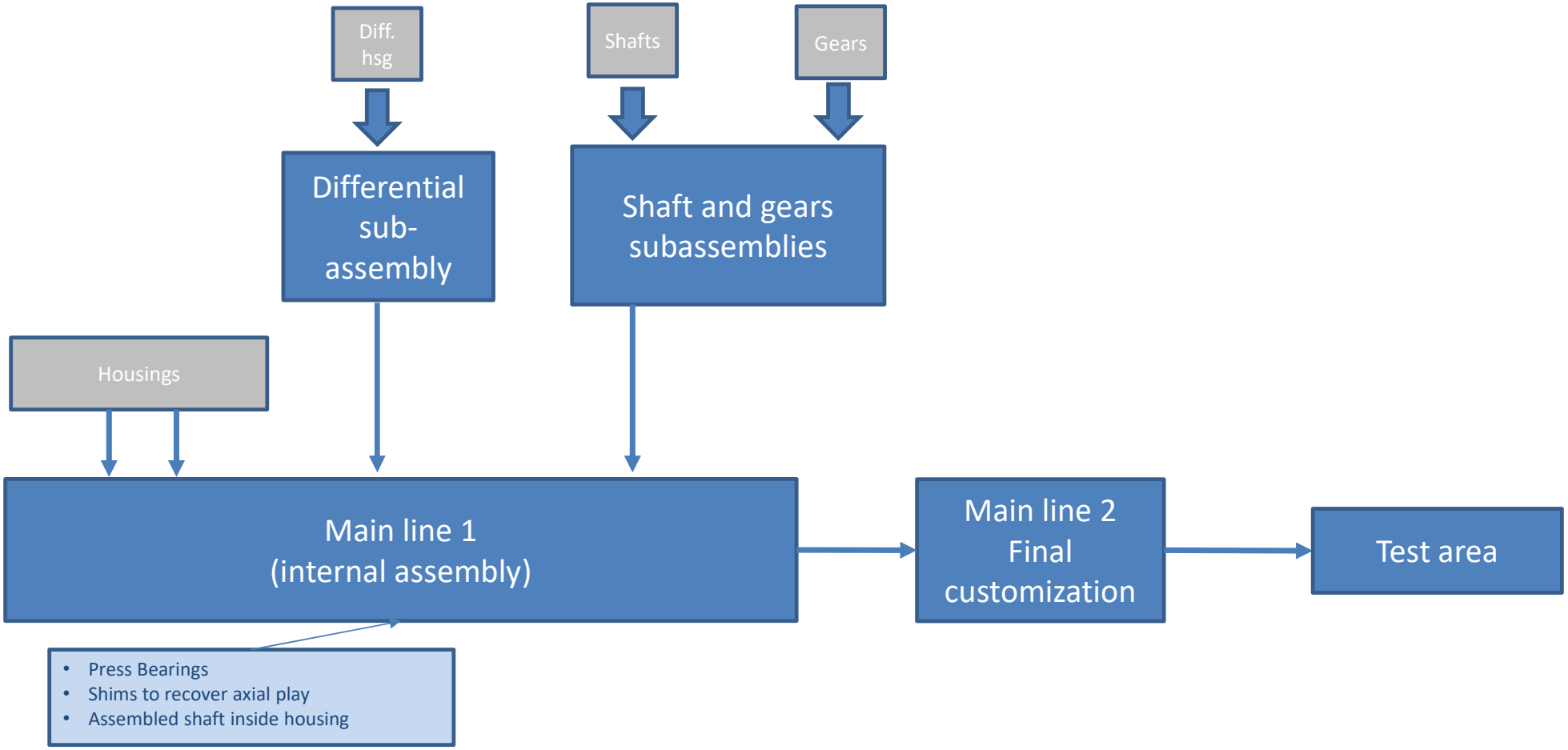
PDP phases and milestones



Introduction to engine assembly

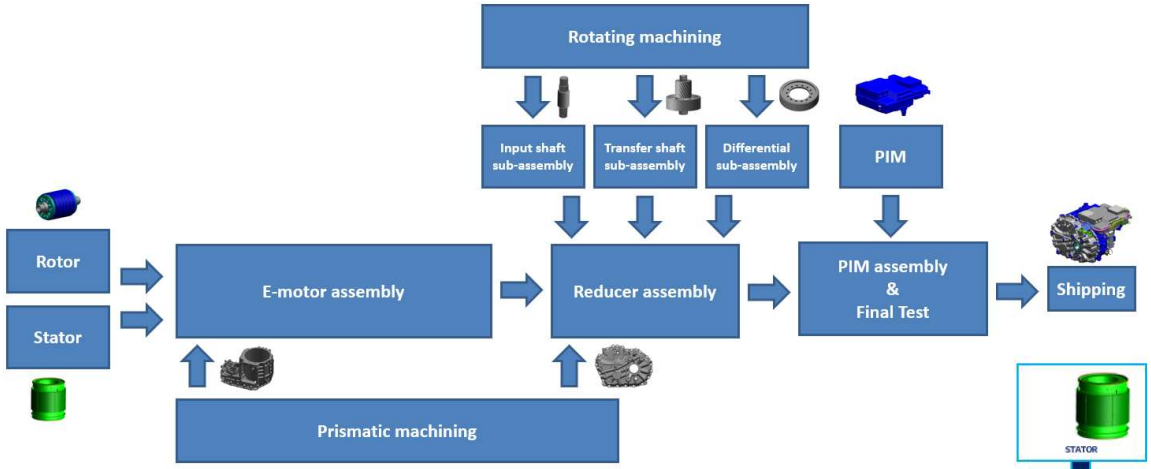


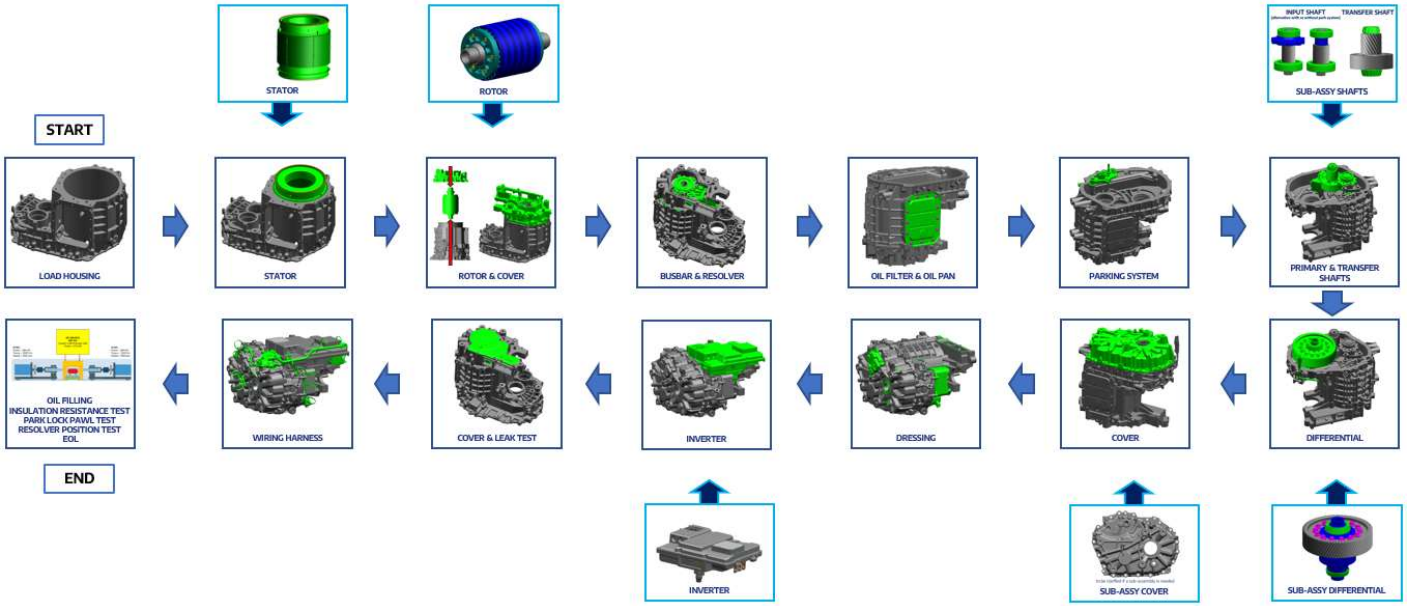
Introduction to transmission assembly



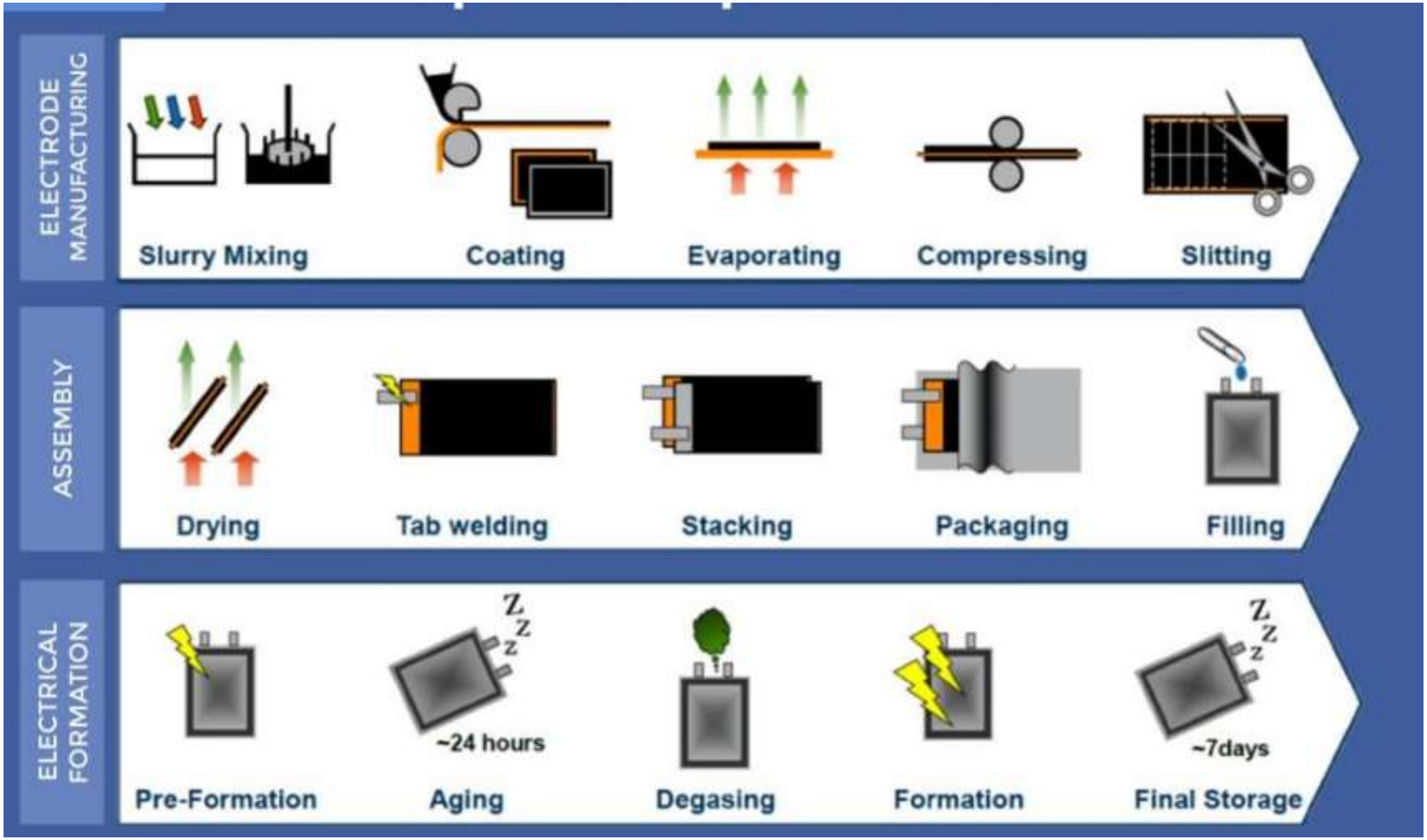
Main operation in EDM assembly

Main consideration : comparing with a classical PWT transmission the **EDM** cinematic archytecture represent a much **simplified structure** : Input shaft + Output (Transfer) shaft + 1 single speed ratio coupled with a ring gear/differential.



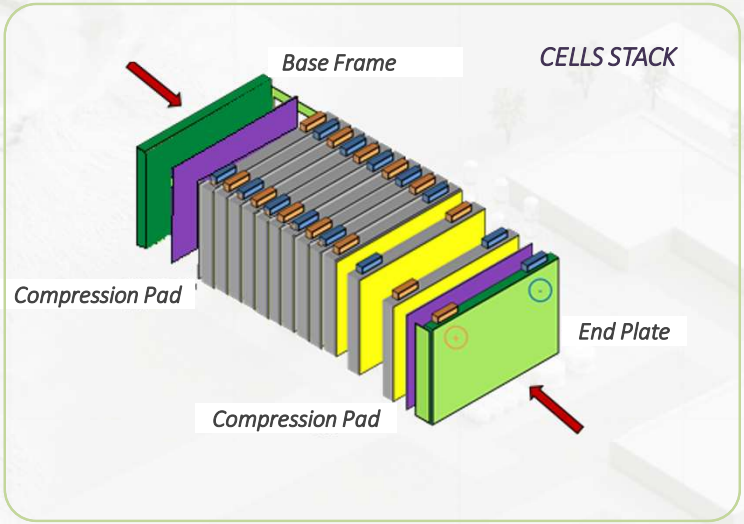


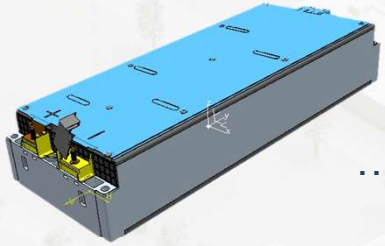
Summary of Cell assembly process



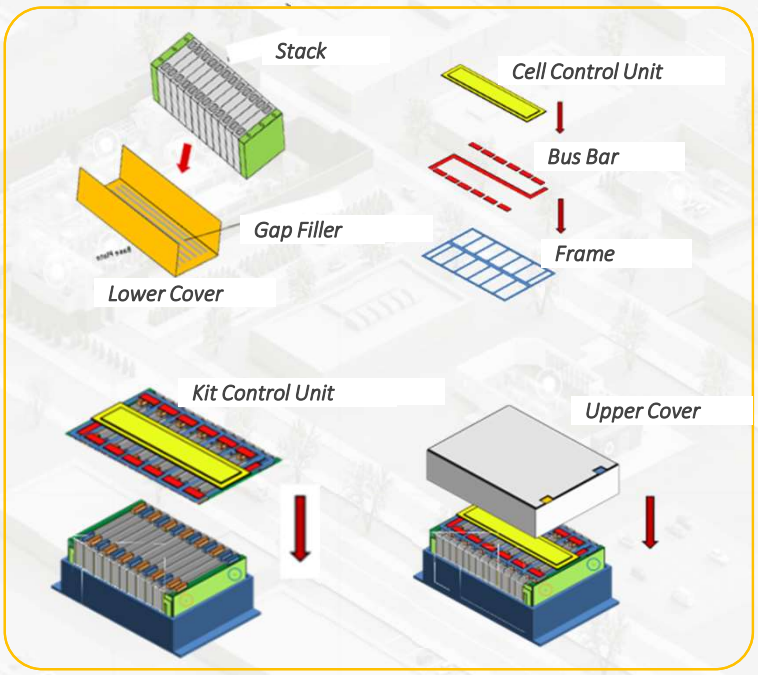
Step 11: Module formation

From the **Cell** …

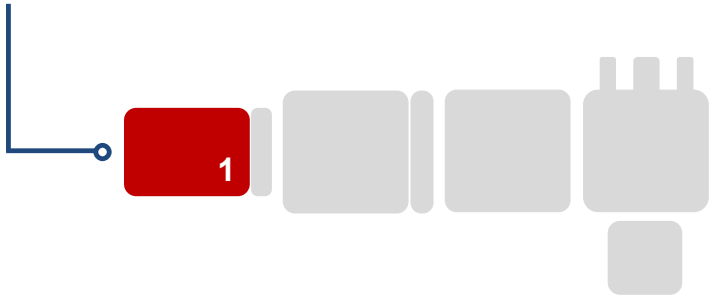




… to the **Module**



Stamping

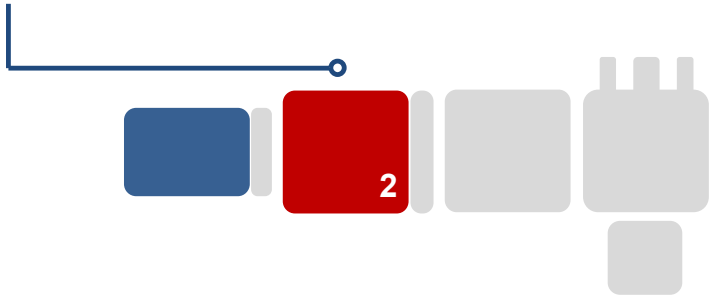


Stamping is the process that includes a variety of sheet-metal forming, such as punching using machine press, blanking, embossing, bending, flanging, etc.

- Capital Intensive area
- High productivity rate: up to 18 strokes/minute
- High flexibility
- Changeover time < 180 seconds
- Hot Stamping technology

- Parts geometry
- Energy consumption
- Noise reduction

Welding (Body in White)

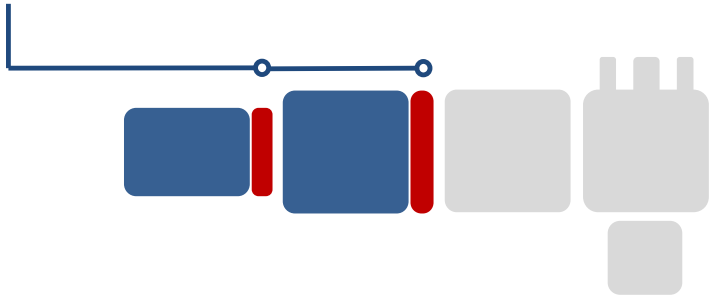


Body in White refers to the stage in which a car body's sheet metal components are welded together. BiW include also other joining process: i.e. gluing, riveting and tightening

- Capital Intensive area
- Geometry Framing > 100 welding points
- Flexibility over Platforms and Models
- Mix Flexibility: 100%

- Parts geometry
- Easy and low-cost maintenability

Quality Centers

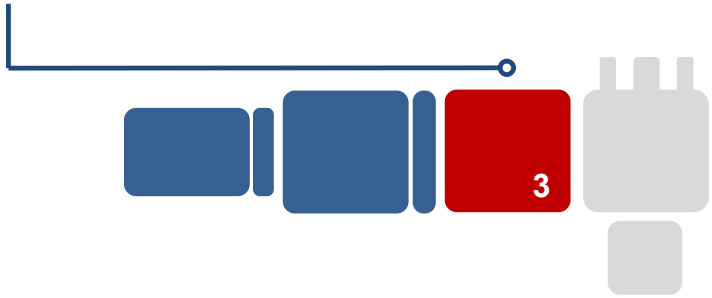


The heart of the plant is in the Quality Center to grant:

- Geometry consistency
- Zero Tolerance Room
- Measuring and Part Testing
- Product and Process Conformity

- Temperature and humidity control
- Resolution of measuring device

Paint

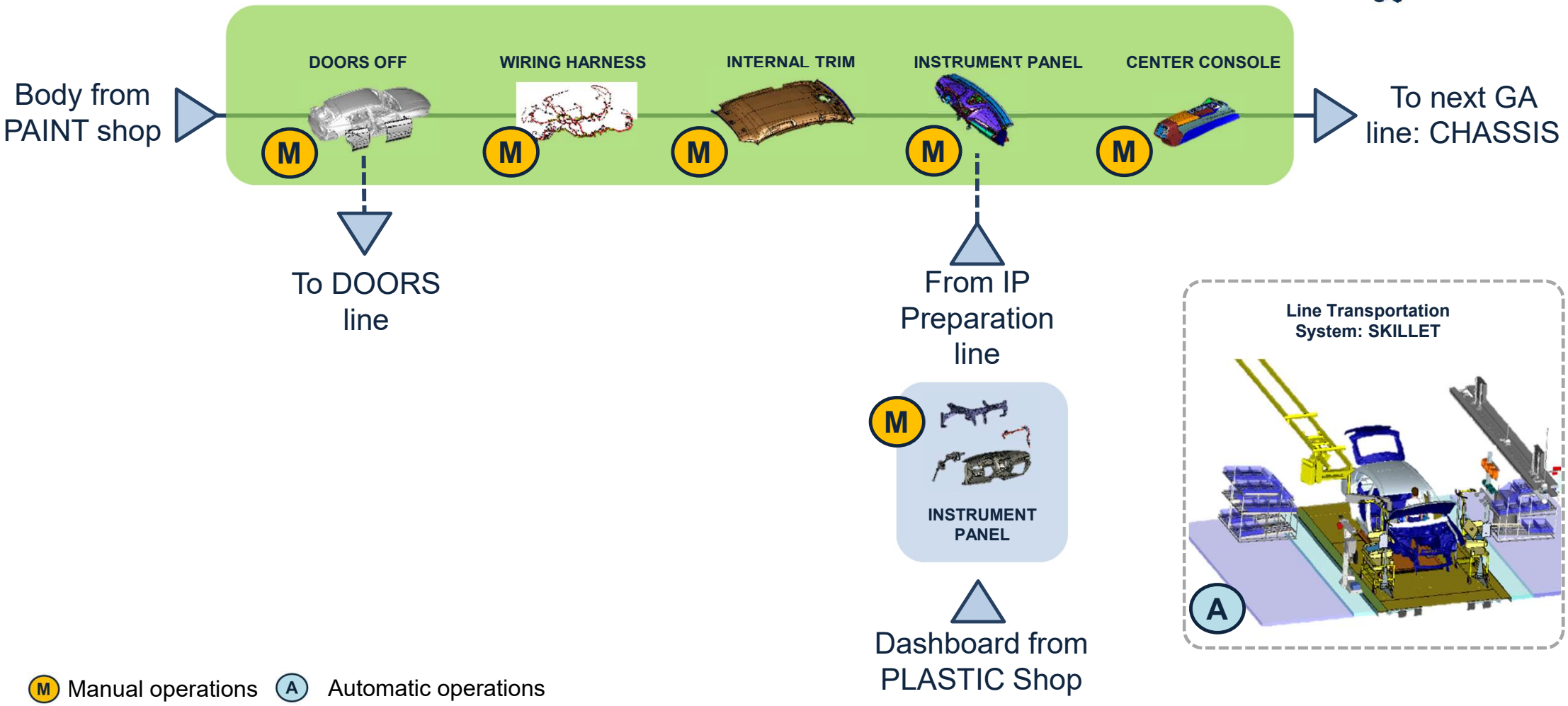


Paint process is the step in which body are cleaned and layers of chemicals and pigments are layed to protect surfaces and provide the final color and glossiness to the vehicle

- Capital Intensive area
- Water based
- Full color Flexibility

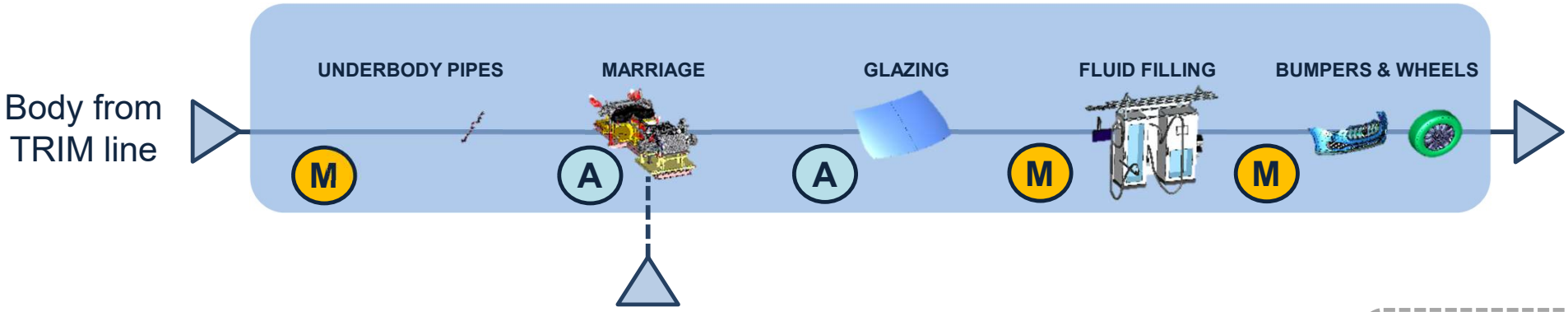
- Energy Consumption
- Temperature and humidity control
- VOCs: reduced emissions
- Clean rooms
- Reduced Water Consumption and Sludge production

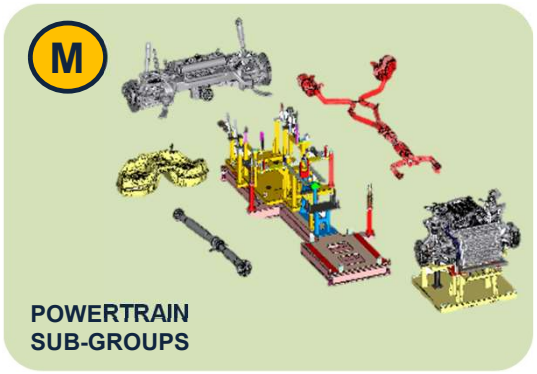
General Assembly (GA) – TRIM – 1 of 4

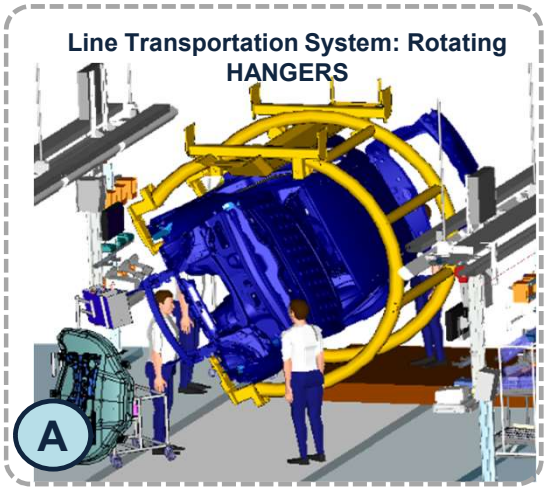


M Manual operations A Automatic operations

General Assembly (GA) – CHASSIS – 2 of 4







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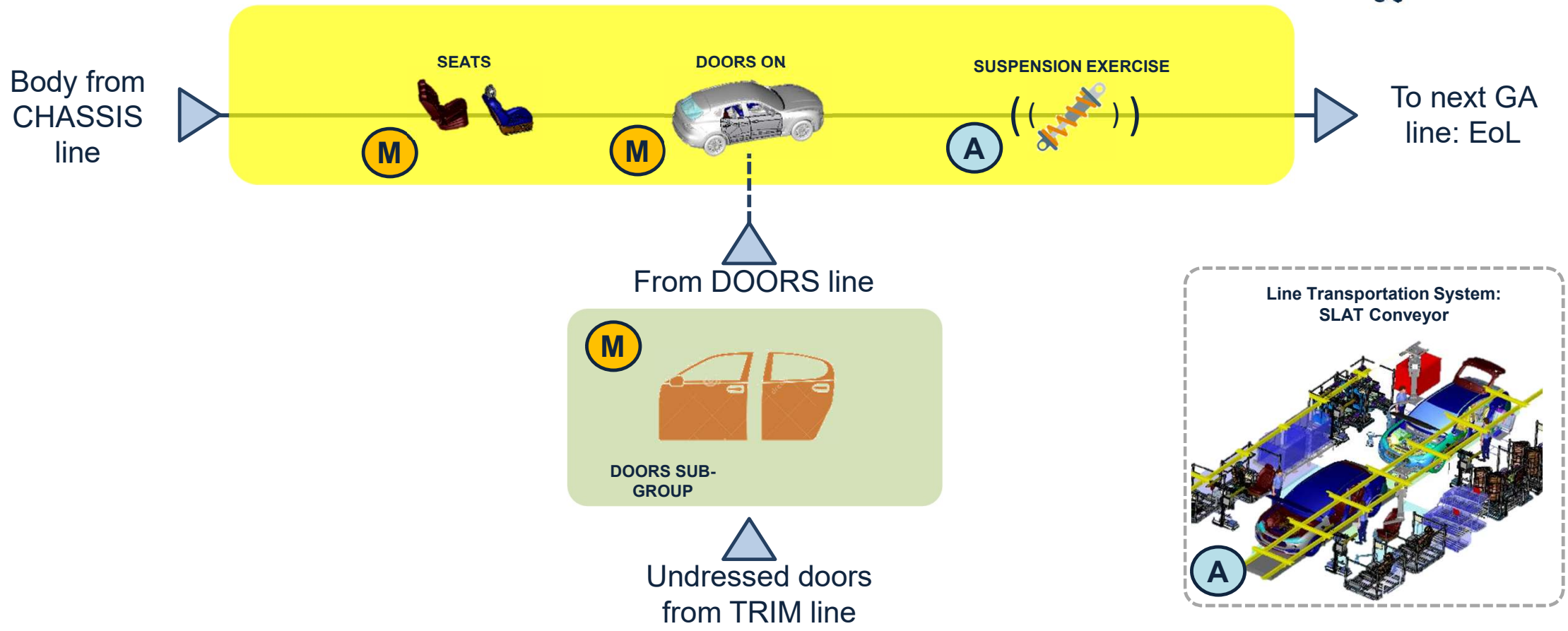
General Assembly (GA) – FINAL – 3 of 4



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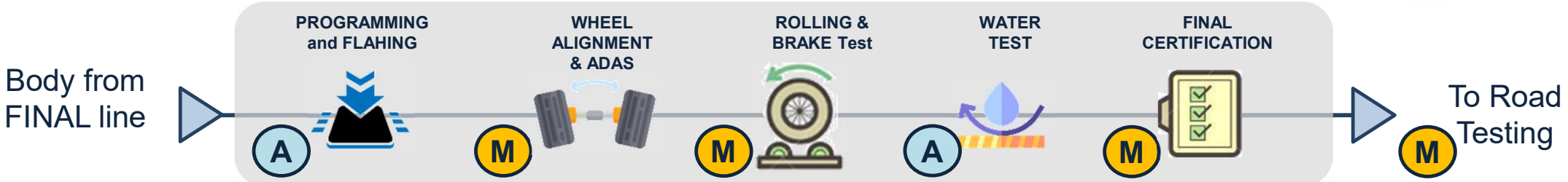
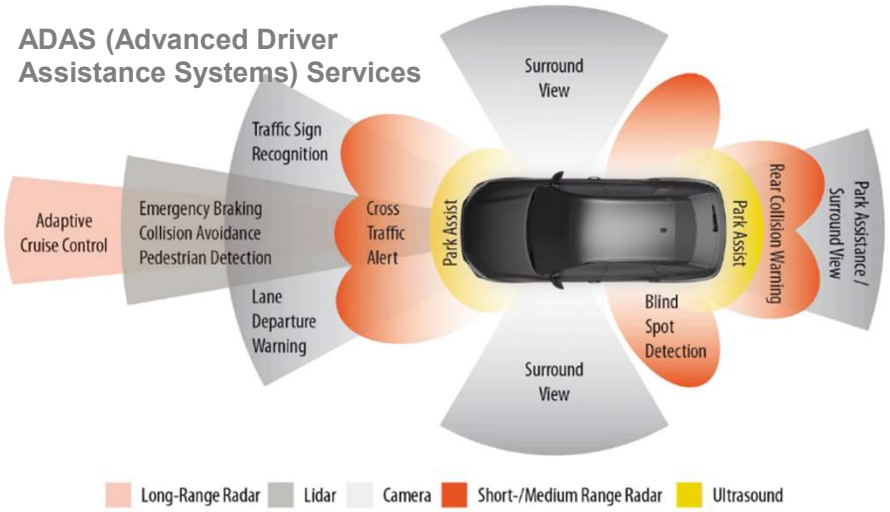
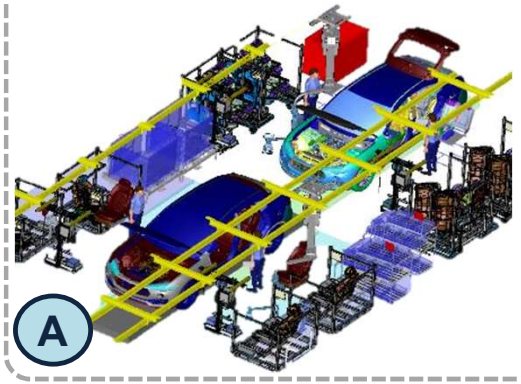
General Assembly (GA) – End of Line – 4 of 4





Line Transportation System: SLAT Conveyor



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