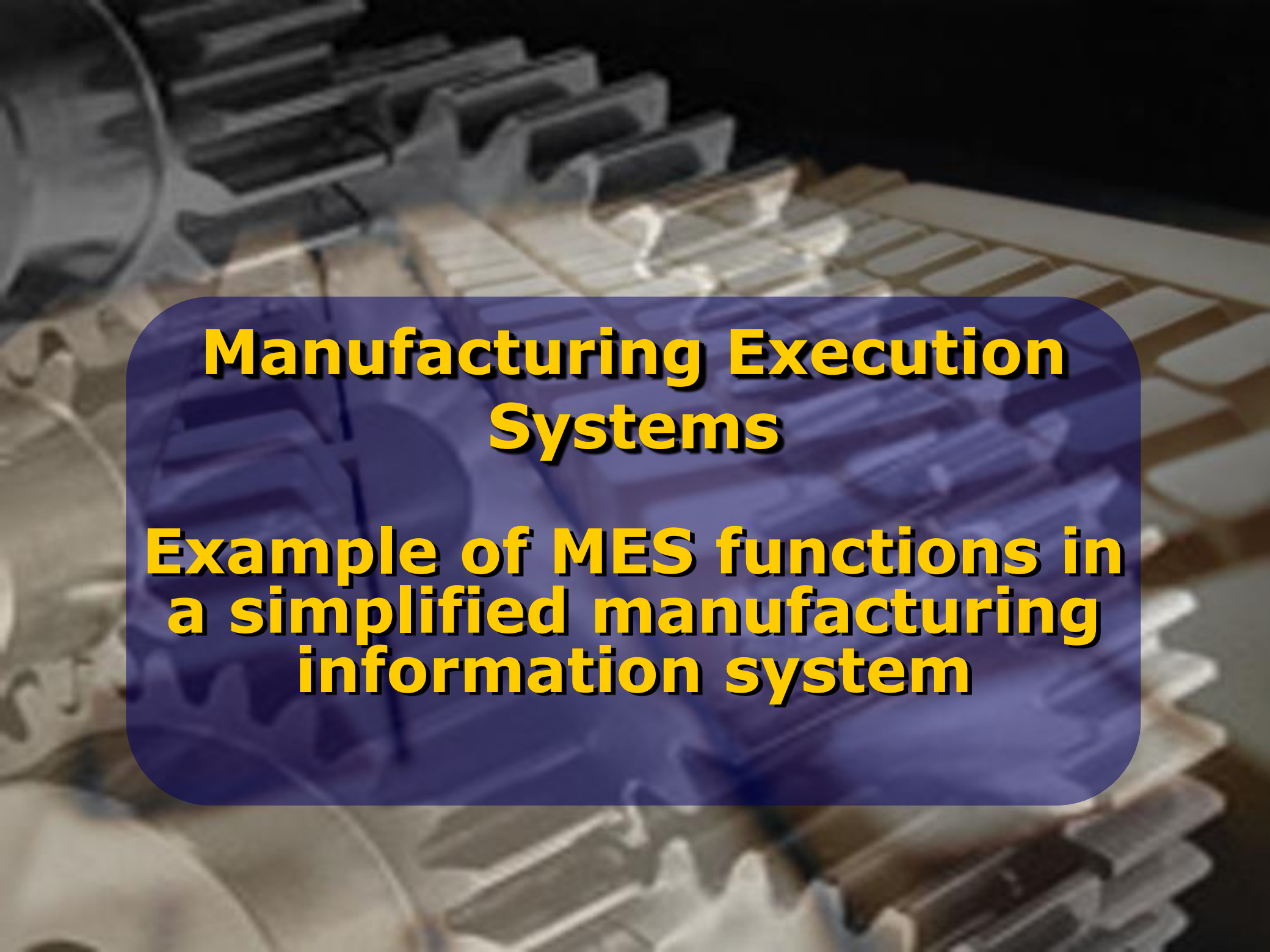

Manufacturing Execution Systems
Example of MES functions in a simplified manufacturing information system

SUMMARY

- Example of an MES operating in a fictitious plant

Primary functions

Support functions:

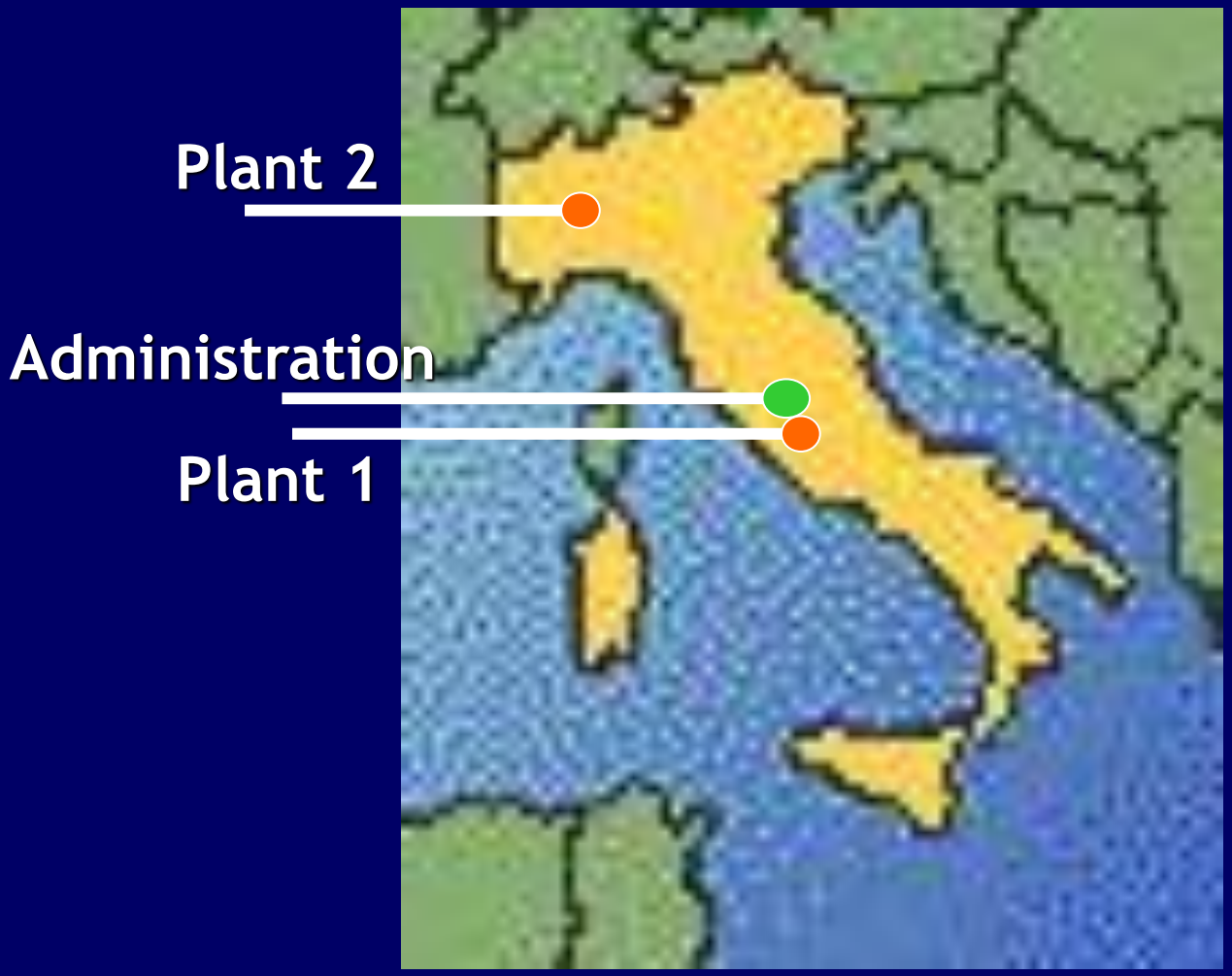
- Statistical process control
- Process data / performance
- Genealogy of the product

MES architecture

- Hardware
- Software

Issues of the current MES version

DIBRISBIKE S.r.l.



DESCRIPTION OF THE PRODUCTION

- Make-to-order bicycle production
- Production process:

  Make the frame
  Assemble with other components

- Product types

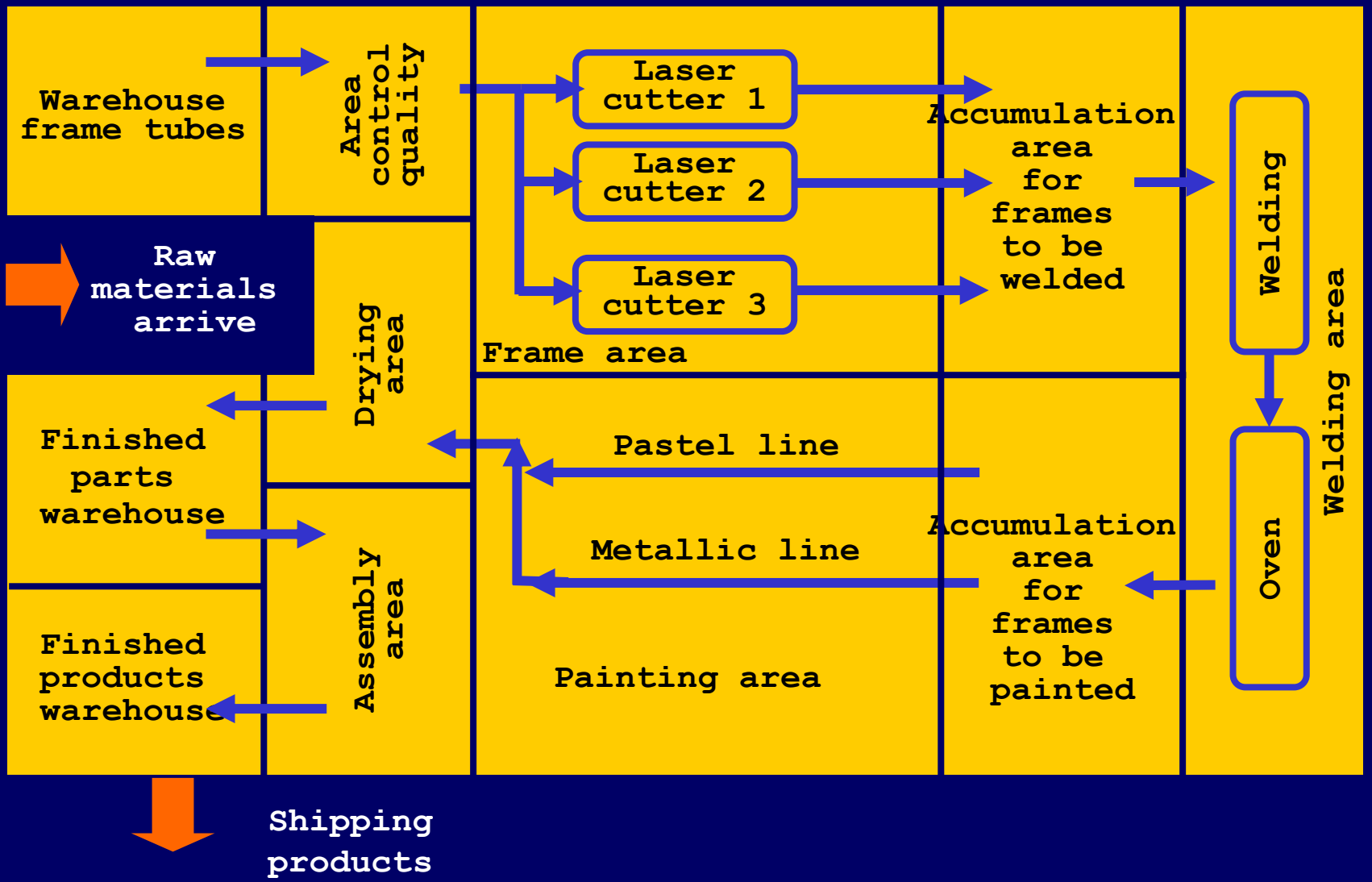
  4 models (graziella, mbike, corsa, customized)
  - Plant 1: production of all models
  - Plant 2: graziella,mbike

PRODUCTION DESCRIPTION

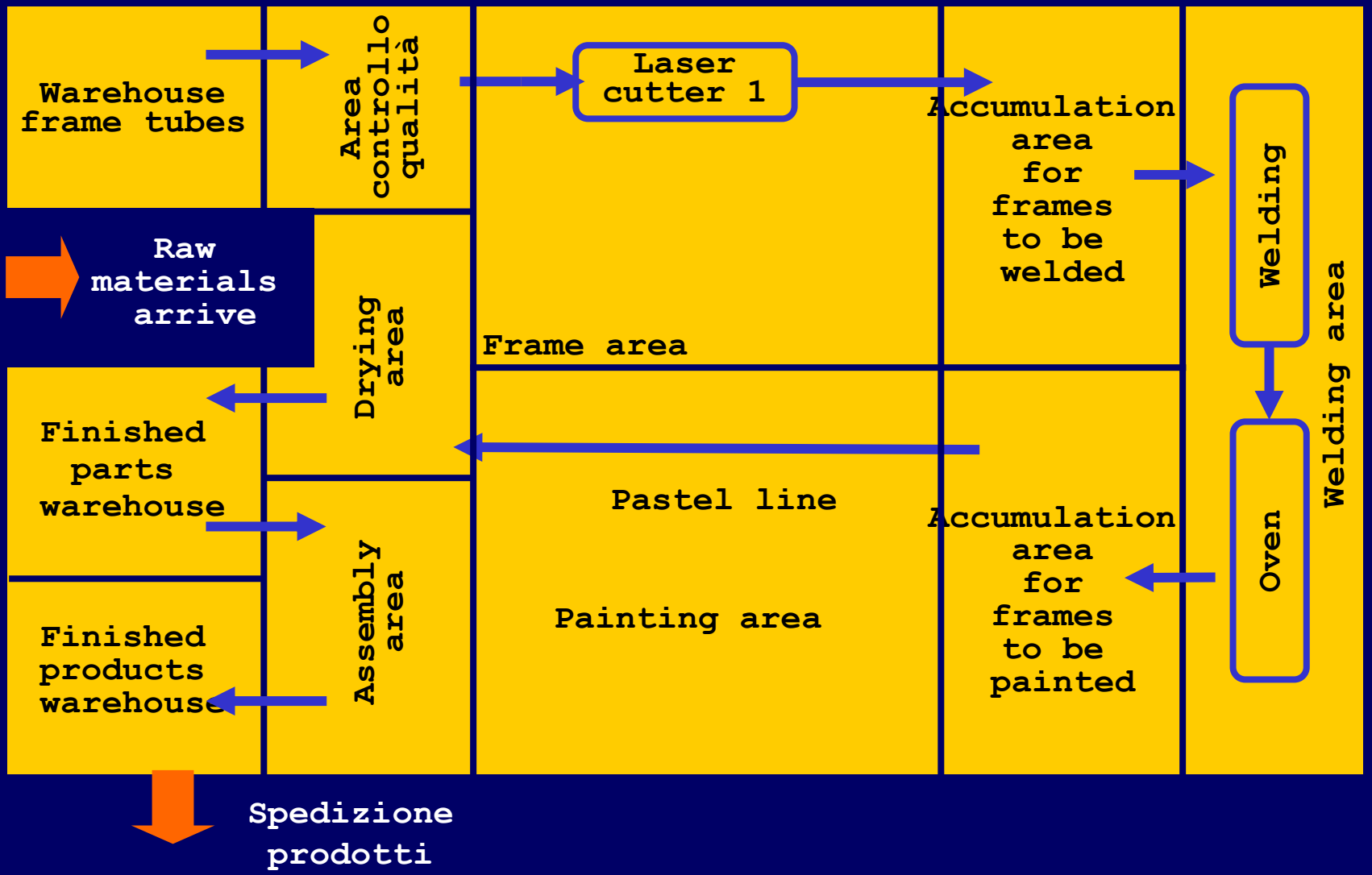
Pastel color (red, blue, green) or metallic (navy blue, gray) lines

- **Plant 1: both lines**
- **Plant 2: just pastel line**

PLANT 1


Warehouse frame tubes
Area control quality
Laser cutter 1
Laser cutter 2
Laser cutter 3
Accumulation area for frames to be welded
Welding
Welding area
Raw materials arrive
Drying area
Frame area
Finished parts warehouse
Pastel line
Oven
Assembly area
Metallic line
Accumulation area for frames to be painted
Finished products warehouse
Painting area
Shipping products

PLANT 2


Warehouse frame tubes
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Raw materials arrive
Drying area
Frame area
Finished parts warehouse
Pastel line
Accumulation area for frames to be painted
Oven
Assembly area
Finished products warehouse
Painting area
Spedizione prodotti

INTERFACE WITH THE PLANNING LEVEL

- The two MES communicate weekly with the ERP present in the administrative office to request the MPS
- For the week of 9 to 13 September, following a precise query to the ERP, the MES of plant 1 obtained the following MPS

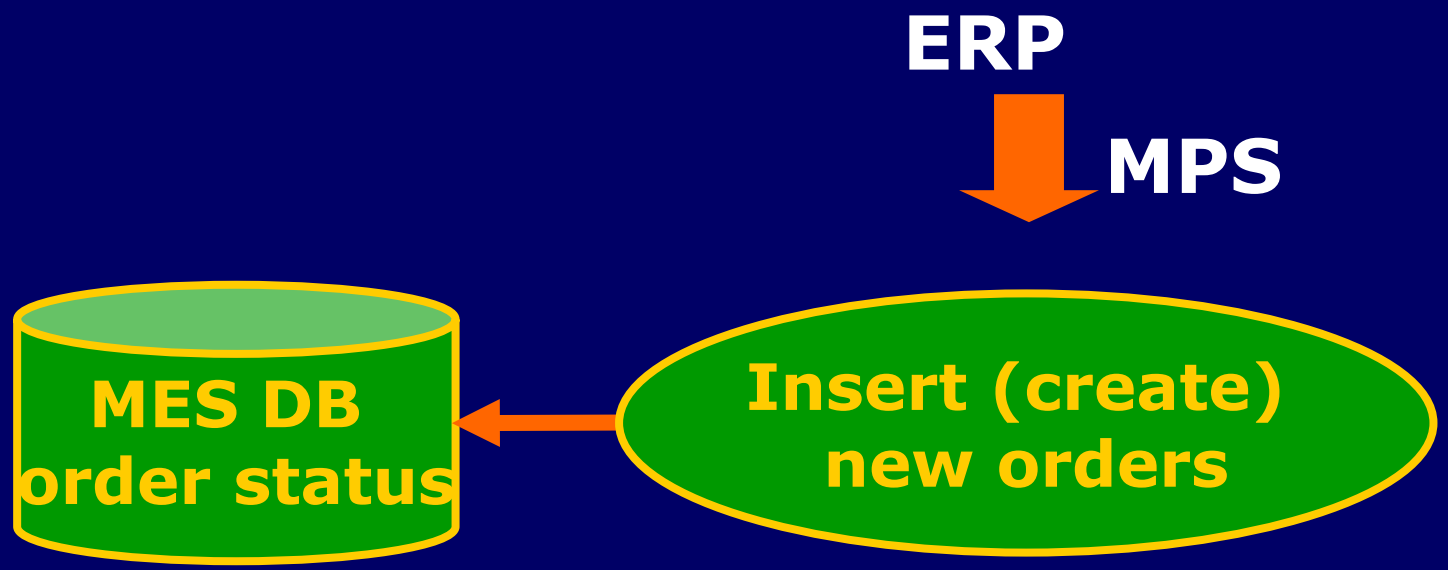
INTERFACE WITH THE PLANNING LEVEL

ERP

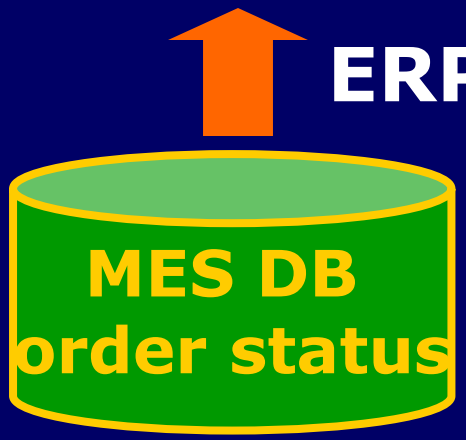
Start	Due date	ID batch	Quantity	Frame type	Colour	Priority
12/09/2022	14/09/2022	L102	120	mbike	blu	4
12/09/2022	15/09/2022	L101	100	graziella	blue	1
12/09/2022	12/09/2022	L100	150	graziella	pink	9
...		...				

MES

INTERFACE WITH THE PLANNING LEVEL

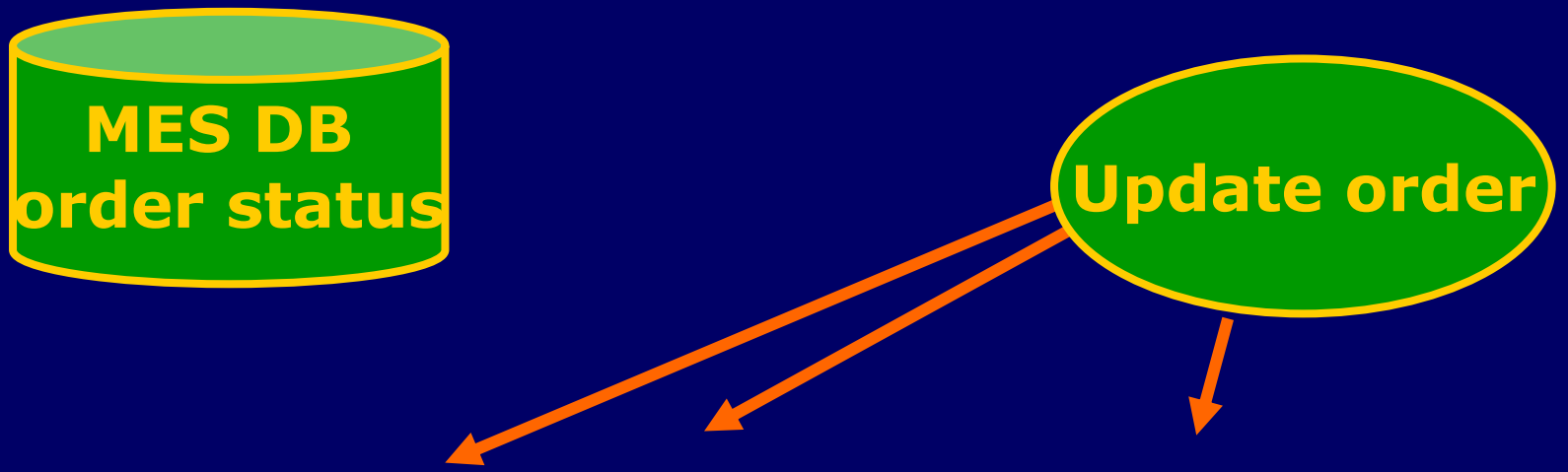


INTERFACE WITH THE PLANNING LEVEL



Start planned	Due date planned	Start	Completion estimated	ID batch	Quantity	Quantity produced	Type
...		...		...			
12/09/22	13/09/22	12/09/22	14/09/22	L100	150	20	graziella
12/09/22	13/09/22	12/09/22	15/09/22	L101	100	30	graziella
12/09/22	12/09/22	...	...	L102	120	10	mbike

ORDER MANAGEMENT



Start planned	Due date planned	Start	Completion estimated	ID batch	Quantity	Quantity produced	Type
...		...		...			
12/09/20	13/09/20	12/09/20	14/09/20	L100	150	20	graziella
12/09/20	13/09/20	12/09/20	15/09/20	L101	100	30	graziella
12/09/20	12/09/20	...	...	L102	120	10	mbike

WORK STATION MANAGEMENT

Work station

Workstation ID	Working area	Description
LC001	Frame	laser cutter
LC002	Frame	laser cutter
LC003	Frame	laser cutter
S001	Welding	welding
F001	Welding	oven
NT001	Painting	conveyor belt pastel line
NT002	Painting	conveyor belt metallic line
...	...	...

WORK STATION MANAGEMENT

Operations

Operation ID	Description
OP001	Cut frame graziella
OP002	Cut frame mbike
OP003	Cut frame corsa
OP004	Cut frame custom
OP005	Frame welding
OP006	Hot treatment: temper welds
OP007	Pastel painting
OP008	Metallic painting
OP009	Drying
OP010	Assembling
...	...

WORK STATION MANAGEMENT

Work stations - Operations

ID	Workstation ID	Operation ID
1	LC001	OP001
2	LC001	OP002
3	LC002	OP001
4	LC002	OP002
5	LC003	OP001
6	LC003	OP002
7	LC003	OP003
8	LC003	OP004
9	...	

WORK STATION MANAGEMENT

Workstation / operation

ID	Workstation ID	Operation ID
1	LC001	OP001
2	LC001	OP002
3	LC002	OP001
4	LC002	OP002
5	LC003	OP001
6	LC003	OP002
7	LC003	OP003
8	LC003	OP004
9	...	

Routing

ID batch	ID piece	Step	Pr. time	Set-up time	Operation/machine
L100	L100-0001	1	10	0	1
L100	L100-0001	2	5	15	12
L100	L100-0001	3	...	...	...

WORK STATION MANAGEMENT

- A procedure reads the list of orders to be executed on that day (including those previously started and not completed) and starts the production by ordering the execution in batches with "earliest due date"
- In each intermediate storage area an ad hoc scheduling algorithm is applied locally on the single piece or on the single batch

WORK STATION MANAGEMENT

- Scheduling (algoritmo di Moore) on painting line
- Example: 6 batches waiting to be painted in pastel colour

Lotto	L001	L002	L003	L004	L005	L006
Due date	15	6	9	23	20	30
Processing time	10	3	4	8	10	6

EDD	L002	L003	L001	L005	L004	L006	Rejected
Due date Proc. time	6 3	9 4	15 10	20 10	23 8	30 6	
Compl.Time	3	7	17				L001
Compl.Time	3	7	*	17	25		L005
Compl.Time	3	7	*	*	15	21	

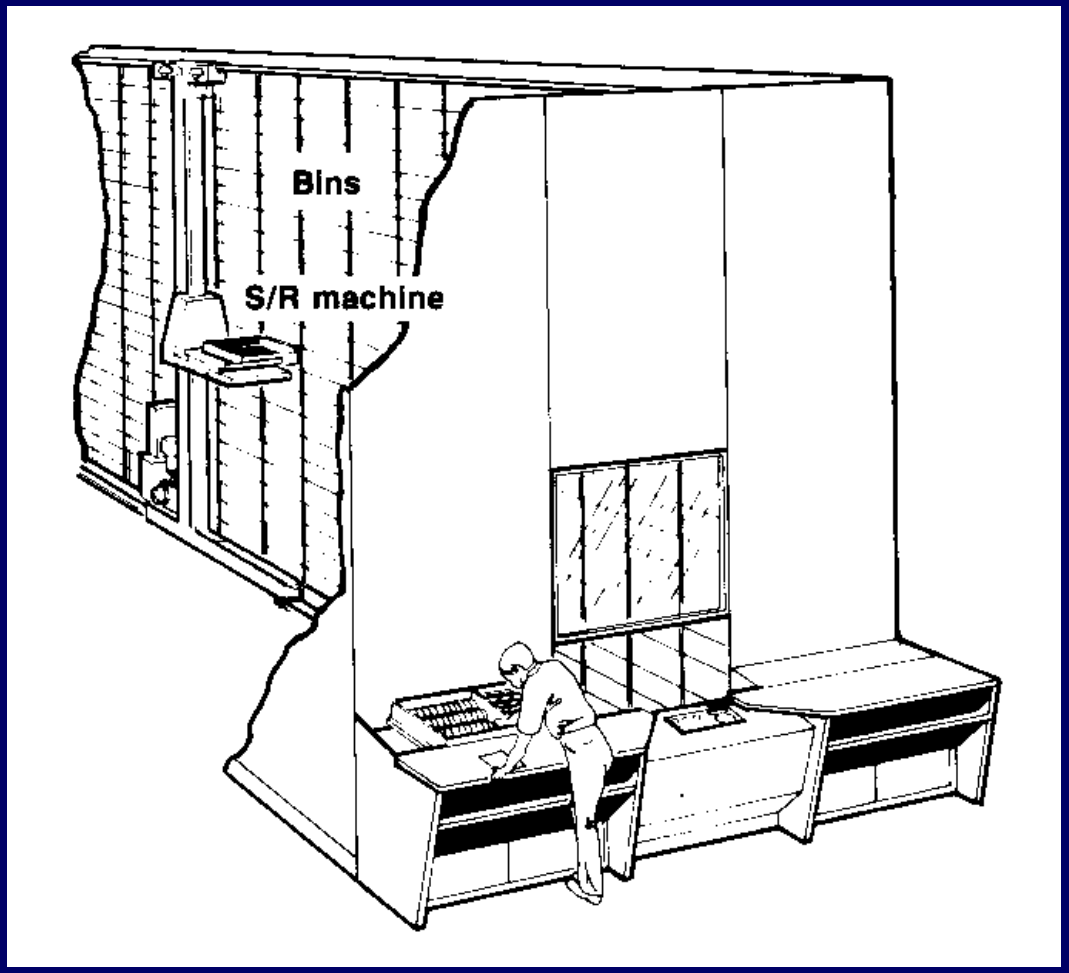
MATERIAL AND WAREHOUSE MANAGEMENT

- The completed parts warehouse is automatically managed by two Automatic Storage/Retrieval System (AS/RS):

  One for the frames

  One for "boxes" containing the other pieces to be assembled

MATERIAL AND WAREHOUSE MANAGEMENT



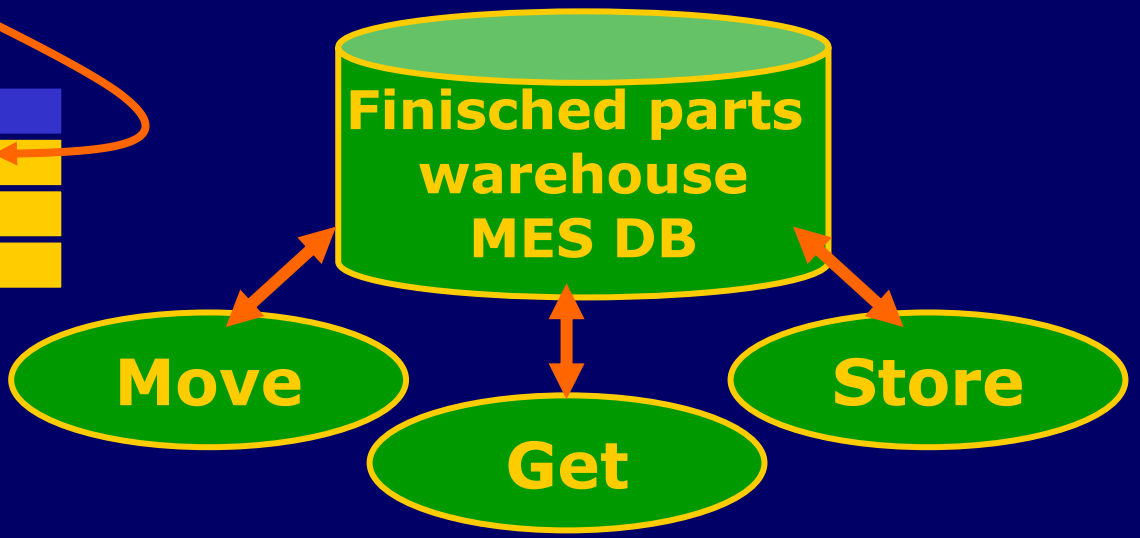
MATERIAL AND WAREHOUSE MANAGEMENT

Box

IDbox	Type	ID gear	IDwheel	Idaccess.	ID saddle	ID chain
SC1000	graziella	-	R0023	F0045	S0801	C0323
SC1001	corsa	CB101	R0024	F0033	S1201	

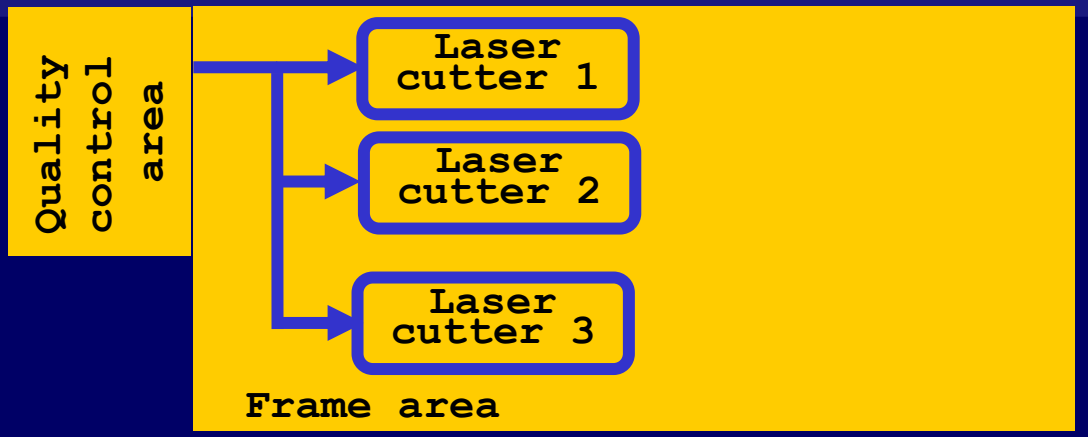
Position

ID	x	y	z	ID box
1	12	1	A	SC1001
2	12	1	B	SC1250
3	12	1	C	-



MATERIAL MOVEMENT

AGV1



AGV

ID AGC	Type
AGV1	AGV
AGV2	AGV
AGV3	AGV
...	...

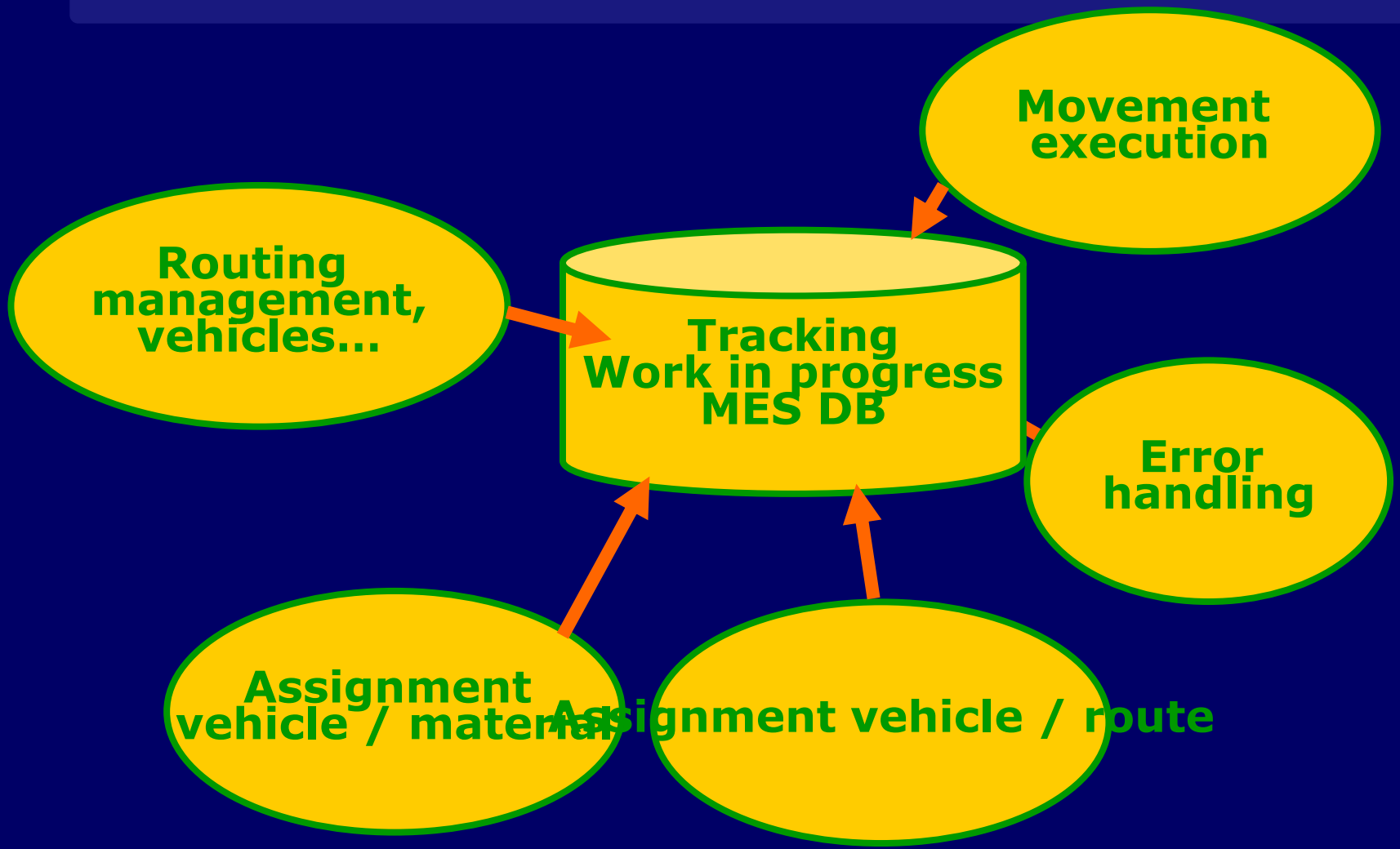
Routes

ID route	Origin	Destination
1	ACQ	LC001
2	ACQ	LC002
3	ACQ	LC003
4	...	...

Assignment

ID AGV / route	ID route	ID AGV	Time assignment	Time start	Time arrival
1	1	AGV1	09:00:01	09:00:40	09:00:59
2	1	AGV2	09:00:01	09:01:40	-

MATERIAL MOVEMENT



DATA COLLECTION

Alarms LC001

ID alarm	Description	
LC001_AL1	Out of calibration	Yes
LC001_AL2	Tube diameter no good	No
LC001_AL3	overheating	Yes

Processes LC001

ID process	Description	Max value	Min value
L001_P1	temperature	0	200
L001_P2	First cut	0	100
L002_P3	Second cut	100	200

Alarms RT LC001

ID	Type	
1	L001_AL1	12/09/2020 14.00.34
2	L001_AL1	12/09/2020 14.00.45
3	L001_AL2	12/09/2020 17.34.54

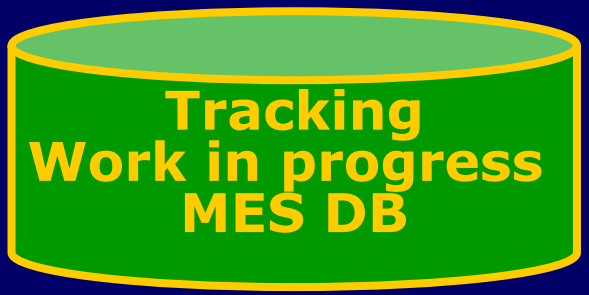
Process RT LC001

ID	Type	Date/time	Value
1	L001_P1	12/09/2020 14.00.00	58
2	L001_P1	12/09/2020 14.00.01	60
3	L001_P1	12/09/2020 14.00.02	62
4	L001_P1	12/09/2020 14.00.03	62
5	L001_P1	12/09/2020 14.00.04	61
6	L001_P1	12/09/2020 14.00.05	62

DATA COLLECTION

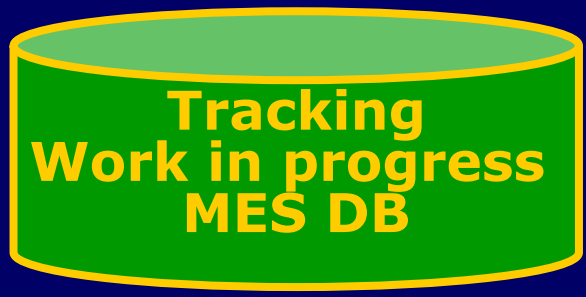
- How can I identify a tube?

  Laser-marked labeling on the outer diameter

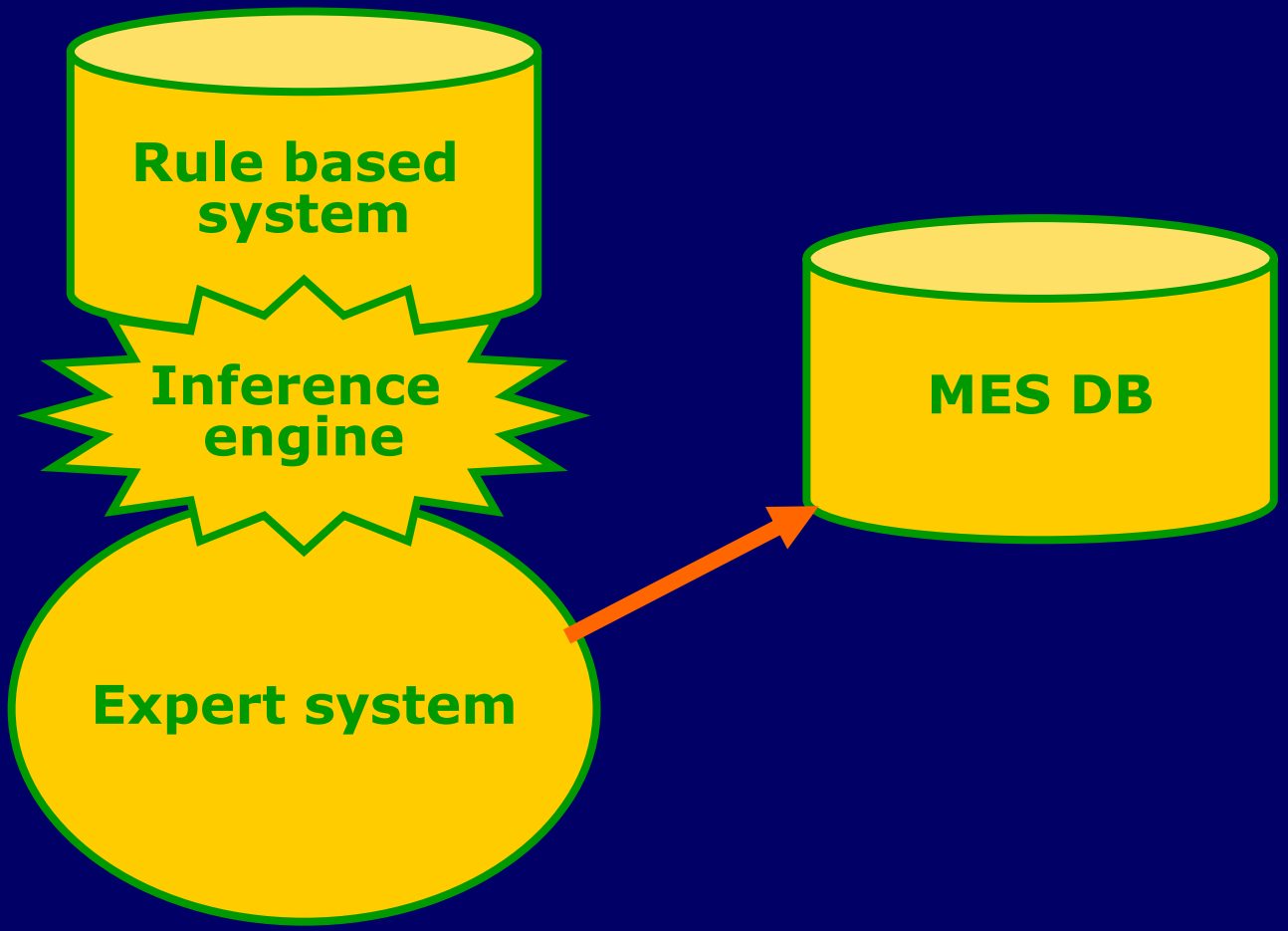


DATA COLLECTION

- For each assembled frame : RFID



MANAGEMENT OF EXCEPTIONS



EXCEPTION HANDLING

- When the temperature in the oven exceeds XXX, notify the quality control and increase the monitoring frequency
- When the temperature in the oven exceeds YYY, it sends an alarm to the database and schedules cleaning with method 4

EXCEPTION HANDLING

- Every 2 hours check the warehouse of the tubes (supplier ABC). If the quantity is less than necessary, notify the production area of a delay, notify ERP, and send urgent email to ABC
- ...

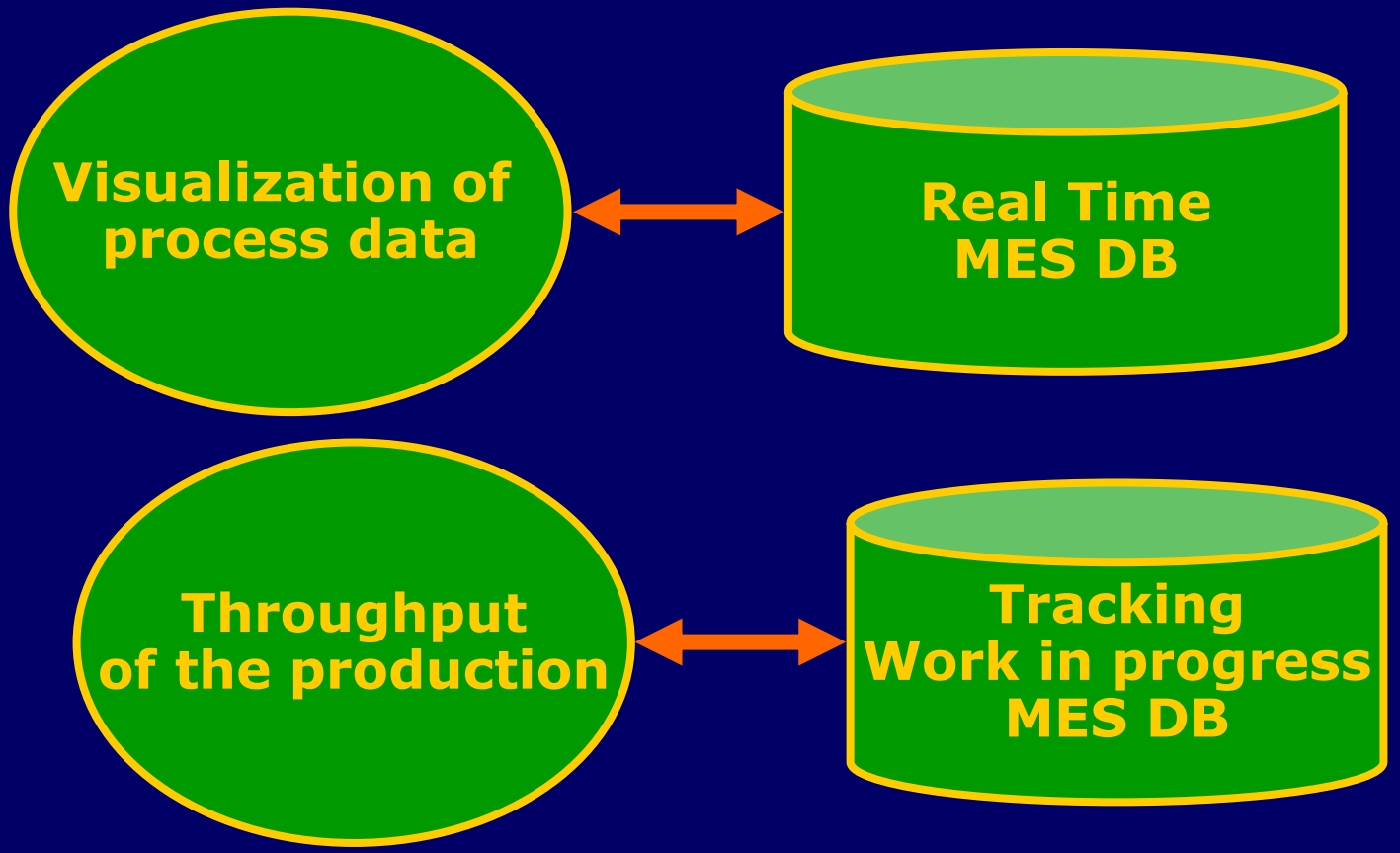
STATISTICAL PROCESS CONTROL

- On raw material
  - Weight (all)
  - Corrosion test (10 per lot of 1000)
  - Ultrasonic inspections (10 per batch of 1000)
- On frame components
  - Length

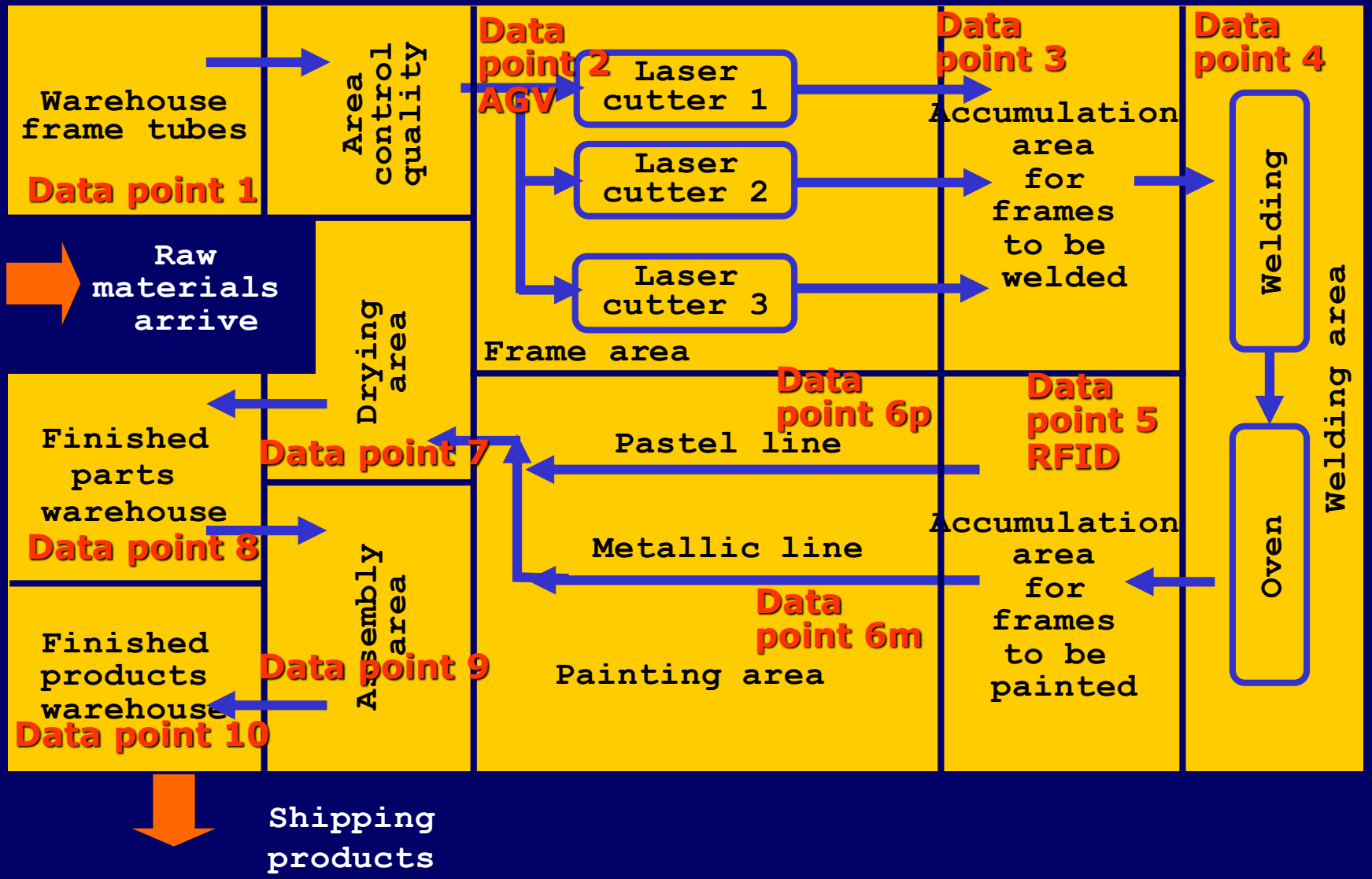
STATISTICAL PROCESS CONTROL

- On the frame
  - Weight
  - Ultrasonic inspections (1 every 100, 1 per batch)
- On the completed product
  - Weight
  - Color
  - Chain / rear wheel transmission
  - ....

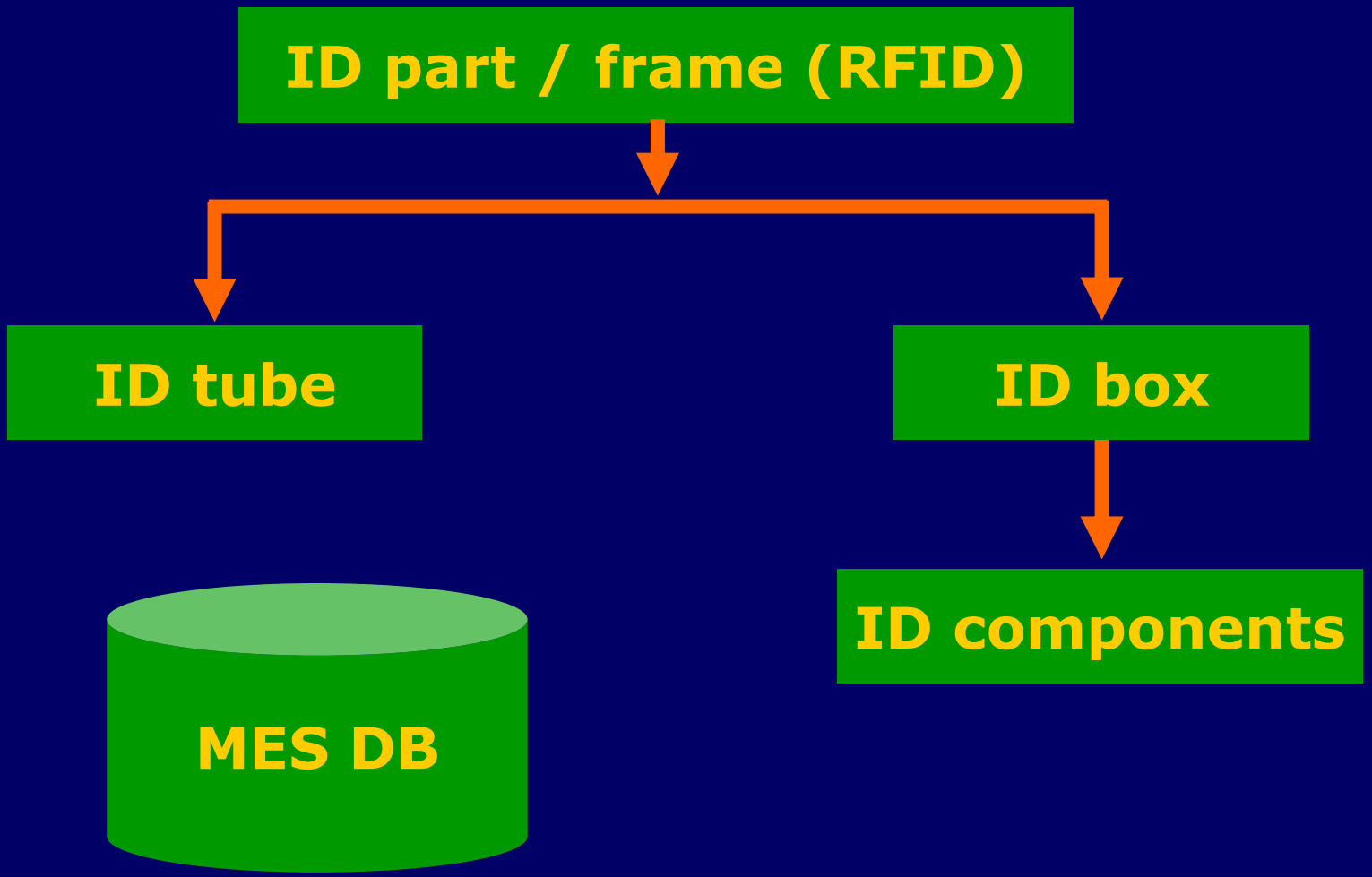
PROCESS DATA / PERFORMANCE



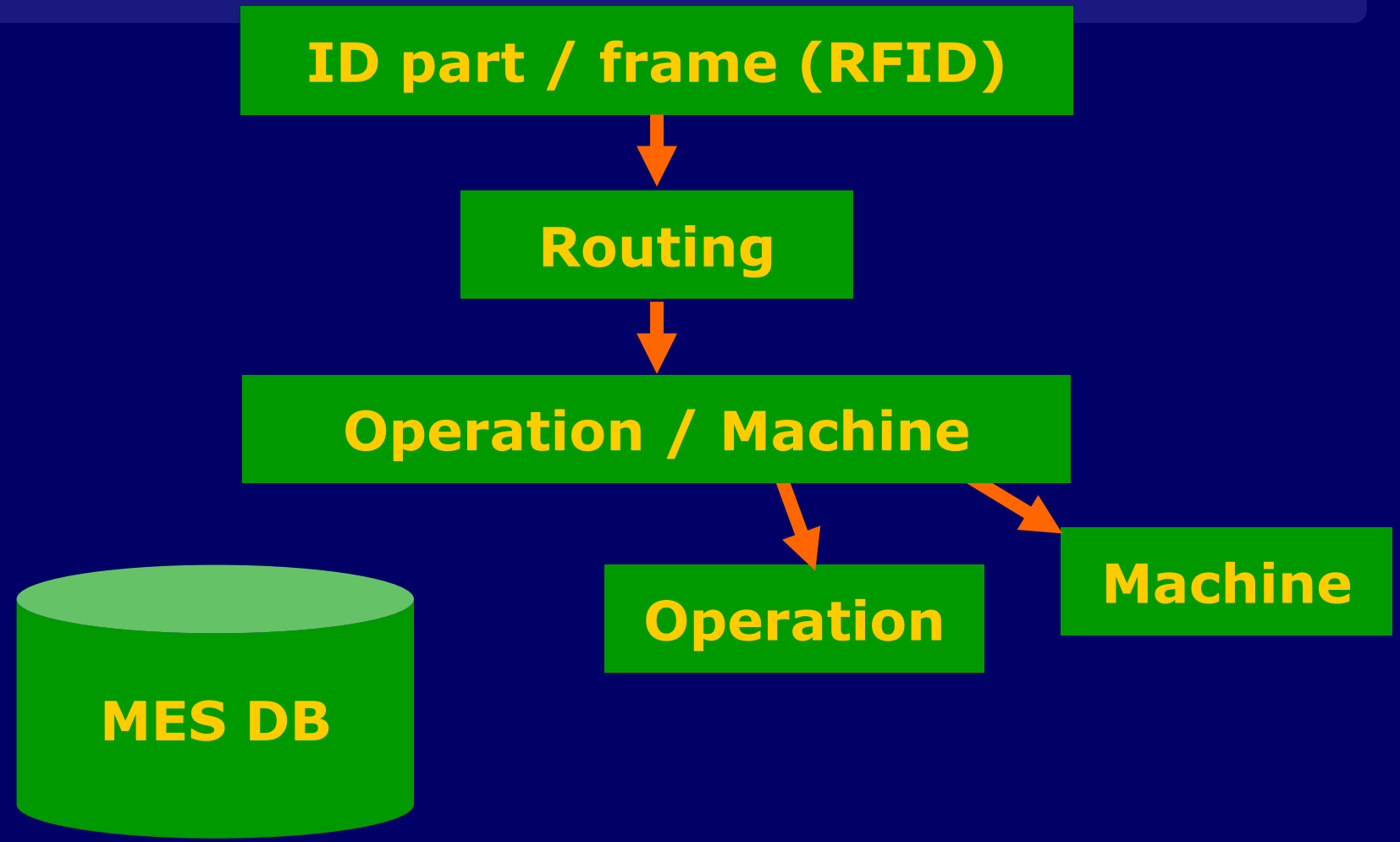
GENEALOGY OF THE PRODUCT



GENEALOGY OF THE PRODUCT: ON MATERIALS



GENEALOGY OF THE PRODUCT: ON PROCESSES AND WORK STATIONS



GENEALOGY OF THE PRODUCT: ON PROCESSES AND WORK STATIONS