



SALEMA: New Aluminium alloys for circular Electric Mobility

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6th October 2023 – The Circular Metal for Future Mobility



Summary

- Project goals and approach
- Contribution to circular economy
- Pilots and demonstrators
- Project structure
- Scrap sorting system
- Alloy development procedure
- Next steps



PROJECT GOAL



European Green Deal poses multiple challenges for the automotive industry:

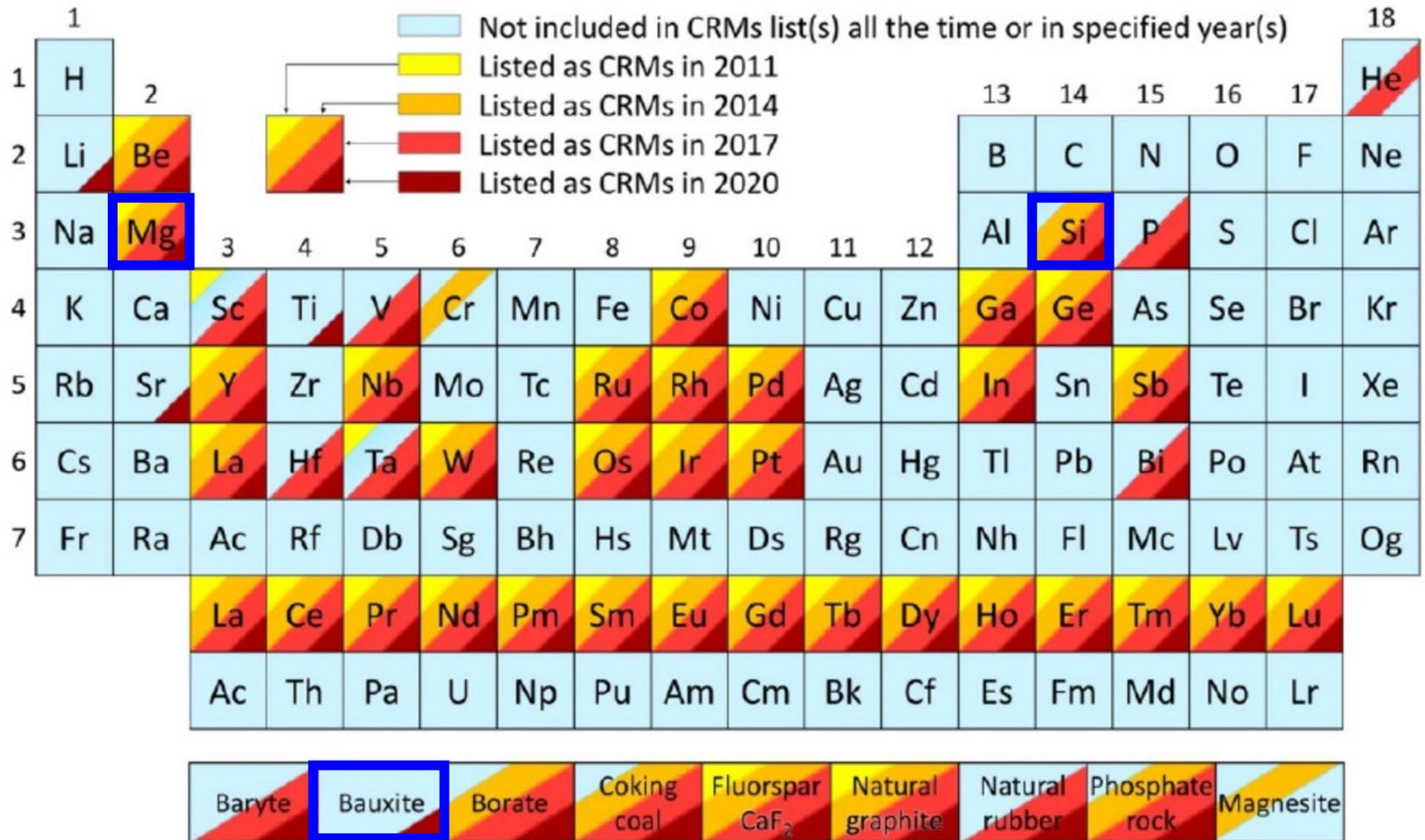
- Need for new, high-performance but lightweight materials
- Decrease the dependencies on imported raw materials while creating a sustainable economy for the future

SALEMA Main objectives:

- To develop a non-CRM dependent aluminium ecosystem, by exploring 2 different approaches:
 - By **substituting primary CRMs with alternative** and commonly available elements
 - By obtaining the **CRMs elements from domestic scrap**, significantly increasing the amount of recycled material



Critical Raw Materials (CRMs) for the EU



- Aluminium is a lightweight and cost-effective material
- Production of Aluminium and its alloys requires bauxite and other Critical Raw Materials (CRM), such as Si and Mg

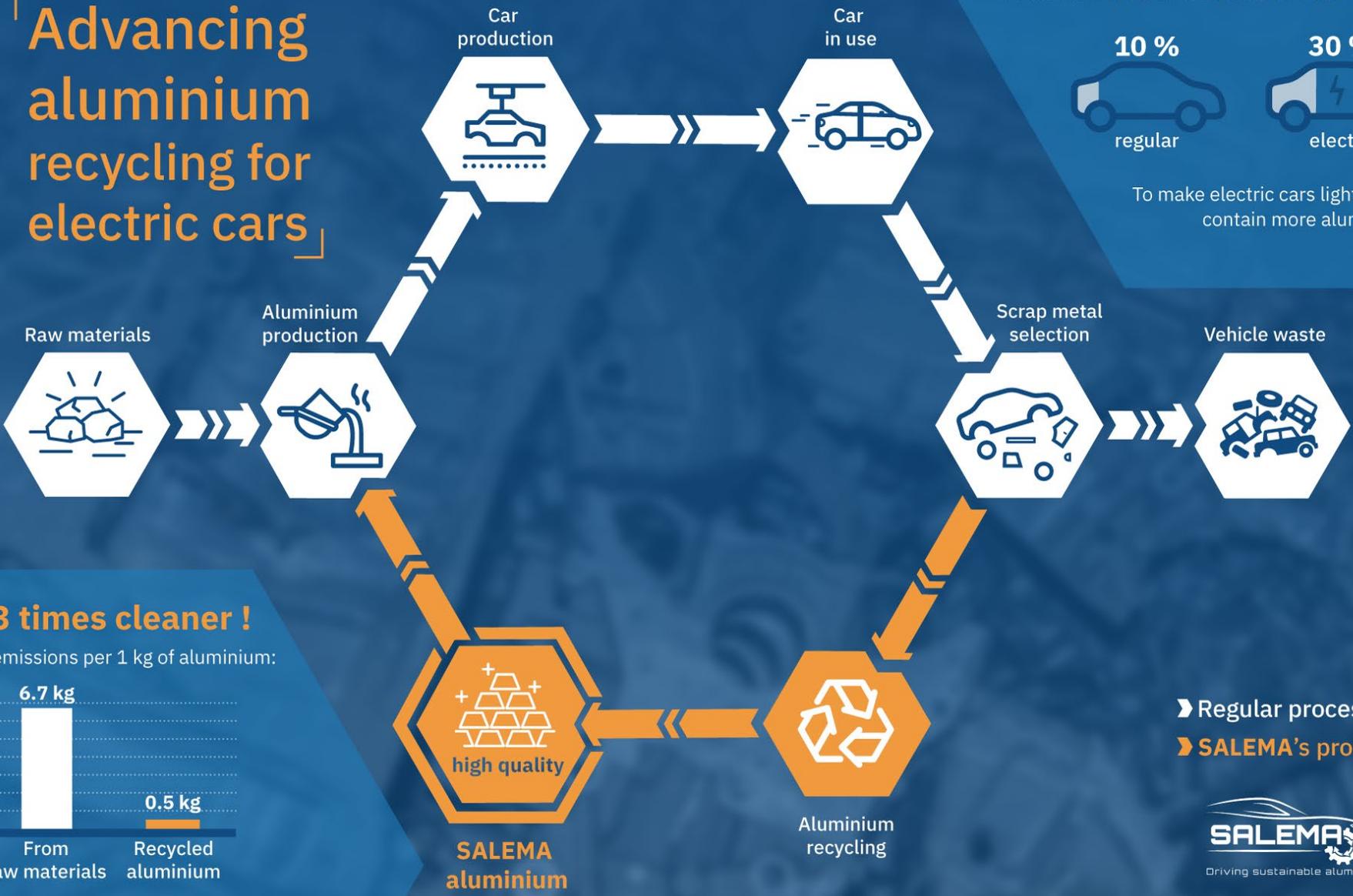


Advancing aluminium recycling for electric cars

Aluminium content in a car



To make electric cars lighter they contain more aluminium.



13 times cleaner !

CO₂ emissions per 1 kg of aluminium:



- ▶ Regular process
- ▶ SALEMA's process

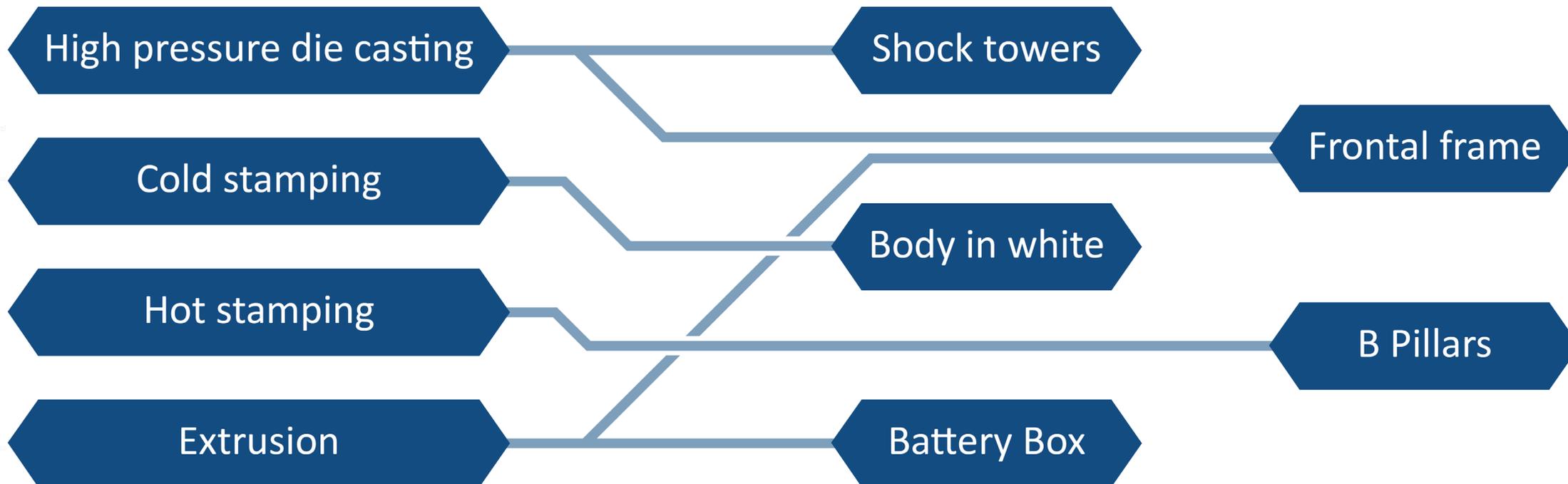


The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003785.



4 PILOTS

5 DEMONSTRATORS



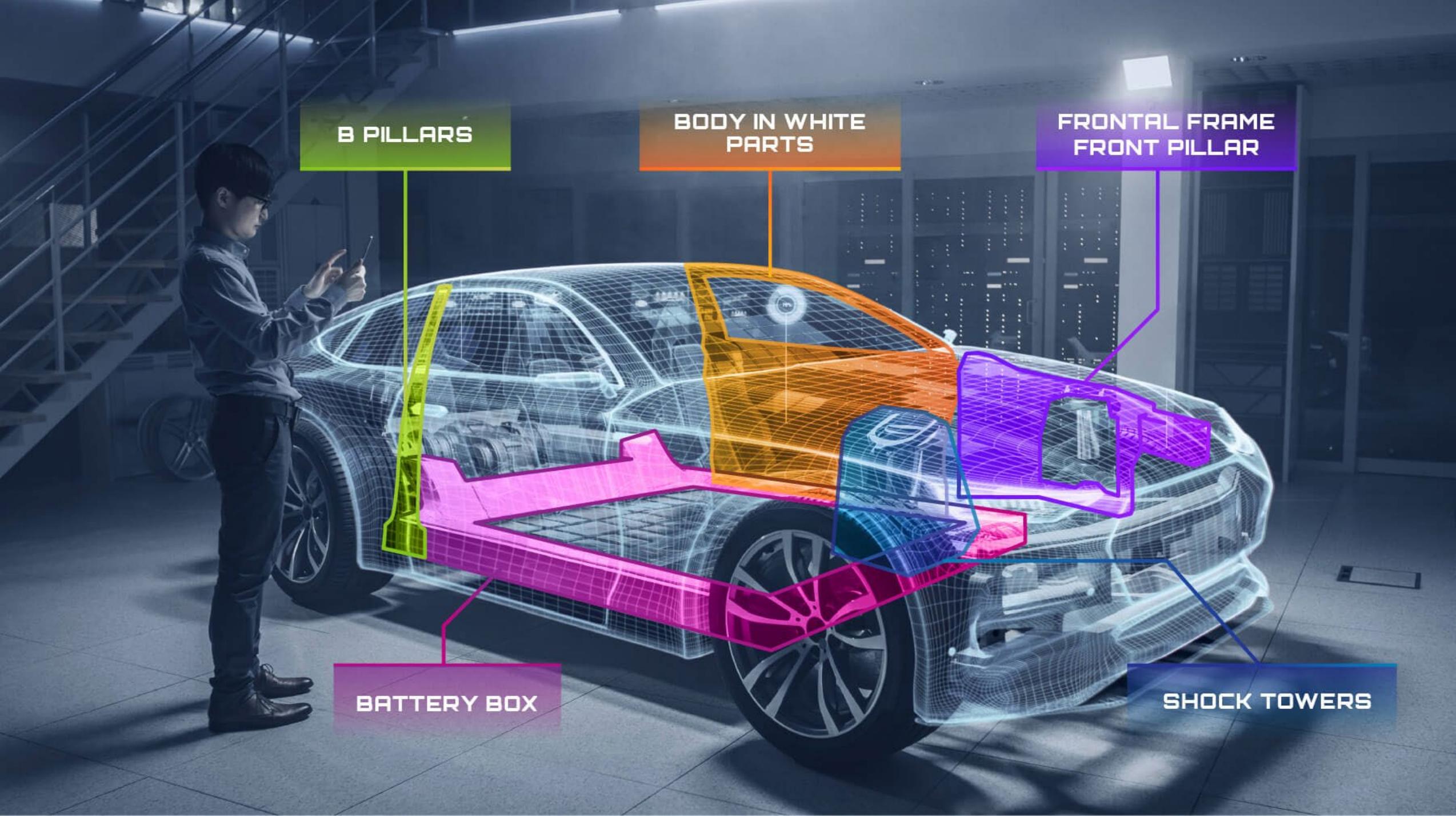
B PILLARS

BODY IN WHITE PARTS

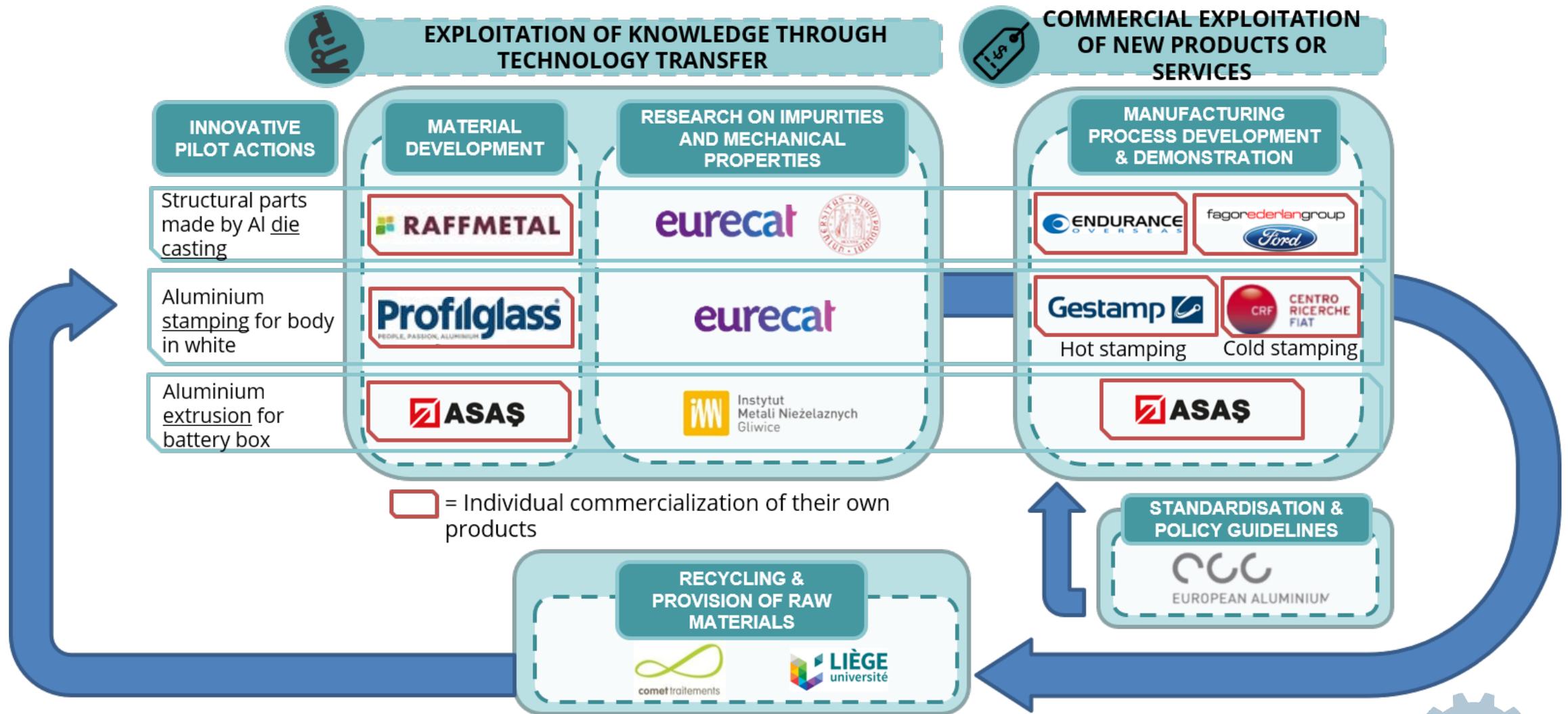
**FRONTAL FRAME
FRONT PILLAR**

BATTERY BOX

SHOCK TOWERS



PROJECT STRUCTURE



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SCRAP SORTING SYSTEM

SENSOR-BASED SORTING SYSTEM

This system was developed as a sensor-based sorting technology for a wide range of applications at the University of Liège. The core of the innovation is the capacity to sort multiple classes in a single pass using a multi-sensor acquisition system and adapt to different streams of materials.

2

DATA FUSION

The information gathered for each object from various sensors is merged or consolidated in a process known as "data fusion".

1

SENSING

High-tech sensors and cameras are employed to analyze objects, collecting relevant information about them.

3

AI

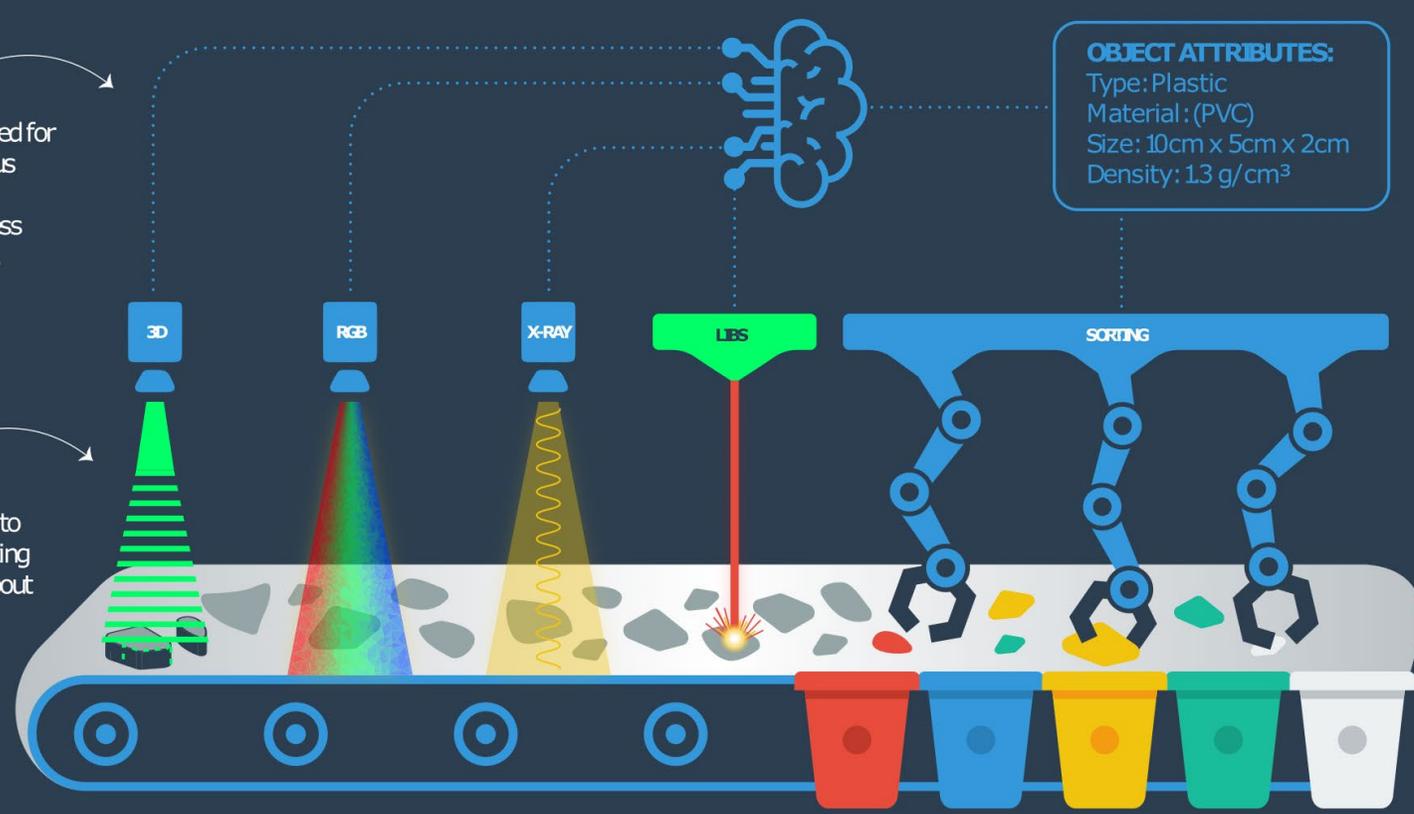
An artificial intelligence system, powered by a neural network, interprets this data to predict the characteristics or category of the object.

OBJECT ATTRIBUTES:
Type: Plastic
Material: (PVC)
Size: 10cm x 5cm x 2cm
Density: 1.3 g/cm³

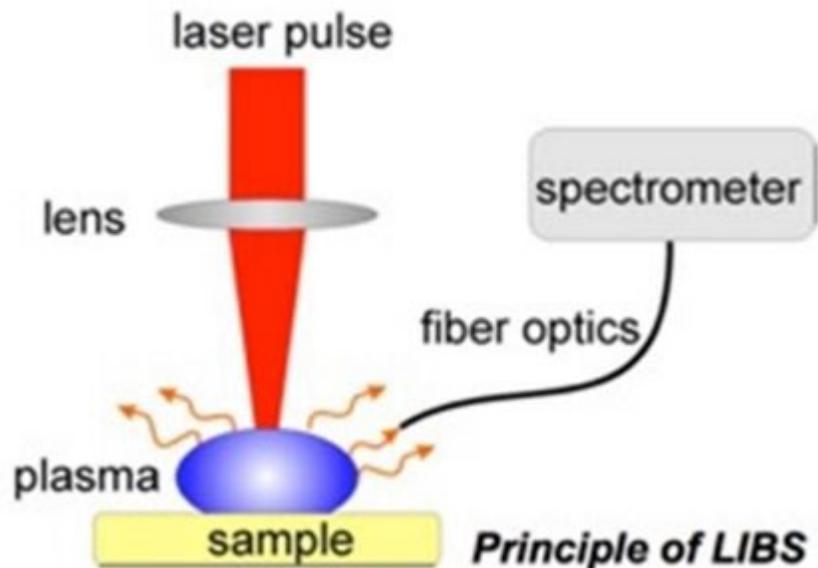
4

SORTING

The machine utilizes a combination of robots and an air ejection system to segregate objects into different categories or groups.

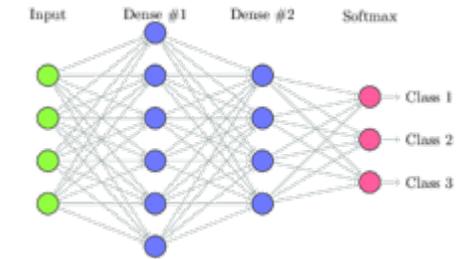


SCRAP SORTING SYSTEM



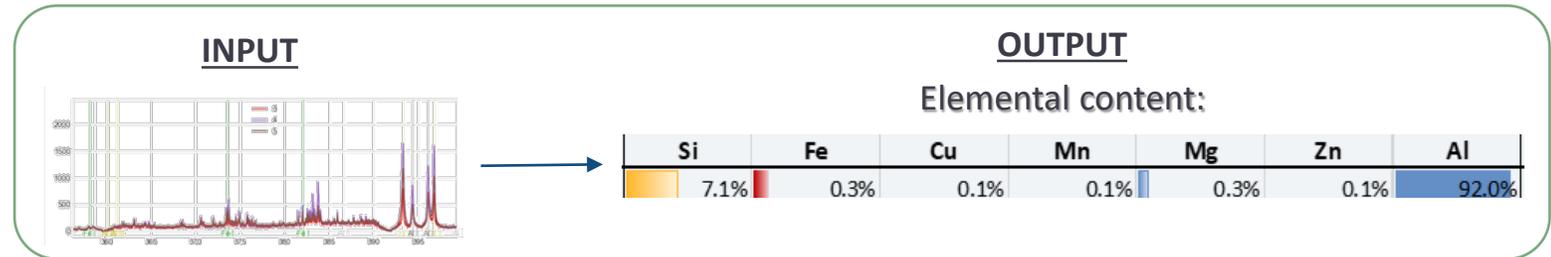
- I. Sample surface is excited by a laser
- II. Temperature increases briefly and a plasma is created
- III. When cooling down, the plasma emits light
- IV. This light contains peaks characteristic of elements present
- V. Optics collect light and transmit it to a spectrometer

SCRAP SORTING SYSTEM



Two complementary approaches:

- Multi-output regression models:
=> Chemical content estimation



- Classification models:
=> Decision for sorting



HPDC ALLOYS WITH REDUCED CRM CONTENT

Conceptual area	Characteristic of phenomenon to be modelled	Category of model
CRM content	Criticality Index	Properly developed
Castability	Fluidity (as the inverse of viscosity)	
	Solidification shrinkage	 + elaboration
	Slag/dross formation tendency	 + elaboration
	Die soldering tendency	 + elaboration
	Hot tearing tendency	 + elaboration



HPDC ALLOYS WITH REDUCED CRM CONTENT



Variants		AlSi10MnMg0.2 Set 6	AlSi10MnMg0.2 Set 7	AlSi10MnMg0.2 Set 8	AlSi10MnMg0.2 Set 8.1
		Extraction Index	Extraction Index	Extraction Index	Extraction Index
variant 1	1	0,65	0,7	0,8	0,9
variant 2	2	0,75	0,8	0,9	1,0
variant 3	3	0,85	0,9	1,0	1,1
variant 4	4	0,65	0,7	0,8	0,9
variant 5	5	0,75	0,8	0,9	1,0
variant 6	6	0,85	0,9	1,0	1,1
variant 7	7	0,65	0,7	0,8	0,9
variant 8	8	0,75	0,8	0,9	1,0
variant 9	9	0,85	0,9	1,0	1,1
variant 10	10	0,65	0,7	0,8	0,9
variant 11	11	0,75	0,8	0,9	1,0
variant 12	12	0,85	0,9	1,0	1,1
variant 13	13	0,65	0,7	0,8	0,9
variant 14	14	0,75	0,8	0,9	1,0
variant 15	15	0,85	0,9	1,0	1,1
variant 16	16	0,65	0,7	0,8	0,9
variant 17	17	0,75	0,8	0,9	1,0
variant 18	18	0,85	0,9	1,0	1,1
variant 19	19	0,65	0,7	0,8	0,9
variant 20	20	0,75	0,8	0,9	1,0
variant 21	21	0,85	0,9	1,0	1,1
variant 22	22	0,65	0,7	0,8	0,9
variant 23	23	0,75	0,8	0,9	1,0
variant 24	24	0,85	0,9	1,0	1,1
variant 25	25	0,65	0,7	0,8	0,9
variant 26	26	0,75	0,8	0,9	1,0
variant 27	27	0,85	0,9	1,0	1,1

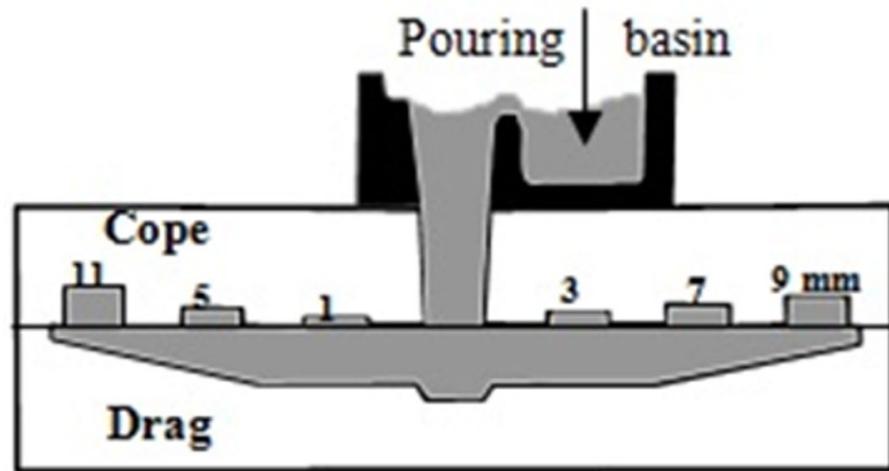
System	Set	Ranking					
		Fluidity	Solidification Shrinkage	Sludge formation	Die Soldering	Hot Tearing	CASTABILITY TOTAL
Al-Mg	1	0,6	0,6	0,3	0,8	0,2	2,5
Al4MgFe	2	0,6	0,4	0,3	1	0,6	2,9
AlSi10MnMg0.3	3	1,5	1	0,5	0,6	1	4,6
	4	1,5	1	0,5	0,6	0,6	4,2
	5	1,5	1	0,5	0,6	0,6	4,2
AlSi10MnMg0.2	6	1,5	1	0,5	0,6	0,8	4,4
	7	1,5	1	0,5	0,6	0,8	4,4
	8	1,5	1	0,4	0,6	0,6	4,1
	8.1	1,5	1	0,4	0,6	0,6	4,1
AlSi8MnMg0.3	9	1,35	0,8	0,5	0,6	1	4,25
	10	1,35	0,8	0,5	0,6	0,8	4,05
	11	1,35	0,8	0,5	0,6	0,6	3,85

System	Set	CRITICALITY INDEX	CASTABILITY TOTAL	BALANCED SCORE
Al-Mg	1	5	2,5	3,3
Al4MgFe	2	4	2,9	3,3
AlSi10MnMg0.3	3	2	4,6	3,7
	4	2	4,2	3,5
	5	2	4,2	3,5
AlSi10MnMg0.2	6	2	4,4	3,6
	7	2	4,4	3,6
	8	2	4,1	3,4
	8.1	2	4,1	3,4
AlSi8MnMg0.3	9	3	4,25	3,8
	10	3	4,05	3,7
	11	3	3,85	3,6



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HPDC ALLOY DEVELOPMENT RECYCLED



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HPDC ALLOY DEVELOPMENT RECYCLED



n=5	%Si	% Fe	%Mn	%Cu	%Zn	%Ti	%Mg
EN AB-43500	9.0-11.5	<0.2	0.4-0.8	<0.03	<0.07	<0.15	0.15-0.6
1	9.89	0.16	0.5	<0.03	<0.03	0.03	0.29
2	9.9	0.16	0.5	0.07	<0.03	0.03	0.29
3	9.81	0.17	0.5	0.13	<0.03	0.03	0.29
4	9.9	0.17	0.5	0.13	0.11	0.03	0.29
5	9.78	0.19	0.51	0.14	0.2	0.03	0.3
6	10.28	0.14	0.58	0.03	<0.03	0.06	0.16
7	10.4	0.21	0.58	0.03	<0.03	0.06	0.16
8	10.39	0.25	0.58	0.03	<0.03	0.06	0.16
9	10.3	0.26	0.61	0.03	<0.03	0.06	0.16
10	10.37	0.26	0.63	0.03	<0.03	0.06	0.16
11	10.32	0.14	0.56	0.03	<0.03	0.06	0.17
12	10.26	0.18	0.62	0.07	<0.03	0.07	0.17
13	10.27	0.21	0.6	0.06	<0.03	0.06	0.16
14	10.31	0.25	0.59	0.11	<0.03	0.06	0.16
15	10.42	0.29	0.6	0.12	<0.03	0.06	0.16



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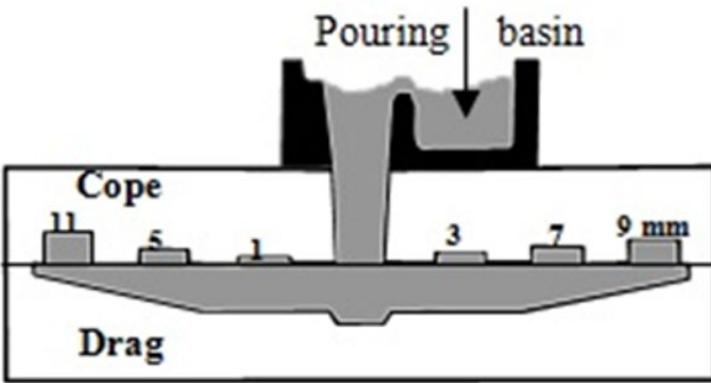
5th International Conference on
Light Materials
LightMAT 2023

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SALEMA

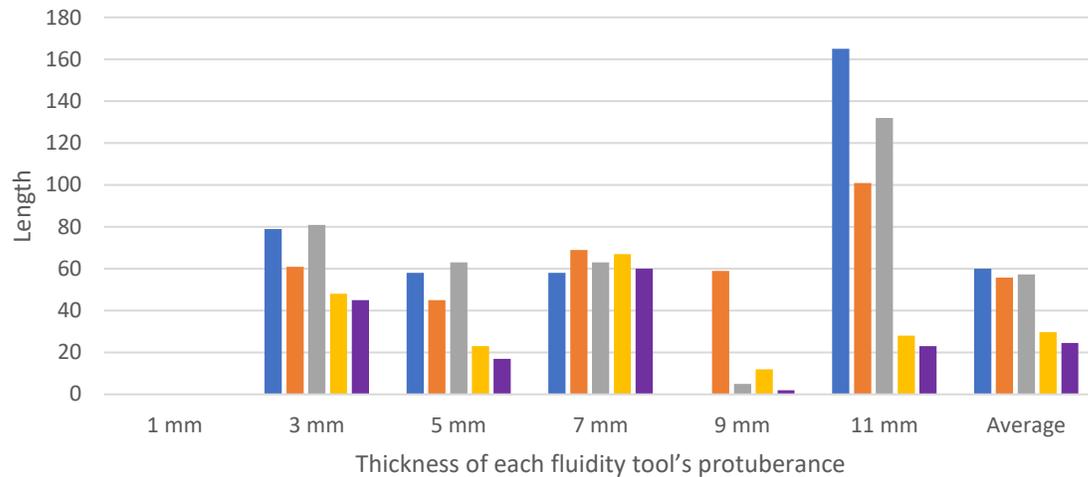


HPDC ALLOY DEVELOPMENT RECYCLED



n=5	%Si	%Fe	%Mn	%Cu	%Zn	%Ti	%Mg
EN AB-43500	9.0-11.5	<0.2	0.4-0.8	<0.03	<0.07	<0.15	0.15-0.6
1	9.89	0.16	0.5	<0.03	<0.03	0.03	0.29
2	9.9	0.16	0.5	0.07	<0.03	0.03	0.29
3	9.81	0.17	0.5	0.13	<0.03	0.03	0.29
4	9.9	0.17	0.5	0.13	0.11	0.03	0.29
5	9.78	0.19	0.51	0.14	0.2	0.03	0.3

Fluidity test result for 1st to 5th specimens



■ Sample 1 ■ Sample 2 ■ Sample 3 ■ Sample 4 ■ Sample 5

Alloy variant number	R _p [Mpa]	R _m [Mpa]	A ₂₅ [%]
1	92 ± 6	169 ± 4	5.9 ± 0.4
2	101 ± 7	177 ± 5	5.9 ± 1
3	98 ± 4	165 ± 16	3.8 ± 2.1
4	91 ± 2	173 ± 9	5.2 ± 1.3
5	105 ± 4	161 ± 27	3 ± 2.1

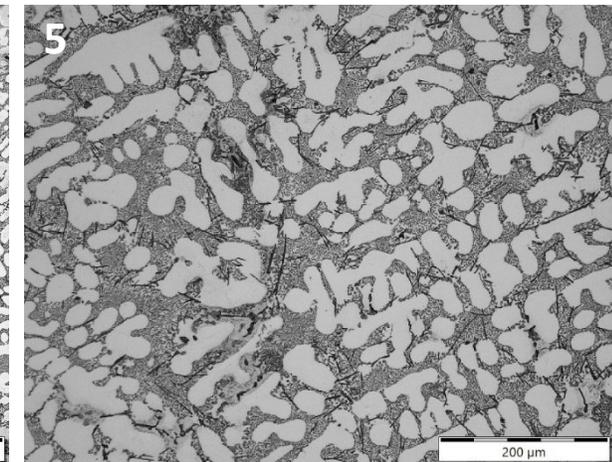
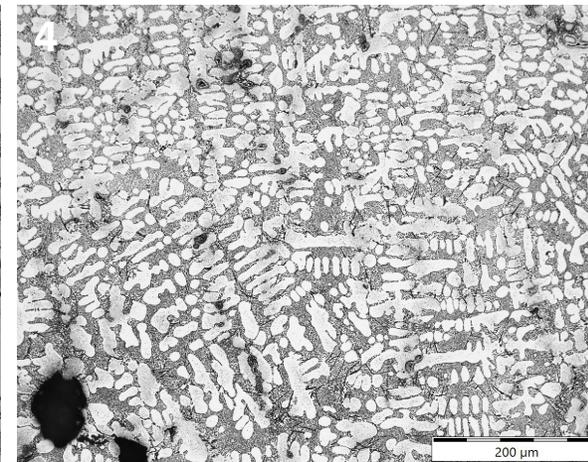
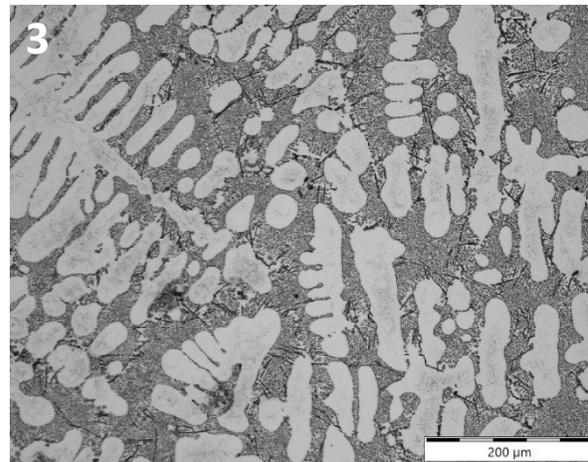
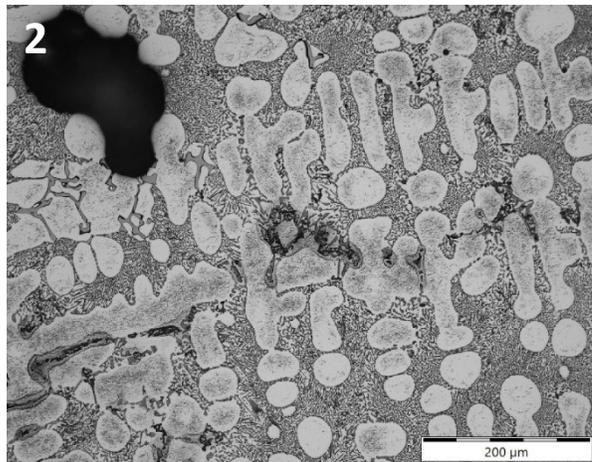
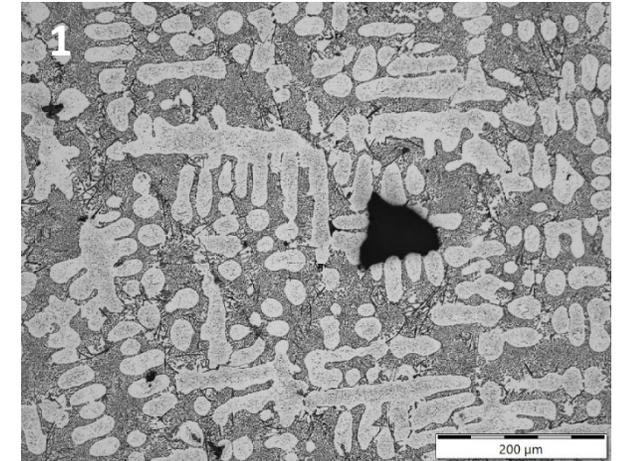


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HPDC ALLOY DEVELOPMENT RECYCLED

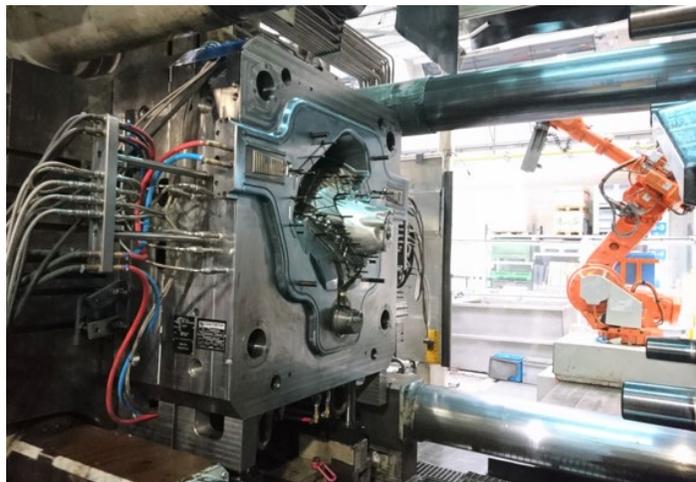
n=5	%Si	%Fe	%Mn	%Cu	%Zn	%Ti	%Mg
EN AB-43500	9.0-11.5	<0.2	0.4-0.8	<0.03	<0.07	<0.15	0.15-0.6
1	9.89	0.16	0.5	<0.03	<0.03	0.03	0.29
2	9.9	0.16	0.5	0.07	<0.03	0.03	0.29
3	9.81	0.17	0.5	0.13	<0.03	0.03	0.29
4	9.9	0.17	0.5	0.13	0.11	0.03	0.29
5	9.78	0.19	0.51	0.14	0.2	0.03	0.3



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INDUSTRIAL VALIDATION IN SHOCK-TOWER

FIRST PROTOTYPES IN EDERTEK.
(TECHNOLOGY CENTER OF FAGOR DERLAN)



F state (as cast)

AlSi10MnMg

$R_{p0,2} = 133 \text{ MPa}$

$R_m = 268 \text{ MPa}$

$A = 6,8 \%$

T7:
480°C/1h
+air cooling
+ 230°C/2h



After HT

$R_{p0,2} = 129 \text{ MPa}$

$R_m = 200 \text{ MPa}$

$A = 12,7\%$



NEXT STEPS

For HPDC:

- Production of Shock Towers with the rest of the alloy variants selected
- Production of Frontal Frame mock up with the corresponding alloy variants
- Characterization of tensile, fatigue, toughness, welding and corrosion properties of all alloy variants tested

For Stamping:

- Conclusion of the production of the hot (b-pillar mock up) and cold stamping demonstrators (door parts) and characterization of properties

For extrusion:

- Manufacturing of extrusion dies and production of the 2 extrusion demonstrators (Frontal Frame mock up and battery box profile) and characterization of properties





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