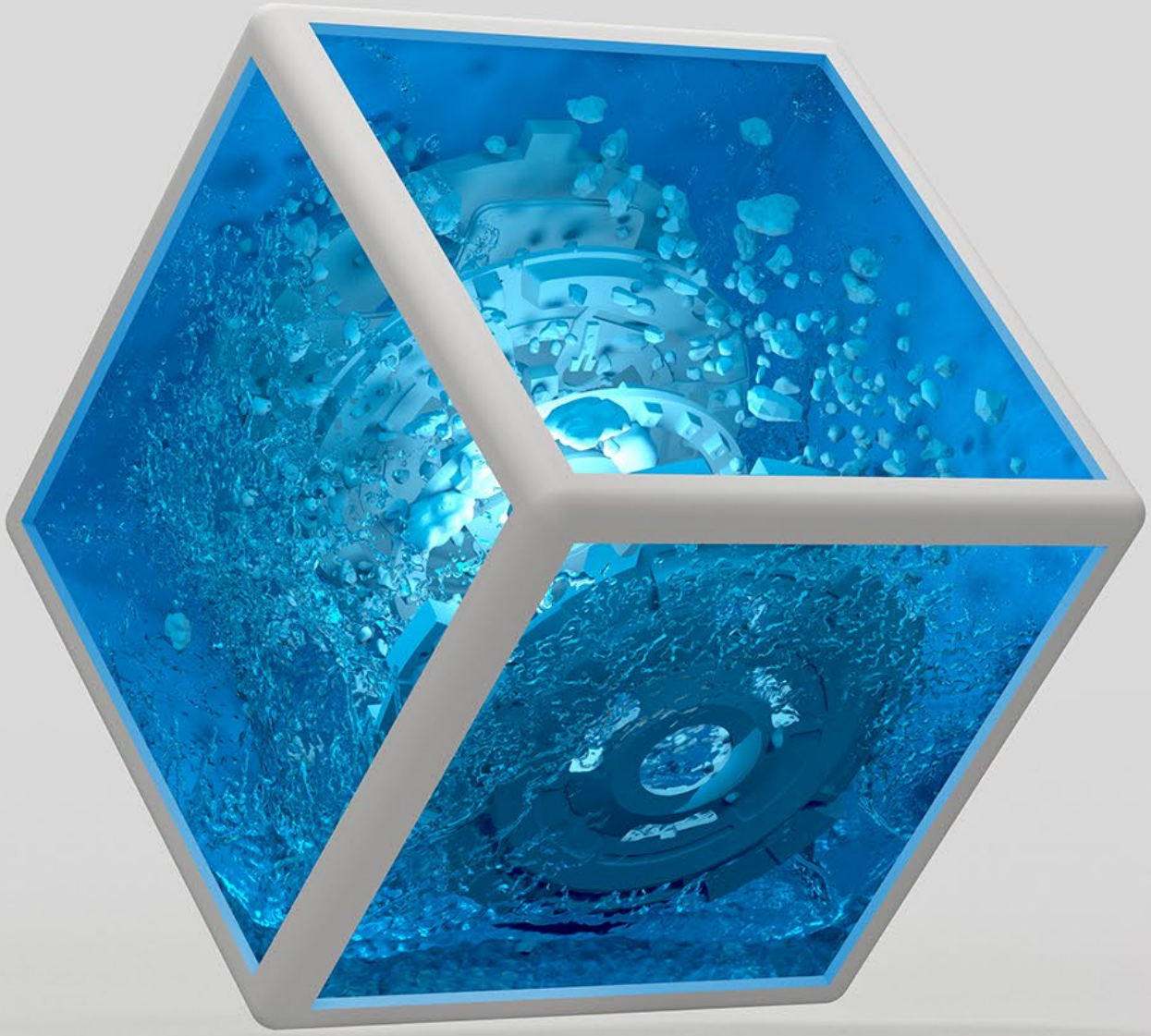

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Engineering Software Steyr GmbH

Encapsulated Paint Shop

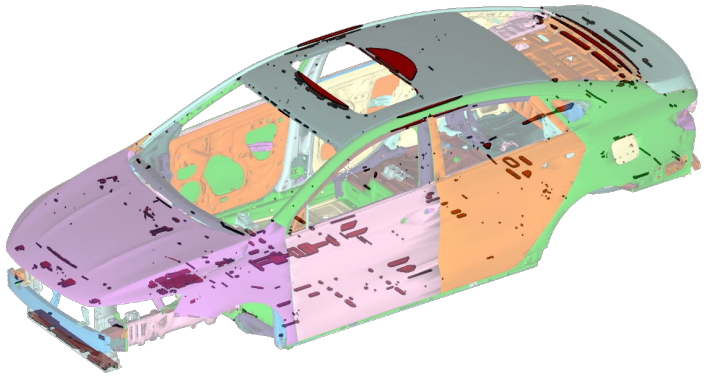
Prof. Dr. Alireza Eslamian

Paint shop by today

alsim Paint Shop

Summary of main disadvantages in state of the art :

- The whole paint shop area is a clean room, and it is difficult to keep this area clean
  - Especially due to maintenance shutdowns or environmental hazards (sandstorms etc.)
- Microorganisms are effecting the process and sustainability issues are created
- Quality issues are occuuring due to:
  - air bubble
  - liquid puddles
  - liquid carry over
  - less control due to two phase atmospheric fluid flow



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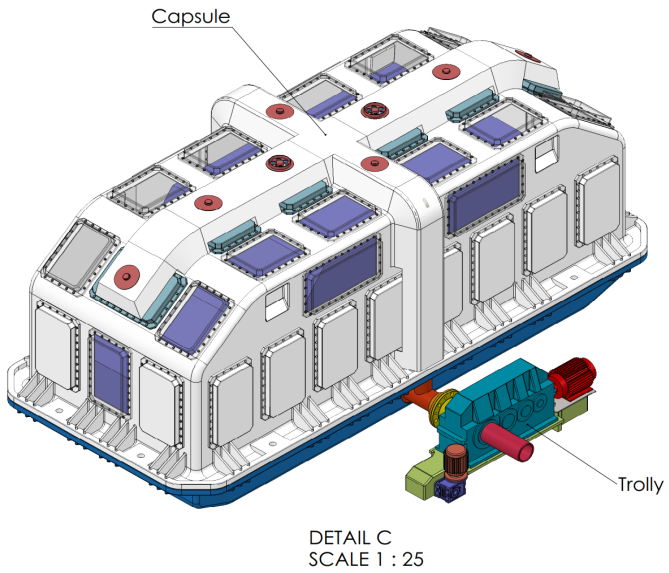
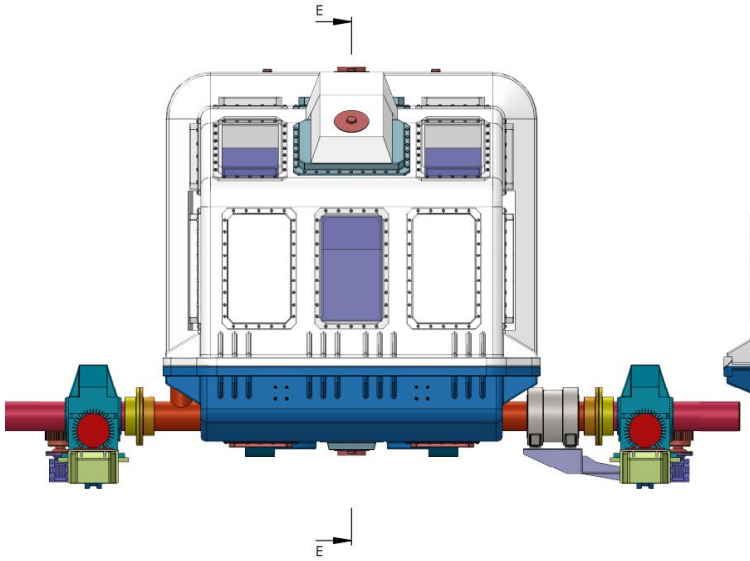
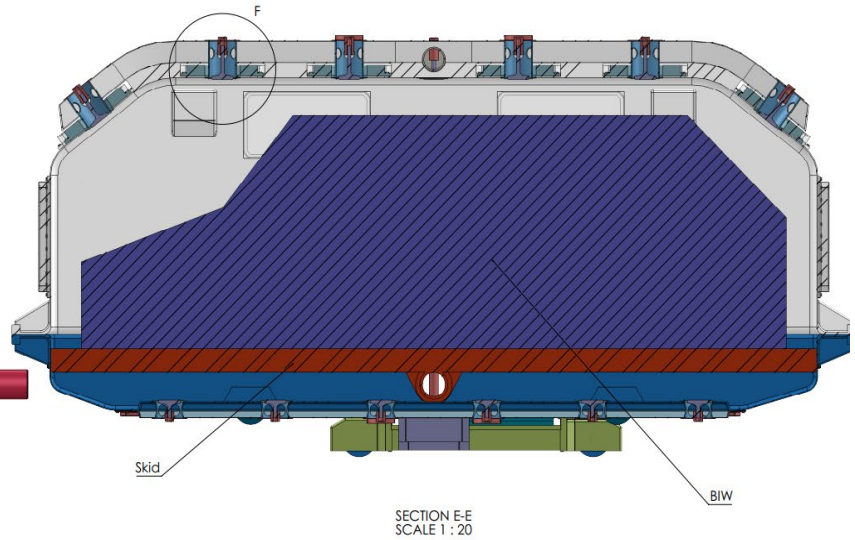
Encapsulated Paint Shop concept

alsim Paint Shop







a) Each car will be provided with a dedicated capsule

b) Each car will be processed under the closed controlled environment inside the dedicated capsule

c) Synchronization of multiple processes in one stage with optimized volume

d) Reducing wastage by optimized volumet

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Loading and unloading with robots

alsim Paint Shop

YouTube Video https://youtu.be/fQUID4B93IM

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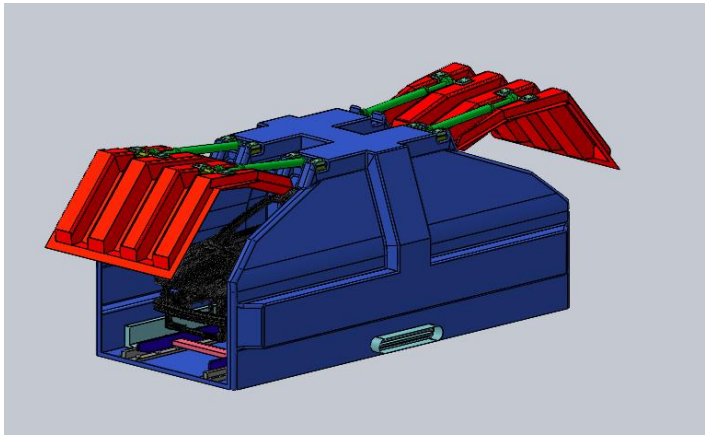
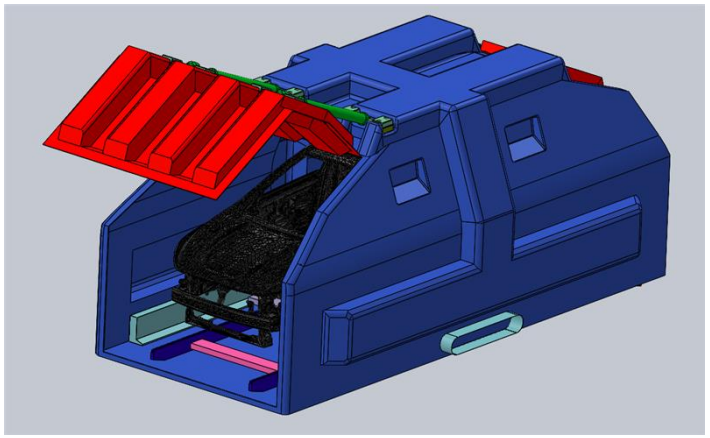
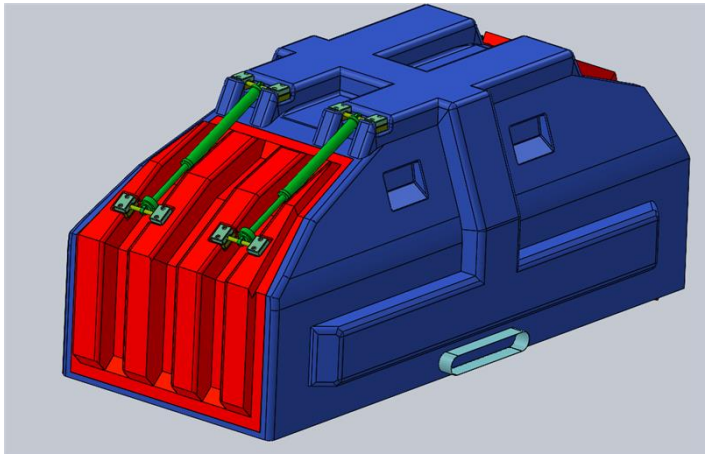
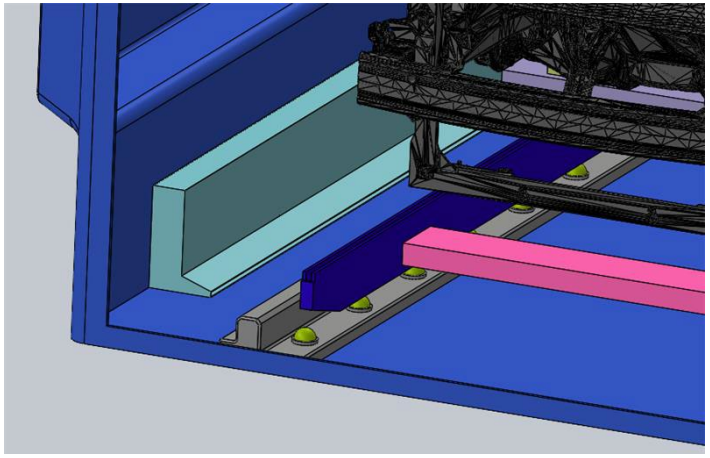
Loading and unloading with conveyors

alsim Paint Shop









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Encapsulated Paint Shop – Schematic layout

alsim Paint Shop

The Objective:

a) Reduce Space

b) Decrease capital costs and add more flexibilities for scaling up and integrating necessary changes in the future

c) Achieve highest quality

d) Reduce process tank capacity

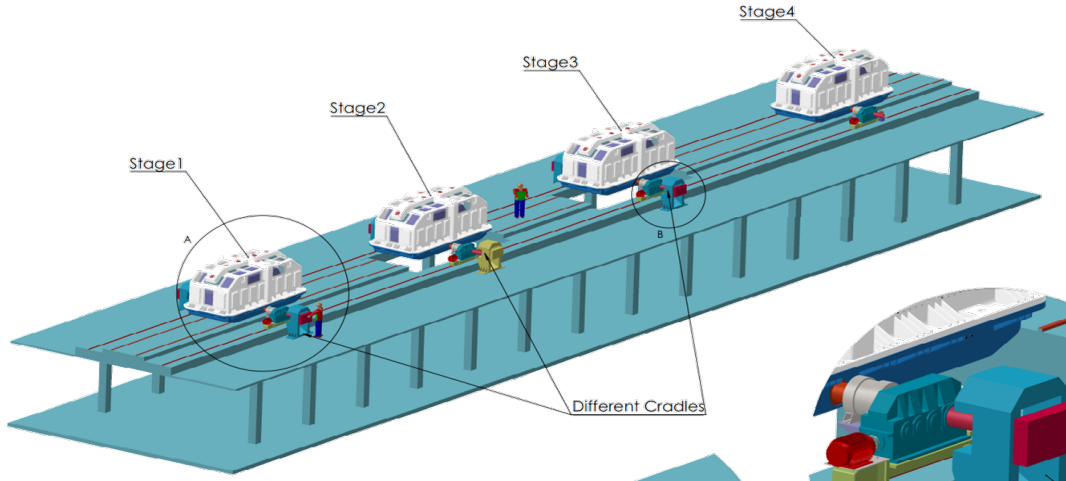
e) Reduce water consumption

f) Reduce energy consumption

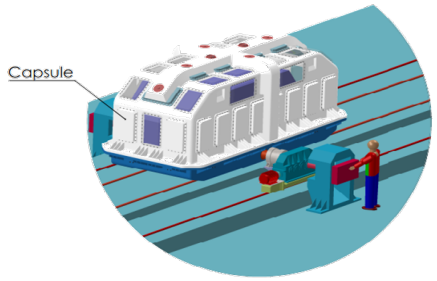
g) Reduce process time

h) Optimize chemical consumption

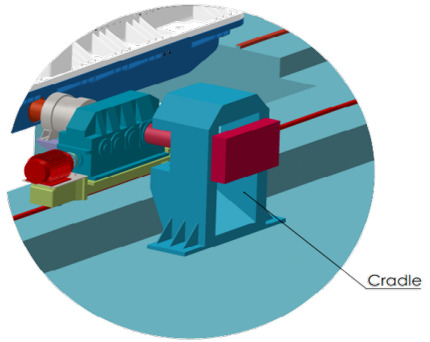
i) Reduce operating power consumption



No.	Item
1	Stage1
2	Stage2
3	Stage3
4	Stage4



DETAIL A
SCALE 1 : 50



DETAIL B
SCALE 1 : 20

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Time study – Encapsulated Paint Shop

alsim Paint Shop

12UPH line includes 18+9 Capsules in 3 different models

Cycle time (Max time taken in a process step), mins	4.87
UPH	12

	Loop 1 - Pretreatment														Loop 2 - CED	LOOP 3 - Post CED Rinses						
	Stage 1		Stage 2	Stage 3		Stage 4	Stage 5		Stage 6	Stage 7		Stage 8	Stage 9		Stage 10	Stage 11	Stage 12		Stage 13	Stage 14		Stage 15	Stage 16		Stage 17
Number of capsules	Capsule 1		Capsule 2	Capsule 3		Capsule 4	Capsule 5		Capsule 6	Capsule 7		Capsule 8	Capsule 9		Capsule 10	Capsule 1 ED	Capsule 1		Capsule 2	Capsule 3		Capsule 4	Capsule 5		Capsule 6
Process	HWR 1	HWR 2	Drain	Degreasing 1	Degreasing 2	Drain	Water Rinse 1	Water Rinse 2	Drain	Zr Treatment		Drain	Water Rinse 3	Water Rinse 4	Drain	CED Bath - Immerse	UF 1		Drain	UF 2		Drain	DI Water Rinse		Drain
	Spray	Immerse		Spray	Immerse		Spray	Immerse		Spray	Immerse		Spray	Dip		Immerse	Spray	Immerse		Spray	Immerse		Spray	Immerse	
Docking, sec	6		6	6		6	6		6	6		6	6		6	6	6		6	6		6	6		6
Time for capsule - lid lifting, sec															10										10
Time for car / capsule movement to stage, sec	10		10	10		10	10		10	10		10	10		10	10	10		10	10		10	10		10
Time for capsule- closing, sec	10															10	10								
Time to fill the process liquid to capsule, sec	60			60			60			60			60			60	60			60			60		
Process time either spray or immerse, sec		150			150			150			150			150		150		150			150			150	
Capsule draining off / emptying time, sec		30			30			30			30			30		30		30			30			30	
Residual solution drain time from BIW, sec		20	30		20	30		20	30		20	30		20	30	20		20	30		20	30		20	30
Detaching, sec		6	6		6	6		6	6		6	6		6	6	6		6	6		6	6		6	6
	86	206	52	76	206	52	76	206	52	76	206	52	76	206	62	292	86	206	52	76	206	52	76	206	62
Cycle time, sec	292			282			282			282			282			292	292			282			282		

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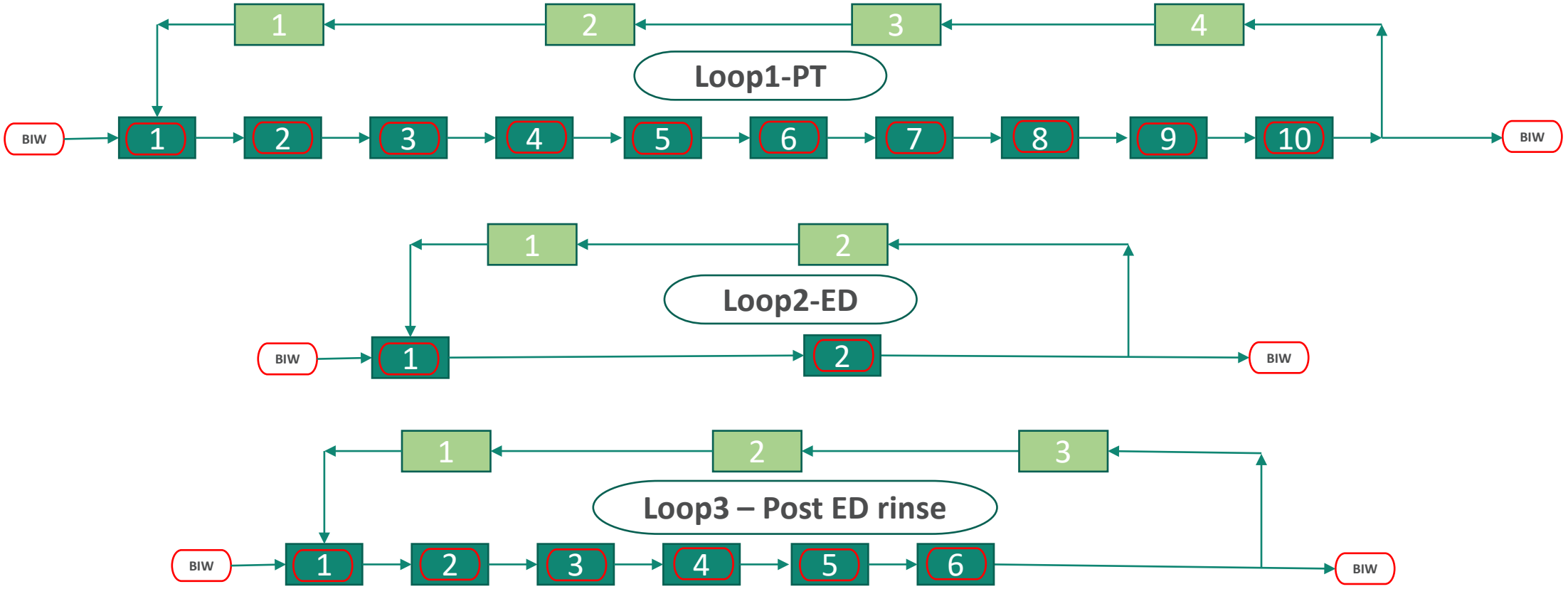
Three main loops

alsim Paint Shop

12UPH line includes 18+9 Capsules in 3 different models



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Time study – Encapsulated Paint Shop

alsim Paint Shop

38UPH line includes 22+13 Capsules in 3 different models

Cycle Time (Max time taken in a process step), min	**1.57**
UPH	**38**

	Loop 1 - Pretreatment														Loop 2 - CED			LOOP 3 - Post CED Rinses							
	Stage 1		Stage 2	Stage 3		Stage 4	Stage 5		Stage 6	Stage 7		Stage 8	Stage 9		Stage 10	Stage 11	Stage 12	Stage 13	Stage 14		Stage 15	Stage 16		Stage 17	Stage 18		Stage 19
Number of Capsules	Capsule 1		Capsule 2	Capsule 3		Capsule 4	Capsule 5		Capsule 6	Capsule 7		Capsule 8	Capsule 9		Capsule 10	Capsule 1 ED	Capsule 2 ED	Capsule 3 ED	Capsule 1		Capsule 2	Capsule 3		Capsule 4	Capsule 5		Capsule 6
Process	HWR 1	HWR 2	Drain	Degreasing 1	Degreasing 2	Drain	Water Rinse 1	Water Rinse 2	Drain	Zr Treatment		Drain	Water Rinse 3	Water Rinse 4	Drain	CED Bath - Immerse			UF 1		Drain	UF 2		Drain	DI Water Rinse		Drain
	Spray	Immerse		Spray	Immerse		Spray	Immerse		Spray	Immerse		Spray	Dip		Immerse	Immerse	Immerse	Spray	Immerse		Spray	Immerse		Spray	Immerse	
Docking, sec	3		3	3		3	3		3	3		3	3		3	6	6	6	3		3	3		3	3		3
Time for capsule - lid lifting, sec															3												3
Time for car / capsule movement to stage, sec	5		5	5		5	5		5	5		5	5		5	10	10	10	5		5	5		5	5		10
Time for capsule- closing, sec	3															6	6	6	3								
Time to fill the process liquid to capsule, sec	30			30			30			30			30			60	60	60	26			25			25		
Process time either spray or immerse, sec		30			30			30			30			30		150	150	150		30			30			30	
Capsule draining off / emptying time, sec		10			10			10			10			10		10	10	10		10			10			10	
Residual solution drain time from BIW, sec		10	15		10	15		10	15		10	15		10	15	30	30	30		10	15		10	15		10	15
Detaching, sec		3	3		3	3		3	3		3	3		3	3	6	6	6		3	3		3	3		3	3
	41	53	26	38	53	26	38	53	26	38	53	26	38	53	29	278	278	278	37	53	26	33	53	26	33	53	34
Cycle time, sec	94			91			91			91			91			93			90			86			86		34

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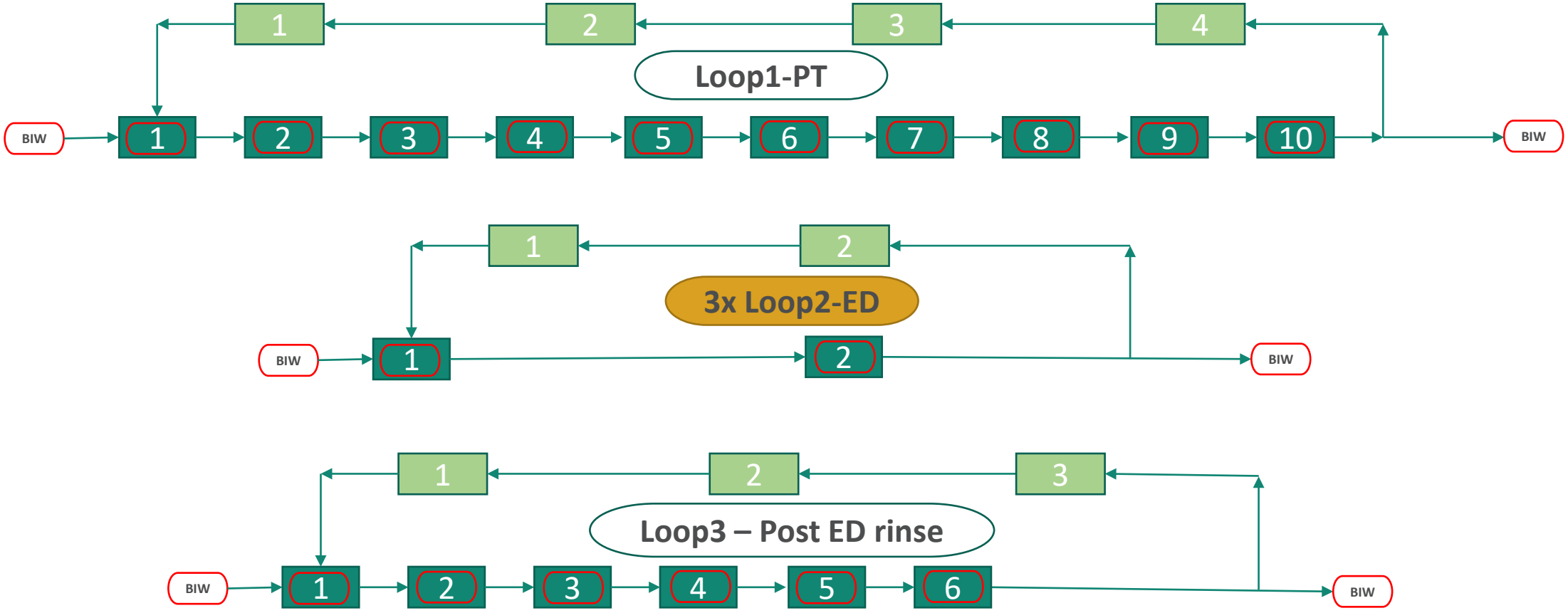
Three main loops

alsim Paint Shop

38UPH line includes 22+13 Capsules in 3 different models



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Comparison of 12UPH & 38UPH lines

alsim Paint Shop

	Loop 1 - Pretreatment															Loop 2 - CED	LOOP 3 - Post CED Rinses								
	Stage 1		Stage 2	Stage 3		Stage 4	Stage 5		Stage 6	Stage 7		Stage 8	Stage 9		Stage 10	Stage 11	Stage 12	Stage 13	Stage 14	Stage 15	Stage 16		Stage 17
Number of capsules	Capsule 1		Capsule 2	Capsule 3		Capsule 4	Capsule 5		Capsule 6	Capsule 7		Capsule 8	Capsule 9		Capsule 10	Capsule 1 ED	Capsule 1	Capsule 2	Capsule 3	Capsule 4	Capsule 5		Capsule 6
Process	HWR 1	HWR 2	Drain	Degreasing 1	Degreasing 2	Drain	Water Rinse 1	Water Rinse 2	Drain	Zr Treatment		Drain	Water Rinse 3	Water Rinse 4	Drain	CED Bath - Immerse	UF 1		Drain	UF 2		Drain	DI Water Rinse		Drain
	Spray	Immerse		Spray	Immerse		Spray	Immerse		Spray	Immerse		Spray	Dip		Immerse	Spray	Immerse		Spray	Immerse		Spray	Immerse	
Docking, sec	6		6	6		6	6		6	6		6	6		6	6	6		6	6		6	6		6
Time for capsule - lid lifting, sec															10										10
Time for car / capsule movement to stage, sec	10		10	10		10	10		10	10		10	10		10	10	10		10	10		10	10		10
Time for capsule- closing, sec	10																								
Time to fill the process liquid to capsule, sec	60																						60		
Process time either spray or immerse, sec		150			150			150			150			150		150		150			150			150	
Capsule draining off / emptying time, sec		30			30			30			30			30		30		30			30			30	
Residual solution drain time from BIW, sec		20	30		20	30		20	30		20	30		20	30	20		20	30		20	30		20	30
Detaching, sec		6	6		6	6		6	6		6	6		6	6	6		6	6		6	6		6	6
	86	206	52	76	206	52	76	206	52	76	206	52	76	206	62	292	86	206	52	76	206	52	76	206	62
Cycle time, sec	292			282			282			282			282			292	292			282			282		

12UPH line includes 18+9 Capsules in 3 different models

	Loop 1 - Pretreatment															Loop 2 - CED			LOOP 3 - Post CED Rinses								
	Stage 1		Stage 2	Stage 3		Stage 4	Stage 5		Stage 6	Stage 7		Stage 8	Stage 9		Stage 10	Stage 11	Stage 12	Stage 13	Stage 14	Stage 15	Stage 16		Stage 17	Stage 18		Stage 19
Number of Capsules	Capsule 1		Capsule 2	Capsule 3		Capsule 4	Capsule 5		Capsule 6	Capsule 7		Capsule 8	Capsule 9		Capsule 10	Capsule 1 ED	Capsule 2 ED	Capsule 3 ED	Capsule 1	Capsule 2	Capsule 3		Capsule 4	Capsule 5		Capsule 6
Process	HWR 1	HWR 2	Drain	Degreasing 1	Degreasing 2	Drain	Water Rinse 1	Water Rinse 2	Drain	Zr Treatment		Drain	Water Rinse 3	Water Rinse 4	Drain	CED Bath - Immerse			UF 1	Drain	UF 2		Drain	DI Water Rinse		Drain
	Spray	Immerse		Spray	Immerse		Spray	Immerse		Spray	Immerse		Spray	Dip		Immerse	Immerse	Immerse	Spray	Immerse	Spray	Immerse		Spray	Immerse	
Docking, sec	3		3	3		3	3		3	3		3	3		3	6	6	6	3		3	3		3		3
Time for capsule - lid lifting, sec															3										3
Time for car / capsule movement to stage, sec	5		5																			5	5		10
Time for capsule- closing, sec	3																								
Time to fill the process liquid to capsule, sec	30																						25		
Process time either spray or immerse, sec		30			30			30			30			30		150	150	150		30				30	
Capsule draining off / emptying time, sec		10			10			10			10			10		10	10	10		10				10	
Residual solution drain time from BIW, sec		10	15		10	15		10	15		10	15		10	15	30	30	30		10	15		15	10	15
Detaching, sec		3	3		3	3		3	3		3	3		3	3	6	6	6		3	3		3	3	3
	41	53	26	38	53	26	38	53	26	38	53	26	38	53	29	278	278	278	37	53	26	33	53	26	33	53	34
Cycle time, sec	94			91			91			91			91			93			90			86			86		34

38UPH line includes 22+13 Capsules in 3 different models

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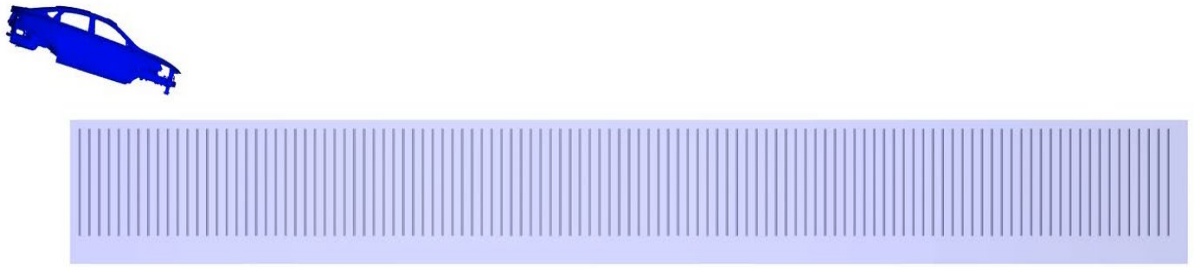
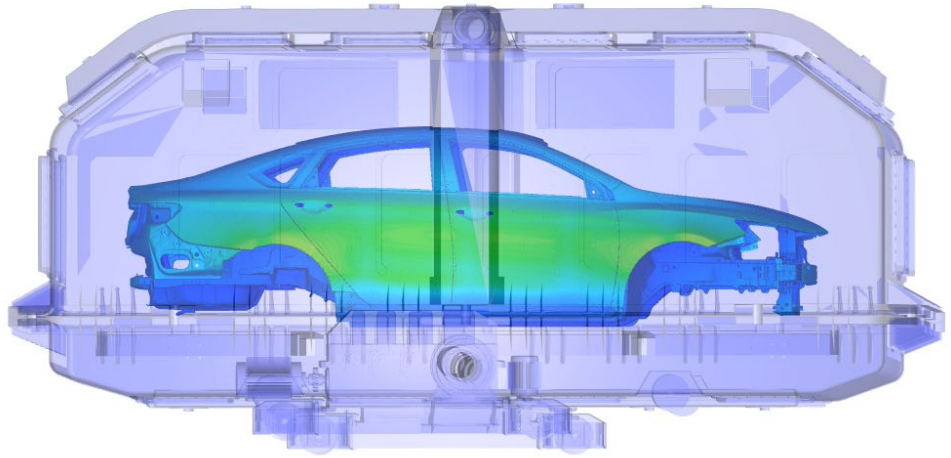
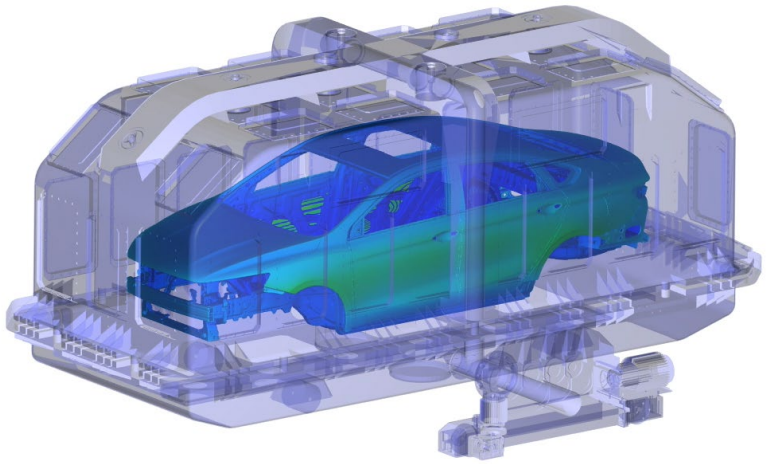
Conventional E-coating vs. Encapsulated Concept

alsim Paint Shop



Conventional e-coating





Capsule concept

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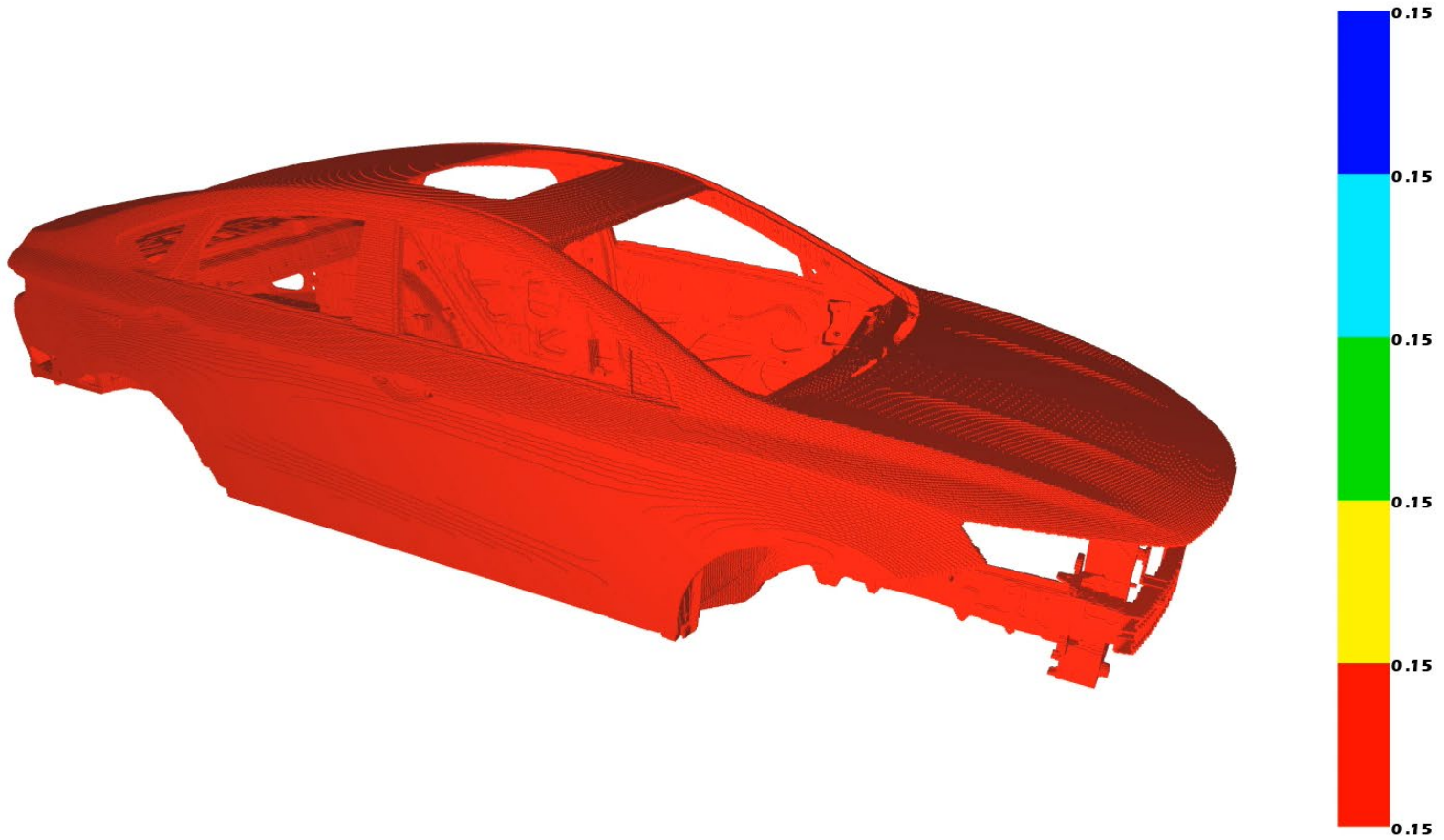
DFT build up - conventional CED process



DFT build up – Encapsulated Paint Shop process

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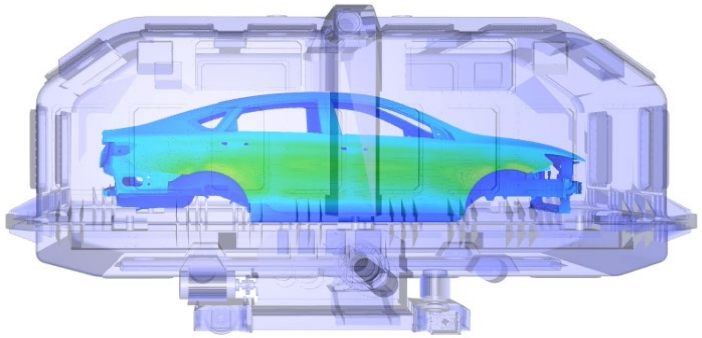

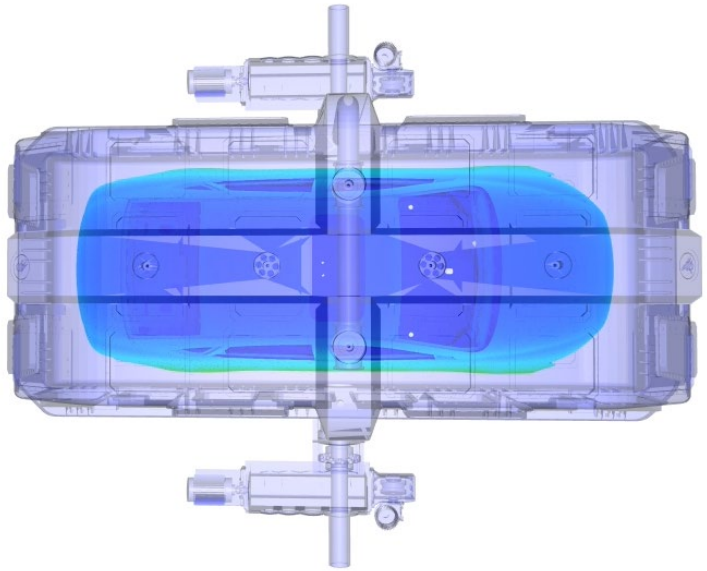

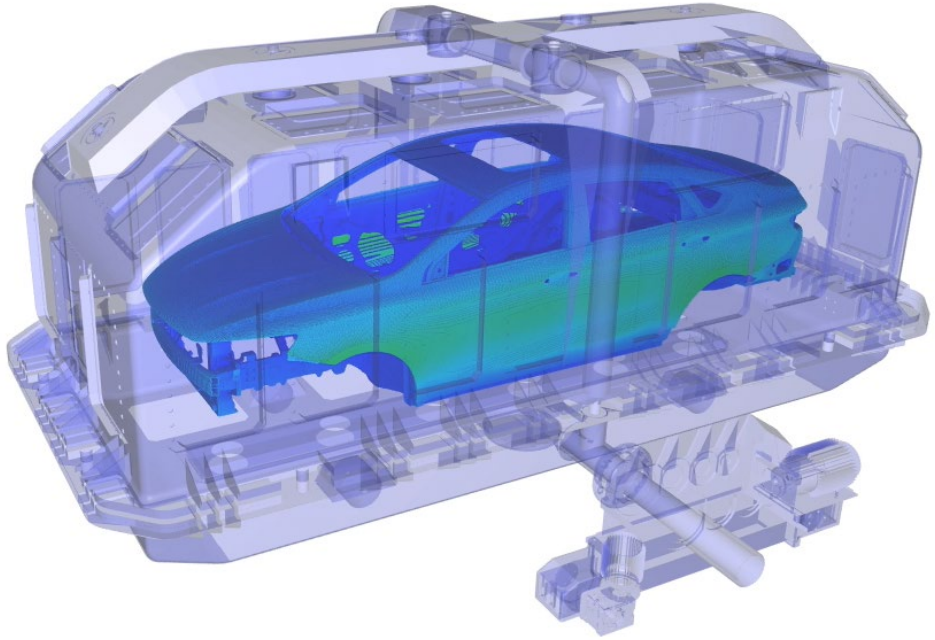

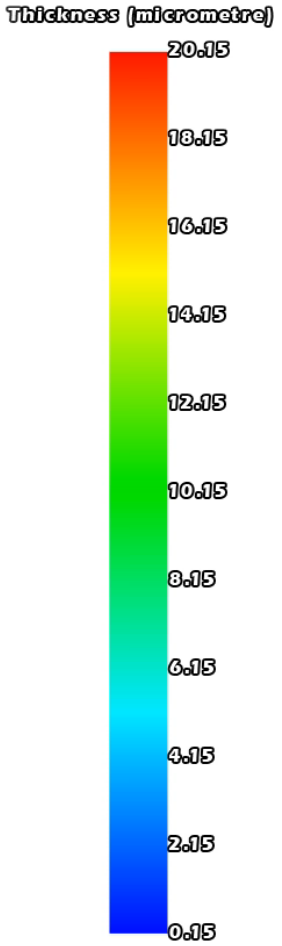

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Comparing the paint shops

alsim Paint Shop

Sl No	Description	Paint shop systems		Remark
		Convensional conveyorised paint shop	Encapsulated paint shop	
1	Over all length, m	250	150	Considering in a single line
2	Tank capacity, m^3 of dip Stages	125	Pretreatment - 40 KTL - 80	Direct saving of water interms of capacity
3	water consumption Inclusive of (DI water as RO), m^3 (during weekly maintenance and filling)	300	150	Draining of water rinses of dip , as well as spray stages
4	Chemical consumption degreasing @ 2.5% (Avg), initial filling	3125	1000	Approximate saving on chemical
5	Energy required in preteratment stages , M Kcal / hr	3.0	1.2	
6	Process time for example CED coating, min	3 - 4`	2- 2,5	
7	Anode surface area required for a car to get processed , square meter	50	25	
8	UF generation. LPH	8000	4000	May not needed higher UF generation in encapsulated ED due to less volume of UF rinses
9	Voltage profile	250 V	250V	Can be reduced
10	Average DFT across the car microns	23	26	Rocker panel DFT to be improved in encapsulated painting system

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Main Advantages

alsim Paint Shop

- Longer lasting paint shop
- Better quality
- Less wastage
- Easy to scale with production volume
- Line is flexible to new designs of car body since new car bodies can come with new capsules
- Shorter process time
- Less on-site contaminations and more sustainability
- Pressure change possible:
  - 1st reduce pressure to reduce air bubbles
  - 2nd fill completely and increase pressure to reduce remaining air bubble sizes.
- Provide a dedicated clean room for each car

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Challenges or high risks ahead

alsim Paint Shop

- Foaming of CED paint and its reduction
- Extra weight because of moving capsules
- Trial with prototype capsule
- Capsuling the oven system – still to be modelled

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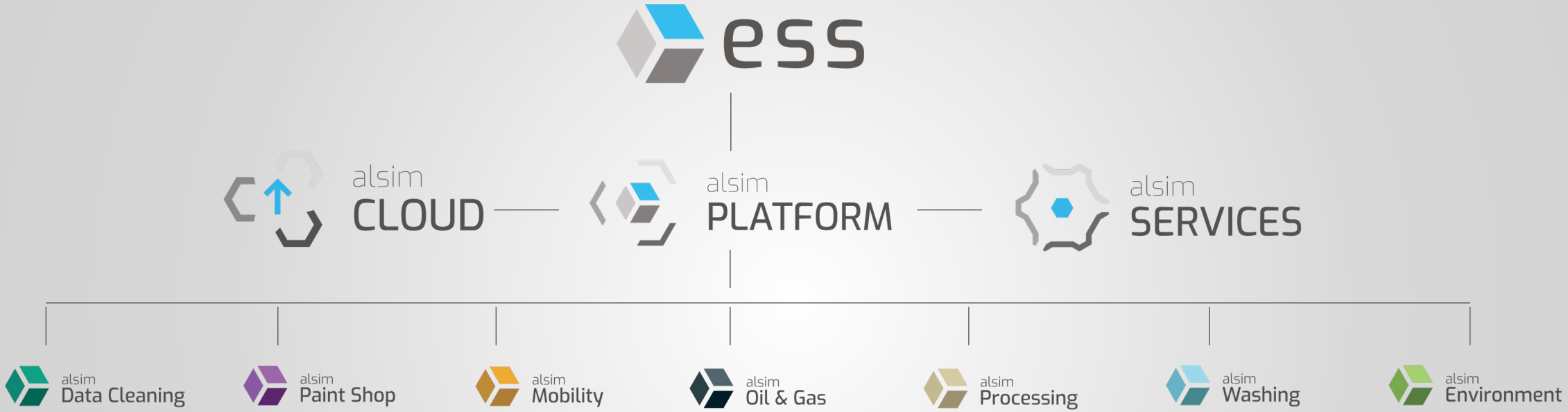

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