+ COMPETENCE
INDUSTRY
MANUFACTURING
4.0

Industria4.0: applicazioni e prospettive della manifattura additiva

E. PISINO
CIM4.0

TORINO
08-04-2022

Agenda

- Il Competence Center Nazionale CIM4.0
- Additive Manufacturing: status e prospettive
- Casi applicativi

THE COMPETENCE CENTER NETWORK

+CIM 4.0

START4.0

ARTES 4.0

CYBER 4.0

MADE Competence Center I4.0

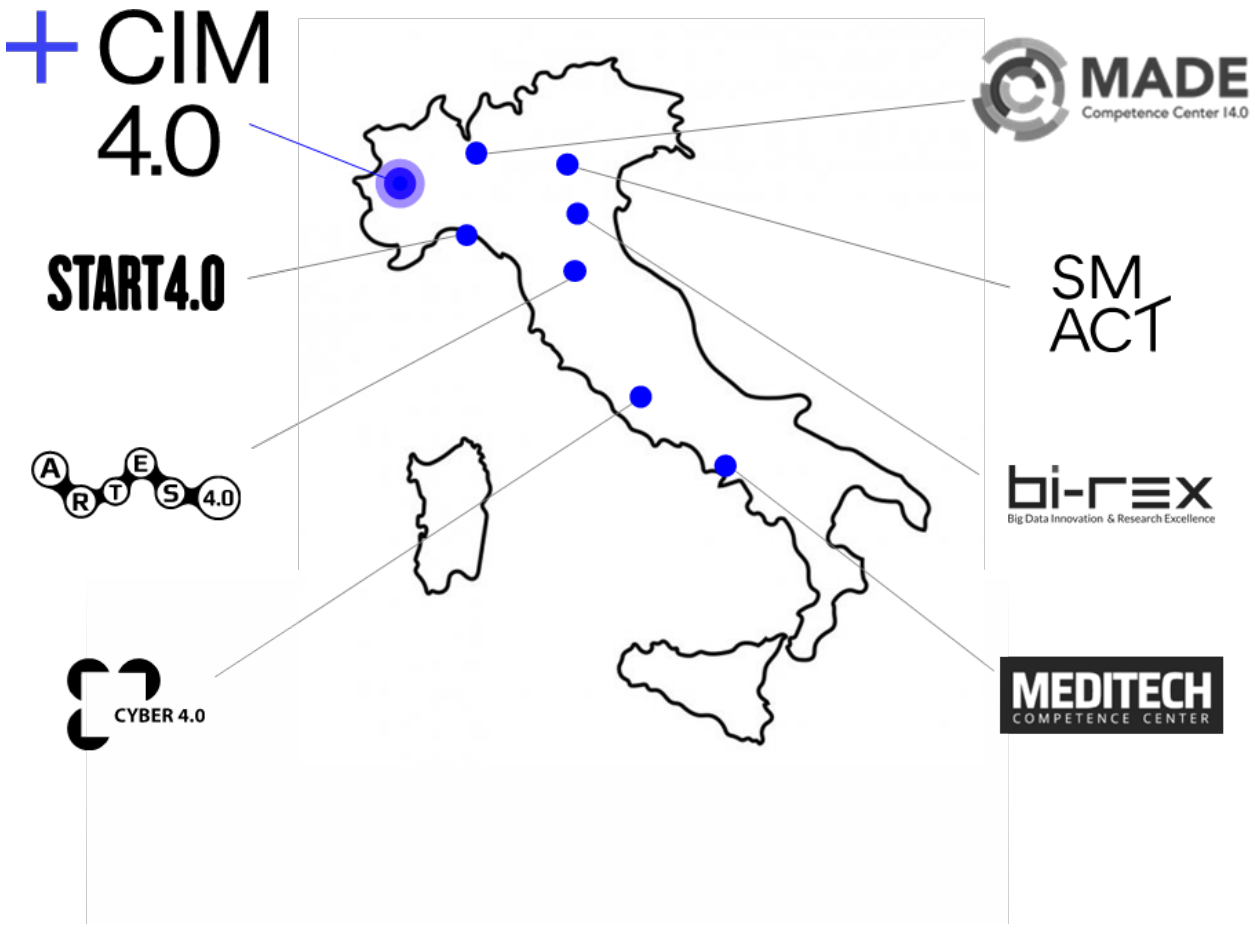
SM ACT

bi-rex Big Data Innovation & Research Excellence

MEDITECH COMPETENCE CENTER

The Competence Center creation is part of the «Piano Nazionale Industria 4.0» plan of the Italian Government

THE COMPETENCE CENTER NETWORK



Competence Center	Reference Research Centers	Investigation Areas
CIM4.0	Politecnico of Turin University of Turin	• Aerospace/Automotive • Digital Factory • Additive Manufacturing
MADE	Politecnico of Milan	• Enabling technologies • Cyber-physics systems
BI-Rex	University of Bologna	• Smart city & Logistics • Big data
Artes 4.0	Scuola Superiore Sant'Anna of Pisa	• Advanced Robotics • AI
Smact	University of Padova and al.	• Agribusiness • Clothing & Furniture • Automation
Start 4.0	University of Genova and al.	• Cybersecurity • Safety (freight transport and infrastructure)
Cyber 4.0	University "La Sapienza" of Rome	Cybersecurity
MedITech	University "Federico II" of Napoli and al.	Integration 4.0: Horizontal and Vertical

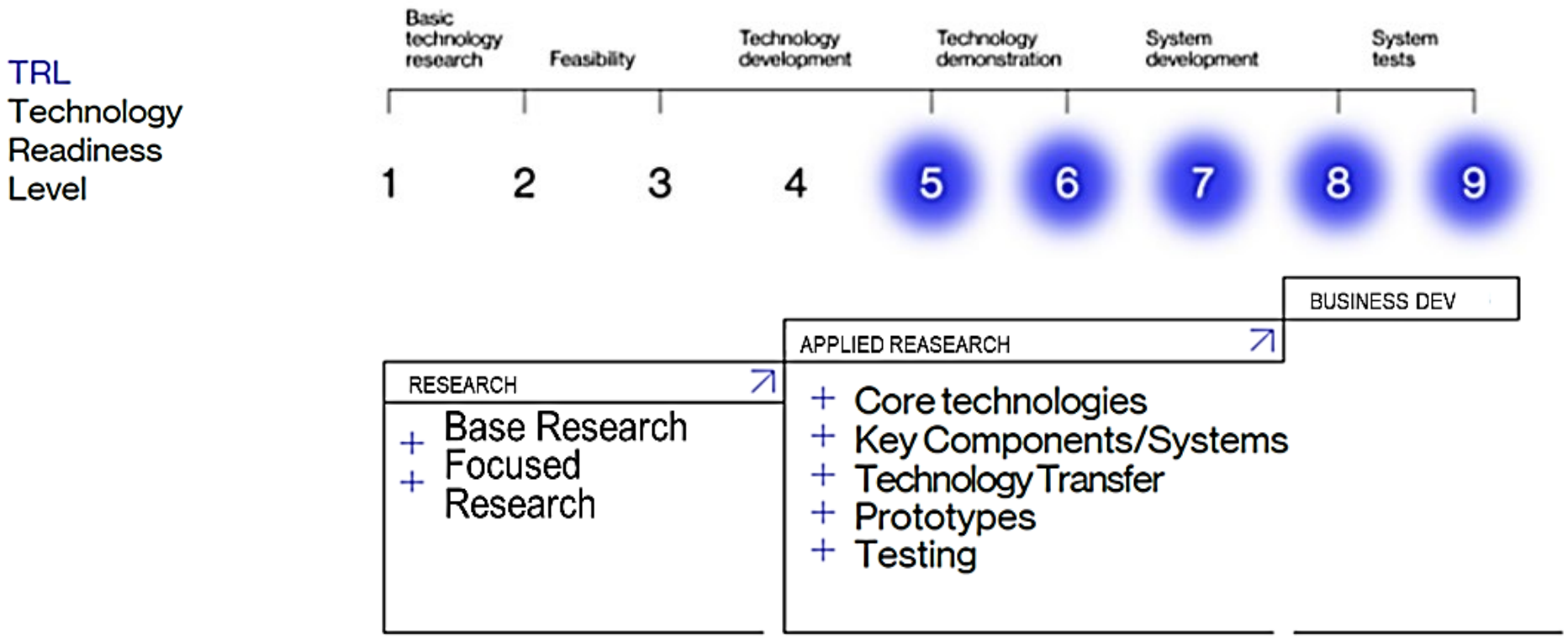
CONSORTIUM AND REFERENCE ECOSYSTEM

FULL MEMEBER
3 PUBLIC BODIES
22 ENTERPRISES
2 ENTERPRISE ASSOCIATIONS

ACTIVITY PARTNER
2/10 PARTNERS

- HIGH EDUCATION
- AUTOMOTIVE TECHNOLOGY CHAIN LEADER
- AEROSPACE TECHNOLOGY CHAIN LEADER
- SOFTWARE TECHNOLOGY PROVIDERS
- HARDWARE TECHNOLOGY PROVIDERS
- SERVICE INTEGRATORS
- END USERS

TECHNOLOGY DEVELOPMENT FOCUS



RISORSE E ASSETS

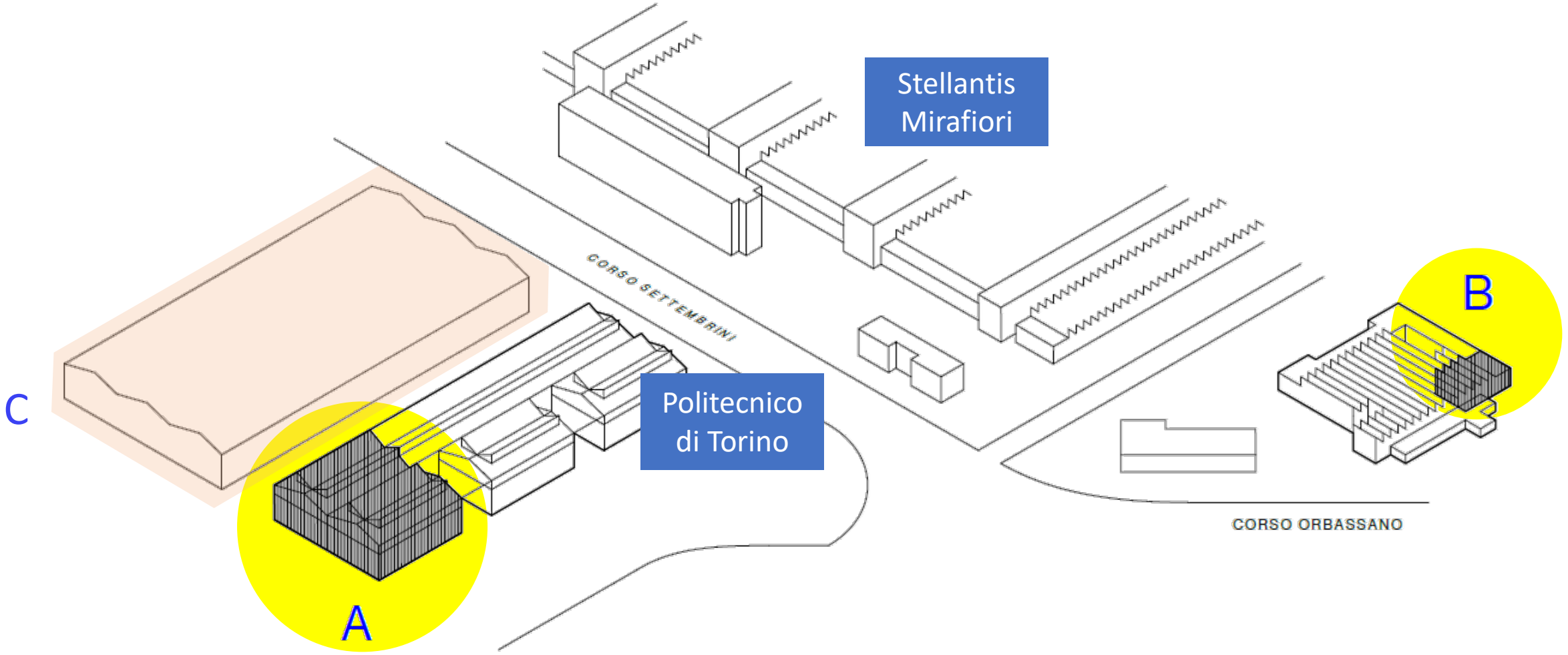
PEOPLE

+ **#20 CIM4.0 specialized personnel**
+ **#138 professional employees** of the Consortium members involved in the activities through several Working Groups (WG)
  - 82 senior resources
  - 34 junior resources
  - 7 associate professors
  - 15 full professors

ASSETS

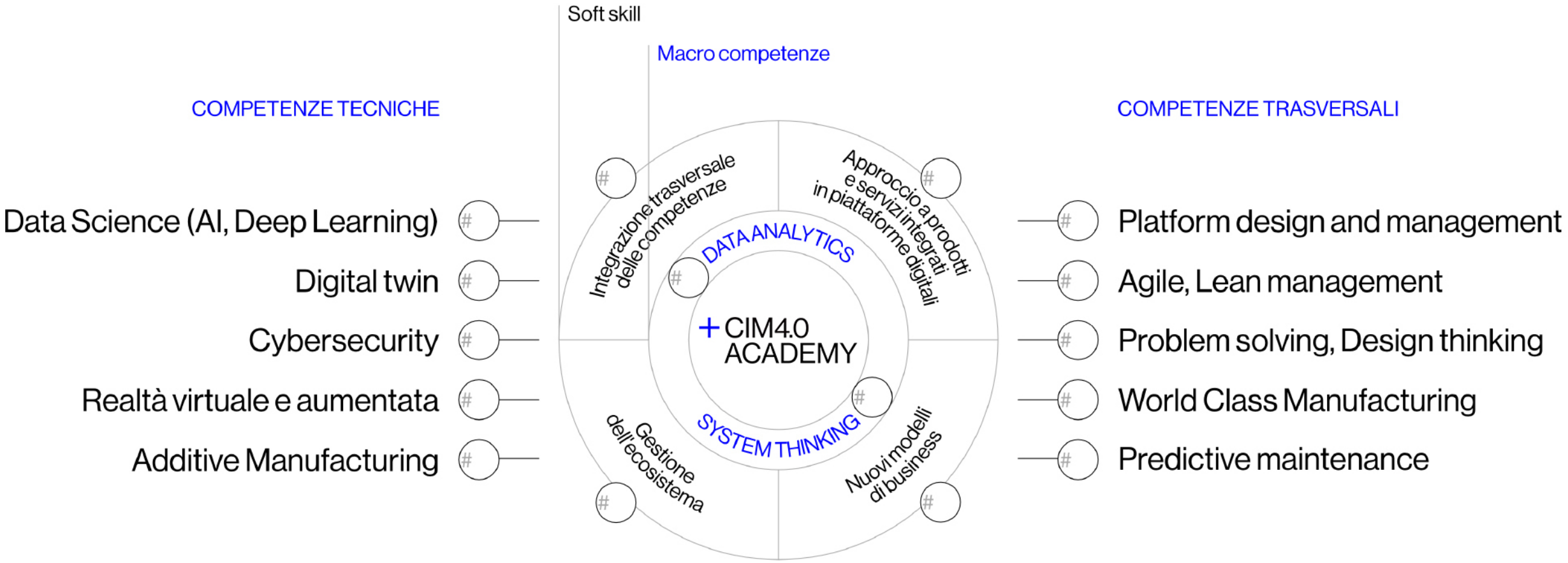
+ 2 open spaces / 20 workstations
+ 2 equipped areas dedicated to training
+ Possibility to access the learning centers of our consortium
+ **2 Pilot Lines: cutting-edge technologies and machinery**
  + **DIGITAL FACTORY**
  + **ADDITIVE MANUFACTURING**

LOCATIONS



A – Sede centrale CIM4.0, corso Settembrini 178	2100	mq
B – Additive Manufacturing Pilot Line, strada della Manta 22	1200	mq
C – New spaces	4000	mq

CONOSCENZE E COMPETENZE PER L'INDUSTRIA 4.0



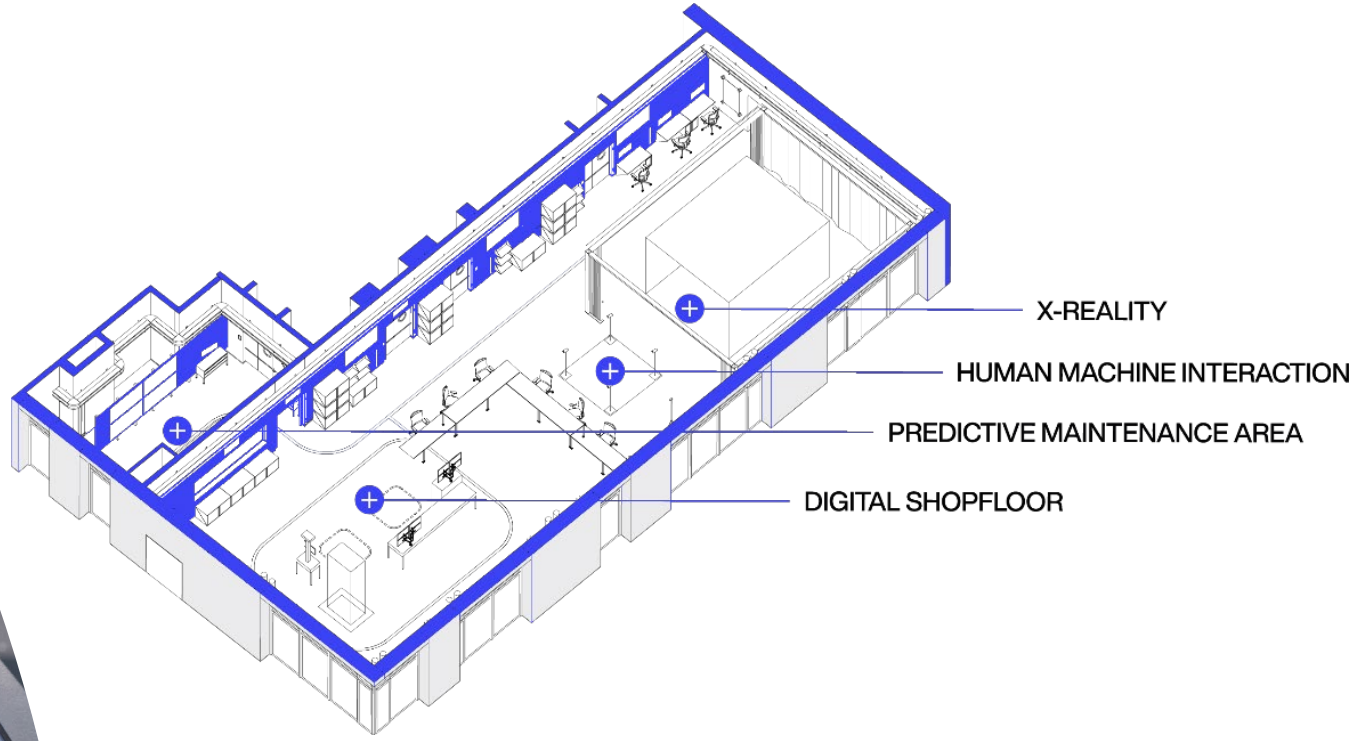
SERVIZI ALLE AZIENDE

ADDITIVE MANUFACTURING

DIGITAL FACTORY

UPSKILLING & RESKILLING

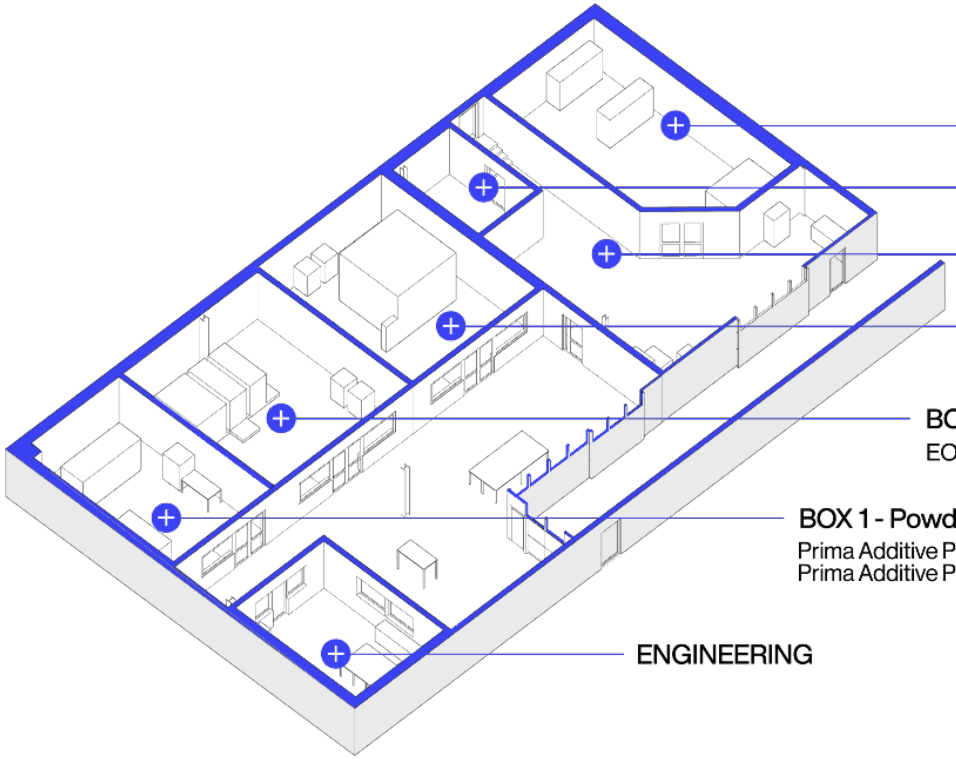
PILOT LINES



DIGITAL FACTORY

PILOT LINES SPACES
Corso Settembrini 178, Torino

PILOT LINES



WAREHOUSE

QUALITY CONTROL

POST PROCESSING

BOX 3 - Direct Energy Deposition
Prima Additive Laserdyne 811

BOX 2 - Powder Bed Fusion
EOS M-400-4

BOX 1 - Powder Bed Fusion
Prima Additive Print Genius 250
Prima Additive Print Sharp 150

ENGINEERING

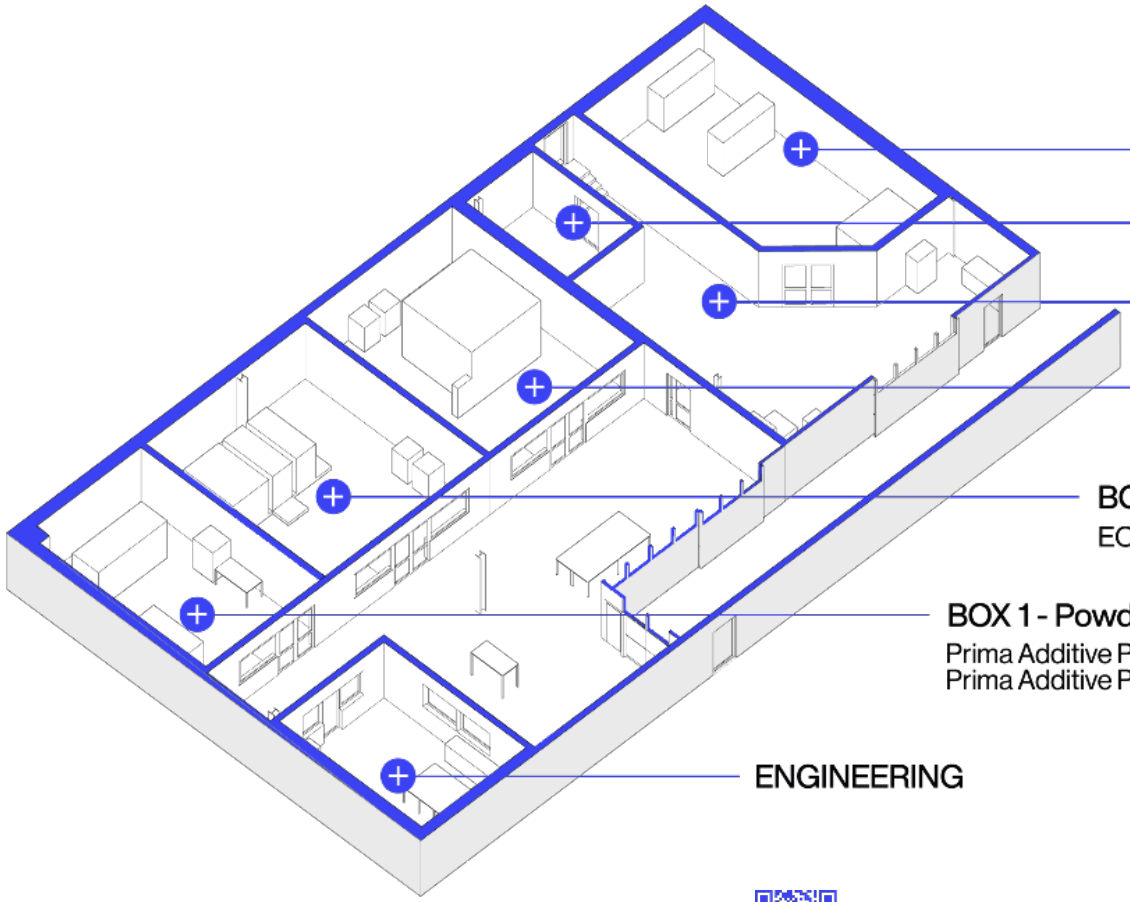
ADDITIVE MANUFACTURING

PILOT LINES SPACES
Strada della Manta 22, Torino

Additive Manufacturing Pilot Line

COMPETENCES
+ AM Machines
+ AM Processes
+ Powders and materials
+ Design and modelling for AM

SERVICES
+ Product development
+ Process parameters definition
+ Best practices definition and product certification
+ Prototypes and pre series production
+ Business and cost analysis
+ Training



WAREHOUSE

QUALITY CONTROL

POST PROCESSING

BOX 3 - Direct Energy Deposition
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Prima Additive Print Genius 250
Prima Additive Print Sharp 150

ENGINEERING

PILOT LINES SPACES
Strada della Manta 22, Torino

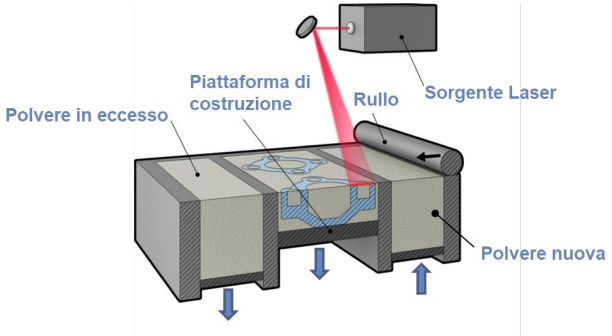
+CIM4.0

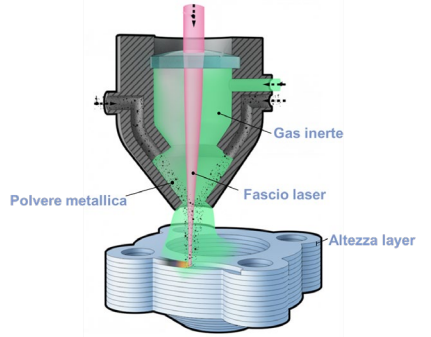
CIM4.0 – Additive Manufacturing Technology

SLM
SELECTIVE LASER MELTING

DED
DIRECT ENERGY DEPOSITION

TECHNOLOGIES





CONTEXT

+ **Realization and production of components with complex geometries of small and medium dimensions that cannot be achieved with traditional manufacturing**

+ **Repair, coatings, addition of custom details, construction of components with a not complex but large geometry**

OBJECTIVE

+ **Process development**: productivity, industrialization, controls on the entire production chain, standardization and automation, validations and certifications
+ **Product development**: product validation and product production, cost reduction
+ **Application development**: maturation in the use of technology in SMEs, guides to DFAM and application

+ **Process development**: deposition quality, accuracy, new materials, productivity and controls during deposition
+ **Application development**: identification in application terms of the needs of OEMs and large companies, application maturation and technology transfer

CIM4.0 – Additive Pilot Line Machinery

SELECTIVE LASER MELTING

Prima Industrie Print Sharp 150

SPECIFICATION

+ Volume: Ø 150 mm, H 160 mm
+ 250WSingle Laser Fiber
+ 8kW
+ Tolerance 0,1 mm

Materials:

+ Aluminum
+ Steel
+ Titanium
+ Nickel based alloys

Prima Industrie Print Genius 250

SPECIFICATION

+ Volume: 262*262*350 mm
+ 500W double Laser Fiber
+ 10kW
+ Tolerance 0,1 mm

Materials:

+ Aluminum
+ Steel
+ Titanium
+ Nickel based alloyl

EOS M400-4

SPECIFICATION

+ Volume: 400*400*400 mm
+ 400W 4 Laser Fiber
+ 22 kW
+ Tolerance 0,1 mm

Materials:

+ Aluminum
+ Steel
+ Titanium
+ Nickel based alloys

DIRECT ENERGY DEPOSITION

Prima Industrie Laserdyne 811

SPECIFICATION

+ Volume: 1100*800*600 mm
+ 3000W Single Laser Fiber
+ 35 kW
+ Tolerance 0,2 mm

Materials:

+ Steel

Agenda

- Il Competence Center Nazionale CIM4.0
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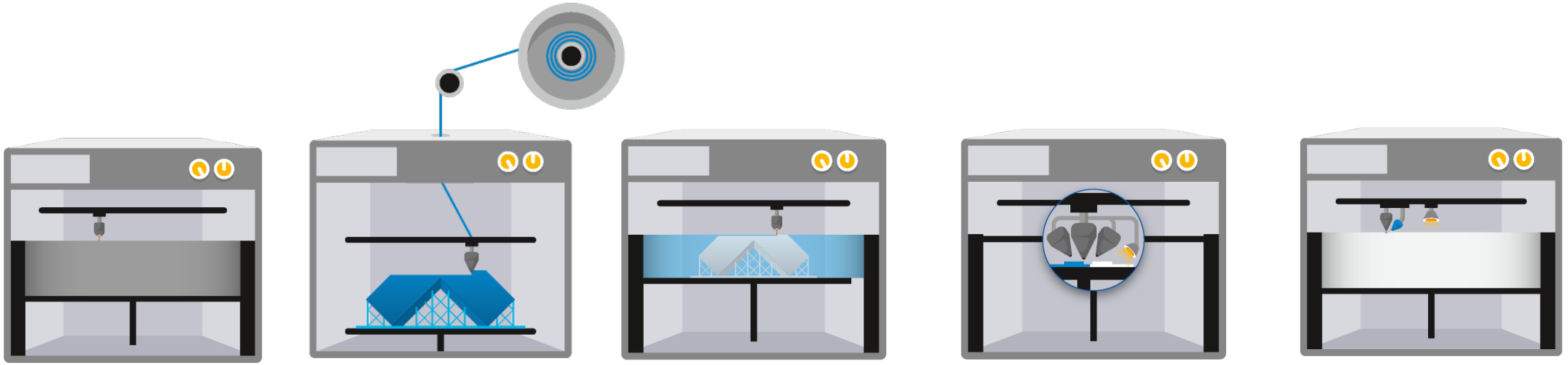
ADDITIVE MANUFACTURING

"Il processo di unione dei materiali per creare oggetti tramite dati provenienti dal modello 3D, di solito strato su strato, al contrario delle metodologie di produzione sottrattiva"

Cambio di paradigma: da tecnologie ***sottrattive*** a ***additive***



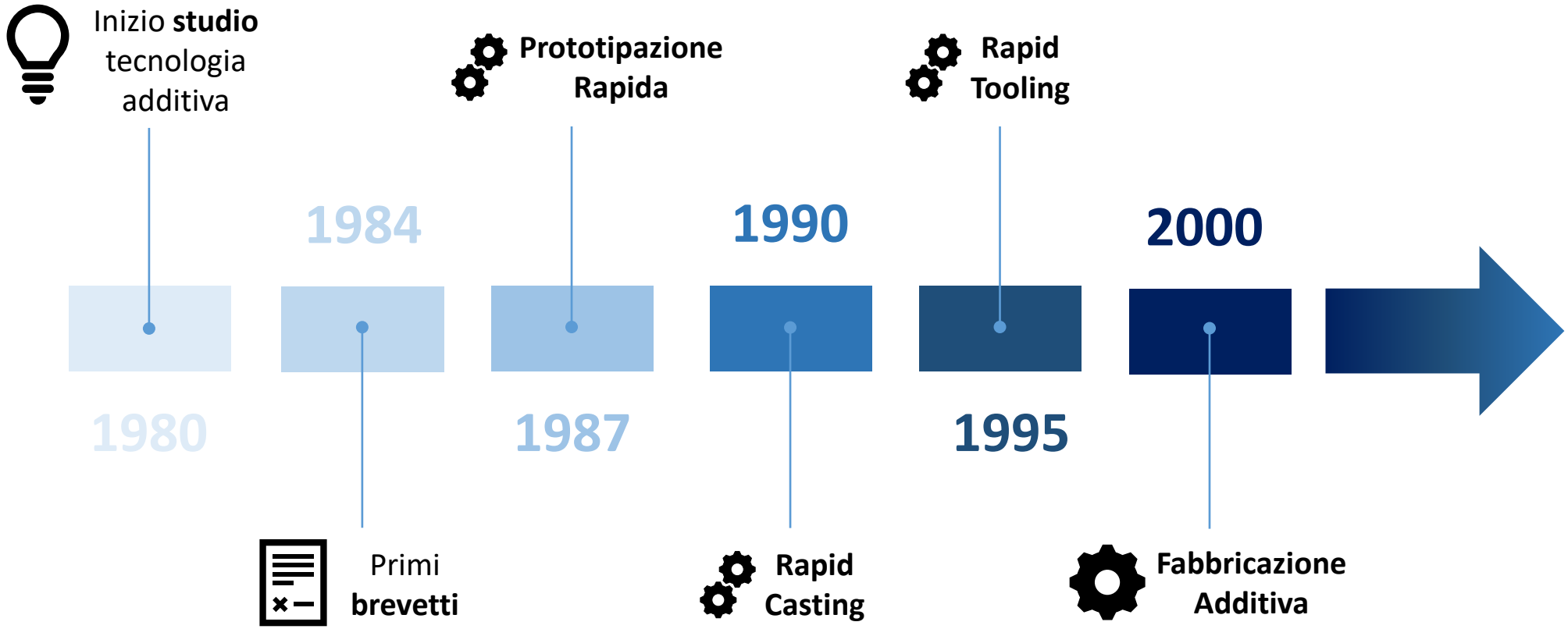
Powder Bed Fusion | ***Material Extrusion*** | **Vat Photopolimerization** | **Material jetting** | **Binder jetting**

materialise.com

Additive manufacturing - General principles - Terminology (ISO/ASTM 52900:2015)

+CIM4.0

LA STORIA


Inizio **studio** tecnologia additiva
1980
1984
Primi **brevetti**
Prototipazione Rapida
1987
1990
Rapid Casting
Rapid Tooling
1995
2000
Fabbricazione Additiva

LA STORIA

1987

Primi **brevetti**

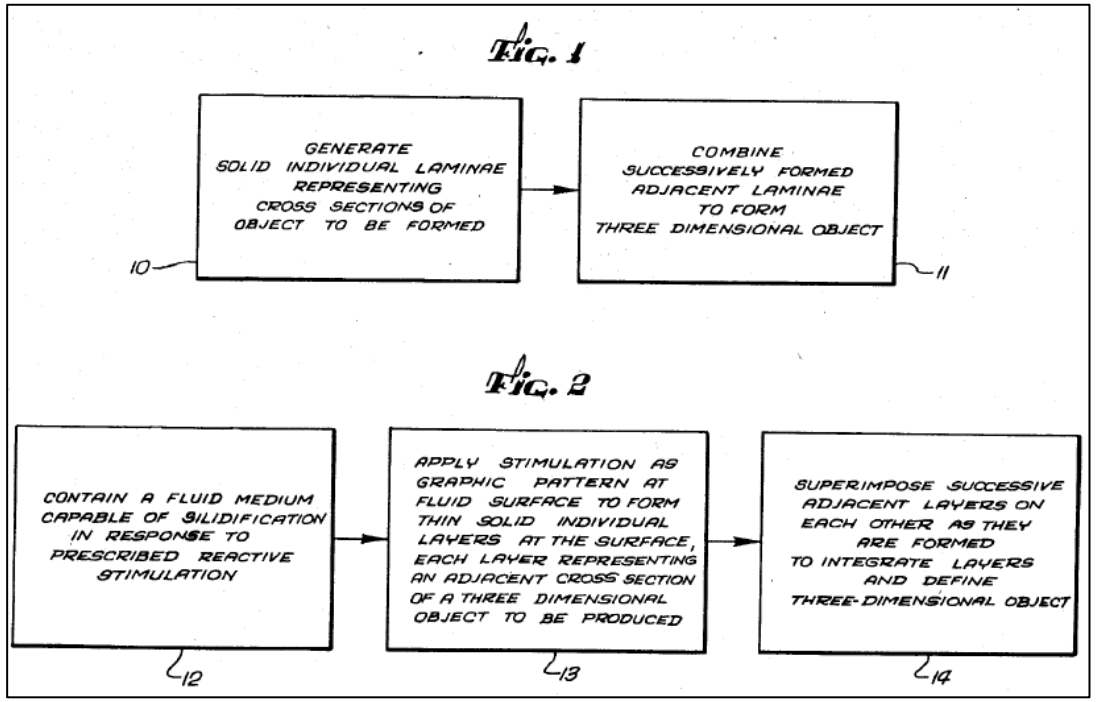
United States Patent [19]

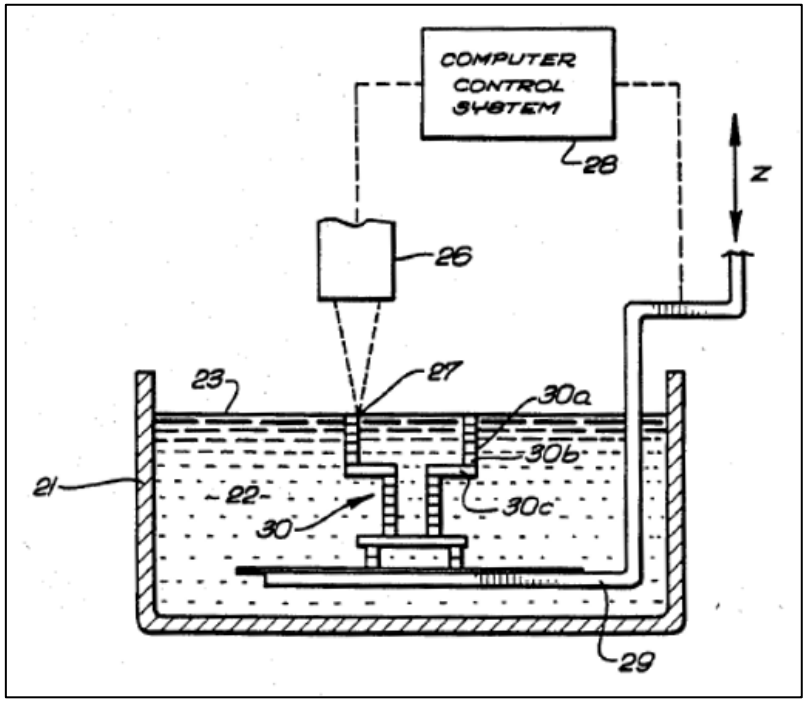
Hull

[54] **APPARATUS FOR PRODUCTION OF THREE-DIMENSIONAL OBJECTS BY STEREOLITHOGRAPHY**

[57] **ABSTRACT**

A system for generating three-dimensional objects by creating a cross-sectional pattern of the object to be formed at a selected surface of a fluid medium capable of altering its physical state in response to appropriate synergistic stimulation by impinging radiation, particle bombardment or chemical reaction, successive adjacent laminae, representing corresponding successive adjacent cross-sections of the object, being automatically formed and integrated together to provide a step-wise laminar buildup of the desired object, whereby a three-dimensional object is formed and drawn from a substantially planar surface of the fluid medium during the forming process.





+CIM4.0

LA STORIA

+CIM4.0

1984

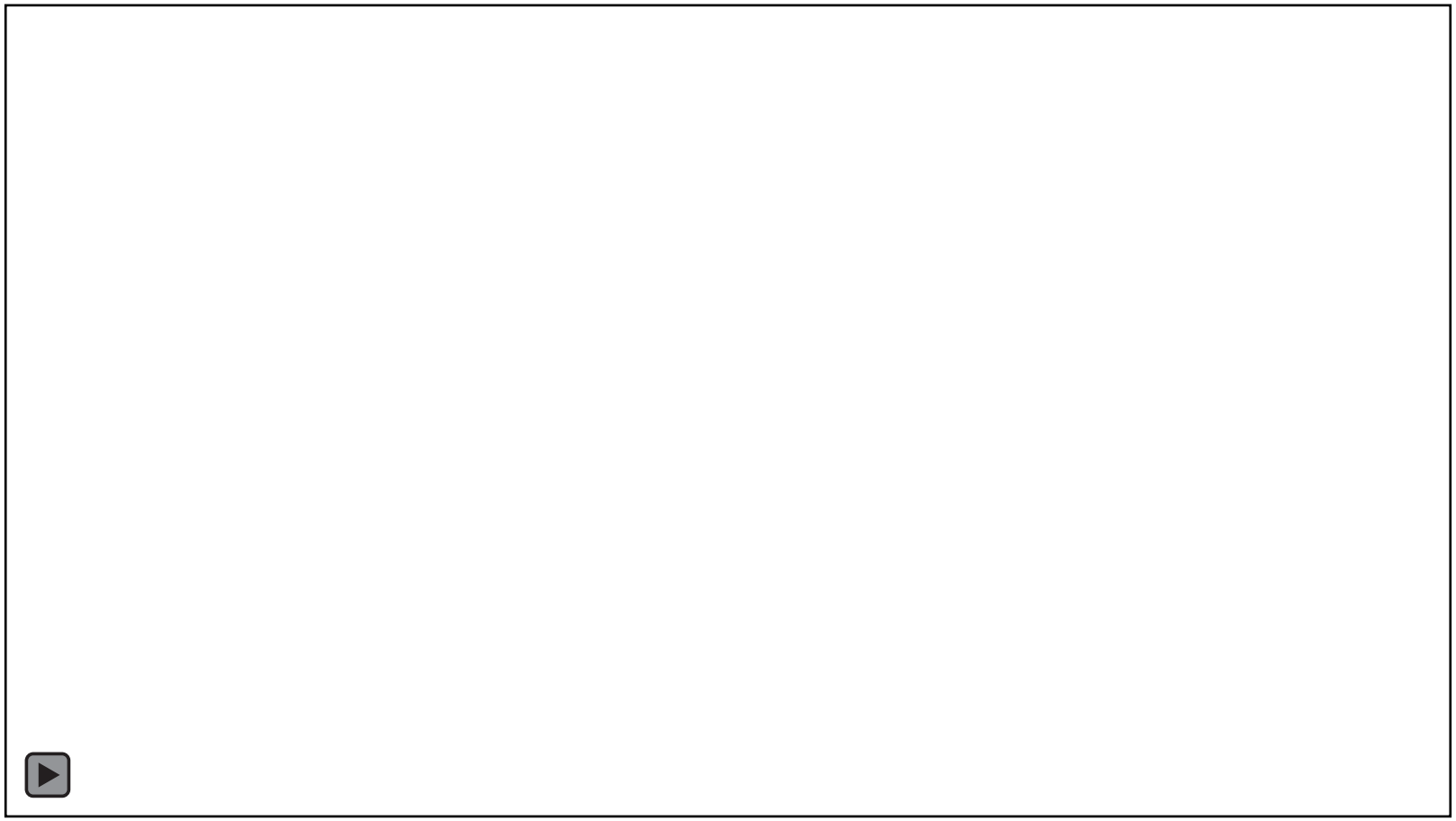
Prototipazione Rapida

La **prototipazione rapida** è “l’applicazione della fabbricazione additiva destinata a ridurre il tempo necessario per produrre prototipi.

Nota 1 alla voce: Storicamente, la prototipazione rapida (RP) è stata la prima applicazione commercialmente significativa per la fabbricazione additiva, e quindi sono stati comunemente usati come termine generale per questo tipo di tecnologia. ”

Additive manufacturing - General principles - Terminology (ISO/ASTM 52900:2015)

https://youtu.be/-TDn25K-Jh4



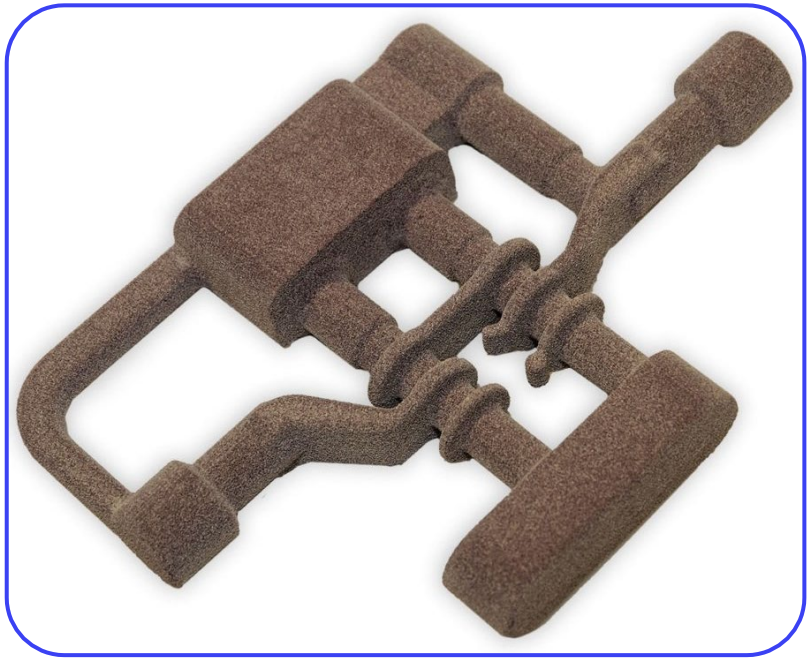
+ Prototipi concettuali
+ Prototipi estetici
+ Prototipi funzionali

LA STORIA

1990

Rapid Casting

Il **Rapid Casting** sfrutta la tecnologia additiva per la realizzazione di **anime per fonderia**. I compenti realizzati vengono quindi sfruttati per la realizzazione di stampi, non di parti. Questi particolari sacrificali sono perfetti per lasciare cavità complesse all'interno di getti metallici.



prototypes.it

+CIM4.0

LA STORIA

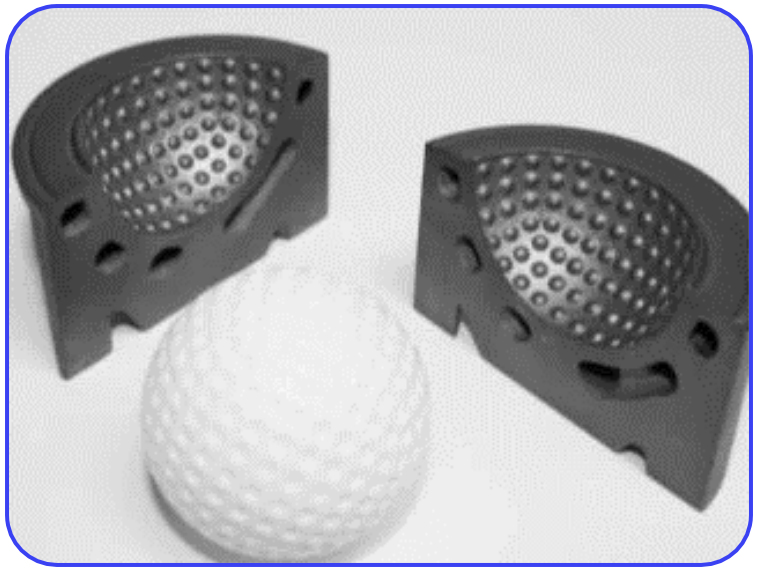
1995

Rapid Tooling

Per **Rapid Tooling** si intende: “applicazione della fabbricazione additiva, destinata alla produzione di **utensili** o componenti di utensili con tempi di realizzazione ridotti rispetto alla fabbricazione convenzionale.

Nota 1: L'utensileria rapida può essere prodotta direttamente dal processo di fabbricazione additiva o indirettamente producendo modelli che sono a loro volta utilizzati in un processo secondario per produrre gli utensili veri e propri.”

- Canali conformali
- Riduzione dei tempi
- Riduzione costo prodotto



Stampo in acciaio per soffiaggio - EOS

Additive manufacturing - General principles - Terminology (ISO/ASTM 52900:2015)

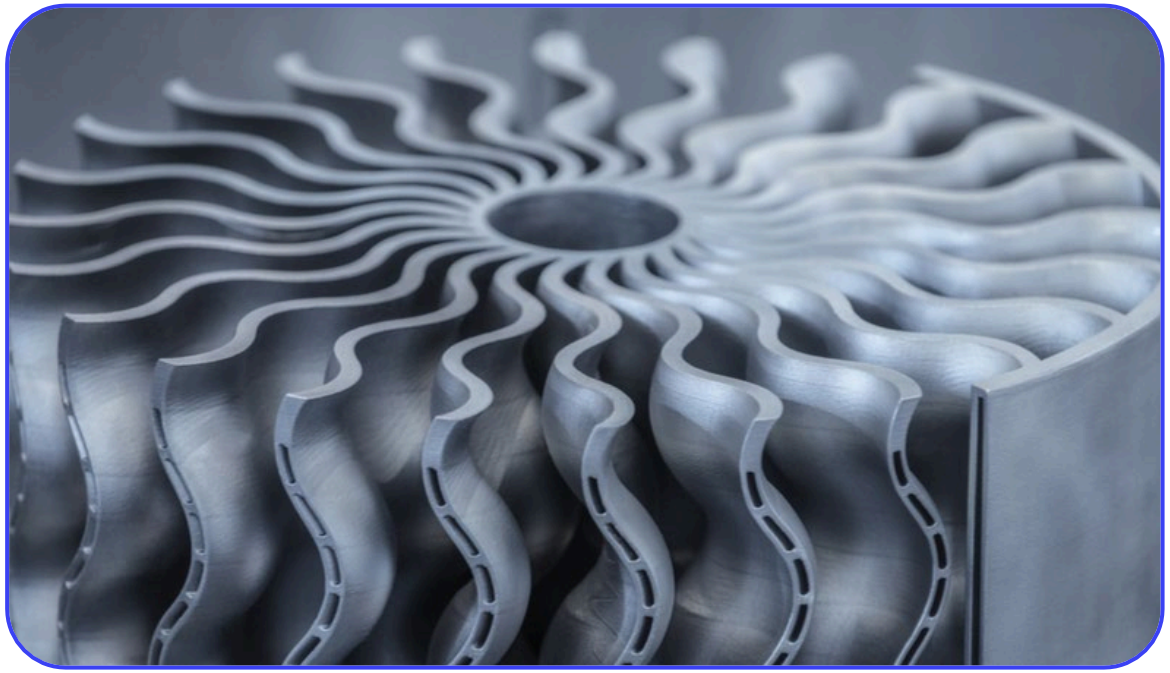
LA STORIA

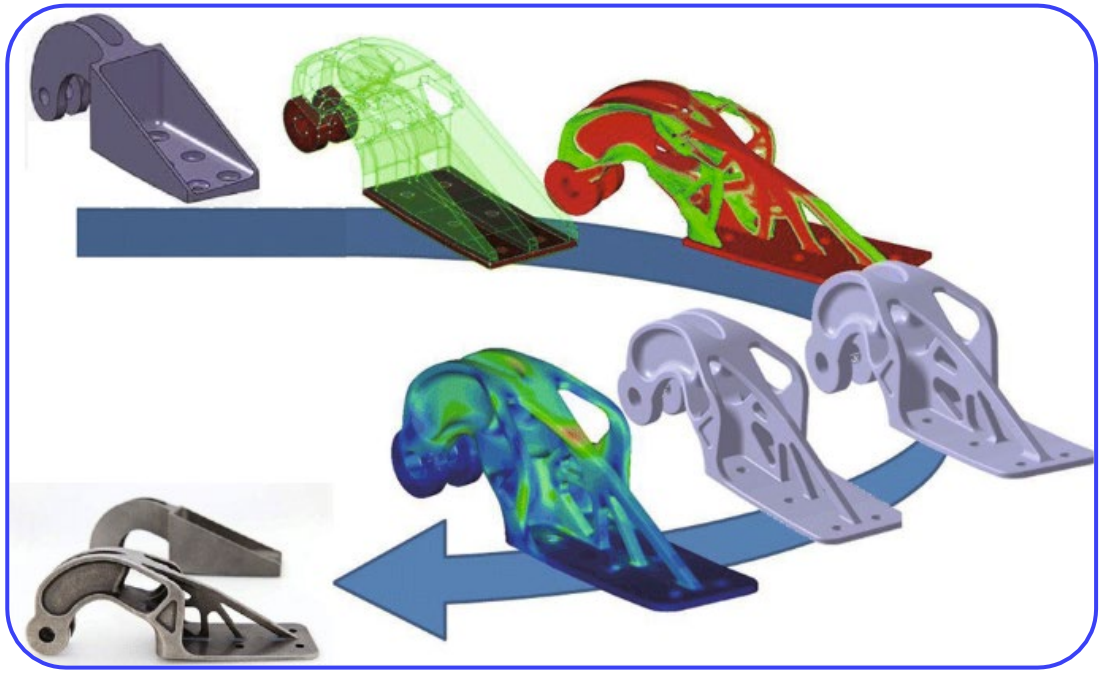
+CIM4.0

2000

Fabbricazione Additiva

La **Fabbricazione Additiva** è “Il processo di unione dei materiali per creare oggetti, tramite dati provenienti dal modello 3D, di solito strato su strato, al contrario delle metodologie di produzione sottrattiva”





Additive manufacturing - General principles - Terminology (ISO/ASTM 52900:2015)

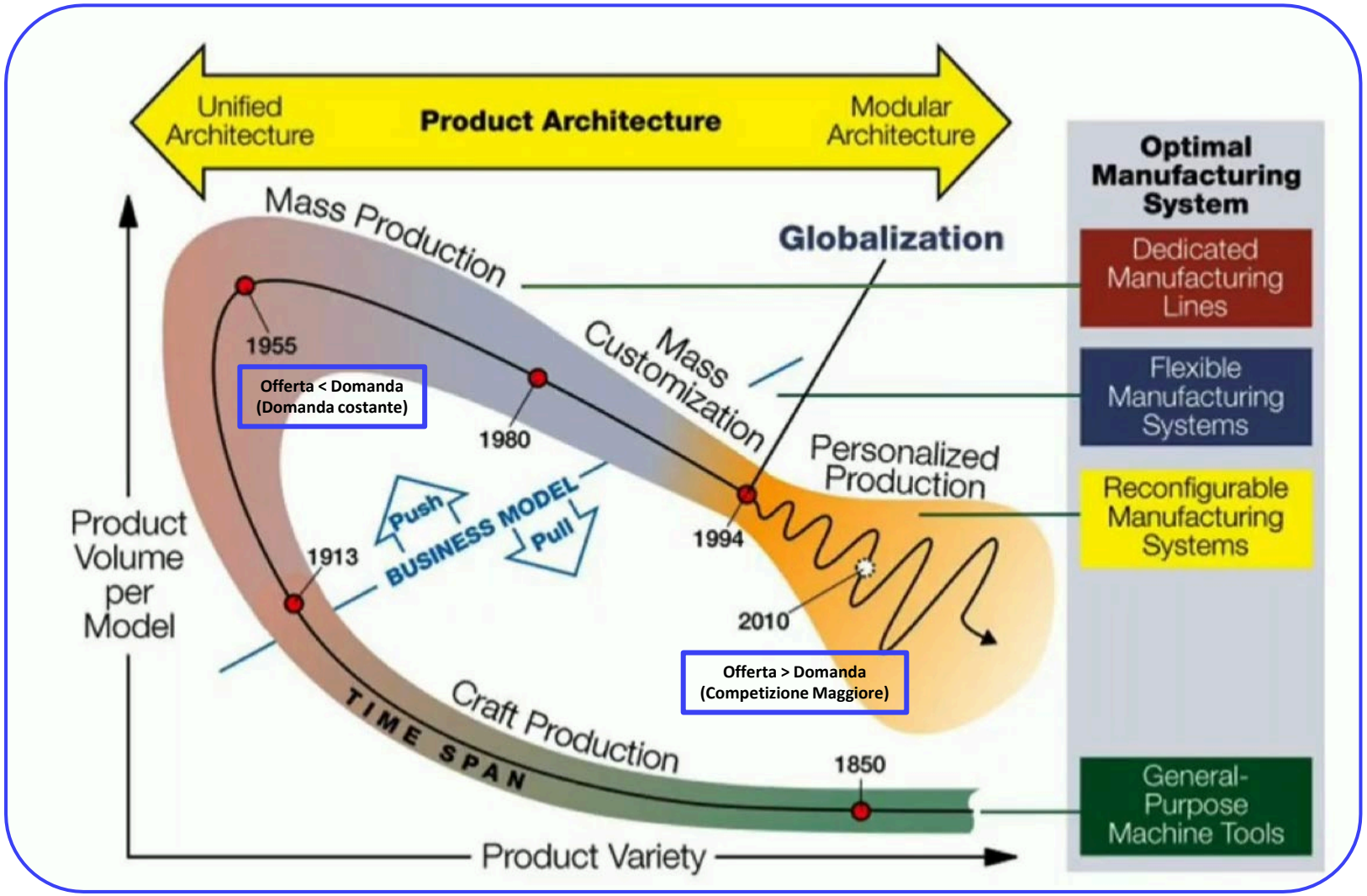
CLASSIFICAZIONE DEI PROTOTIPI

Prototipazione Rapida ⟷ | **Fabbricazione Additiva** ⟷

	PROTOTIPI CONCETTUALI	PROTOTIPI FUNZIONALI	PROTOTIPI TECNICI	PROTOTIPI PRESERIE
OBIETTIVI	• Valutazione della forma • Verifiche di montaggio • Analisi delle difficoltà tecnologiche	• Valutazione delle prestazioni con prove funzionali • Ottimizzazione del prodotto per la funzione	• Valutazione delle prestazioni del prodotto e del ciclo di fabbricazione • Ottimizzazione delle tecnologie di fabbricazione	• Valutazione finale del prodotto
MATERIALE	Qualsiasi	Simile	Molto simile	Definitivo
TECNOLOGIA DI FABBRICAZIONE	Qualsiasi	Qualsiasi	Simile	Definitiva

EVOLUZIONE DEI SISTEMI PRODUTTIVI

+ Nuovi modelli organizzativi per rispondere alle richieste del mercato, con prodotti personalizzati ad elevata variabilità



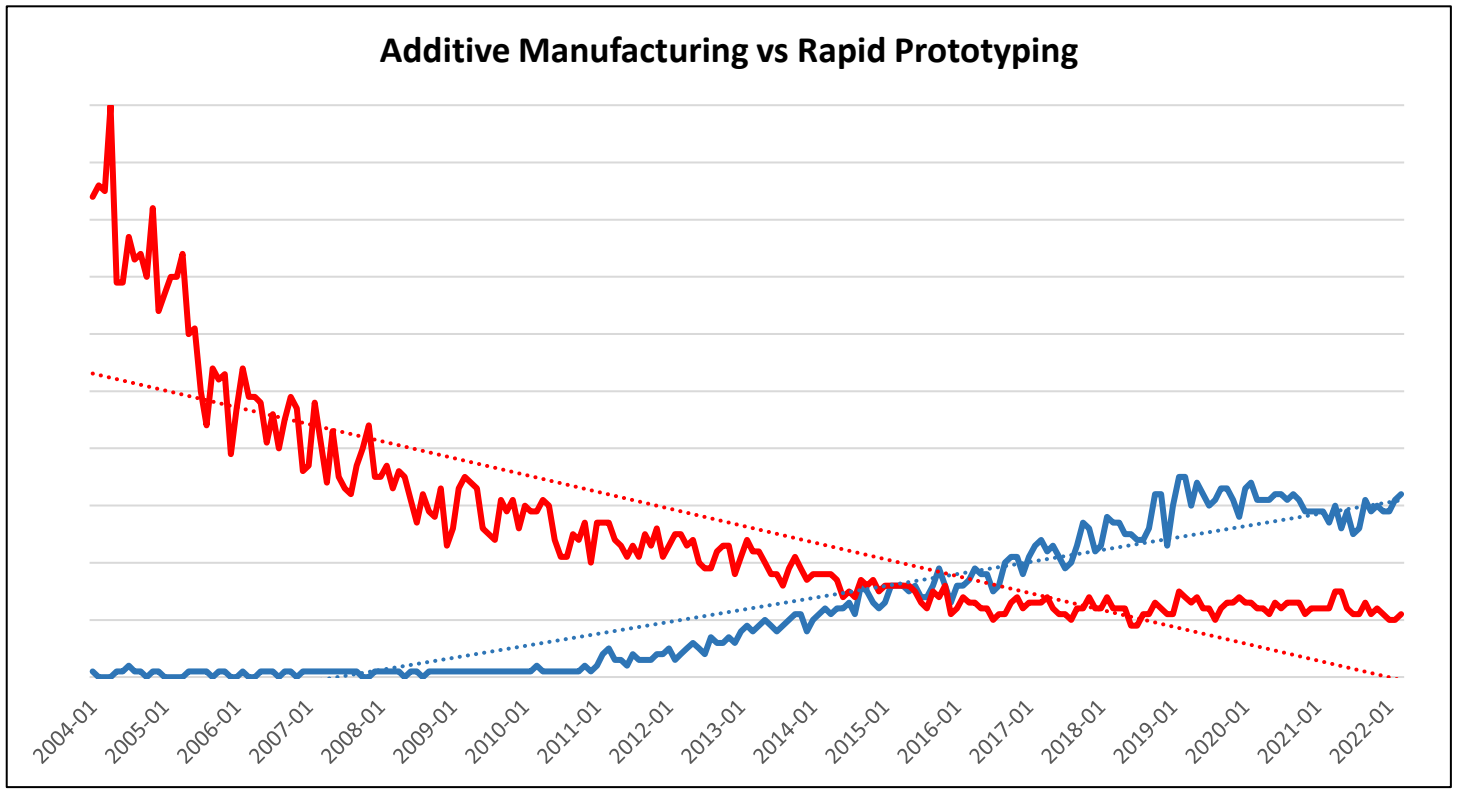
Koren, Yoram (2010). The Global Manufacturing Revolution (Product-Process-Business Integration and Reconfigurable Systems)

+CIM4.0

IL PANORAMA

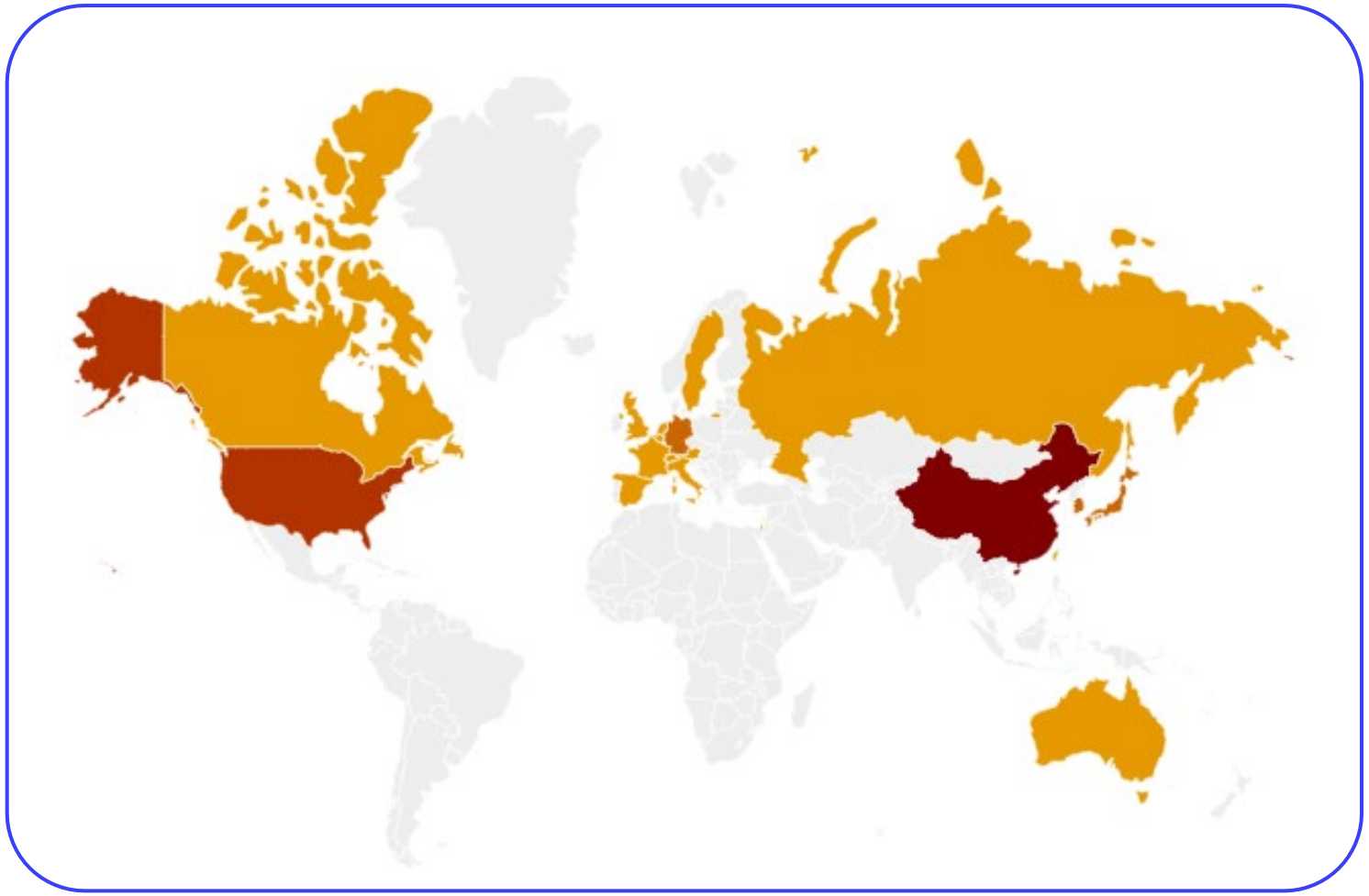
Additive Manufacturing

Rapid Prototyping



+CIM4.0

IL PANORAMA BREVETTUALE



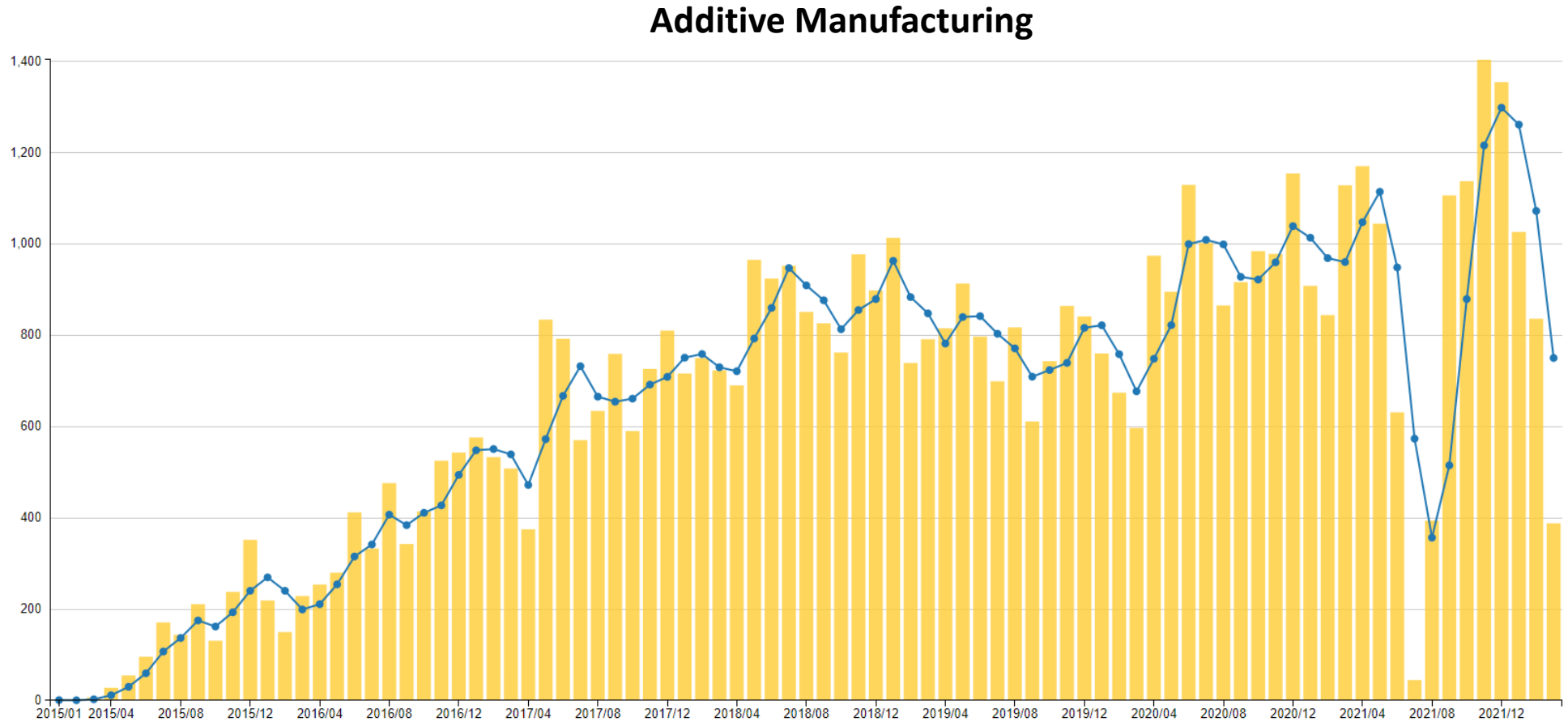
-20 paesi più innovativi nel campo dell'additive manufacturing-

#	Paesi	Brevetti
1	Cina	12907
2	Stati Uniti	5801
3	Japan	3277
4	Germania	2548
5	Korea	2465
6	Taiwan	680
7	Francia	540
8	Regno Unito	361
9	Olanda	288
10	Svizzera	234
11	**Italia**	**162**

PATENT INSPIRATION

+CIM4.0

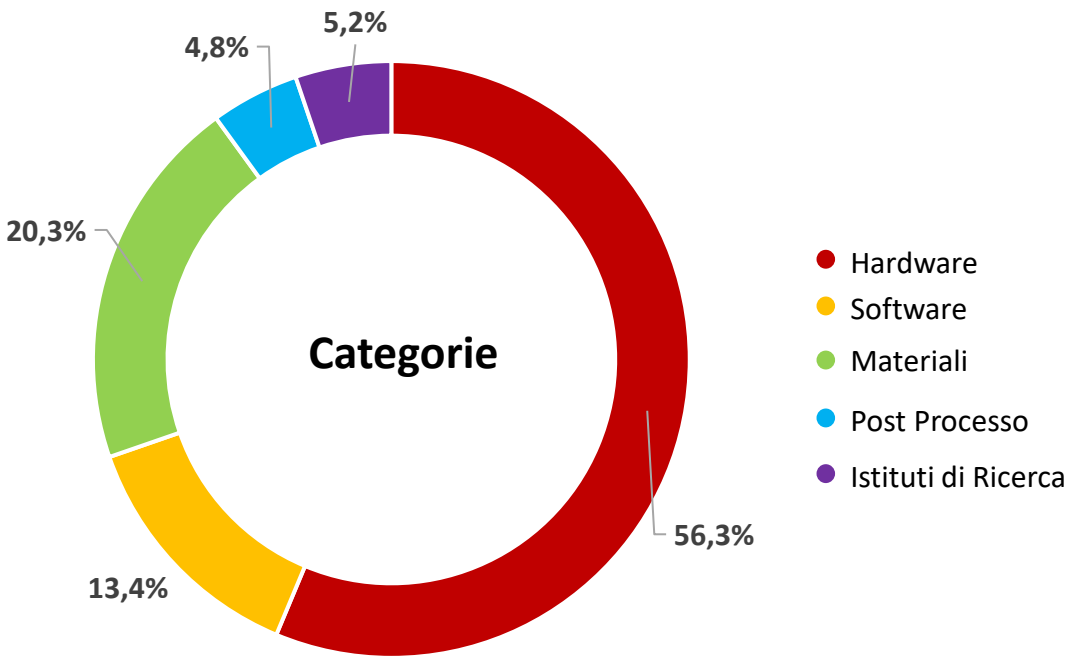
IL PANORAMA BREVETTUALE

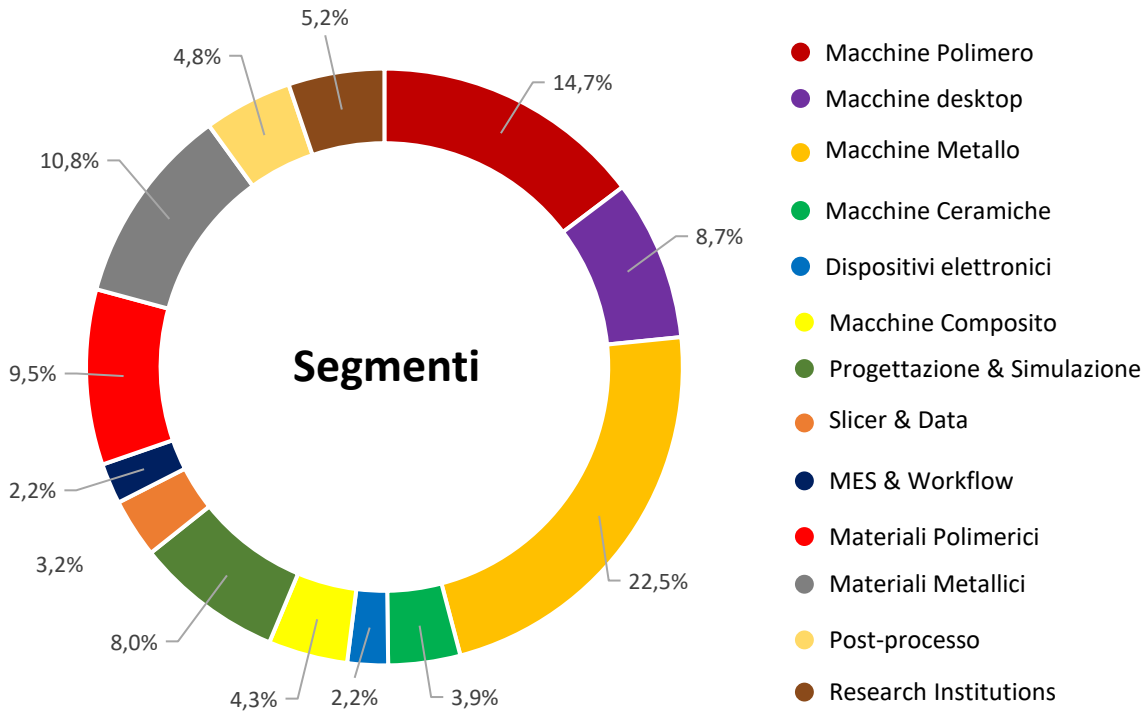


PATENT INSPIRATION

+CIM4.0

SETTORI DI APPLICAZIONE

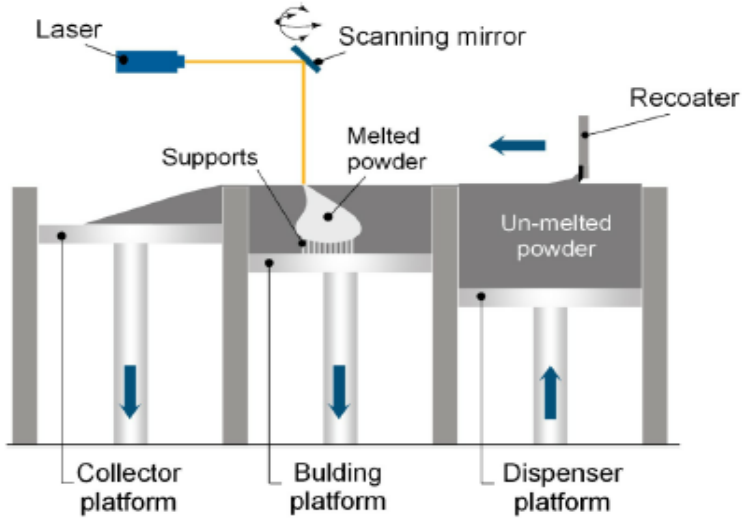




IL PROCESSO L-PBF

"*Il processo di unione dei materiali per creare oggetti tramite dati provenienti dal modello 3D, di solito strato su strato, al contrario delle metodologie di produzione sottrattiva*" [1]

Laser Powder Bed Fusion (L-PBF)



EOS GmbH

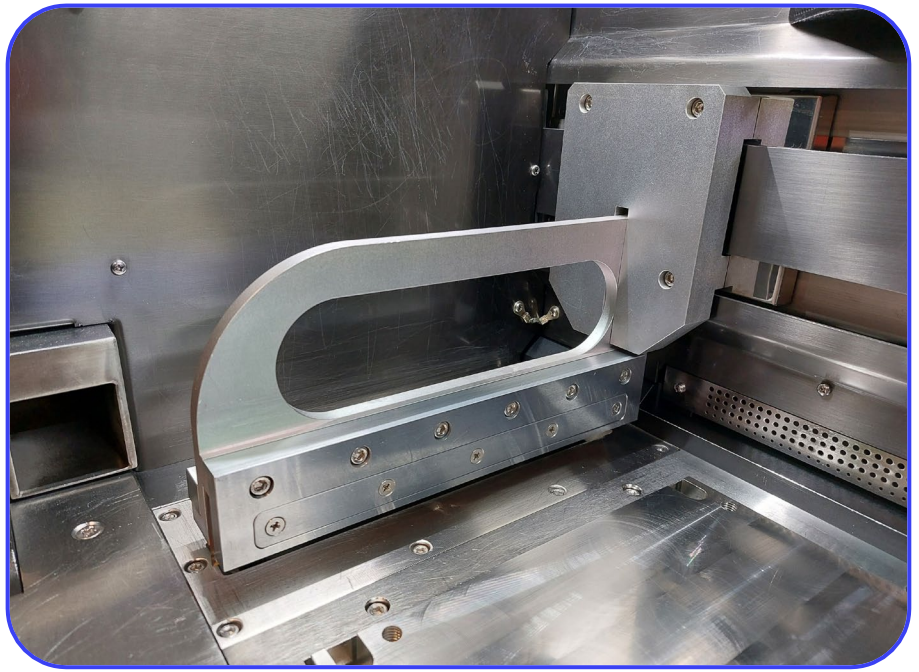
[1] ASTM F2792-12a, "Standard Terminology for Additive Manufacturing Technologies," (Withdrawn 2015) ASTM International, pp. 1–3, West Conshohocken, PA, 2012.

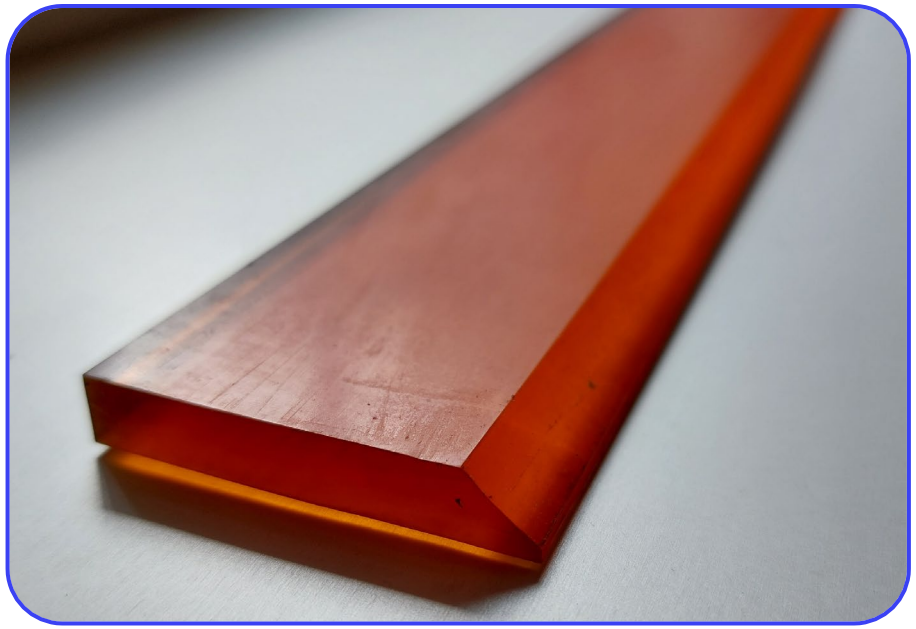
MACCHINE METALLO L-PBF

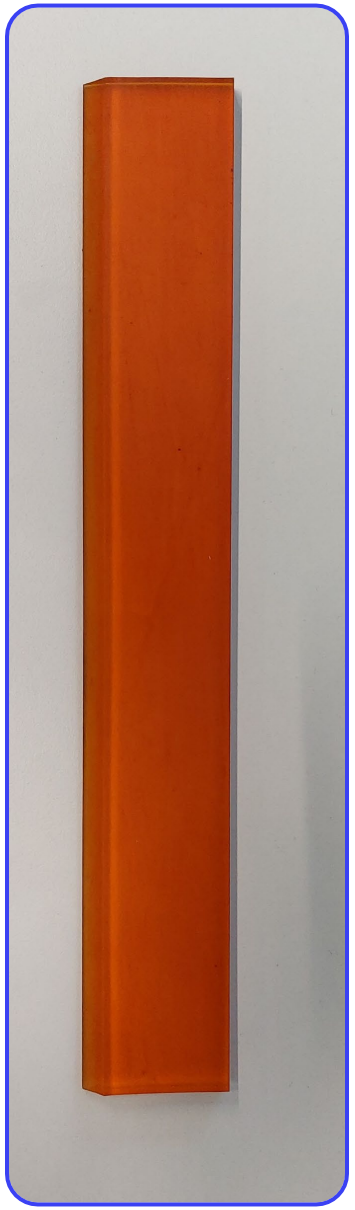
Print Genius 250

- Volume di costruzione ≈ 260 x 260 x 350 mm
- 2 Laser da 500W
- Potenza = 10kW
- Tolleranza = 0,1 mm

MACCHINE METALLO L-PBF







Print Genius 250

+CIM4.0

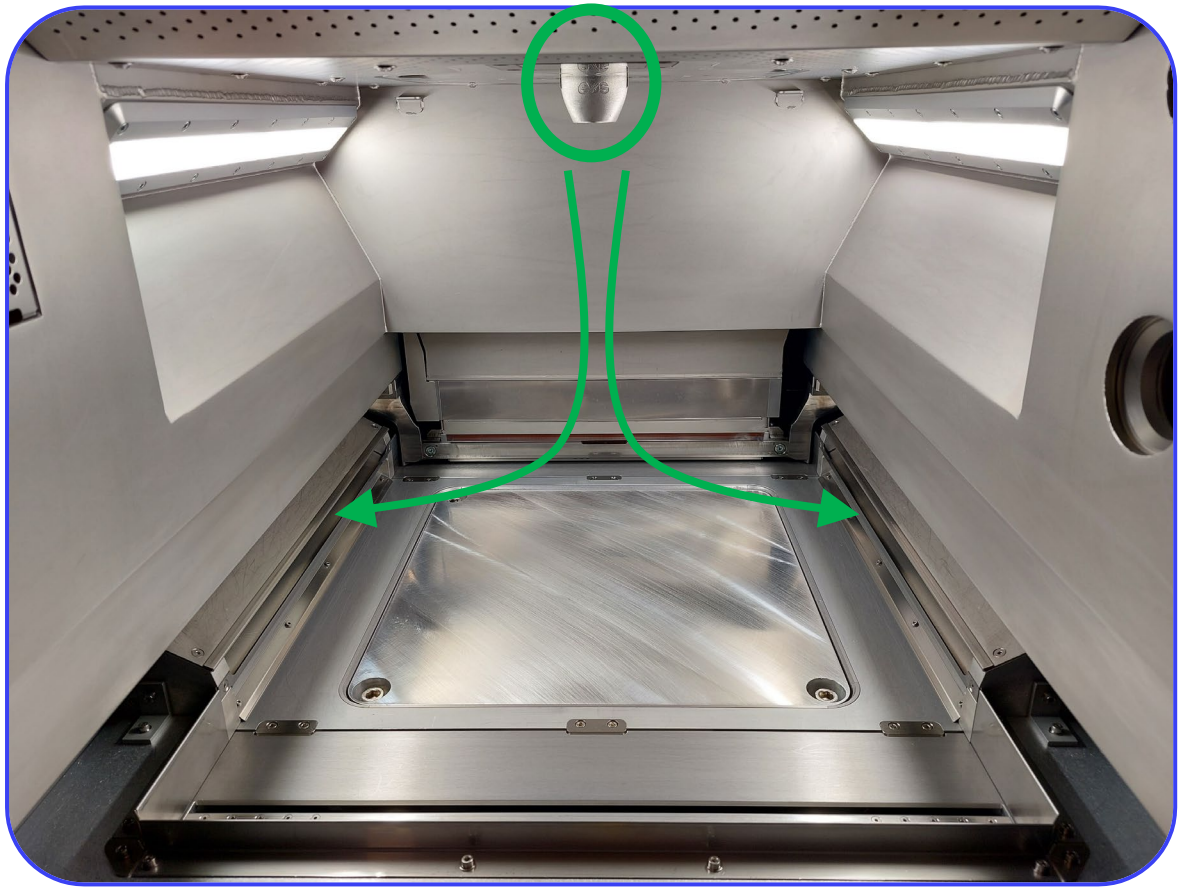
MACCHINE METALLO L-PBF

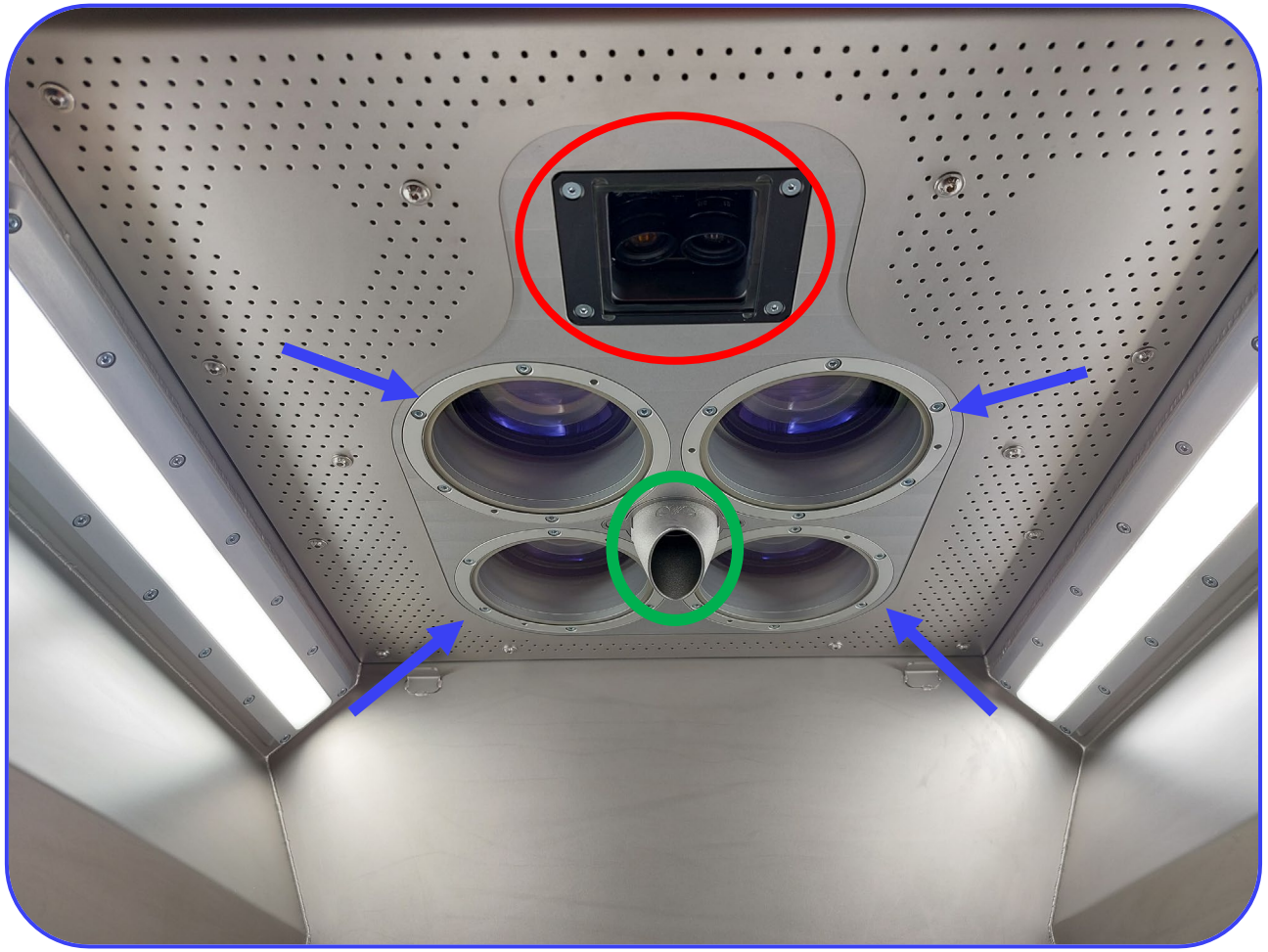
EOS M400-4

- Volume di costruzione ≈ 400 x 400 x 400 mm
- 4 Laser da 400W
- Potenza = 22kW
- Tolleranza = 0,1 mm

MACCHINE METALLO L-PBF

EOS M400-4

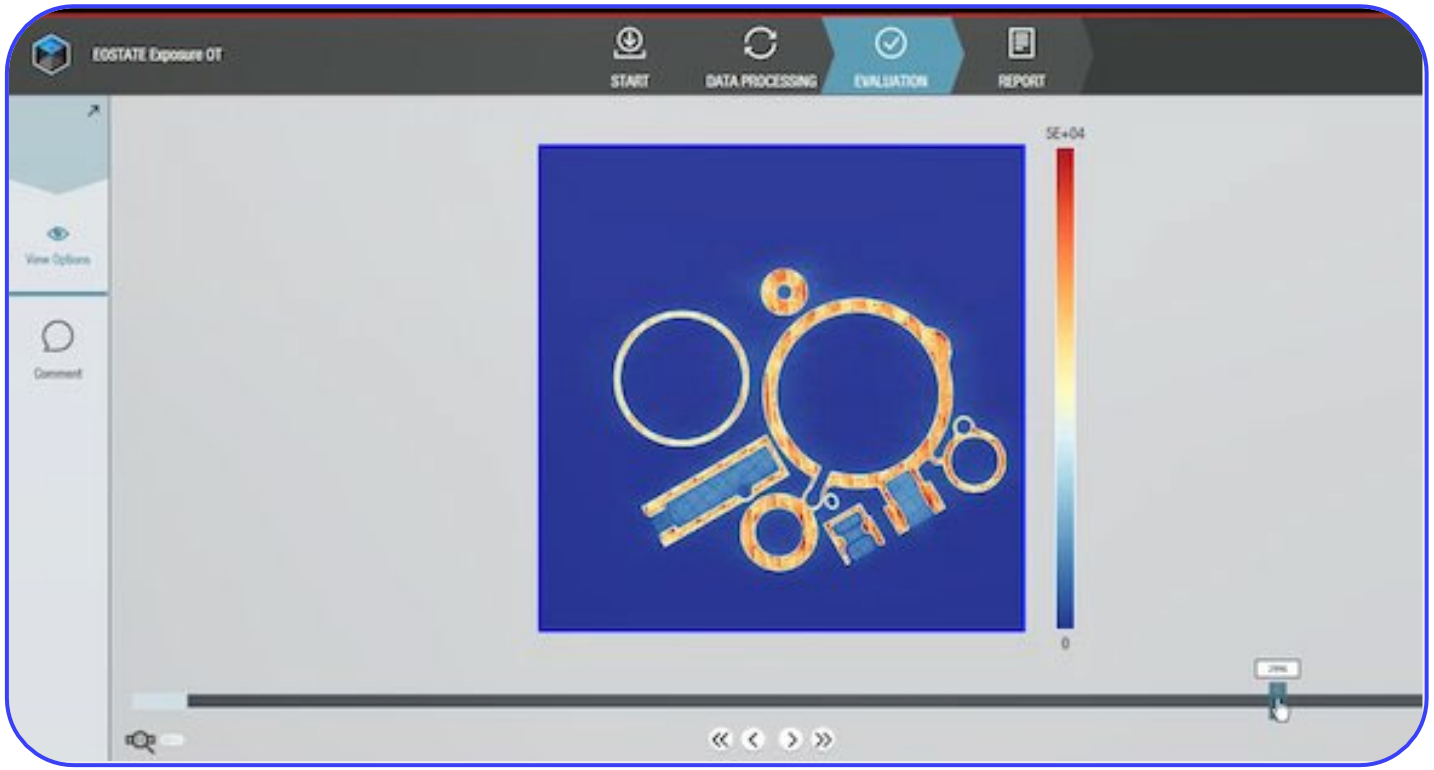




- 4 Laser da 400W
- Ugello gas inerte (AM)
- 2 Fotocamere

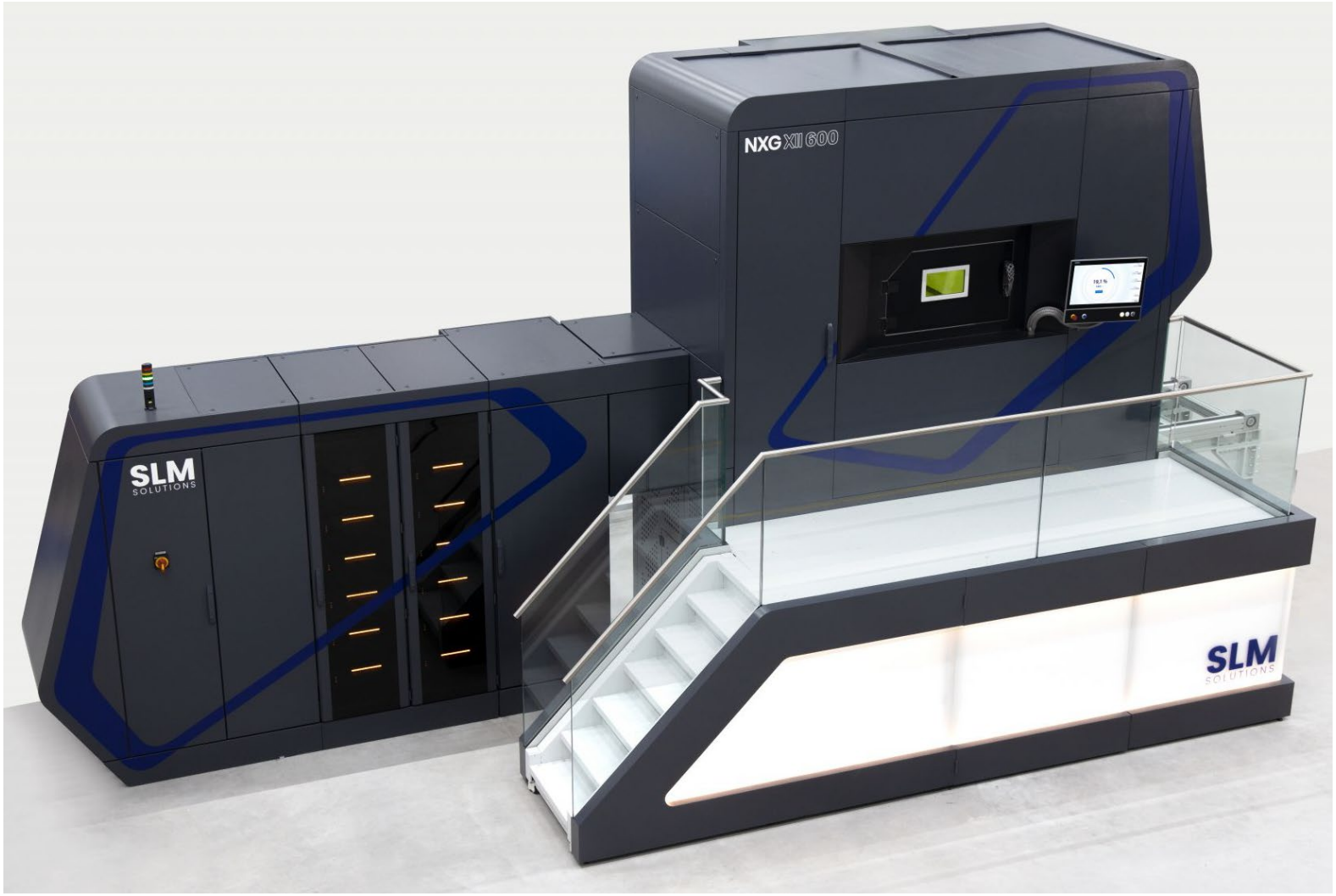
+CIM4.0

MACCHINE METALLO L-PBF



+CIM4.0

INNOVAZIONE HARDWARE METALLO



SLM Solution - NXG XII 600

- 12 laser da 1kW ciascuno
- Volume di stampa: 600x600x600 mm
- Zoom Function
- Pre-heating station esterna
- Depowder station esterna

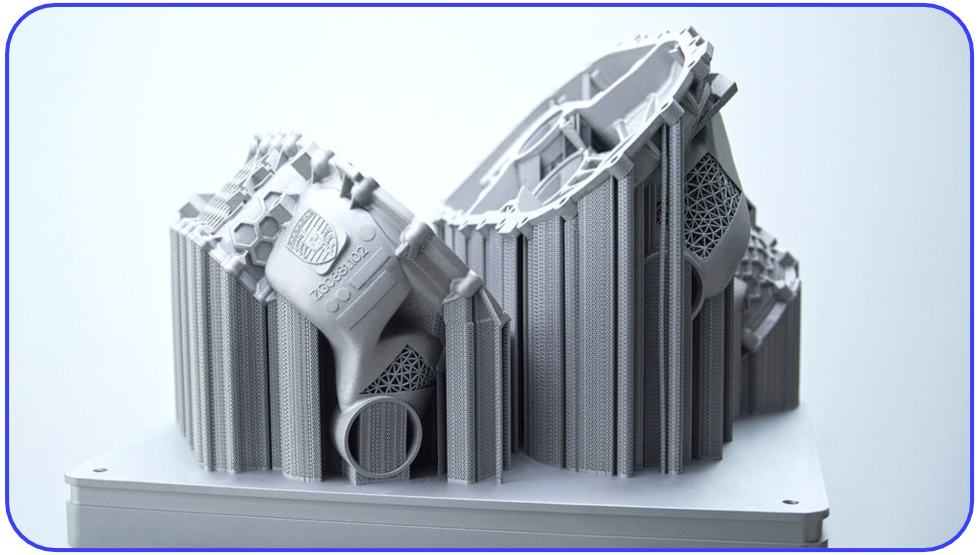
SLM Solution NXG XII 600

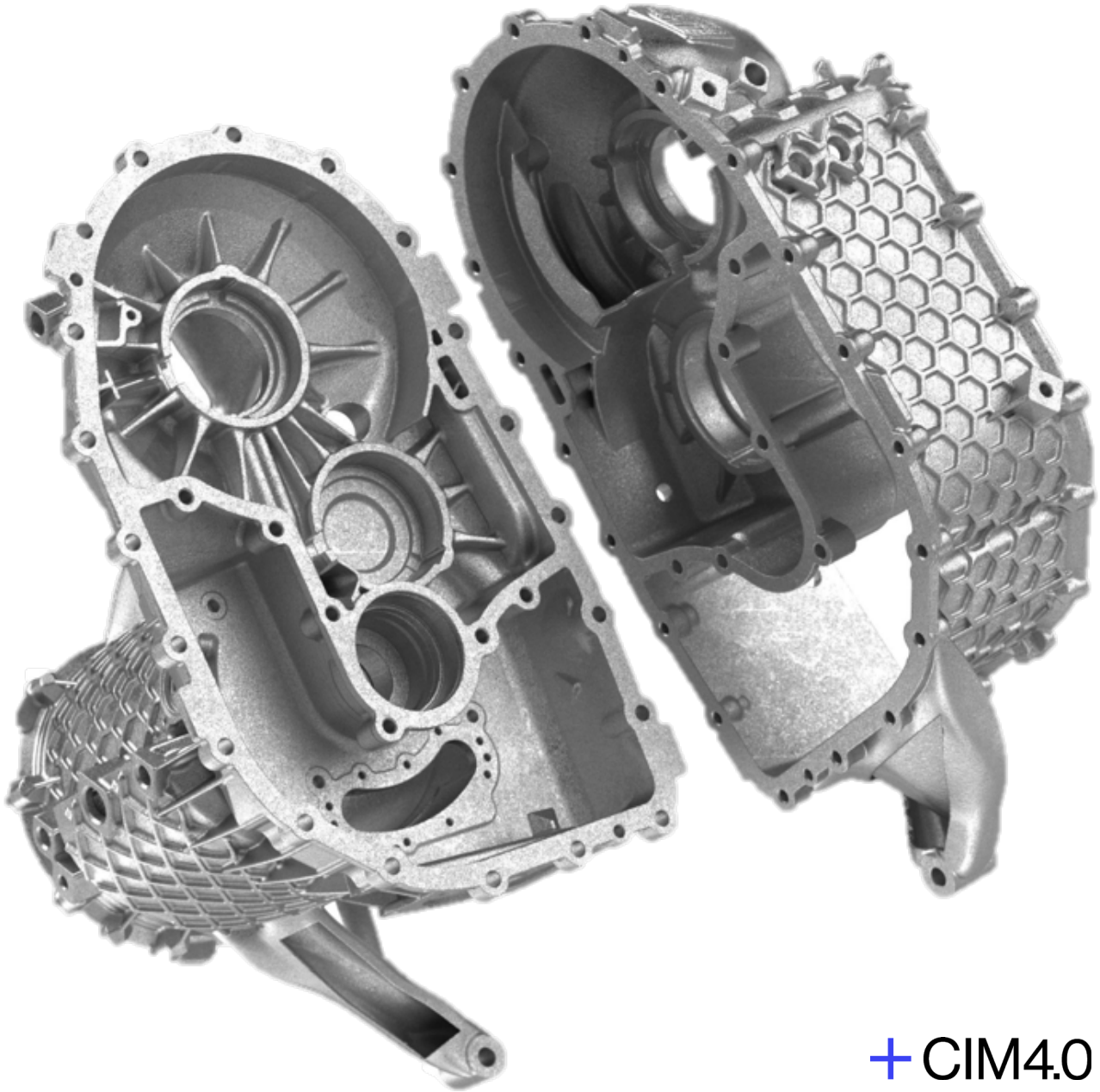
+CIM4.0

INNOVAZIONE HARDWARE METALLO

Prototype Electric motor housing (Porsche)

- Dimensione: 590 x 560 x 367 mm
- Peso: 15,5 kg
- Materiale: AlSi10Mg
- Tempo di produzione: 21 ore





SLM Solution NXG XII 600

+CIM4.0

LE NORMATIVE

19 PUBLISHED ISO STANDARDS* under the direct responsibility of ISO/TC 261

30 ISO STANDARDS UNDER DEVELOPMENT* under the direct responsibility of ISO/TC 261

ASTM INTERNATIONAL

ASTM Additive Manufacturing Technology Standards

- Application
- Design
- Materials and Processes
- Terminology
- Test Methods

2.1. STANDARD REFERENCES

Reference	Title
ISO 286-2	Geometrical product specifications (GPS) - ISO code system for tolerances on linear sizes - Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts
ISO 2768-1 / 2	General tolerances – Part 1: Tolerances for linear and angular dimensions without individual tolerance indications / Part 2: Geometrical tolerances for features without individual tolerance indications
ISO 17296-2 / 3	Additive manufacturing — General principles — properties – Part 2: Overview of process categories and feedstock / Part 3: Main characteristics and corresponding test methods
ISO/ASTM 52900	Additive Manufacturing — General principles – Terminology
ISO/ASTM 52901	Additive Manufacturing — General principles – Requirements for Purchased AM Parts
ISO/ASTM 52915	Standard Specification for Additive Manufacturing File Format (AMF) Version 1.2
ISO/ASTM 52921	Additive Manufacturing — Standard Terminology for Additive Manufacturing - Coordinate Systems and Test Methodologies
EN 10204	Metallic Products – Types of Inspection Documents
EN 15085	Railway Applications – Welding of Railway Vehicles and Components
EN 16016	Non Destructive Testing – Radiation Methods – Computed Tomography
EN 61675	Radionuclide imaging devices. Characteristics and test conditions. Positron emission tomographs
ASTM E1441	Standard Guide for Computed Tomography (CT) Imaging
ASTM F2924	Standard Specification for Additive Manufacturing Titanium-6 Aluminum-4 Vanadium with Powder Bed Fusion
ASTM F3122	Evaluating Mechanical Properties of Metal Materials Made via Additive Manufacturing Processes
ASTM F3184	Standard Specification for Additive Manufacturing Stainless Steel Alloy (UNS S31603) with Powder Bed Fusion

PREVISIONE DELLE TENDENZE FUTURE

CARATTERISTICHE	TREND	ASPETTI PRINCIPALI
Volume di lavoro		• La difficoltà nel controllo del processo renderà l'aumento dei volumi di lavoro moderato
Velocità di produzione		• Differenti spessori del layer • Aumento della stabilità del processo (sistemi di monitoraggio online)
Costo delle macchine		• Le migliorie apportate ai macchinari per l'incremento della produttività e per il controllo della qualità ne aumenteranno il costo, solo parzialmente compensate dall'economia di scala
Costo dei materiali		• I prezzi della polvere fissati dai fornitori di sistemi AM non riflettono i costi di produzione • Con l'aumento del volume del mercato, i produttori di polveri metalliche venderanno direttamente ai clienti finali
Costi di lavoro		• Sistemi affidabili ridurranno lo sforzo per la risoluzione dei problemi • Rimozione automatica della polvere in eccesso

AM Opportunities

PRE-PRODUCTION | PRODUCTION | AFTER-SALES

DESIGN

+ Acceleration and simplification of product innovation
+ Customization
+ Increase of design complexity
+ Topological optimization
+ Parts integration

ENGINEERING

+ Prototypes
+ Fast pre-series
+ Development flexibility

TOOLING

+ Additive tools to improve performances

PRODUCTION

+ Less scrap and fewer raw materials required
+ Low volumes production
+ Reduction of assembly work

MARKETING

+ Low energy consuptions (green economy)

SPARE PARTS

+ Local production enabled
+ Wharehouse cost reduction

+CIM4.0

AM Limitations

PRE-PRODUCTION | PRODUCTION | AFTER-SALES

DESIGN | ENGINEERING | TOOLING | PRODUCTION | MARKETING | SPARE PARTS

DESIGN

- Lacking design tools and guidelines to fully exploit possibilities of AM
- Training efforts required
- Limited “printable” materials

ENGINEERING

- Missing quality standards
- Size of build volume
- Support structures required

PRODUCTION

- Skilled labor and strong experience needed
- Low surface quality
- Low production throughput speed
- AM Business model vs conventional

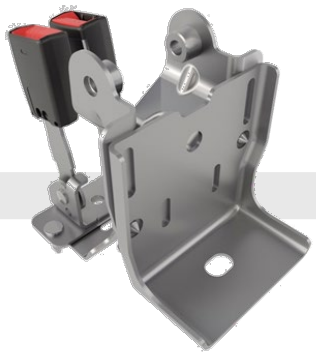
MARKETING

- No economies of scale
- High raw material cost

CIM4.0

USE-CASE: AUTOMOTIVE PART DESIGN
PUNCH TORINO – ex General Motors

Generative Design & Additive Manufacturing



8 components into **1 part – 40%** lighter – **20%** stronger

Il nostro approccio e i servizi al cliente

Schema proposto per analizzare attrezzature, component, sottogruppi o sistemi sviluppati in Additive Manufacturing

PHASE 1

OPPORTUNITIES ANALYSIS

Time: 2 mesi

PHASE 2

IMPLEMENTATION STRATEGY DEFINITION

Time: 2 mesi

PHASE 3

PILOT PROJECT EXECUTION

Time: 6 mesi

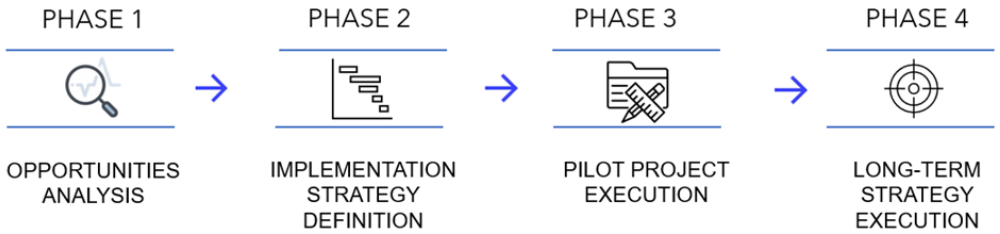
PHASE 4

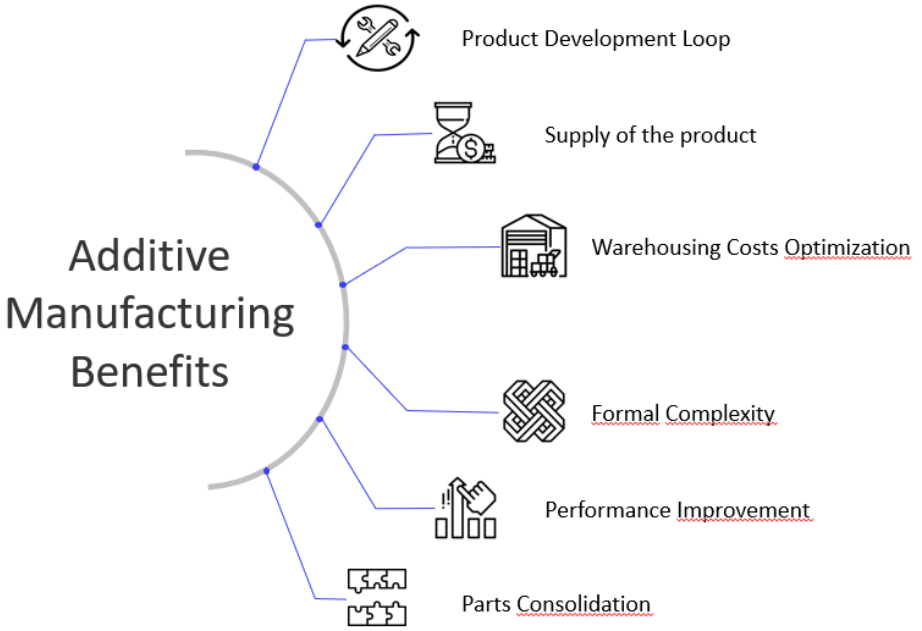
LONG-TERM STRATEGY EXECUTION

Additive Manufacturing: use case

Descrizione del progetto

L'obiettivo del progetto è stato fornire a FPT una consulenza su come implementare l'Additive Manufacturing all'interno dei propri processi aziendali. Partendo da un'analisi di circa 100 componenti si è strutturata una strategia a breve, medio e lungo termine per sfruttare i benefici dell'Additive a 360°C





Partner coinvolti

- 4D Engineering
- Prima Industrie
- Punch Torino
- Reply Protocube
- Politecnico di Torino

Stato di avanzamento

Completate fase 1 e fase 2 tra dicembre 2020 e luglio 2021

Avviata la fase tre di re-engineering e prototipazione per 8 sistemi/componenti

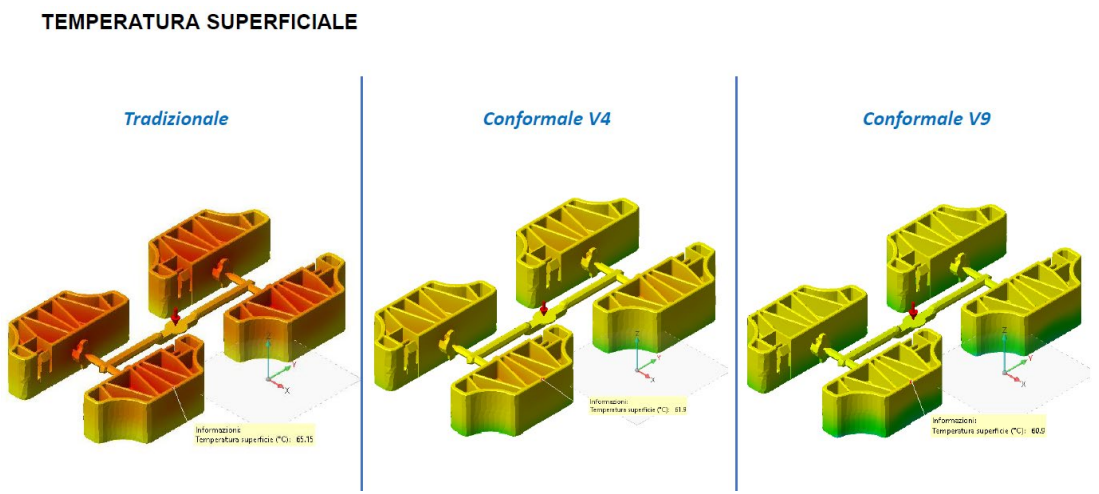
Progetti ambito Additive Manufacturing

Tecno Bajardi s.r.l.

+CIM 4.0

Descrizione del progetto

Partendo da uno stampo per iniezione plastica già progettato e realizzato da Tecno Bajardi, si è riprogettato un inserto utilizzando il Design for Additive Manufacturing (DfAM) e studiando i possibili rendimenti e miglioramenti rispetto allo stampo prodotto con tecnologie tradizionali. Sfruttando la linea pilota del CIM4.0 si è realizzato il prototipo, validato i risultati su pressa del Cliente e si è fornito a Tecno Bajardi una procedura per facilitare l'approccio all'Additive Manufacturing nella progettazione e realizzazione degli stampi.



Partner coinvolti

- Politecnico di Torino – centro IAM
- Reply Protocube

Stato di avanzamento

Progetto avviato a giugno 2021.

Completato a febbraio 2022

Agenda

- Il Competence Center Nazionale CIM4.0
- Additive Manufacturing: status e prospettive
- Casi applicativi

Ispezione Tunnel La Maddalena

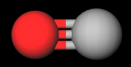
webuild | +CIM 4.0

Obiettivi

Sviluppo un **sistema a guida remota innovativo**, finalizzato alla sostituzione dell'uomo **nell'esplorazione** di tratti **di cunicoli** o gallerie di cui non sono noti i **rischi per la salute dei lavoratori**

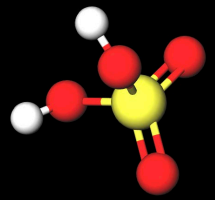
Raccolta dei parametri ambientali (temperatura, umidità, gas) per individuare le aree in cui gli operatori possono intervenire in sicurezza

Gas da monitorare:



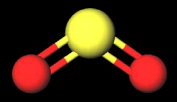
Monossido di carbonio

CO



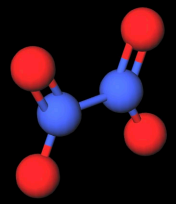
Acido solfidrico

H_2S



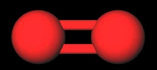
Anidride solforosa

SO_2



Biossido di azoto

NO_2

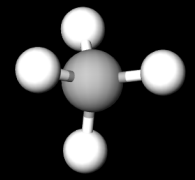


Ossigeno

O_2

Radon

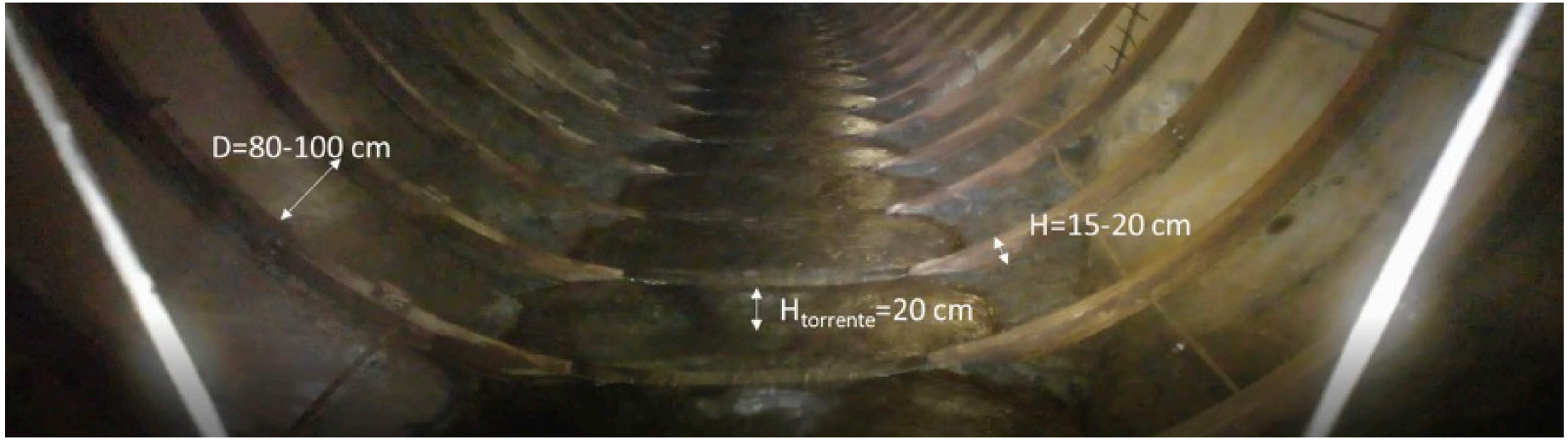
Rn

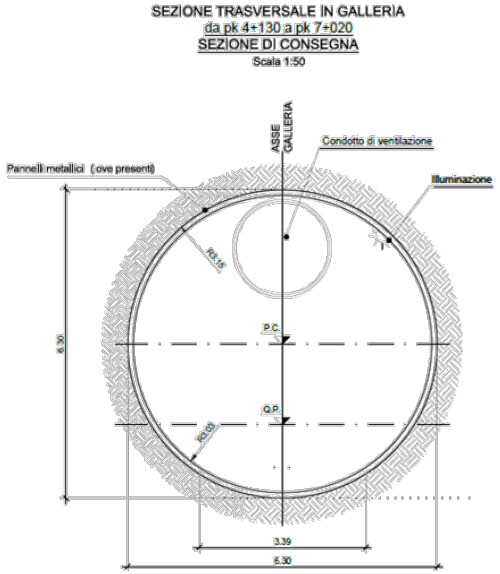


Gas infiammabili

CH_4

Definizione requisiti





Caratteristiche Del Sito	Requisiti Del Prototipo
Il cunicolo ha **diametro di circa 6m**	Larghezza max 1.600mm
Il **fondo** del cunicolo è **irregolare** Sono presenti **centine metalliche** per circa il 70% dello sviluppo longitudinale aventi altezza **di 15-20cm** dal fondo galleria e spaziatura longitudinale variabile	Ruote con pneumatici runflat, tassellatura specifica Hmin >25cm D ruote >60cm Passo circa 2m Trazione integrale
La **temperatura** all'interno del cunicolo è stimata in circa **40 gradi** con **elevato tasso di umidità (95%)**.	Batterie al Pb (no Li per maggior rischio incendio)
Vi sono copiose **venute d'acqua** che ruscellano sul fondo dello scavo per un'altezza almeno pari a quella delle centine	Protezione IP di centraline e cablaggi Preferibile batteria basso voltaggio (48V)
Il tratto da esplorare inizia a circa 4km dall'ingresso. La **tratta** da esplorare è **di circa 3000m complessivi**, da suddividere in sotto-tratte di massimo 500m ciascuna	Range comunicazione: 1.000m Capacità batterie >20kWh

Project Management

Challenge: 4 mesi da avvio a operatività

➔Concept selection basata su hard points
➔Selezione partner in base a competenze
➔Approccio modulare alla progettazione
➔Sviluppo in parallelo (*concurrent engineering*)
➔Sviluppo in laboratori remoti (collaborazione 4.0)
➔Pre-test in galleria per taratura sensori e comunicazione
➔Testing su simulacro di galleria

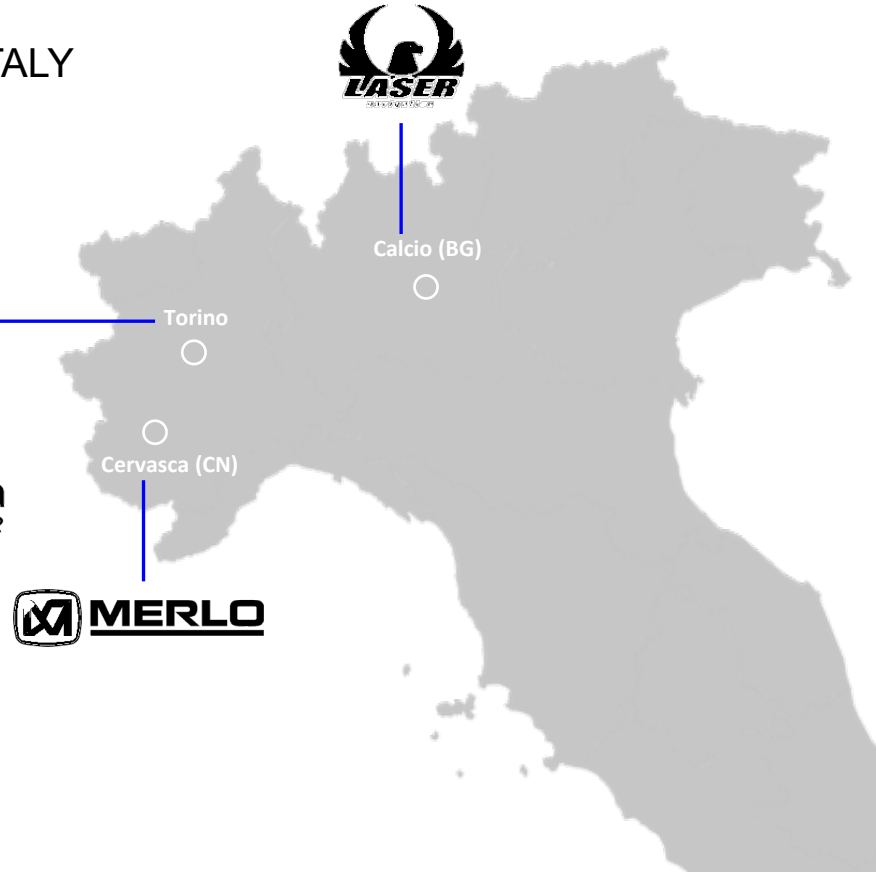
MADE IN ITALY

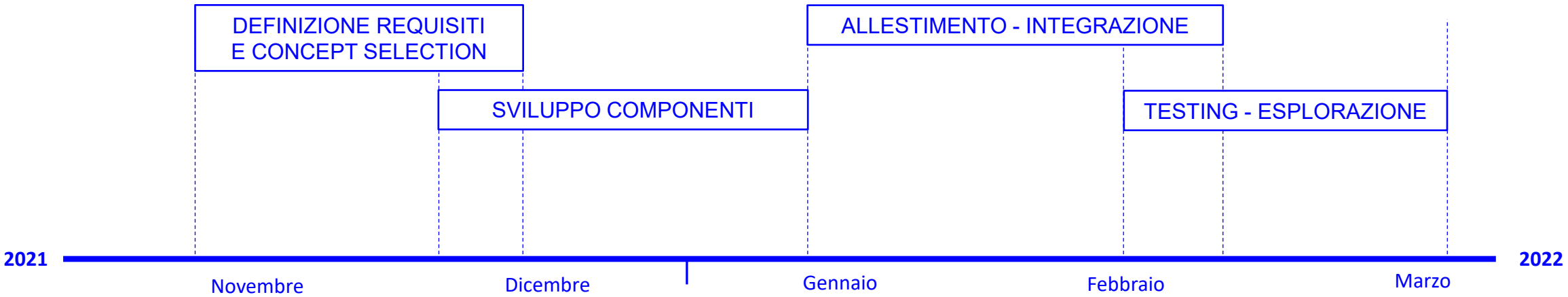
+CIM4.0

iren

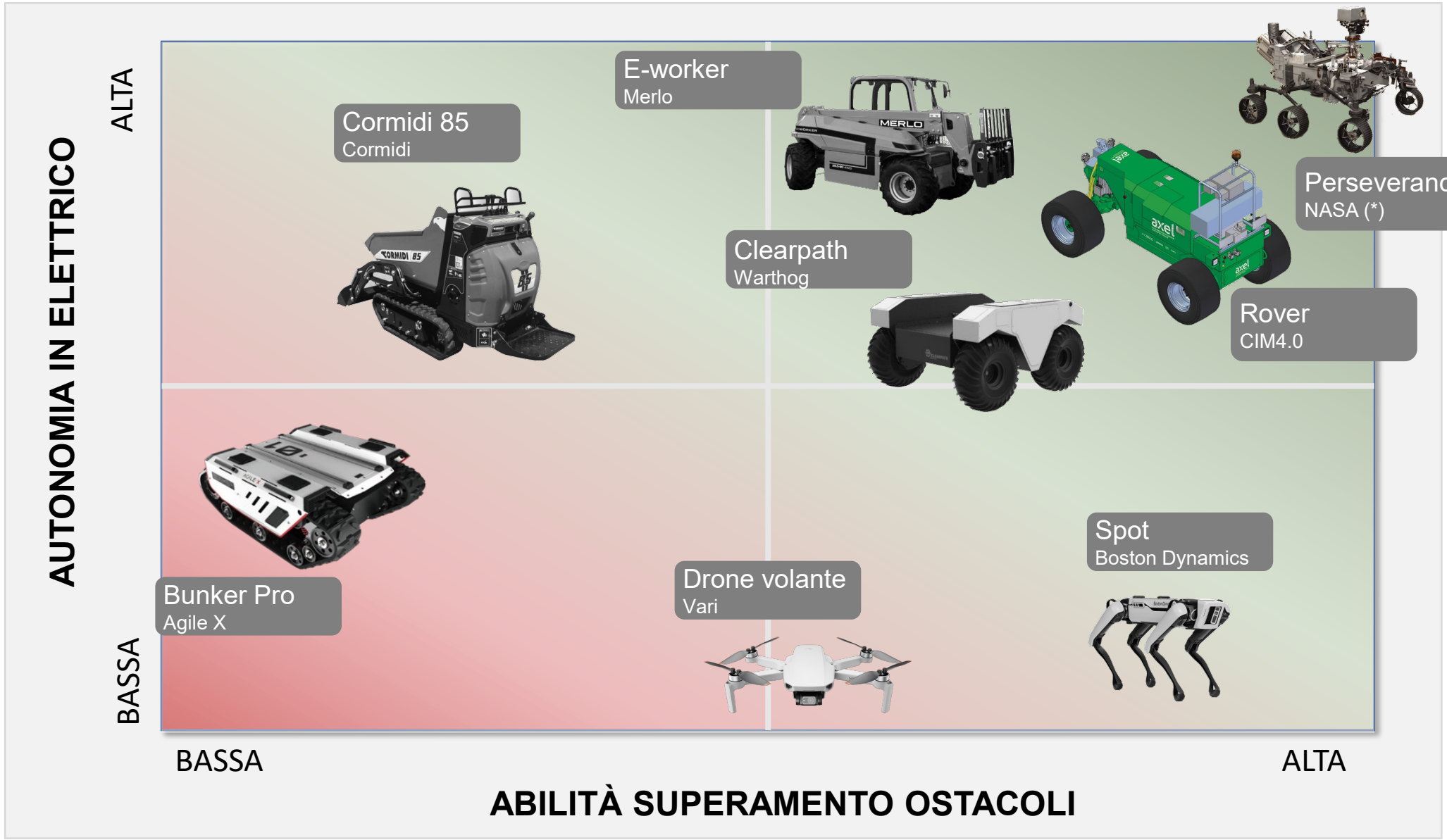
REPLY CONCEPT

ThalesAlenia Space

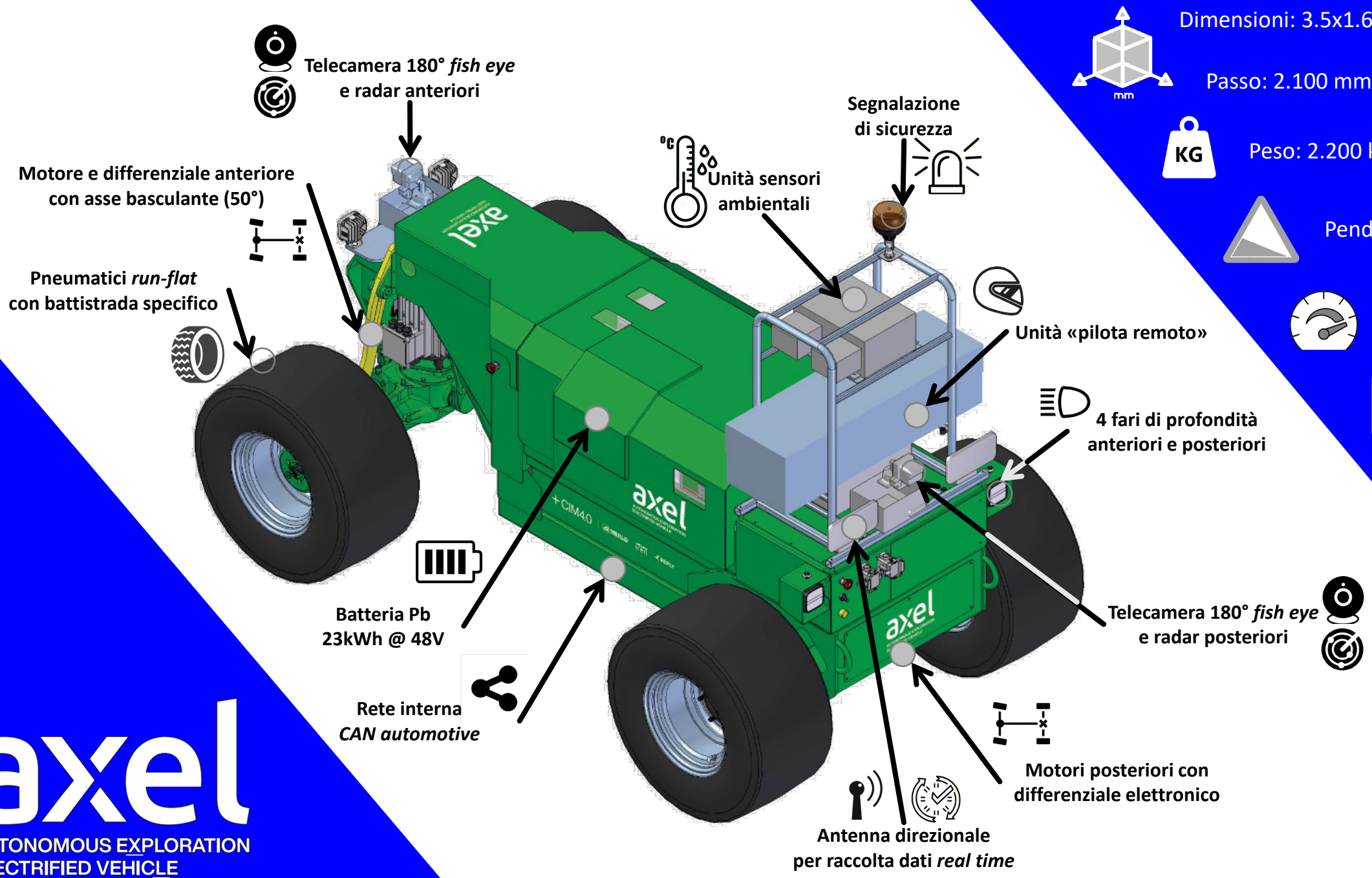




Concept selection



(*) Non disponibile



Dimensioni: 3.5x1.6x1.8 m

Passo: 2.100 mm

Peso: 2.200 kg

Pendenza: 60%

Vmax: 5km/h

Guado: 25 cm

Protezione acqua IP55

axel

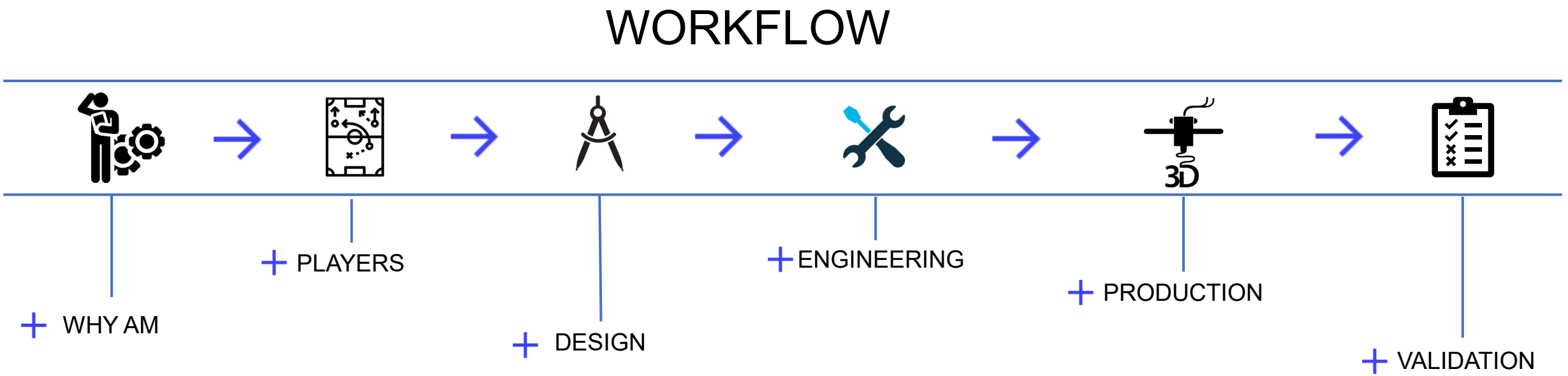
AUTONOMOUS EXPLORATION
ELECTRIFIED VEHICLE

COMPETENCE INDUSTRY MANUFACTURING 4.0

April 2022

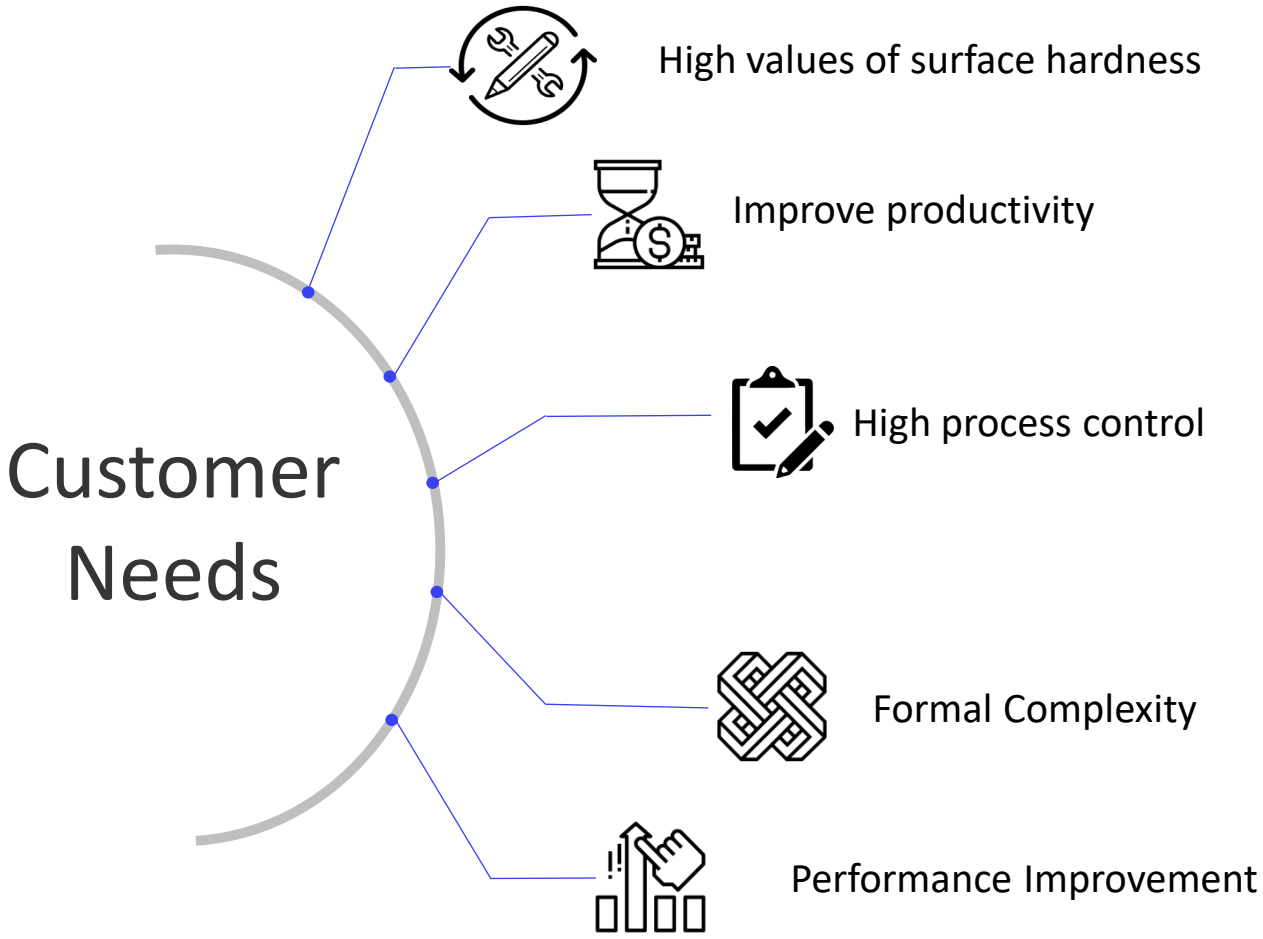
Tecno Bajardi s.r.l.

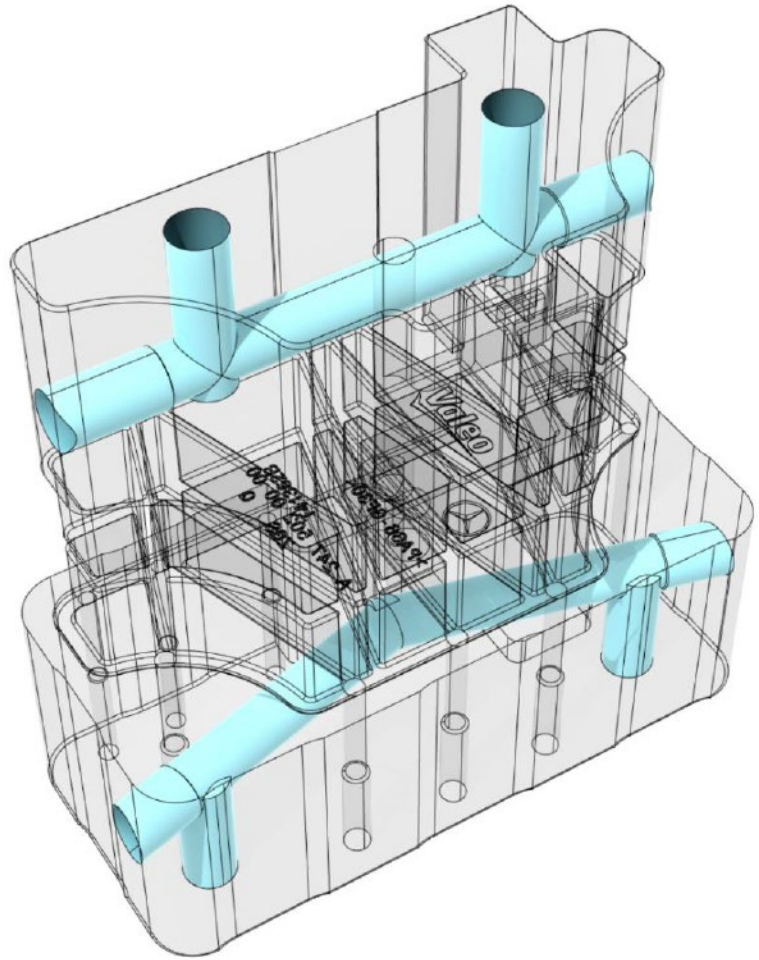
AM conformal cooling application



+CIM4.0

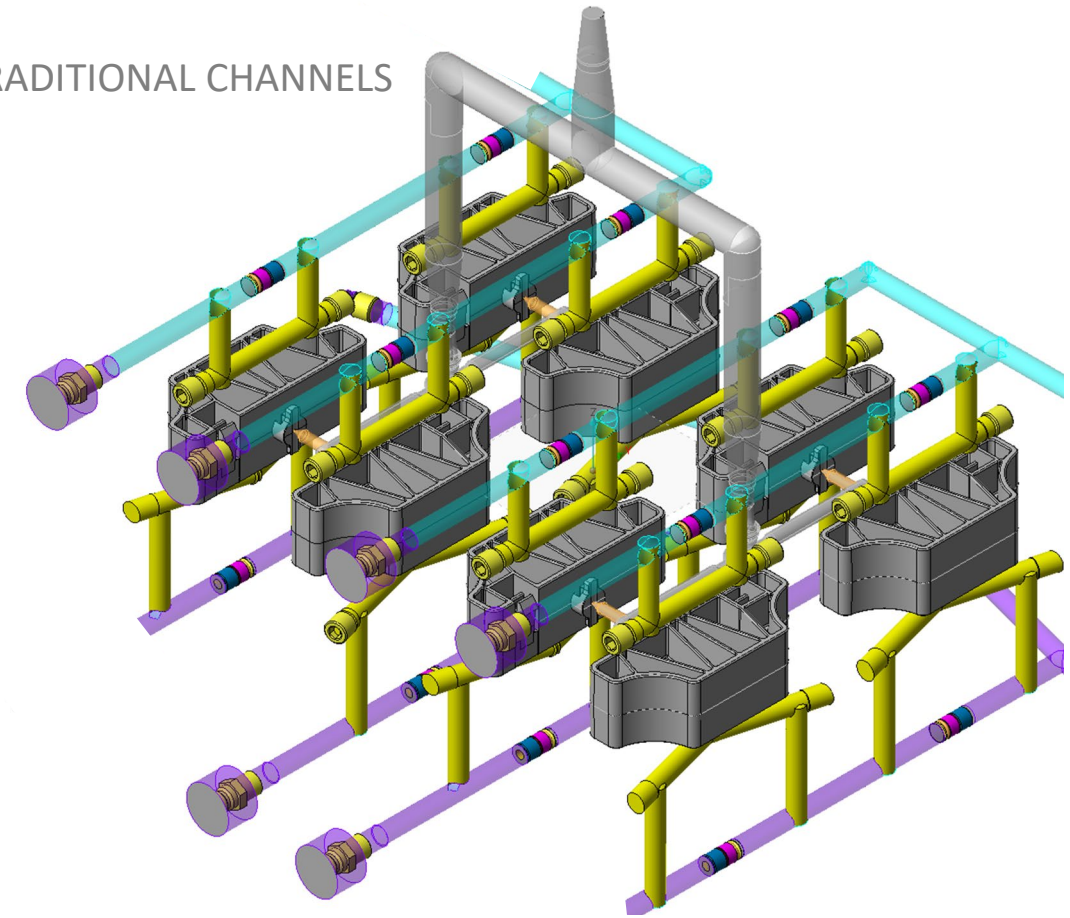
Why Additive Manufacturing





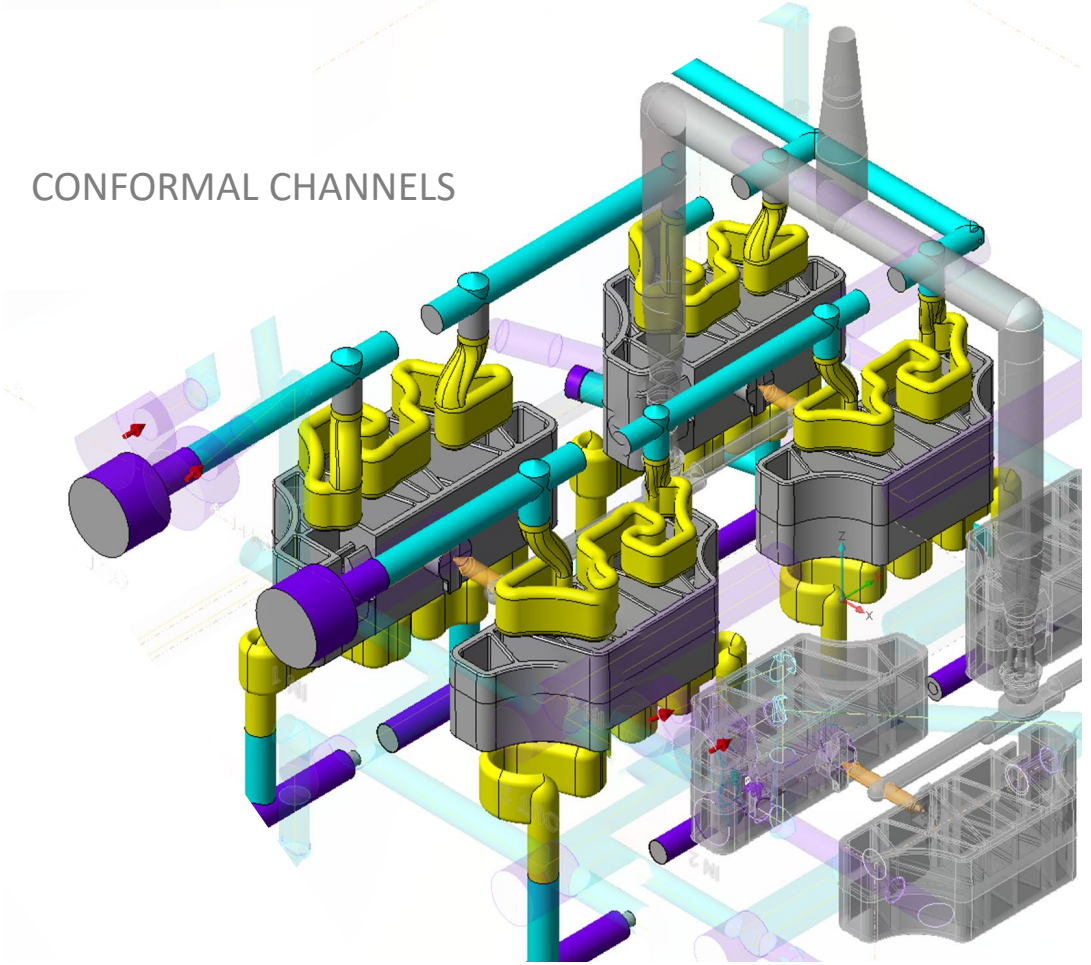
Design

TRADITIONAL CHANNELS



+ Traditional channels were linear and far from the surface in contact with the workpiece.

CONFORMAL CHANNELS

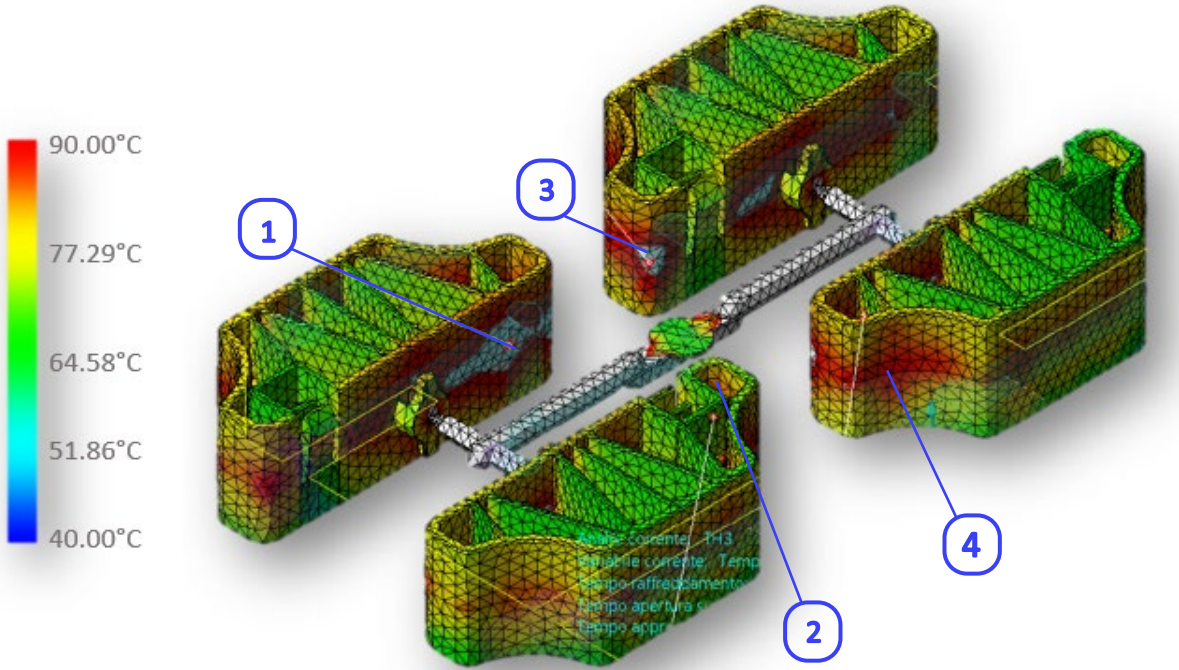


+ After redesigning, the channels follow the shape of the mold and are closer to the workpiece surface.

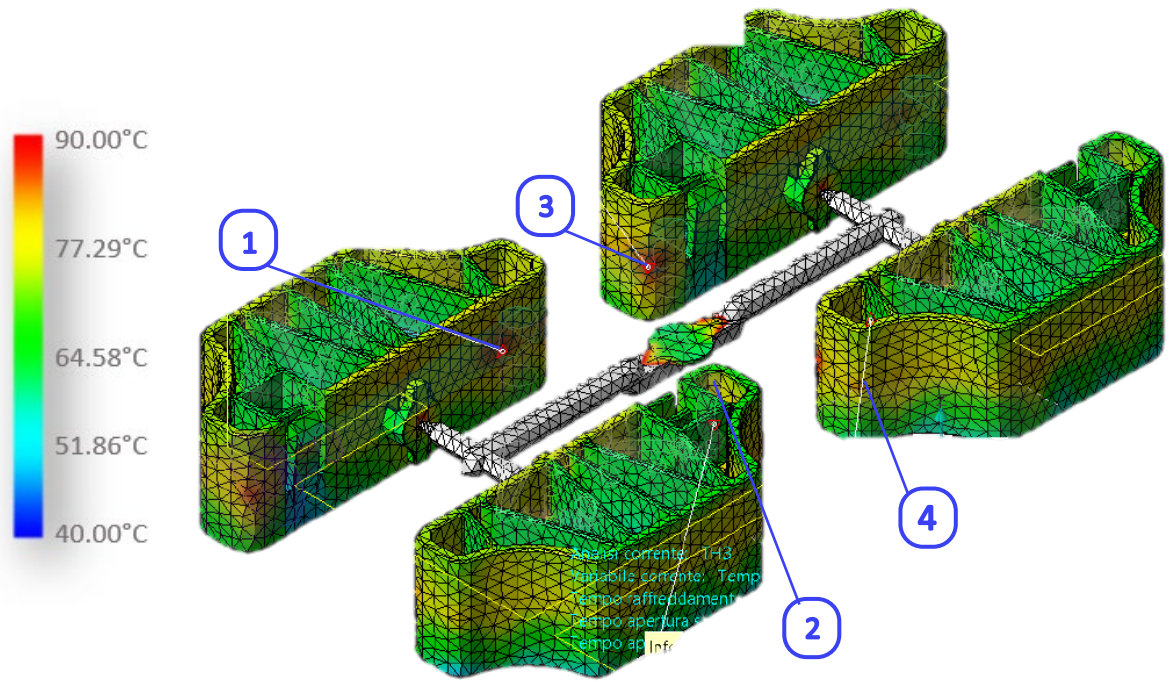
+CIM4.0

Engineering

TRADITIONAL COOLING TEMPERATURE MAP



CONFORMAL COOLING TEMPERATURE MAP



+ Results in term of ΔT on the hotspots after a colling time of 22,6s:

1 ΔT= **-6.41 %**

3 ΔT= -5.32 %

2 ΔT= -5.76 %

4 ΔT= -5.84 %

→

+ Results in term of time saving:

Cycle time reduced by **7.5%** at the same temperatures

+CIM4.0

Production

PHASE 1

PROCESS PARAMETERS DEVELOPMENT

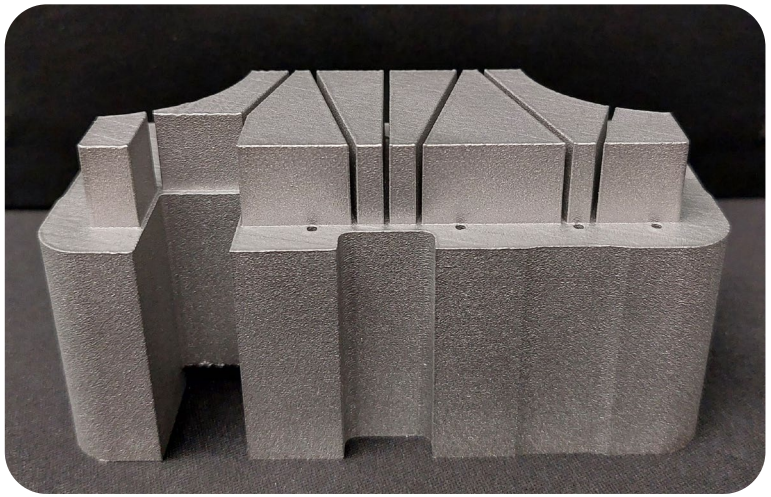
1-2 weeks

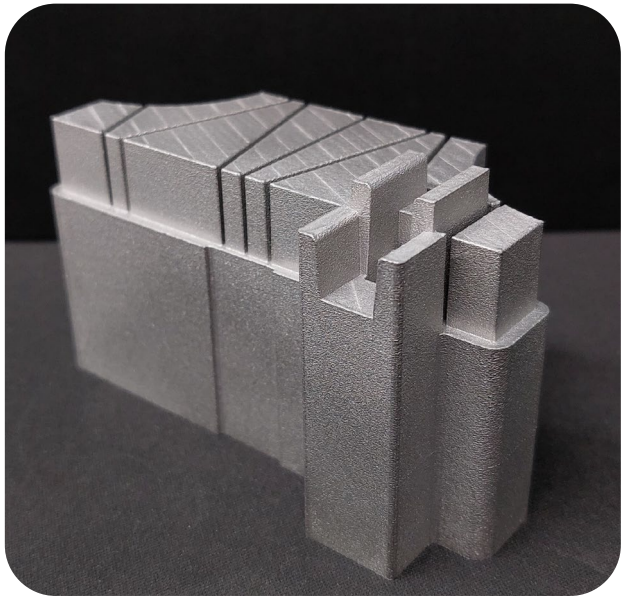
- Material: maraging steel MS1
- Obtained density = 99,81 %
- Hardness = 54 HRC
- Productivity = 4,22 cm^3/h

PHASE 2

PRINTING & POST PROCESSING

1 week





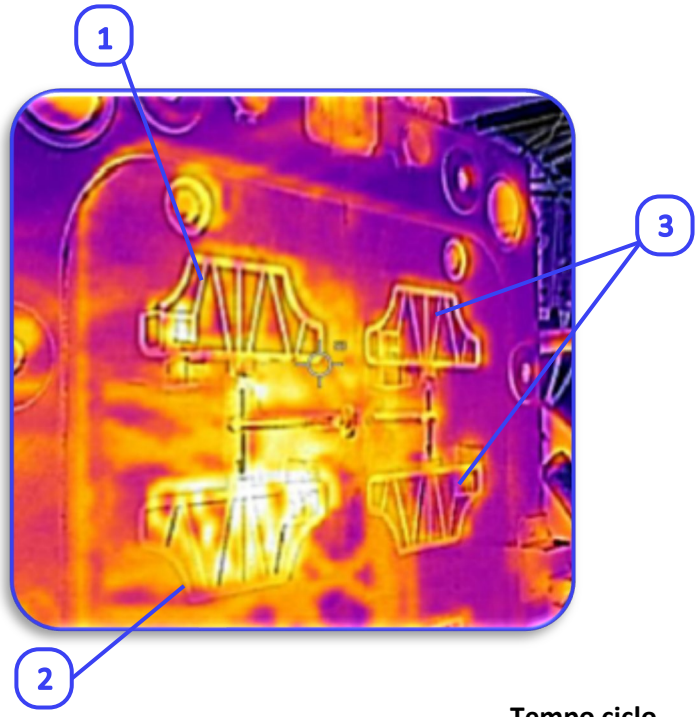
+CIM4.0

Experimental Validation

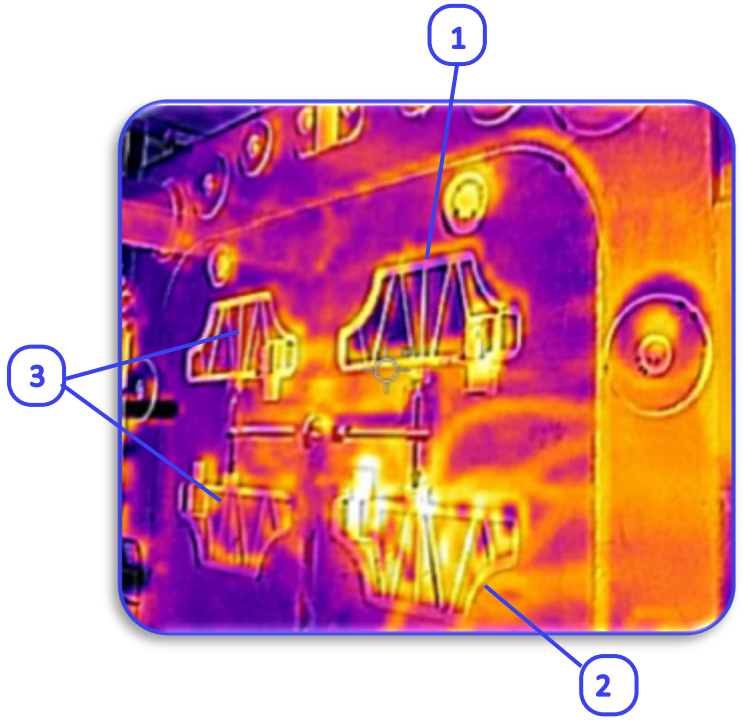
87,6 °C

20,1 °C

MOBILE MOLD TEMPERATURE MAP
WITH A CYCLE TIME OF 24.6s



FIXED MOLD TEMPERATURE
MAPWITH A CYCLE TIME OF 24.6s



1. Conformal cooling mold
2. Traditional mold
3. Not working molds

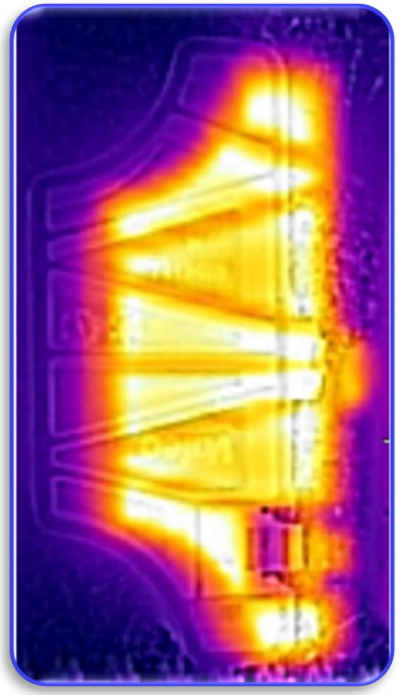
	Tempo ciclo	19,9 [s]	21,2 [s]	24,6[s]	25,5 [s]	27,5 [s]
FIXED MOLD	Tradizionale [°C]	105	98	95	72	70
	Conformale [°C]	85	82	76	71	68
	ΔT	**-20**	**-16**	**-19**	**-1**	**-2**
MOBILE MOLD	Tradizionale [°C]	117	114	98	93	90
	Conformale [°C]	98	94	90	70	68
	ΔT	**-19**	**-20**	**-8**	**-23**	**-22**

As the cycle time decreases, the conformal mold has a temperature about 20°C lower than the traditional one.

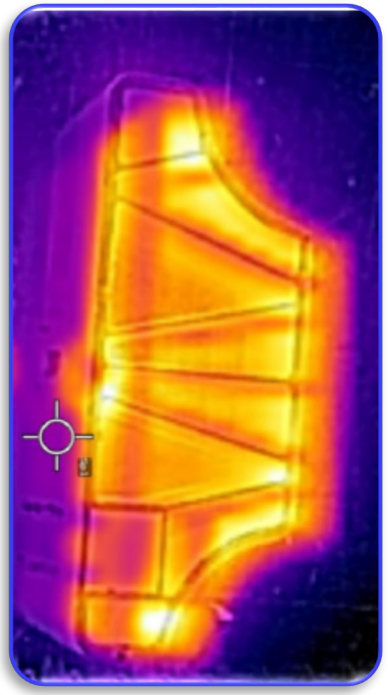
+CIM4.0

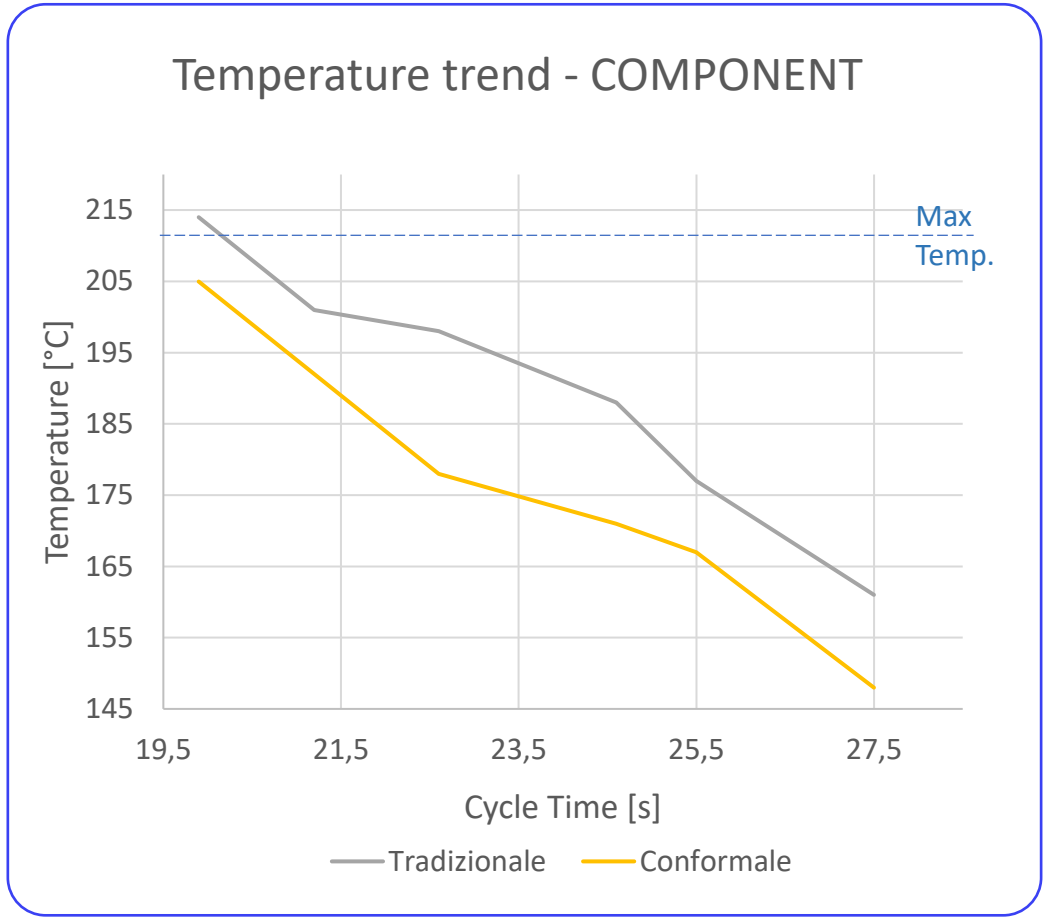
Experimental Validation

COMPONENT TEMPERATURE MAP - TRADITIONAL MOLD



COMPONENT TEMPERATURE MAP - CONFORMED MOLD





The conformal mold component has a lower extraction temperature than the material limit (210°C), even for particularly low cycle times. Unlike the traditional component that exceeds this limit.

+CIM4.0

Take away

RESULTS

LEAD TIME

THREE MONTHS

High values of surface hardness ✓

Improve productivity → Cycle time reduced by 10%

High process control → Obtained by CFD simulation

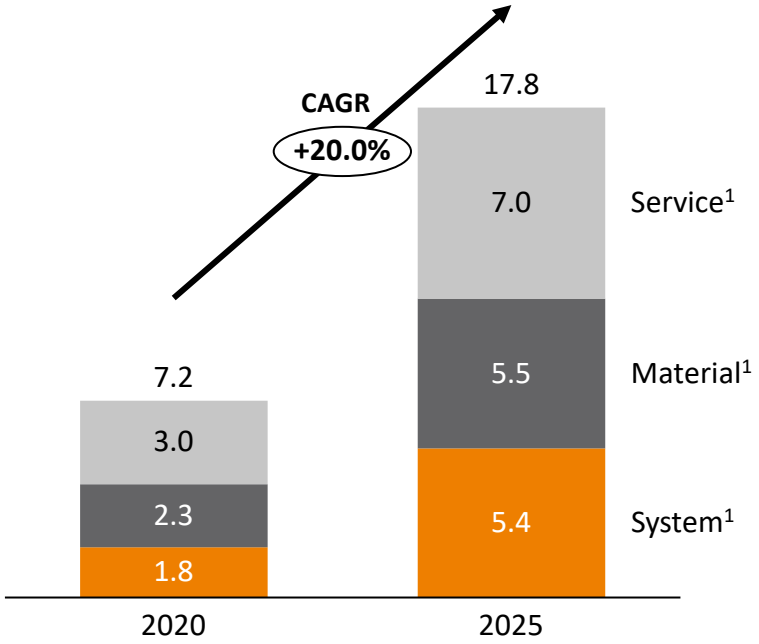
Formal Complexity ✓

Performance Improvement → Further improvements can be achieved by redesign other elements of the mold

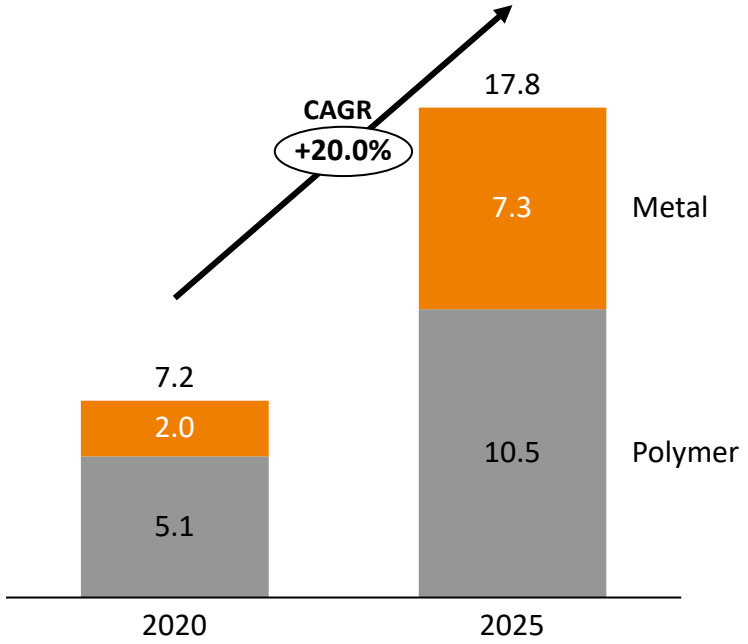
MERCATO

Market Overview – AM Market Size

AM Market size and processed material by value, 2020-25 - €bn, %



Market split by processed material



Market split by category

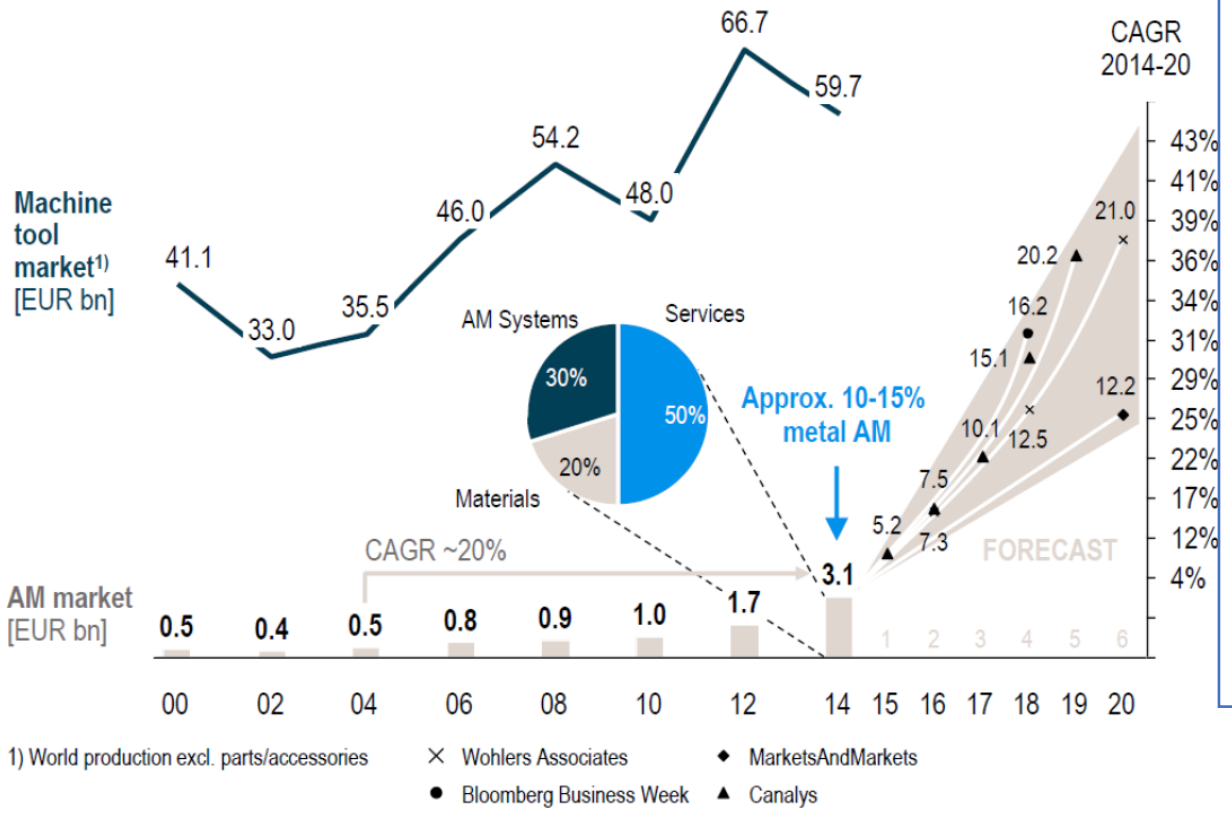
- Overall metal and polymer AM market size in 2020 is valued at **€7.2bn**, while the annual expected growth is 20% until 2025, to reach a total market of €17.8bn in 2025
- Today Polymer market is more than double larger than metal
- **Metal market is projected to increase faster than Polymer** at a CAGR of 29.3%, while the latter is expected to have a CAGR of 15.5%

Sources: AMpower Report 2021
Notes: [1] System is intended to be referred as new machines sold, material is referred to powder and ancillaries used to utilize the AM technology, service is referred to after sales services and after parts

NEL 2015 dicevamo:…..

Overview on Additive: Market Trend

Global AM market development (Source: Roland Berger)



Details

- Market growth between 2010 and 2014 was **higher than 30% p.a.**
- **Future market growth** expected to range **between 25 and 40%** depending on different sources
- Up to 2014, German manufacturers provided **almost 70% of the 1,601 metal AM systems** (PBF) sold worldwide

Source: Roland Berger;
Source: Additive Manufacturing –next generation Amnx, Roland Berger, April 2016

NEL 2015 dicevamo:…..

Overview on Additive: Market Trend

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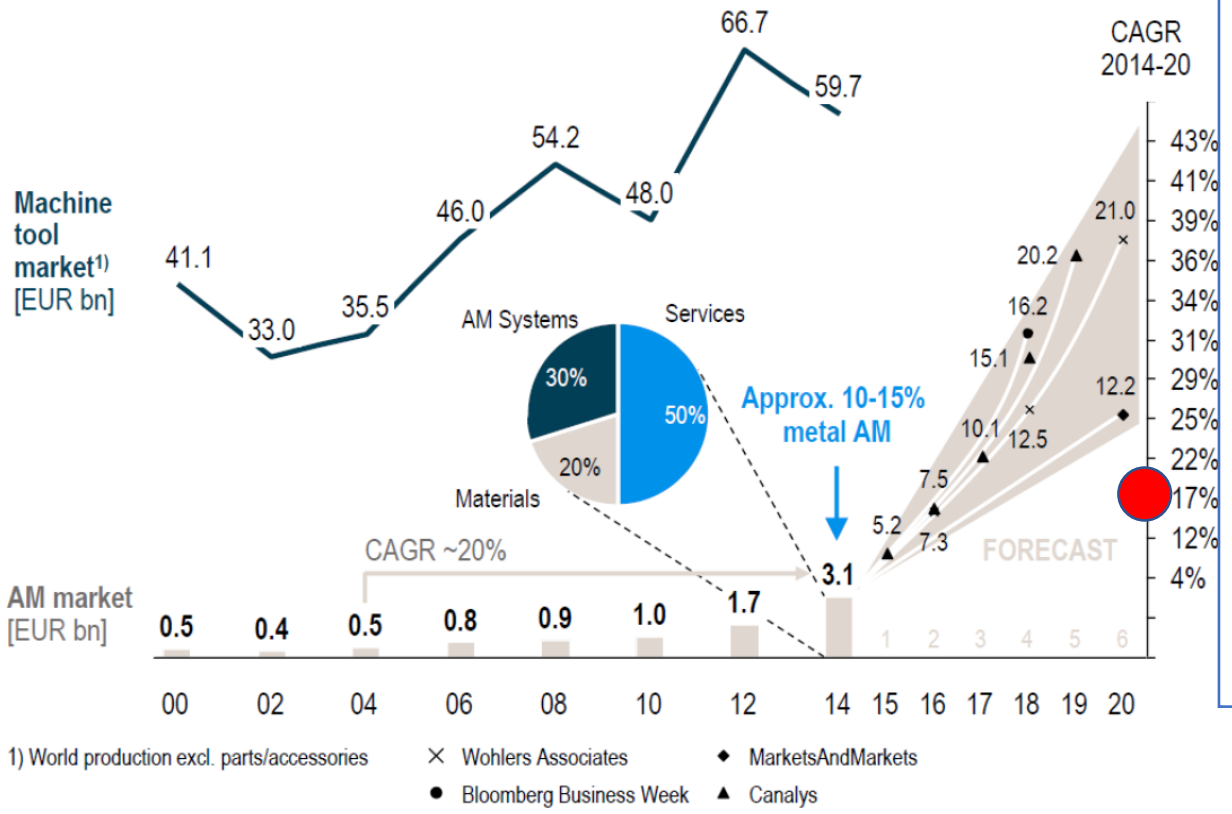

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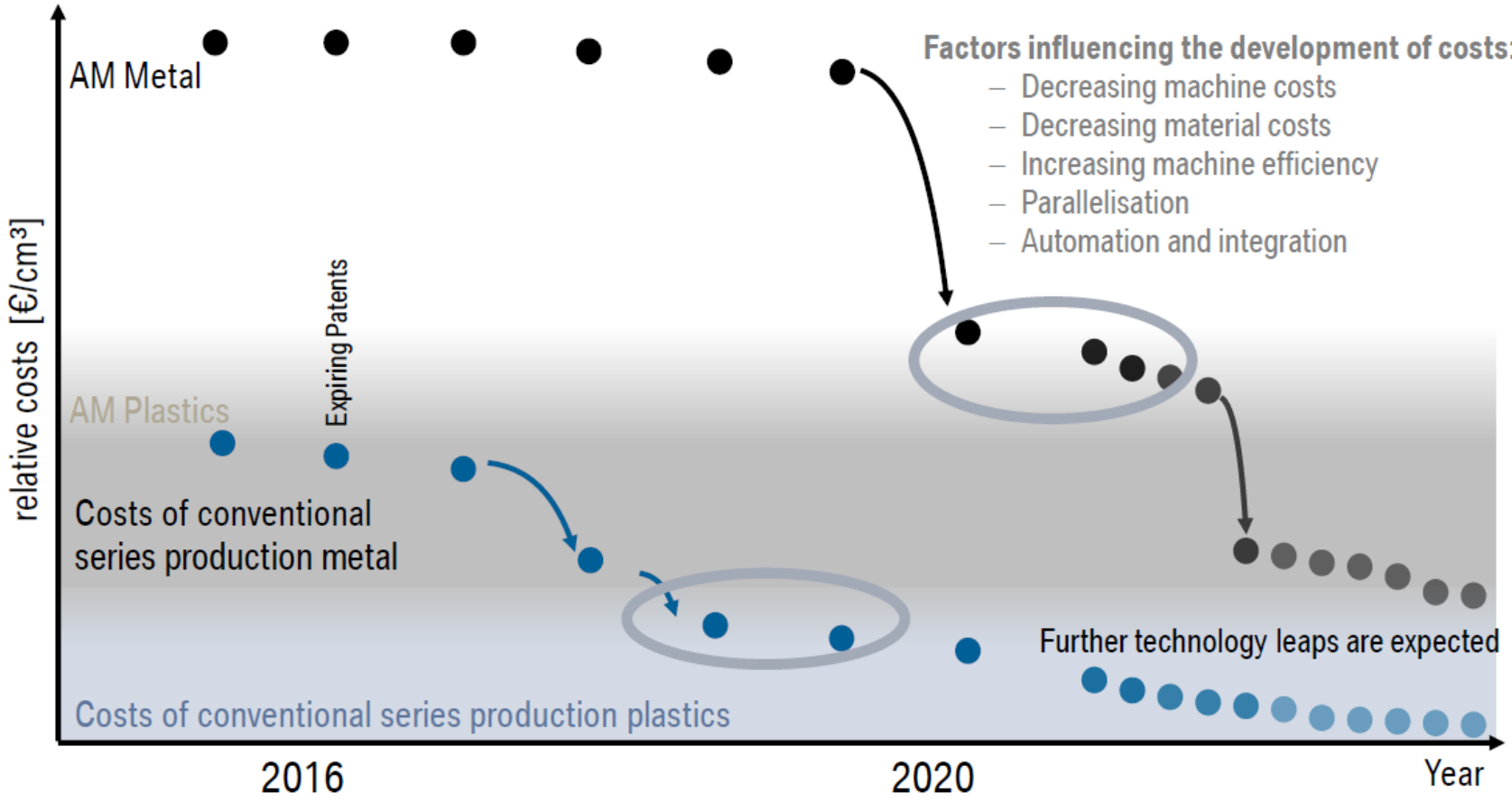
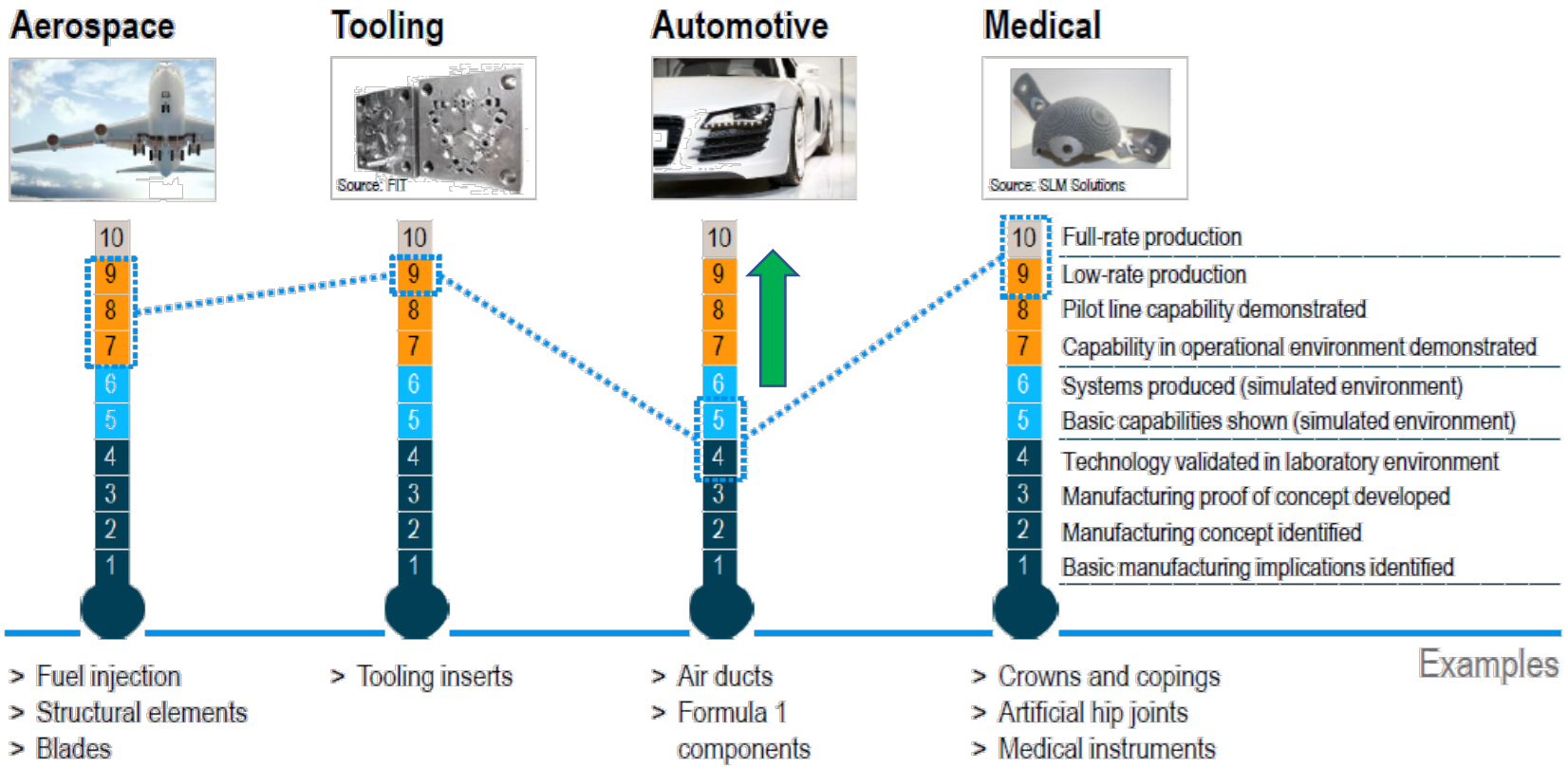
NEL 2015 dicevamo:.....

Overview on Additive: Costs Trend



NEL 2015 dicevamo:…..

Overview on Additive: TRL



Source: Roland Berger;
Additive Manufacturing (AM) – Opportunities in a digitalized production, Additive Manufacturing European Conference , Brussels, June 23rd, 2015

Additive manufacturing: roadmap and key challenges

ROADMAP (rif. EUCAR)

eucar
EUROPEAN COUNCIL FOR AUTOMOTIVE R&D
Expert Group

NOW	2025 LIKELY DEVELOPMENTS	+2025 FUTURE SCENARIOS
Design and Prototyping	*After-market customization, Vehicle restoration*	*Light-weight & specialist components in some vehicles (Niche, low volume parts)*
Rapid prototyping	*Printed electronics embedded in parts*	Crowd-sourced vehicle design & manufacture
Low volume specialist manufacturing (i,.e. functional hand-tools)	*3D printing coexisting with traditional manufacturing*	*Rows of 3D printers on factory floors*

KEY CHALLENGES

eucar
EUROPEAN COUNCIL FOR AUTOMOTIVE R&D
Expert Group

Short Term (<5 years)

- Productivity
- Automotive grade materials & Processes
- Multi-materials
- Integrated process and product simulation
- Smart tooling & parts
- LCA & recycling

Mid Term (5-10 years)

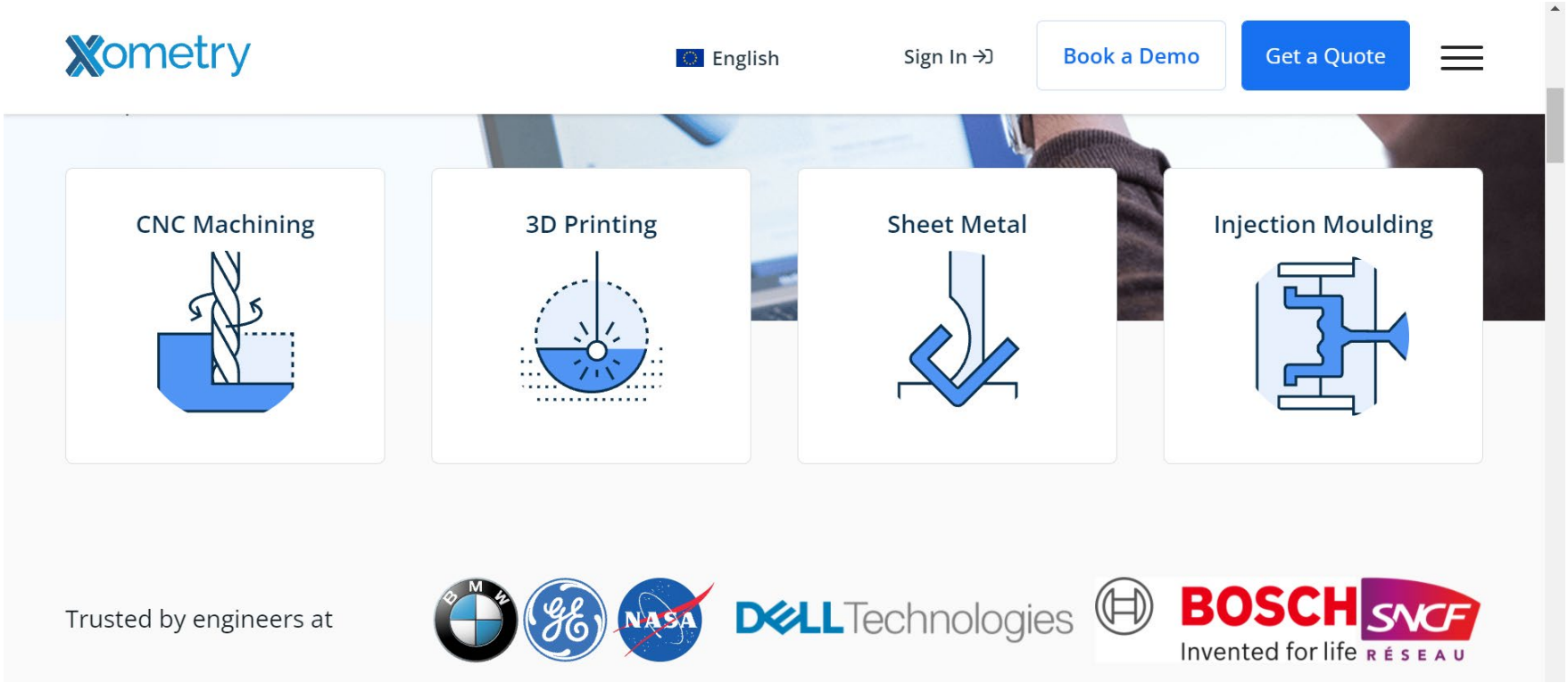
- Printer enhancement
- Self-controlled printers
- Advanced structures simulation
- Virtual machine design
- Next generation applications
- Quality & anti-counterfeit methods
- Education

Long Term (10+ years)

- Future AM processes
- Advanced materials
- Virtual material development
- CO2-less spare parts/repairs
- Liability & IPR

CIM4.0 – Additive Manufacturing Pilot Line achievement

L'azienda tedesca Xometry Europe (https://xometry.eu) ha accreditato CIM4.0 come partner per la realizzazione di pezzi e campioni realizzati in AM: secondo loro indicazioni, presso CIM sono stati stampati con la tecnologia a letto di polvere tre campioni con differenti contenuti e difficoltà, è stata verificata la qualità del prodotto attraverso una check list creata ad hoc, i pezzi inviati alla loro sede per la certificazione e ora, ottenuto il parere positivo, potremo accedere alla loro piattaforma on line e accettare di eseguire alcune lavorazioni per terzi, a seconda del prezzo offerto, della tecnologia e materiali richiesti.



+ COMPETENCE
INDUSTRY
MANUFACTURING
4.0

Industria4.0:
applicazioni e prospettive della manifattura additiva

E. PISINO
CIM4.0

TORINO
08-04-2022

GRAZIE PER L'ATTENZIONE

fabbrica futuro
TECNOLOGIE, MODELLI ORGANIZZATIVI E PERSONE
TORINO