



**Centro Sviluppo  
Materiali S.p.A.**

# CSM FOR MECHANICS & TRANSPORTATION INDUSTRY

*INTEGRATED TECHNOLOGICAL SOLUTIONS FOR INDUSTRY*



*From “steel” to “component”  
The CSM reliable approach to the product development*

Centro Sviluppo Materiali S.p.A. - is facing to *mechanics* as the industrial environment which can really take advantages of its services in aiming worldwide competitiveness of material producers and *end-users*.

CSM technological offer to the *mechanics and transportation industry* (i.a., rail, automotive, ship) covers the whole exigencies of this sector by integrating the needs for more and more performing, cost-effective materials and reliable processes typical of the *semi-product manufacturers* to those of the *components producers* whose targets can be satisfied only with a **concurrent engineering** approach involving a wide spectrum of technologies and methodologies:

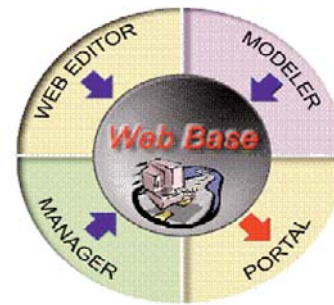
- **Knowledge-based design**
- **Process-Product Quality Improvement**
- **Materials Design, Process & Product Metallurgy**
- **Numerical Modelling & FEM, Metal Forming and Shaping**
- **Materials & corrosion technology**
- **Surface engineering**
- **Welding, Joining and Cutting technology**
- **Advanced Mechanical Testing and Microstructure Analysis, Residual Stresses, Failure Analysis.**

Thus, all these **capabilities** are making the *Centro Sviluppo Materiali S.p.A.* a “quasi-unique atelier” for *mechanics* whose aim is to turn the customer needs into *innovative prototype solutions of components*.

## KNOWLEDGE-BASED DESIGN

The *Centro Sviluppo Materiali S.p.A.*, through *WebBase* and its applicative *Tech Dbw*<sup>©</sup> tool, has developed and made allowable to industry an Internet/Intranet software system which permits to create and manage *Web Engineering Data-Base applications*. It is a powerful instrument making easier the access to the *enterprise Know-How* and a real *time-compression* flexible tool for any design exigency. Several applications are now allowable (*coating process data, component supply-chain, industrial vehicle*

*structures, multi-media stamping archive, etc.*)



## MATERIALS DESIGN, PROCESS & PRODUCT METALLURGY

The *materials design* and *metallic alloys* of interest for the *mechanics and transportation industry* - regardless their chemical composition - are the rear end of several sequential complex manufacturing steps where *metallurgy* is the driving element for designing the *best practices-to-product*.

Likewise, both metallurgy and more generally alloy technology are influencing all the successive steps which turn the *semi-product* into a real component and/or equipment. The development of the through-the-process metallurgy of plain carbon and microalloyed steels, from solidification to final thermo-mechanical processing and heat treatment, with particular attention to basic aspects, is a main task for material tailoring to end-user needs.

The following main activities are carried out by CSM:

- Study of phase transformation of steels and alloys.
- Validation and application of physical-mathematical modelling for predicting the evolution of microstructure and precipitation.
- Development and qualification of flat, tubular and long products made of microalloyed and low alloy steels, including weldability issue.
- Metallurgy of welding.
- Development and application of methods for the morphological and analytical characterisation of microstructural constituents and second phases.

Three main areas can be identified:

- a) Physical metallurgy of thermomechanical processes (for flat long tubular product);
- b) Development and application of mathematical models (for flat long tubular product);
- c) Improvement/development of steel products.

The activities in this field have been mainly concentrated on the following areas:

- Quenched and tempered steels for flat and long products, and seamless pipes, precipitation hardened in order to improve the combination of strength, toughness and sulphide stress corrosion cracking resistance
- Development of multi phase steels for long products, characterised by a microstructure of polygonal ferrite, martensite and bainite having good strength, ductility and drawability
- Development of steels and on-line heat treatments for long products (e.g. rods, rails)
- Application of new welding techniques.

Various laboratories operate according to quality assurance regime for advanced metallographic investigations.

Application of scanning electron microscopy (SEM) and energy dispersive spectrometry (EDS) has allowed combining automatic image analysis (AIA) with the micro-analytical information. At present, five SEM-EDS are used, three of which are equipped with digital control of the electron beam, AIA and quantitative microanalysis facilities. One SEM is also equipped with Orientation Image Microscopy device, able to get local crystallographic information.

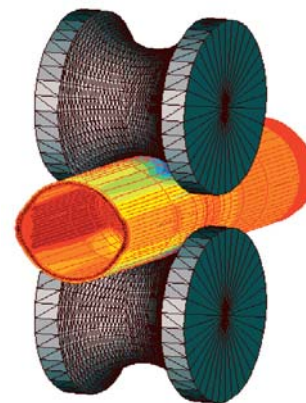
Transmission electron microscopy with scanning attachment (STEM) and high resolution EDS microanalysis is used to have an on-line morphological, chemical and crystallographic information. Dilatometers are used for phase transformation studies, in particular for the measurement of critical temperatures and the determination of isothermal and continuous cooling diagrams.

## NUMERICAL MODELLING & FEM, METAL FORMING AND SHAPING

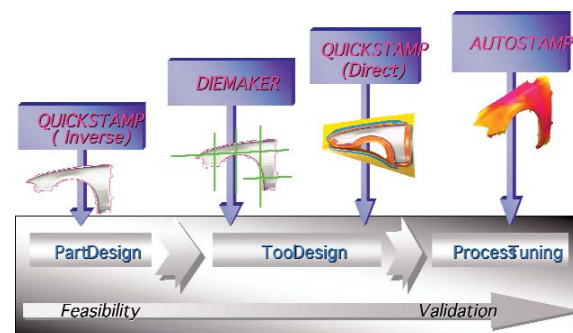
Numerical modelling and Finite Element

Simulation of physical phenomena, devoted to both the analysis and optimisation of in service performances of mechanical part, sub-assembly and complete structure, and the design and optimise of traditional or innovative forming processes represents one of the key elements currently used to identify tailored technologies enabling the correct use of materials for *mechanics and transportation industry*.

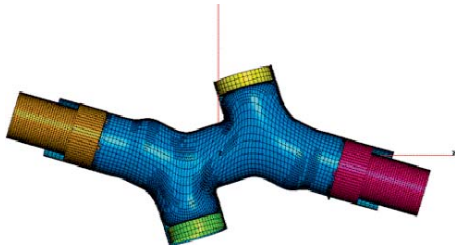
In this context the use of reliable numerical methodologies represents the winner aspect of the CSM action, being fully integrated with the adoption of pilot experimental facilities and supported by a deep and consolidated know-how on the materials. CSM has over 15 year experience in providing methodologies and tools for the simulation of complex forming processes, either cold, hot and warm forming technologies. Traditional drawing and deep drawing of sheet and wire forging, hydroforming of sheet, pipes and bars super plastic forming (SPF), Rolling, Roll Forming, Bending & Stretch Bending, Extrusion, Drawing, Tube Rolling are some of the technological process CSM is able to simulate, giving the possibility to relate the effect of process variables on the result of the forming process.



Tube Rolling Simulation by TUB3



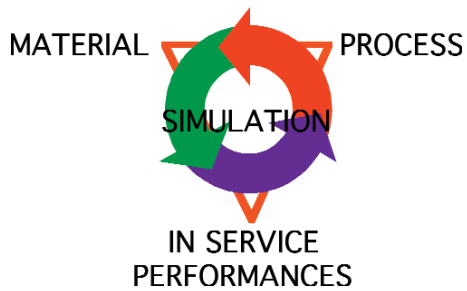
Approach to sheet forming process



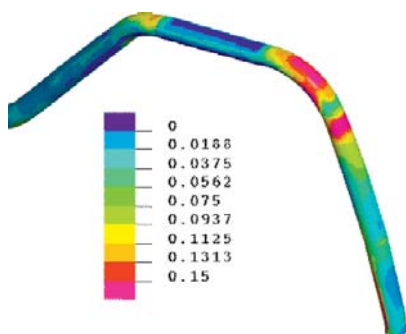
Tube Hydroforming simulation

Optimisation of heat treatment conditions, estimating also phase distribution and effect on fatigue life can be performed by commercial and proprietary software specifically developed at CSM. Simulation of welding and joining processes, estimating final microstructure, thermal distortions and residual stresses is also available at CSM computational centre.

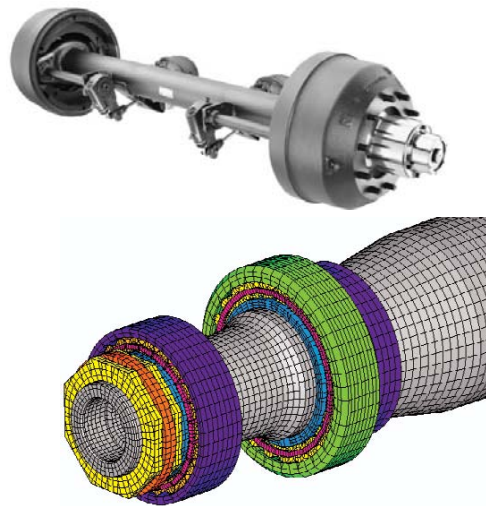
Specific procedures are used to transfer the final stress-strain state after the forming process (residual stresses, material hardening) to the component for subsequent in service performances assessment.



Approach to Product Performance Simulation

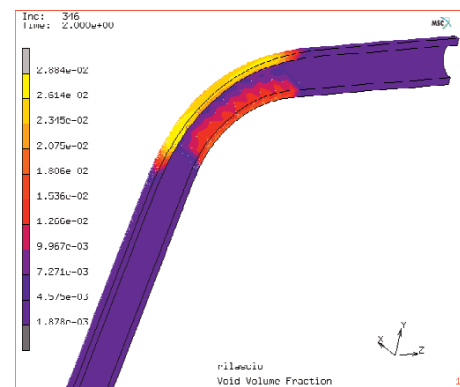


Simulation of an Automotive Stabiliser Bar Forming Process and Performances



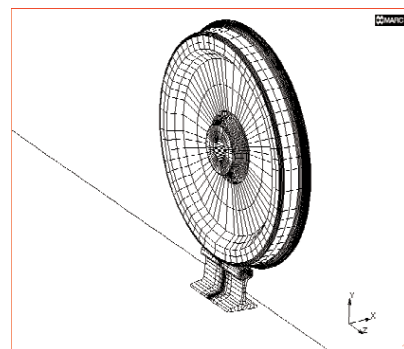
Finite Element model of a Trailer Axle involving enough details to effectively describe fatigue behaviour of the assembly

Advanced material modelling can be implemented by using standard FE code features or customised routines, in order to take into account for complex thermo-mechanical behaviour, phase transformations, anisotropy, damage.



Simulation of pipe cold bending and evaluation of plastic damage induced by the process

Non linear stress analysis is currently performed in fully interaction with mechanical testing in order to investigate the static and fatigue behaviour of components under complex loading. State of the art design and verification criteria are also adopted in this context.



Non linear rail-wheel interaction modelling for rolling contact fatigue assessment.

The experience acquired in the past is today available to the shareholders, car makers, supplier and sub-supplier, upon tailored agreements.

## Software

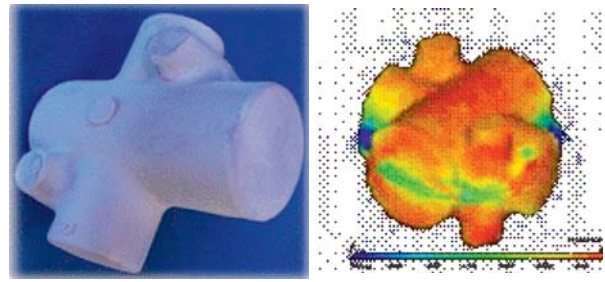
The most relevant and effective software for industrial simulation are available at CSM:

- *PAM Stamp* for sheet metal forming and Hydroforming
- *PAM QUICKSTAMP*, *Altair HYPERFORM*, *SIMEX* for one step sheet stamping simulation
- *PAM Crash/SAFE* and *LS-DYNA* for crash test and analysis
- *PAM Shock* for high speed impact analysis
- *PAM-SYSWELD* for heat treatment and welding simulation
- *MSC MARC* for multi-purpose non-linear calculations, structural analysis and general metal forming
- *ABAQUS* for multi-purpose non-linear calculations, structural analysis and metal forming.
- *TUB3* for tube rolling simulation
- *MSC NASTRAN* for multi-purpose non-linear calculus
- *Altair OPTISTRUCT* for structural topological and topographical optimisation
- *MSC ADAMS* for multi-body kinematic and dynamic analysis of mechanical systems
- *SuperForge* for forging process simulation
- *ProCast* for foundry process simulation
- *CalcoSoft* for modelling the foundry process
- *FLUENT* for internal and external fluid dynamic simulation, including combustion process and furnace design.

As for as Computer Aided Design (CAD) and Computer Aided Engineering (CAE) concerns the most powerful and reliable software are available at CSM, namely Master Series V12, Pro Engineer WildFire 3, Hypermesh 7.0, AUTOCAD, RINOCEROS 3.0.

In this respect, the *Centro Sviluppo Materiali S.p.A* is endowed with a large number of laboratory, medium-sized and industrial equipments which, well-balanced and blended

with the high level metallurgical skillness of its



researchers, allow it to really support both the semi-product manufacturer and the end-users towards the development of more performing solutions.

According with a flexible and pragmatic approach to the market CSM is now facing mechanics and transportation industry as a supplier, too, thus guaranteeing it the easy and quick procurement of small batches of special steel and alloys even as metallurgical powder.

Some of CSM experimental endowments are listed underneath:

- *Foundry, powder, near-net-shape and rapid prototyping technology;*
- *Heat treatment technology;*
- *Heat Furnace technology;*
- *Hot and cold rolling mill technology;*
- *Forging and superplastic forging technology*
- *Sheet forming and hydroforming technology*
- *Hot isostatic pressing technology;*
- *Sintering and cold pressing technology;*
- *Pickling technology;*



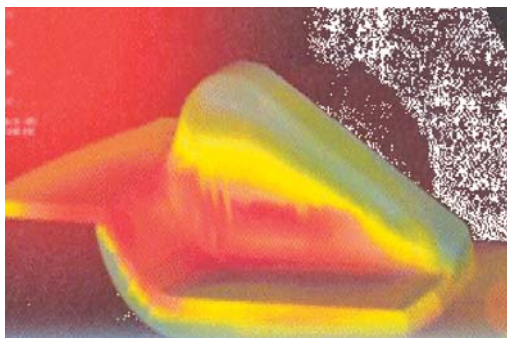
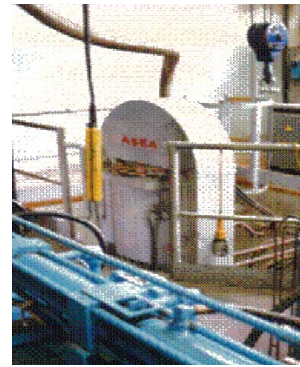
CSM's Semi-Industrial Hydroforming Press for Sheet and Pipes (3000 tons, 4000 bars)

The CSM prototyping centre located in Melfi allows prototyping and small production of components by means of the innovative Hydroforming technology. Innovative project concerning the application of

the technology to high thickness pipes have been successfully completed, which allow gain a very deep knowledge directly transferable to design of new concepts for mechanics and transportation industry.

Specific projects and/or pilot production activities have been developed together with relevant Customers (Iveco, CRF & FIAT Auto, Giugiaro, Pininfarina, Zeuna, Magneti Marelli, Pirelli Tyres, Tetrapak, Magnetto Automotive, Magnetto Wheels, Emarc, Ansaldo Breda, Fincantieri, Alenia Aeronautics, Avio, Tenaris, Nuovo Pignone).

These experimental equipments are also strongly supported by a remarkable capability in terms of *calculus* and *modelling* which, together with *rapid prototyping* and *tooling* technology, allow the centre to shorten the *time-to-market* and make the new products development itself more refined and exquisite.



The CSM capability in terms of mechanical and thermomechanical *calculus* and *modelling* which, together with *rapid prototyping* and *tooling technology*, allow the centre to shorten the *time-to-market* and make the new products development itself more refined and exquisite.

The CSM capability in terms of *Advanced prototyping* and *tooling* is guaranteed through the availability of such equipments as

- **3D System SLA 250/40** for assembly testing, fittings and investment casting
- **EOS Eostin-M 250** for injection dies manufacturing
- **MEIKO LC 510** for application of high precision small items.



## **MATERIALS & CORROSION TECHNOLOGY**

The corrosion is the ubiquitous phenomena occurring on metal alloys which can cause the progres-

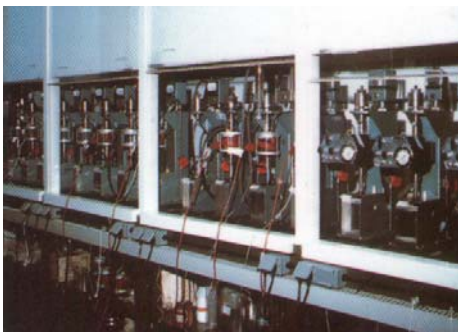
sive deterioration of the component functionality or its disruptive and sudden failure, because of the concurrent effect of the on-exercise dynamic or static loads applied to structures or components, too.



The CSM has over 40 years experience in providing cost-effective solutions in terms of *material development, performance assessment and components* aimed to minimise *failures* and maximise performance.

The *Corrosion Lab* is fully integrated on *product development* by offering to the customer a wide test capability including the following topics:

- *Stress corrosion cracking and Sulphide stress corrosion cracking;*
- *Corrosion and Stress Corrosion Resistance;*
- *Corrosion Fatigue;*
- *Hydrogen embrittlement (also at high pressure and temperature);*
- *General and localised corrosion;*
- *Behaviour of materials and components in natural and simulated aggressive environment;*
- *Corrosion monitoring in service.*



The main customers of *CSM Corrosion Labs* are: Thyssen Krupp-AST, Tenaris, ENI, SnamProgetti, BP, Shell, Exxon Mobil, Statoil, FINCANTIERI, ENEL, White Good Producers, SMEs etc.

## SURFACE ENGINEERING

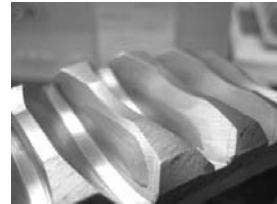
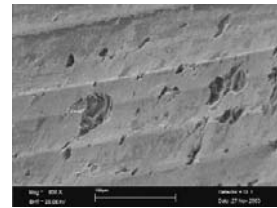
Today, better performing surfaces in terms of wear and corrosion resistance, low friction are unavoi-

dable technological demands from customers.

CSM can give broader perspectives in developing new products for *mechanics* being able to integrate the *surface technology* to the *product* just at the feasibility study level.

CSM capabilities on surface technology give large opportunities to *customers* being structured to develop:

- *Analysis and modelling* of the in-service conditions of the component and its *failures*;
- *Special Surface analysis techniques* are available: *XPS, GDOES, XRD*;



- *Design and development* of thick coatings by Controlled Atmosphere Plasma Spray (CAPS), High Velocity Oxy Fuel (HVOF), and Plasma Transferred Arc (PTA)

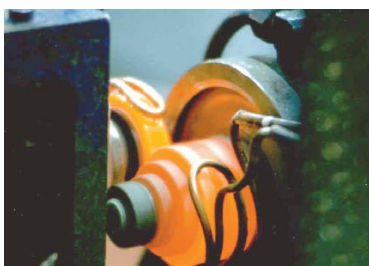
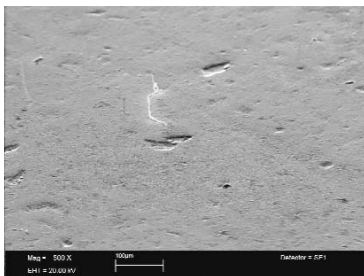
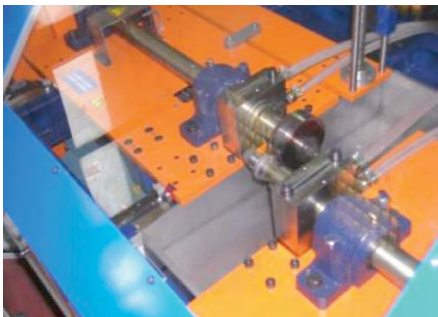


- *Design and development* of Thin Coatings by PA-PVD (arc, sputtering, PMCS)

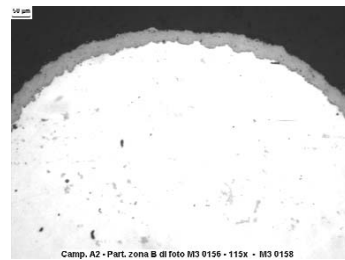
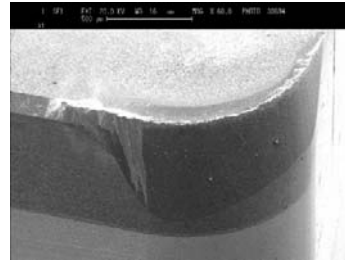




- Tribological testing (available tribometers: pin-on-disk, ring-on-ring, high temperature (1200°C) ring-on-ring, thermal fatigue (1200°C), fretting (up to 600°C), Rolling Contact Fatigue).



- New cermet material for tools and *machinability testing* (continuous and interrupted test,  $V_{10}$  measure, etc.).



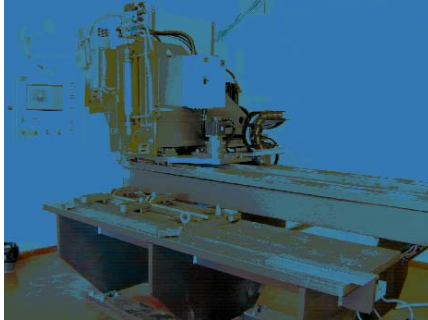
CSM Patent (multilayer coatings for monocycles)

The main customers of *CSM Surface Technology Labs* are: TetraPak, Rossi Motoriduttori, IMA, Tenaris, TK-AST, Iveco, Fiat, Berco, Piaggio Aero Industries, Pirelli Tyres, SMEs.

## WELDING, JOINING AND CUTTING TECHNOLOGY

The *CSM Laser Technology Lab* has become, today, a well-known reference for *mechanics and transportation industry* as able to fit skills of researchers on welding technologies to a solid competence about the related material technologies.

Being endowed with a well-balanced mix of traditional (GTAW, GMAW, PAW, etc.) and such more advanced technologies as laser (*CO<sub>2</sub>* and *Nd:YAG laser*), hybrid welding (laser + arc) and, more recently, *Friction Stir Welding*, it can satisfy customers needs both in terms of *new products development* and *small added-value productions*.



*Friction Stir Welding equipment*

Laser technology has been used to replace resistance spot welding process for stiffeners assembly of side panels of Light Rail Vehicle trams committed to AnsaldoBreda by Los Angeles County Metropolitan Transportation Authority. Fabrication has been performed using the new assembly technology and the manufacturing facilities available at CSM.



*Component of side panel laser welded*



*Nd: YAG laser facility*

The main customers of *CSM Laser Technology Labs* are: Fincantieri, Alenia, AnsaldoBreda, Finmeccanica, Tenaris and many SMEs.

## ADVANCED MECHANICAL TESTING AND MICROSTRUCTURE ANALYSIS, RESIDUAL STRESSES, FAILURE ANALYSIS

The product development is supported by a solid testing and analysis capability at CSM based on the following laboratories:

- **Mechanical testing laboratory** which operates at the level of specimens and small, medium and large-sized components;



- **Creep testing laboratory** specialised for high temperature qualification of materials at mono- and biaxial loads;

- **Chemical and microstructure analysis laboratory** endowed with state-of-the-art apparatus as TEM, SEM+EDS+WDS, ESCA, GDOES, QTM and chemical equipments fitted to give the whole analysis of materials even at traces levels;

- **Residual stress laboratory** endowed with state-of-the-art apparatus as Hole Drilling machine, X-ray diffraction system and extensometers for application of conventional and advanced Sachs' methodology on by-products, components and equipments;



*Residual stress measurement device by Hole Drilling*



*Sachs method - Steel pipe internal diameter boring out.*



*X-ray diffraction device and typical employment.*

# The Castel Romano Area

Castel Romano lies midway between Rome and the Southern Lazio industrial area. It is close to the Pomezia industrial area, 30 minutes from the town of Latina, 15 minutes from the EUR office district and 30 minutes from Fiumicino and Ciampino airports. It is close to the Roma III and Tor Vergata campuses of Rome University and near to other important private industrial and research structures operating in a wide range of sectors (pharmaceuticals, chemicals, biotechnologies, IT and telecommunications).

Located in an area of great regional landscape and environmental value, it is classified in target zone 2-92.3 C eligible for Italian and EU facilitations for the realization of infrastructures, corporate investments and research and innovation projects.



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