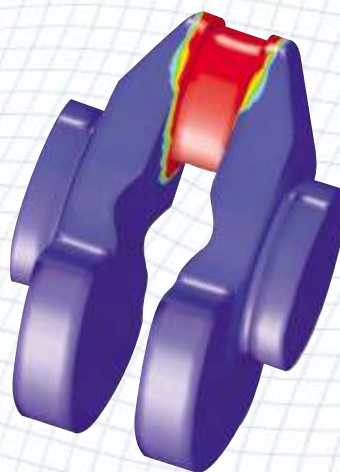
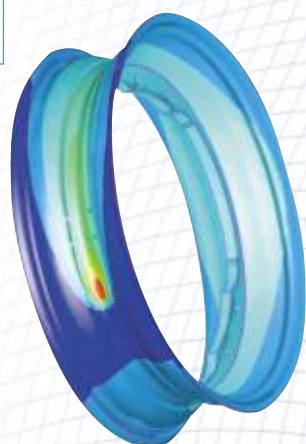
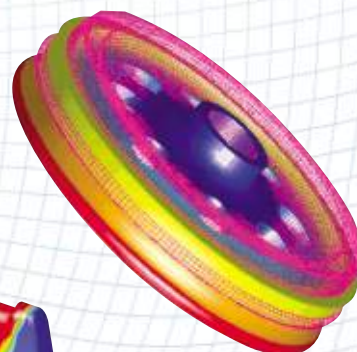




# SYSWELD

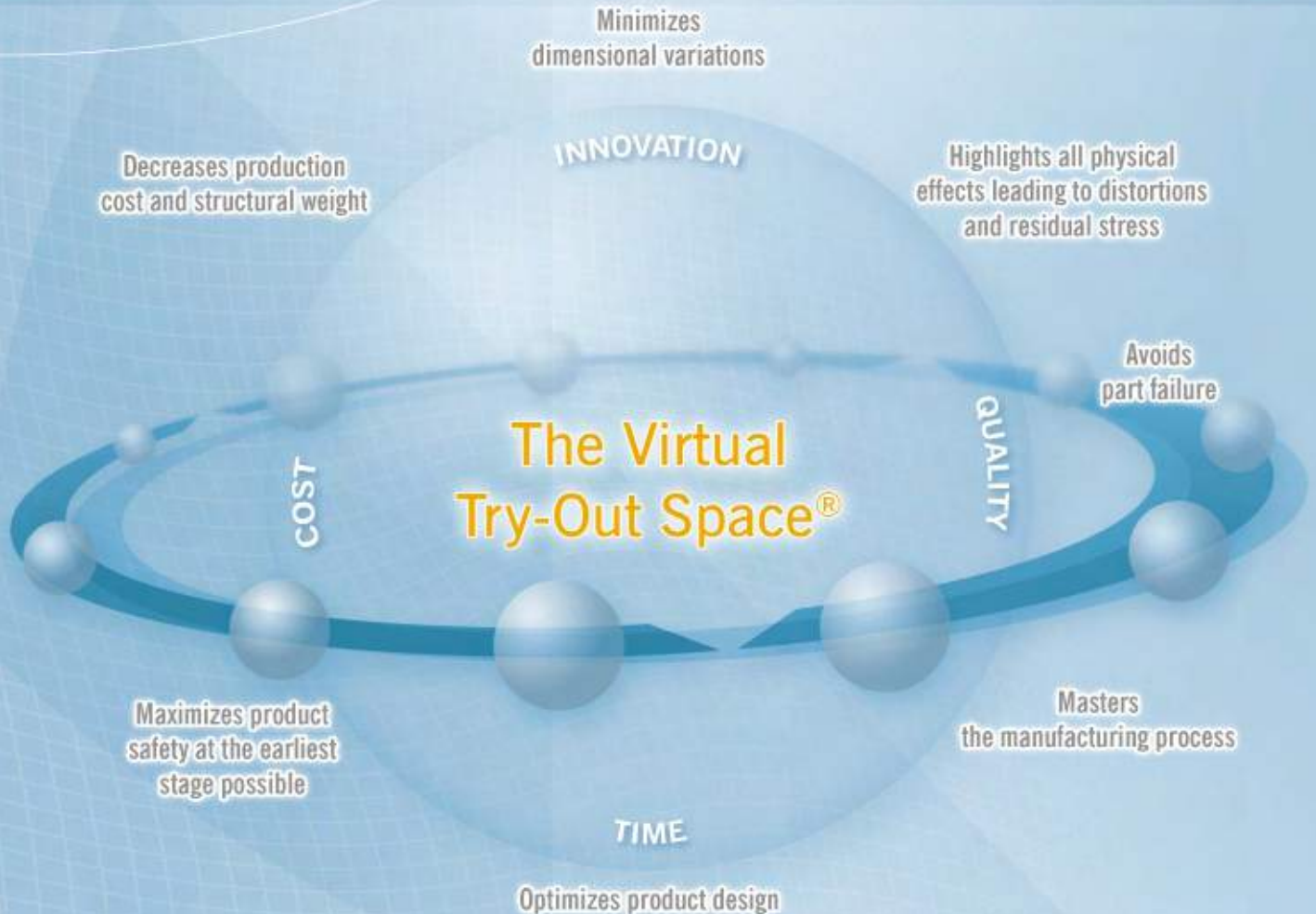
Engineering Simulation  
Solution for Heat Treatment,  
Welding and Welding Assembly



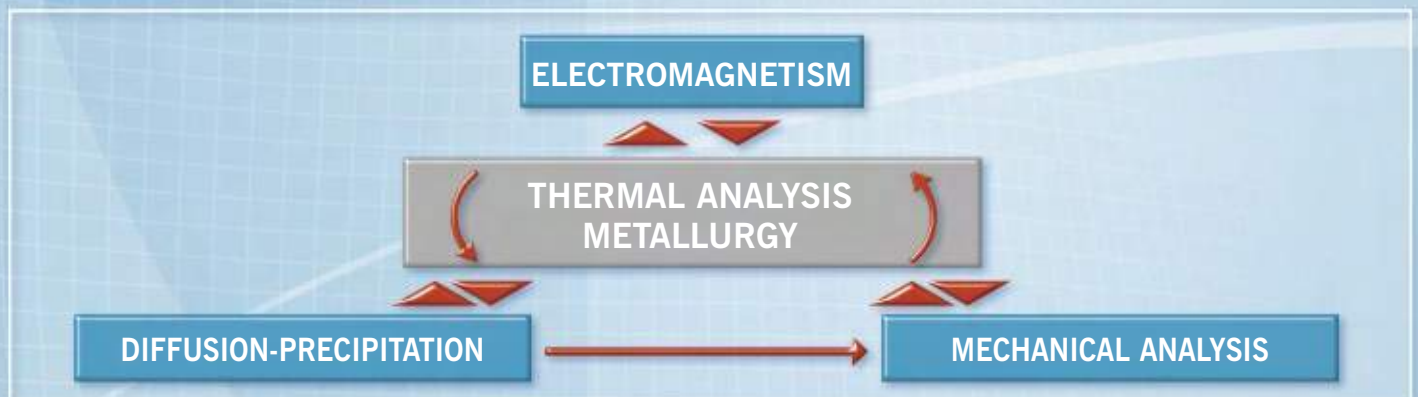
# SYSWELD in the Virtual Try-Out Space

*Simulation is the best approach to master design, manufacturing process and in-service problems at the earliest product stage possible.*

*Resulting from more than 20 years of development, SYSWELD is the leading tool for the simulation of heat treatment, welding and welding assembly processes, taking into account all aspects of material behavior, design and process.*



“Looking behind the complex physics embedded in Heat Treatment, Welding and Welding Assembly”



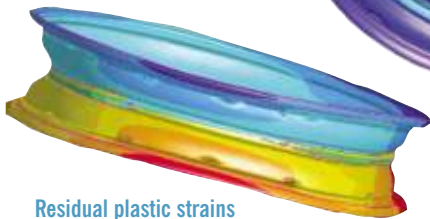


# SYSWELD Meets Industrial Needs

## Welding

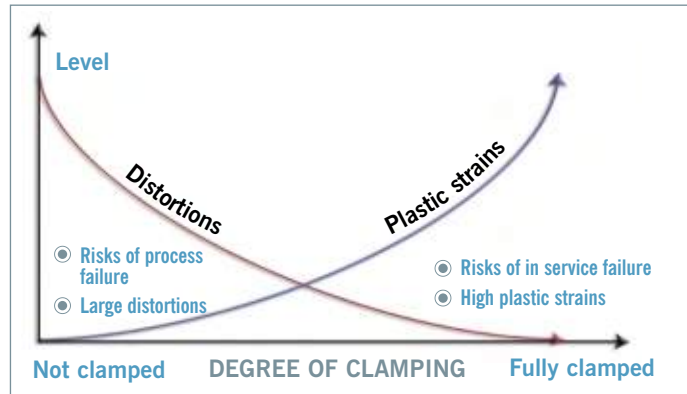
Key success factors in the welding industry focus on eliminating as much as possible the distortions of structural assemblies and component repair, as well as addressing durability problems related to welding processes. Engineers involved in welding try to find the optimum between distortions, residual stresses and plastic strains by fully optimizing the process type and the process parameters, bringing understanding of their influence of the part shape and the resultant material behavior.

Low distortions due to a specific part clamping



Residual plastic strains

Finding out the process window:  
Where is the optimum ?



SYSWELD is a powerful tool that guides engineers to find out the optimum process parameters with respect to distortions, residual stresses and plastic strains.

## Taking into account the typical engineering questions

- Is the manufacturing process feasible ?
- How long will the part last ?
- Which tolerances have to be achieved ?
- How can design flaws be avoided ?

## Heat Treatment

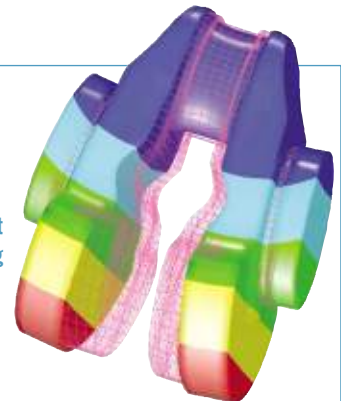
Heat treatment is an indispensable step in the manufacturing of metallic products, especially in the automotive industry and in aerospace engineering. Critical success factors in the heat treatment market focus on safe processes, minimizing part distortions and improving durability. Engineers involved in heat treatment are looking for:

- Process feasibility,
- A minimum amount of distortions,
- A high resistance of contacting surfaces against wear,
- A specific microstructure fitting to the in-service purpose,
- A dedicated distribution of residual stresses.

By deliberate manipulation of the chemical and metallurgical structure of a component, mechanical properties such as hardness, yield stress and tensile stress are selectively controlled.

Distortions can be minimized and forming of cracks can be detected and avoided.

Distortions of a crankshaft after quenching



Compressive stresses on the rolling surface of a train wheel

SYSWELD enables the coupled modeling of complex physical phenomena such as electromagnetism, heat transfer, diffusion and precipitations of chemical elements, phase transformations and mechanics.

# SYSWELD, the Driving Force for Welding Simulation Technology, from Process...

## SYSWELD, the complete solution for handling virtual welding

SYSWELD guides engineers to:

- Evaluate residual distortions

Assembling a structure requires sequential continuous and/or spot welding joints. Therefore, defining the welding sequence and the places where the parts will be welded is crucial for the correct completion of the welding assembly process. Simulation allows prediction and minimization of distortions which generate an increase of the overall product quality as well as drastic cost saving.

- Minimize residual stresses

Simulating the welding process aims to control the process in a way that minimizes the stress gradient and tensile surface stresses. As a result, lifetime of a part increases as fewer cracks appear after load cycles. Compressive stresses can also be detected on the surface of the component, therefore improving part quality and avoiding corrosion risks due to tensile stresses.

- Study the sensitivity of geometry, material and process parameters

Used in the design phases, SYSWELD decreases costly design errors. At each step of the development cycle, the cost of corrections gradually increases. SYSWELD helps to optimize part geometry, materials and process parameters during the early stages of a new design cycle avoiding expensive engineering changes that could occur later.

- Optimize the welding process

SYSWELD allows user-defined weld sequencing and control of the weld manufacturing parameters such as velocity, energy input and many others.

## SYSWELD answers engineers' questions

Empowered by the Advisor technology, an automatic solver, and a multi-physics post-processor, SYSWELD takes into account multiple factors such as:

- Process parameters,
- Part geometry,
- Thermal, metallurgical and mechanical material behavior.

SYSWELD features a comprehensive material database that covers the major steels and aluminum alloys in the market.

## SYSWELD simulates all major Welding processes

- Continuous welding

- Laser,
- MIG,
- Electron-beam,
- ...

*"The challenge in the nuclear industry is to increase the life span of components. Welding repairs are categorized using SYSWELD on many different kinds of defects."*

- Resistance and Spot welding

*"Spot welding is very common in the automobile industry. With the coupling between electromagnetism, heat transfer, metallurgy and mechanics, this process is accurately simulated with SYSWELD."*

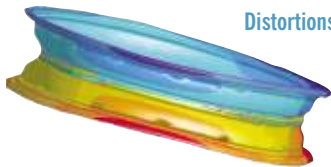
Temperature field



Material transformations



Distortions



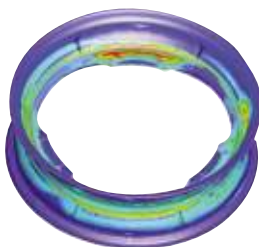
Residual yield stress distribution



Residual plastic strains



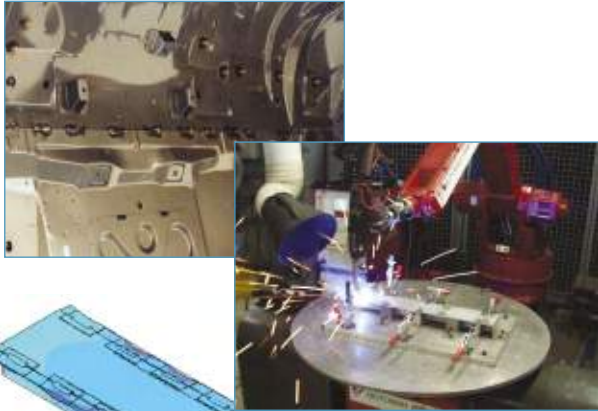
Stresses due to welding and in-service loading



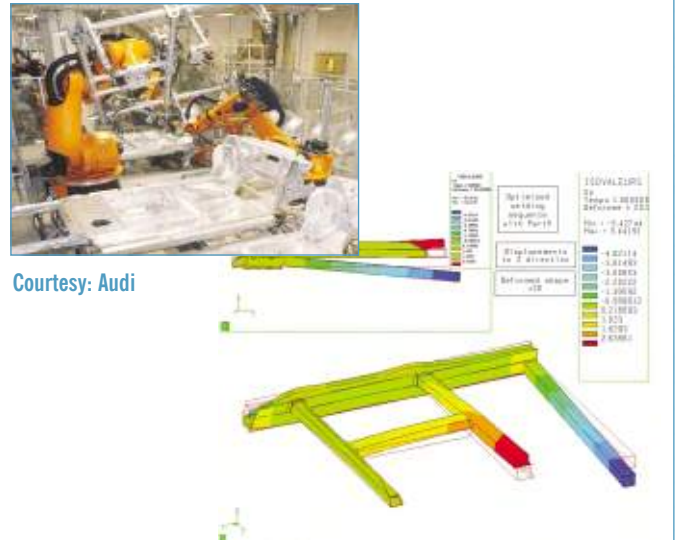
Continuous welding of a motorcycle rim

# ... to Application

## AUTOMOTIVE INDUSTRY Welded Assemblies

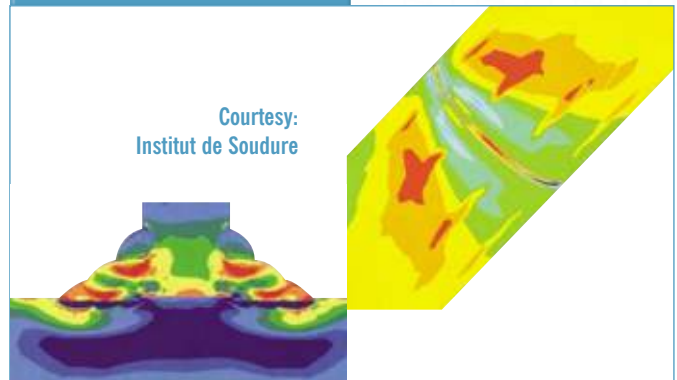


## Space Frame Welding



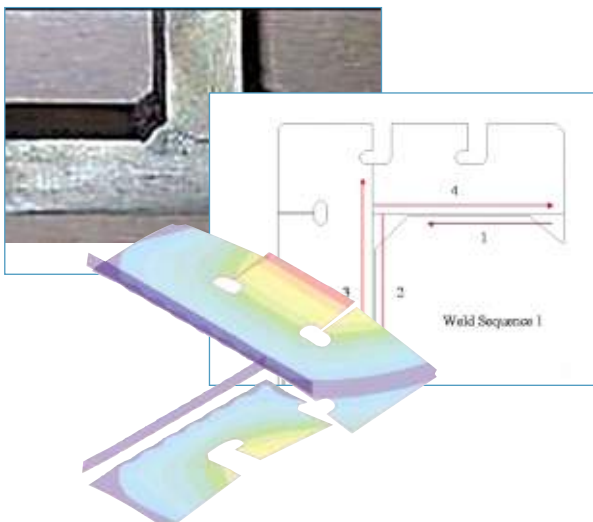
Courtesy: Audi

## HEAVY INDUSTRY Multilayer Welding

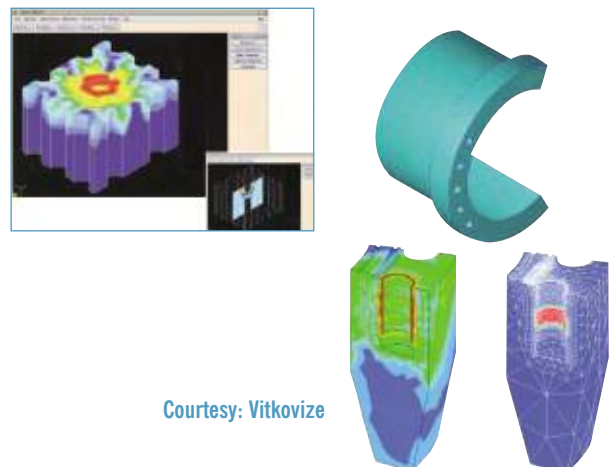


Courtesy:  
Institut de Soudure

## SHIPBUILDING INDUSTRY Welded Assemblies



## NUCLEAR INDUSTRY Weld Repair



Courtesy: Vitkovize



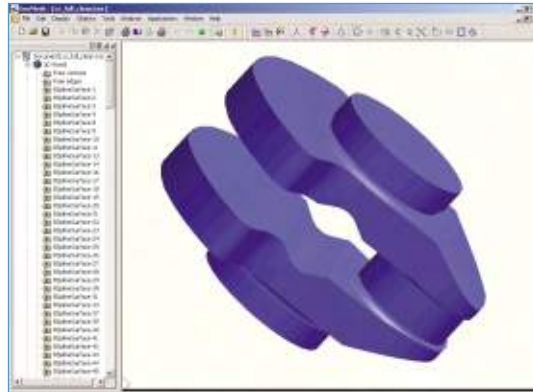
# SYSWELD

## SYSWELD/GEOMESH CAD DATA IMPORT/EXPORT

SYSWELD/GEOMESH provides graphical modeling capabilities for manipulating FE meshes. Native CAD data is imported, automatically cleaned and prepared for FEM analysis.

## Meshing capabilities and group concept

SYSWELD/GEOMESH provides engineers with powerful algorithms for the generation of FE models. Patch independent surface meshes and fully automatic volume meshing (hexahedrons, tetrahedrons) is available for welding and heat treatment analysis. The group concept allows simple and complete interfacing to any existing meshing tool, and so the definition phase of the numerical problem is extremely short and simple.



Native CAD model of a crankshaft

## Comprehensive Material database

SYSWELD features a comprehensive material database. The thermal, mechanical and metallurgical material properties are quite complex and depend on temperature and phases. Included are major steels, aluminum alloys and gray iron.

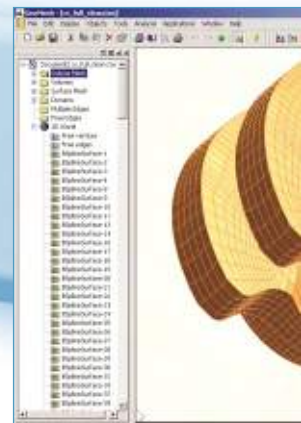
## SYSWELD advisors working the engineering way

The advisor technology radically reduces the time needed to set up computations for heat treatment, welding and welding assembly simulations. SYSWELD offers a fully intuitive process-driven methodology to set up simulations through three types of advisor:

- Heat treatment advisor,
- Welding advisor,
- Assembly advisor.

*Cost-effective, SYSWELD offers an easy handling and a friendly set of tools for engineers with limited experience in FEM technology. It helps to optimize heat treatment and welding assemblies. Compared to a traditional approach, SYSWELD provides a solution to reduce simulation time. Therefore it enables a drastic minimization of prototypes, leading to a high return on investment.*

**Hexahedral mesh of a crankshaft.**  
dedicated to heat treatment analysis of the thickness.



# in Action

*SYSWELD benefits*  
*ds-on and user-*  
*ls. It enables*  
*imited knowledge*  
*y to control and*  
*atment, welding*  
*mbly processes.*  
*al-and-error*  
*ELD is the key*  
*e cost and lead*  
*generates a*  
*ion of physical*  
*g to*  
*vestment.*

*The layered mesh generator is*  
*sis from the surface and through*



Heat transfer  
coefficient wizard

Compressive stresses displayed on the distorted structure



Straightforward and simple workflow, from the definition of  
the project to the start of the computation

## Multiphysics Post-Processor

The multiphysics post-processing capabilities provide instantaneous process information for the evolution of:

- Temperature field,
- Heating and cooling rates,
- Metallurgical structure of the material,
- Distortions,
- Stresses,
- Yield stress of the modified material,
- Plastic strains.

### Result analysis

SYSWELD provides a variety of techniques for reviewing process results including:

- Contour plots,
- Iso-lines and Iso-surfaces
- Vector-Display,
- x-y diagrams,
- Symbol plots,
- Numerical representation,
- Cutting planes,
- Animations.

## Automatic solver

The SYSWELD solver provides an automatic solution for welding and heat treatment problems, covering all related complex mathematics and material physics. Depending on temperature, phases and proportion of chemical elements, thermal and mechanical properties are computed including phase transformations enthalpy, melting and solidification of material, large strains, plasticity and transformation plasticity.

## Graphical user interface: efficiency, flexibility

The interface comprises engineering tools to adjust all necessary process parameters and a straightforward and simple workflow, as part of the heat treatment, welding and assembly advisors.

# SYSWELD, the Driving force for Heat Treatment Simulation Technology, from Process...

## SYSWELD, the complete solution for handling heat treatment technology

SYSWELD performs simulations taking into account all physical phenomena involved in the heat treatment process. It provides extended databases for materials – phases and temperature dependent - and quenching media. The numerical methods implemented are highly optimized for the computation of heat treatment processes.

Specific technical capabilities are provided for the Finite Element modeling of the heat treated structure. The requested high quality in computed results requires a refined layered mesh from the surface through a few millimeters of thickness of the part. For 2 dimensional structures, a guided layered mesh generator is available. For 3 dimensional structures, a fully automatic layered hexahedral mesh generator is accessible for solid parts of any complexity. As a result, SYSWELD drastically reduces the time to mesh parts while offering high quality Finite Element models.

## SYSWELD answers engineers' questions

From the start of the software to the start of the computation it usually takes 30 minutes or less, including Finite Element modeling. Even 3D computations of distortions and residual stresses are performed in less than one day. As a consequence, answers are provided more efficiently to the basic questions from heat treaters and designers:

- Is the selected heat treatment process feasible ?
- Is the selected steel feasible ?
- Is the selected quenching media suitable ?
- Is the process window safe against process tolerances ?
- Is the part hard where it should be hard ?
- Is there any crack risk occurring during the process ?
- Are the obtained distortions acceptable ?
- Are the residual compressive stresses high enough and well positioned ?

The heat treatment product solution is especially suited for heat treatment job shops, which need to ensure the feasibility of a heat treatment process within one day.

## SYSWELD simulates all major heat treatment processes

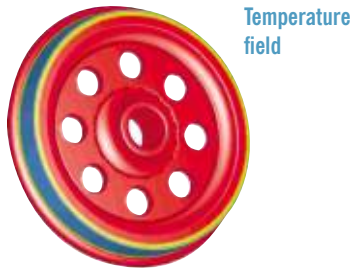
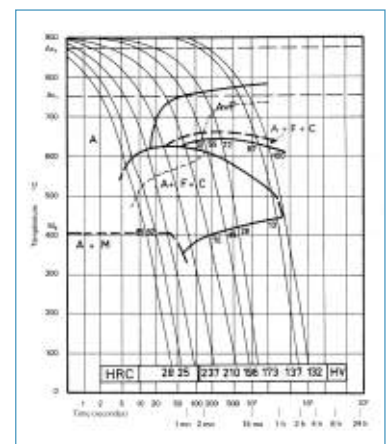
*SYSWELD computes and optimizes all basic steps of the heat treatment process:*

- Austenitization for surface hardening
- Austenitization for through hardening
- Quenching, austempering, martempering and tempering

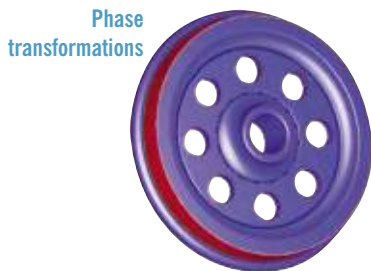
*SYSWELD simulates the following processes:*

- **Surface hardening**
  - Induction
  - Laser
  - Electron beam
  - ...
- **Through hardening**
  - Direct
  - Austempering
  - Martempering
  - ...
- **Thermo-chemical heat treatment**
  - Carburizing
  - Nitriding
  - Carbonitriding
  - ...
- **Tempering**

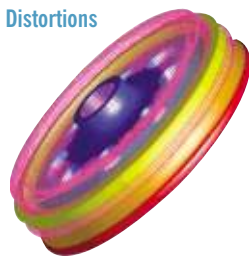
Typical CCT diagram



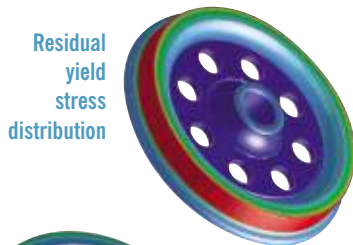
Temperature field



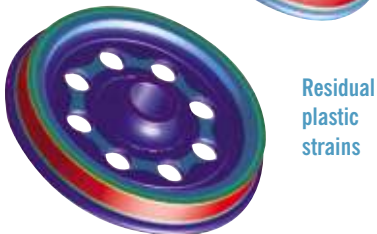
Phase transformations



Distortions



Residual yield stress distribution



Residual plastic strains



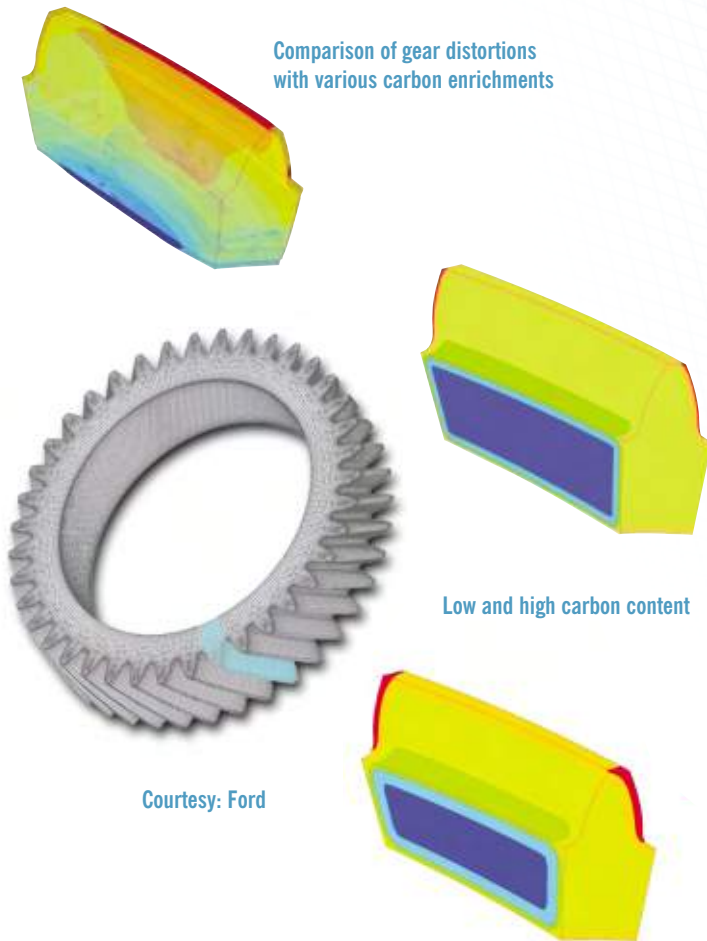
Residual compressive stresses

Through hardening of a train wheel

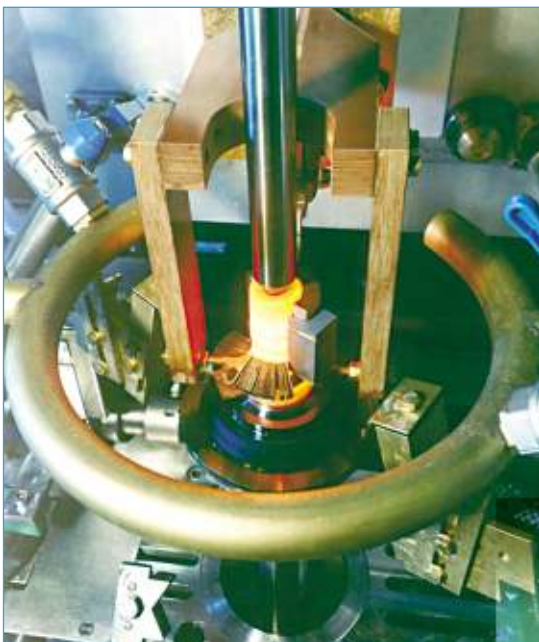


# ... to Application

## Case hardening of gears

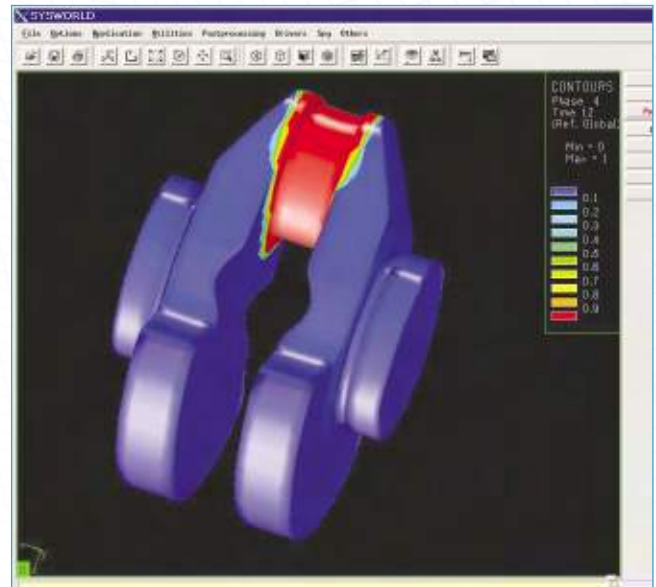


## Heat treatment process



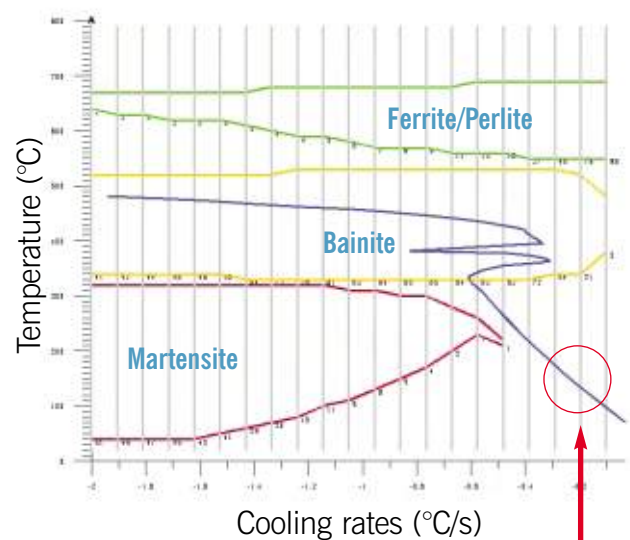
Courtesy: EFD Induction Group

## Surface heat treatment of a crankshaft



## Judgement of process feasibility and stability against process tolerance

Cooling rates over temperature in the CCT-diagram, for any critical point of the structure.

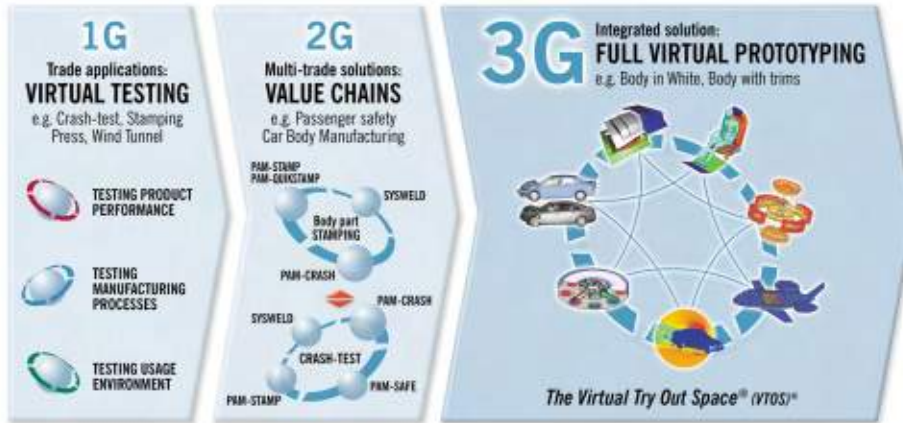


Cooling rates are too low to give martensite at a critical point of the structure.

# SYSWELD in the Virtual Try-Out Space

*SYSWELD is not only a simulation tool, it is also a design optimization tool, created to help you gain competitive advantage.*

## Paving the way towards the digital factory



*Companies within the heat treatment, welding and assembly markets face high pressure to reduce costs and lead times, as well as to increase part quality. These objectives can be achieved by focusing on manufacturing process optimization and part improvement. To better respond to industrial constraints, ESI Group pursues its continuous collaborative development of SYSWELD and helps engineers to reduce the number of prototypes leading to the migration towards the digital factory.*

## Chaining stamping and welding simulation

ESI Group's value chain for Virtual Manufacturing products includes PAM-STAMP, the integrated stamping solution to master the complete manufacturing chain from die design feasibility to stamping validation and optimization. Chaining with SYSWELD brings state-of-the-art manufacturing prediction.

### Chaining SYSWELD and PAM-STAMP

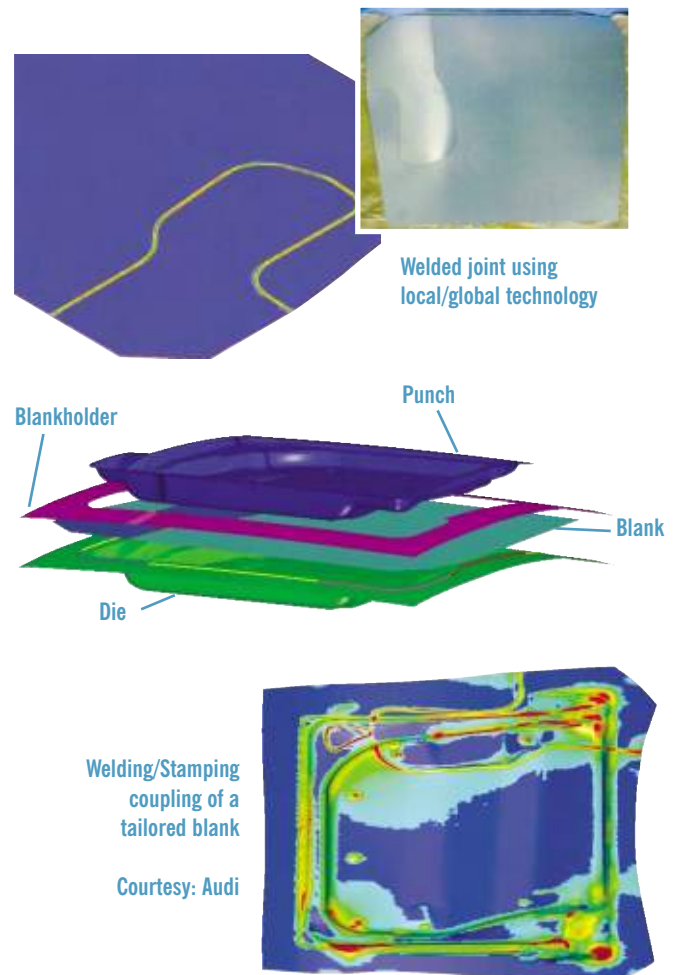
Welding tailored blanks generates material changes around the welding joints that influences the stamping behavior. Chaining SYSWELD and PAM-STAMP provides the user with key data about changes in material properties like yield stress reduction. The residual stresses from welding are taken into account for the spring back simulation.

### Benefits:

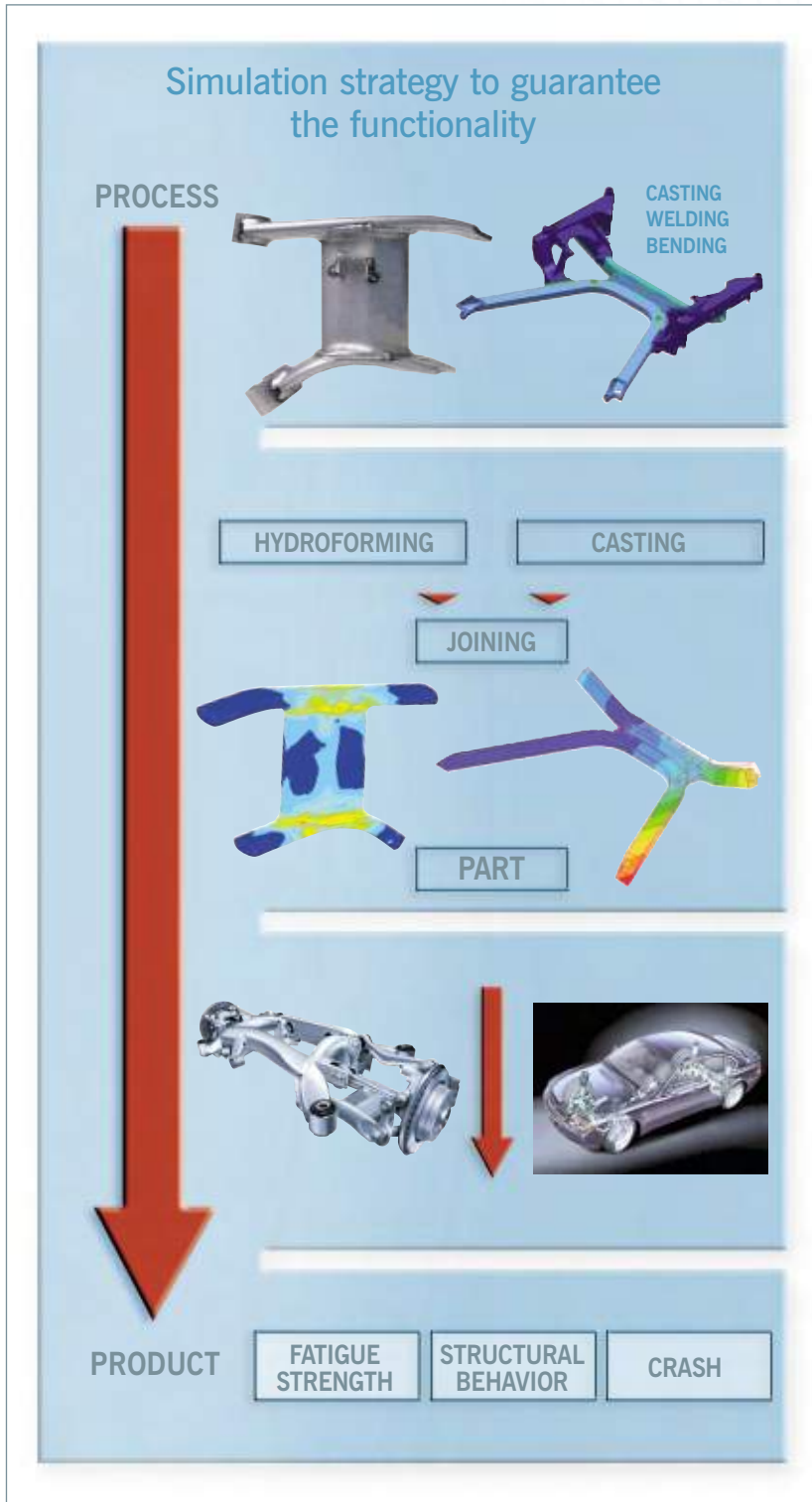
- Improved products and tooling design
- More accurate process simulation
- Reduced tooling modifications

### Chaining PAM-STAMP and SYSWELD

Welding stamped components made from aluminum and steel alloy is today the mission-critical operation for body-in-white and suspension systems. Combining PAM-STAMP and SYSWELD brings an accurate assessment of real blank thickness, change in material, distortions, residual stresses and residual plastic strains.



# SYSWELD Masters Joining Technology



*Car manufacturers are under high pressure to decrease weight, costs, time-to-market and increase quality by optimizing heat treatment and welding processes at the earliest stage in the design process.*

*A car component is manufactured from different parts which are stamped, cast, bent, then welded and connected together to fit the welding assembly requirement.*

*SYSWELD is the ideal simulation tool for improving the welding and welding assembly processes, ensuring better part quality.*

*It provides realistic input data for subsequent structural behavior, durability and crash analyses. It is a unique engineering solution tool, which can lead to unsurpassed productivity gain.*

## SUPPORTED PLATFORMS:

PC and Unix workstations

## References and partnerships

Arcelor, Audi, BMW, Bechtel Bettis, Bosch, Corus, DaimlerChrysler, Delphi, EADS, Ford, Framatome, Fuji Electric, GKN, GM, Hawtal Whiting, Hyundai Heavy Industry, Japeic, Knolls Atomic Power, Korean Heavy Industries, Mitsui

Babcock Energy Ltd, POSCO, PSA Peugeot-Citröen, QinetiQ Ltd, Renault, Rolls-Royce Aerospace, Samsung Heavy Industry, SKF, Toshiba, Toyota, Vallourec, Volvo, Wagon, ZF, ...



# ESI Group around the world

## ESI GROUP HEADQUARTERS

### ESI Group

6 RUE HAMELIN

BP 2008-16

75761 PARIS CEDEX 16

FRANCE

Phone: +33 (0)1 53 65 14 14

Fax: +33 (0)1 53 65 14 12

## ESI GROUP MARKETING

### ESI Group

PARC D AFFAIRES SILIC

99 RUE DES SOLETS

BP 80112

94513 RUNGIS CEDEX

FRANCE

Phone: +33 (0)1 41 73 58 00

Fax: +33 (0)1 46 87 72 02

## FRANCE

### ESI FRANCE

Sales & Technical

Headquarters

PARC D AFFAIRES SILIC

99 RUE DES SOLETS

BP 80112

94513 RUNGIS CEDEX

France

Phone: +33 (0)1 49 78 28 00

Fax: +33 (0)1 46 87 72 02

### ESI FRANCE

LE DISCOVER

84 BD VIVIER MERLE

69485 LYON CEDEX 03

FRANCE

Phone: +33 (0)4 78 14 12 00

Fax: +33 (0)4 78 14 12 01

## GERMANY

### ESI GmbH

Sales & Technical

Headquarters

Mergenthalerallee 15-21

D-65760 Eschborn

Germany

Phone: +49(0)6196 9583-0

Fax: +49(0)6196 9583-111

### ESI GmbH

Niederlassung München

Augustin-Rösch-Str. 23

D-80935 München

Germany

Phone: +49 89 43 650017

Fax: +49 89 43 650019

## BENELUX & SCANDINAVIA

### ESI BV

Gebouw Kortland

Nieuwe Tiendweg 11

2922 EN Krimpen aan den IJssel

The Netherlands

Phone: +31 180 514860

Fax: +31 180 518533

## CZECH REPUBLIC & EASTERN EUROPEAN COUNTRIES

### MECAS ESI s.r.o.

Úslavská 10

326 00 Plzen

Czech Republic

Phone: +420 377 432 931

Fax: +420 377 432 930

## SPAIN

### The Virtual Try-Out Space S.L.

Edificio IKEA, Oficina 311

C/ Estartetxe, 5

48940 Leioa (Bizkaia)

Spain

Phone: +34 94 480 47 60

Fax: +34 94 480 51 99

## UNITED KINGDOM

### ESI-UK Limited

John Eccles House

Robert Robinson Avenue

The Oxford Science Park

Oxford, OX4 4GP

United Kingdom

Phone: +44 (0) 1865 338007

Fax: +44 (0) 1865 338100

## SWITZERLAND

### Calcom ESI SA

Parc Scientifique EPFL

CH-1015 Lausanne

Switzerland

Phone: +41 21 693 2918

Fax: +41 21 693 4740

## USA

### ESI North America

Corporate Headquarters

12555 High Bluff Drive

Suite 250

San Diego, CA 92130

USA

Phone: +1 (858) 350 0057

Fax: +1 (858) 350 8328

### ESI North America Commercial Headquarters

36800 Woodward Avenue

Suite 200

Bloomfield Hills, MI 48304

USA

Phone: +1 (248) 203 0642

Fax: +1 (248) 203 0696

### ESI CFD

215 Wynn Drive

Huntsville, AL 35805

USA

Phone: +1 (256) 726-4800

Fax: +1 (256) 726-4836

## SOUTH AMERICA

### ESI Group South America Technical Support Office

Rua Artur de Azevedo,

1857 cj.45

São Paulo - SP 05404-015

Brazil

Phone/Fax: +55 11 3062-3698

## JAPAN

### Nihon ESI K.K.

Headquarters & Sales Division

Maeda Building,

45-18 Oyama-cho

Shibuya-ku

Tokyo 151-0065

Japan

Phone: +81 3 6407 2347

Fax: +81 3 6407 2395

### Nihon ESI K.K.

Kansai Branch Office

Advance Esaka 5F

8-10 Toyotsu-cho

Suita-shi

Osaka 564-0051

Japan

Phone: +81 6 6330 2720

Fax: +81 6 6330 2740

### Nihon ESI K.K.

Technical Office

Maeda Bldg.

45-18 Oyama-cho

Shibuya-ku

Tokyo 151-0065

Japan

Phone: +81 3 3466 6866

Fax: +81 3 3466 6863

## KOREA

### Hankook ESI

157-033, 5F KOMEGA bldg., 660-6

Deungchon-3Dong, Gangseo-ku

Seoul

South Korea

Phone: +82 2 3664 0073

Fax: +82 2 3662 0084

## SOUTH-EAST ASIA

### ESI Group South-East Asia Technical Office

52A-3B, Jalan PJU 1/3B

SunwayMas Commercial Center

47301 Petaling Jaya

Selangor

Malaysia

Phone: +603-78064187

Fax: +603-78047354

## CHINA

### ZHONG GUO ESI CO., LTD

Unit 608A, Guangdong Soft-Park

No. 11 Caipin Road, Complex bldg

Guangzhou Science City (GSC)

Guangzhou city 510663

China

Phone: +86 (020) 8235 6272

Fax: +86 (020) 8235 6107

## About ESI Group

*ESI Group is a pioneer and world leading provider of digital simulation software for prototyping and manufacturing processes that take into account the physics of materials.*

*ESI Group has developed an entire suite of coherent, industry-oriented applications to realistically simulate a product's behavior during testing, to fine tune the manufacturing processes in synergy with the desired product performance, and to evaluate the environment's impact on product usage.*

*ESI Group's product portfolio, which has been industrially validated and combined in multi-trade value chains, represents a unique collaborative, virtual engineering solution, known as the Virtual Try-Out Space (VTOS), enabling a continuous improvement on the virtual prototype. By drastically reducing costs and development lead times, VTOS solutions offer major competitive advantages by progressively eliminating the need for physical prototypes.*



[info@esi-group.com](mailto:info@esi-group.com)  
[www.esi-group.com](http://www.esi-group.com)