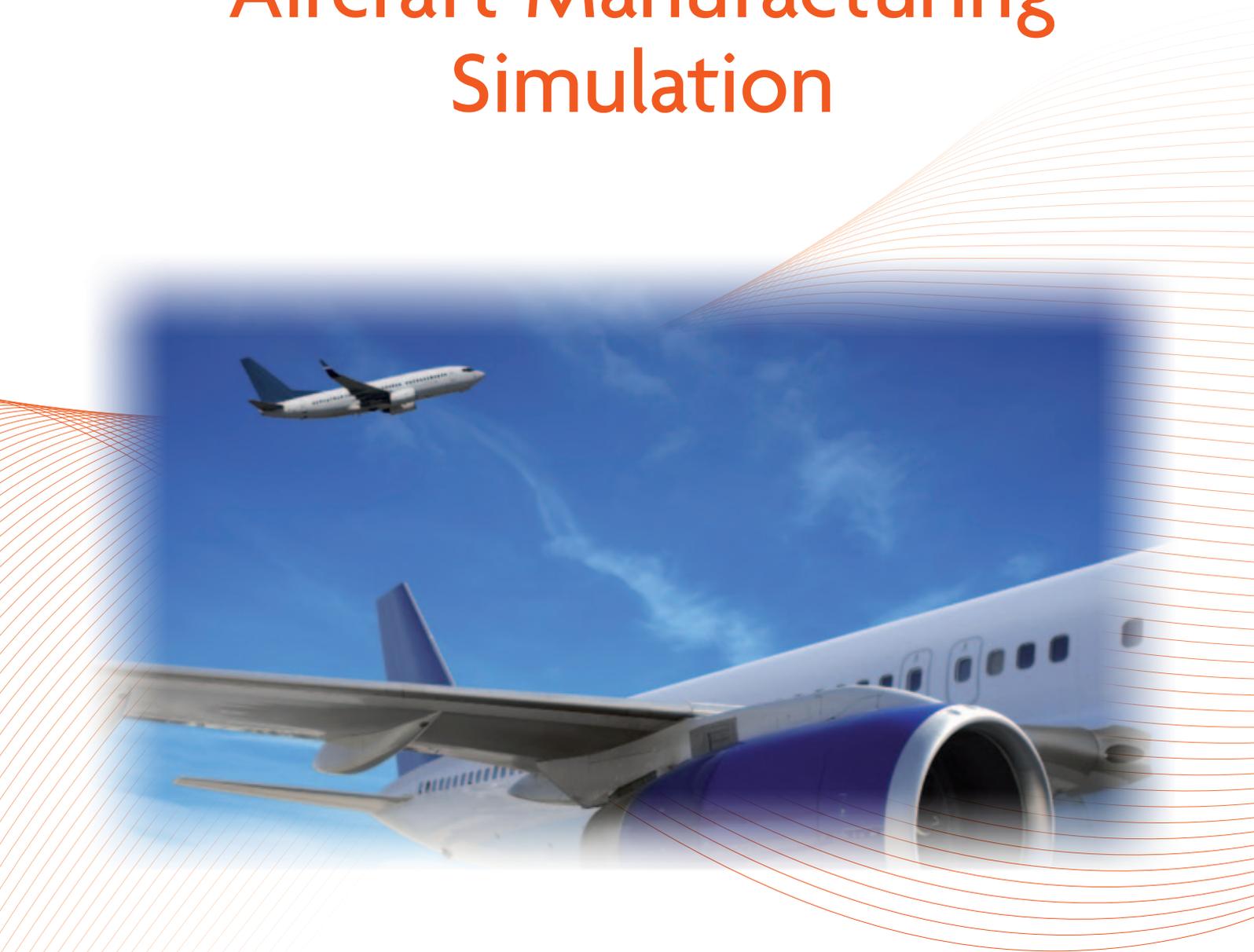


Aircraft Manufacturing Simulation



BENEFITS

- Assess the drapeability and formability of fiber composites at the design stage
- Design your manufacturing process to maintain desired fiber angles and porosity level for high stress applications or maximum damage tolerance
- Deliver precision composite parts without costly tool revisions or prototype builds
- Rapidly design replacements for existing metallic components to more quickly respond to customers' desire to switch to composites
- Respond credibly to issues that arise during manufacturing with physics-based knowledge presented in a compelling and understandable format

Engine Components

As the aviation industry strives to cut its emissions, the weight reduction of aircraft components is a priority

Today composites are being used in many non-rotating engine components such as exhaust flaps, fan stator vanes, ducts, inlet plenums, fairings and nose cones. Rotating components such as propellers and turbo-fan blades are also using an increasing amount of composite materials. However, special considerations must be applied regarding the durability and damage tolerance in highly critical components due to the increased scatter in both strength and fatigue life.

The production of parts for aircraft engine applications often involves the use of Liquid Composites Molding (LCM). Resin injection or infusion are methods of composite parts fabrication well suited to manufacture complex-shaped details repeatedly to tight dimensional tolerances. In the LCM process, fibrous pre-forms are first shaped under pressure or vacuum from stacks of fabric, and then placed in most of the time metal tooling that matches the shape of the desired part. The tool is then injected or infused with heated resin.

The benefit of the metal tooling is that a high level of part reproducibility and consistency in assembly operations should be maintained. However, unforeseen problems often arise. Metal tooling can retain heat during the curing cycle which affects the critical chemical reaction rates. Stresses locked in during curing are released as the tooling is removed resulting in parts that are out of tolerance and unusable. The complex issues are expensive and often nearly impossible to fully resolve through trial and error.

Solution

ESI has simulation tools designed specifically to help resolve issues with these LCM processes. Injection/infusion strategies (gates, vents, media.. location), pressure in the mold, cure rates, porosity degree and residual stresses can be analyzed and resolved before expensive tooling is committed. Issues on the production floor can be addressed more quickly and quality improved more effectively when aided by physics-based simulation technology.

Airframe Components

Advanced composites have emerged as the light weight structural materials of choice for many aerospace applications

Composite materials can deliver significant weight reduction to the airframe due to their superior strength and anisotropic stiffness properties. First developed for military applications, composites now play a significant role in primary and secondary airframe structures. However, there is an increased variability in the mechanical properties of these critical composite structures due to the relatively high influence of manufacturing processes on the final part performance when compared to their metallic alternatives.

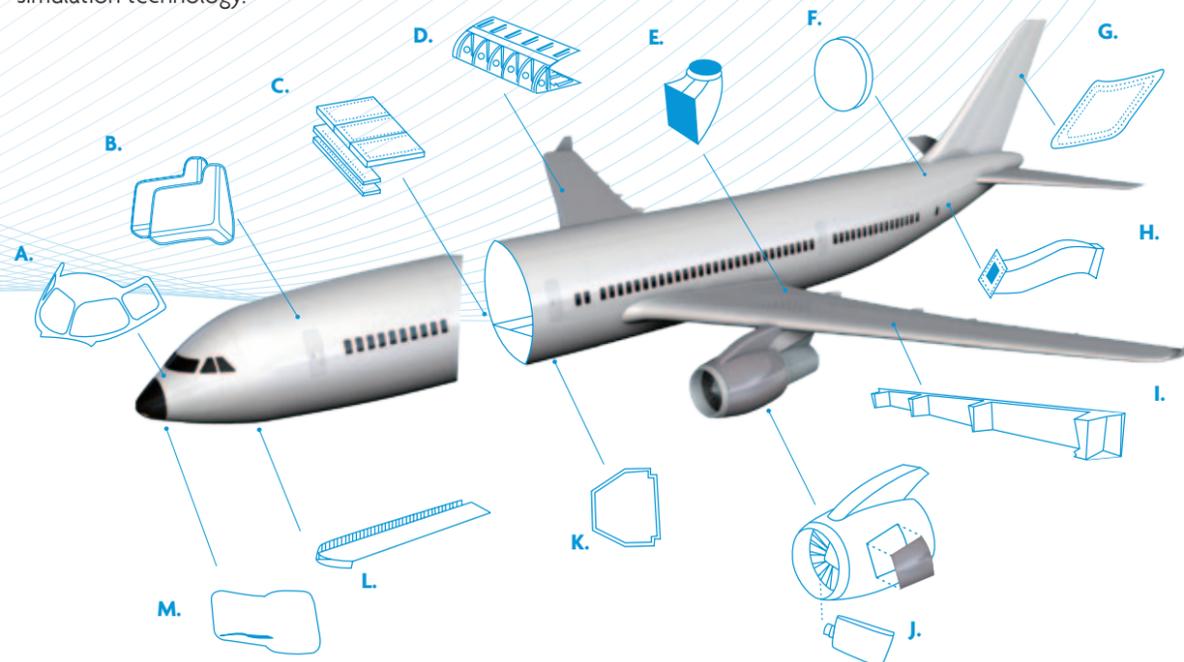
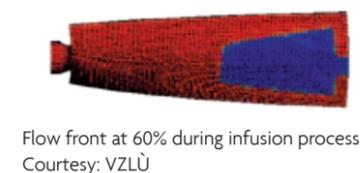
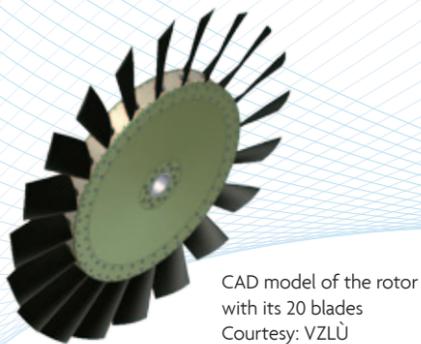
As composite aircraft applications increase, more efficient methodologies are needed to design the structures using a wide variety of composite materials and processes to precisely deliver the specified mechanical properties. LCM and prepregs thermo-forming each have specific design issues related to draping, injection /infusion strategy, curing, and geometric stability after tool removal. Thermoplastics and carbon fiber composite components using these processes are relatively common today, while fiber-metal laminates (FML) such as GLARE, are increasingly being applied to commercial aircraft.

Solution

ESI offers a full suite of composites manufacturing tools specifically designed to address these materials and processes. The manufacturing simulations can also be coupled with ESI's structural analysis software to allow rapid transition from manufacturing design to performance assessment, which is a critical issue with airframe components. Based on more than 20 years of experience simulating the most advanced manufacturing processes, ESI products and engineering services can solve the core issues associated with the most difficult composite manufacturing challenges.

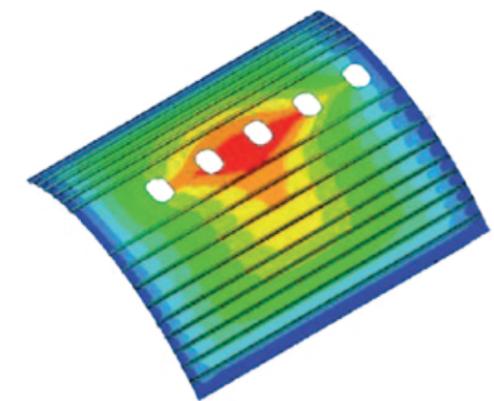
KEY FEATURES

- Tool pre-heating determination
- Forming and draping toolsets available for LCM and thermo-forming
- Influence of preform deformation on local permeability
- Resin injection/infusion and flow analysis
- Automated dry-spot identification
- Curing reaction modeling
- Autoclave simulation
- Shape distortion prediction
- Stress analysis
- Optimization and process automation available
- RTM now available in DMP versions to further reduce solution times



Commercial Aircraft Typical Composite Structures

- | | |
|--|-----------------------------|
| A. Cockpit frame | H. S-duct |
| B. Fuselage and interior brackets | I. Wing spar |
| C. Cargo floor panel and beam | J. Nacelle and blade |
| D. J-nose/blowdown panels | K. Landing gear door |
| E. Air conditioning duct | L. VCSF tunnel scoop |
| F. Rear pressure buckhead | M. VCSF nose scoop |
| G. VOR antenna | |



Filling time
Courtesy: EADS Innovation Works

BENEFITS

- Avoid stray grain nucleation and maintain homogenous microstructure
- Avoid freckle chains
- Avoid areas prone to internal recrystallization
- Avoid micro-porosities that can initiate cracks, reducing component durability
- Avoid filling defects like early solidification
- Predict the microstructure and mechanical properties of the as-cast or post heat treatment component for critical applications
- Predict and control residual stresses to maintain geometric integrity and mechanical properties
- Predict core deformation during pour and solidification as well as shell cracking
- Accelerate new process technology introduction (new furnace, new alloys...)
- Effective, early design for manufacture capability to improve yield and reduce costs

Engine Components

Ingenuity and new technological advancements are transforming metal casting

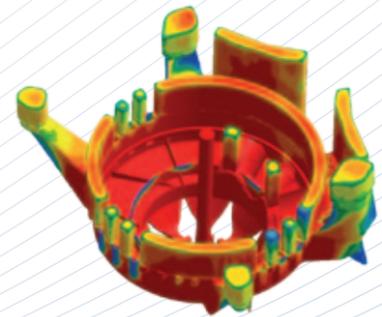
ESI simulation solutions are keeping pace with the industry. New processes continue to be developed for the manufacture of aircraft engine components where each process is specific to the metal used and the results desired. Within each process there are several variables that impact the design of the final product. These variables are increasingly difficult to understand as material science advances and the specifications for final components become more difficult to meet.

Solution

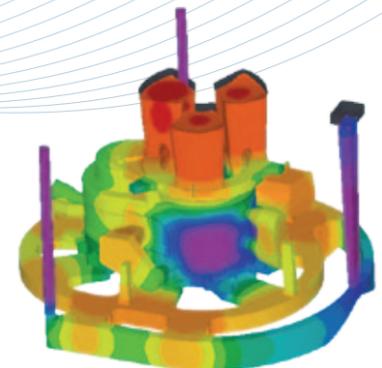
ESI's casting simulation software and engineering services have been used to produce the most advanced aircraft castings such as turbine blades, burners and impellers for turbocharger for over 20 years. ESI simulation can make sure engineers see precisely what is happening during the casting process to improve yields, accelerate your time to delivery, and minimize risks.



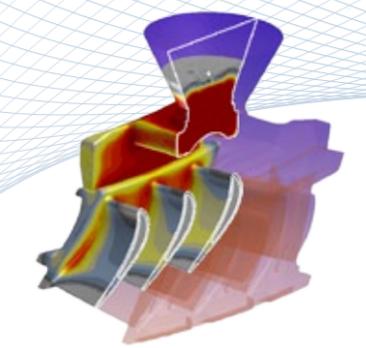
High Pressure Turbine Blade (left), with cut-away view showing typical passages (right)
Courtesy: Rolls Royce



Aluminum helicopter gearbox housing
Courtesy: ZF Aviation Technology



Aircraft engine component solidification
Courtesy: CPP-Minneapolis, formerly Hitchcock Industries



Solidification profile of fan blade casting
Courtesy: Rolls Royce

Airframe Components

The metal casting process today has become integral to the aircraft manufacturing industry

Casting can be used to create complex geometric parts with relative ease, irrespective of the size of part. Cast metal products are found in many components for airframes and interiors as the process is very economical and generates little waste.

An expanding and diverse range of casting alloys are used to deliver the most economical or lightest weight component for each application. Every alloy has particular physical and mechanical characteristics, as well as its own casting properties, machinability, weldability, corrosion resistance, heat treatment properties, and other characteristics.

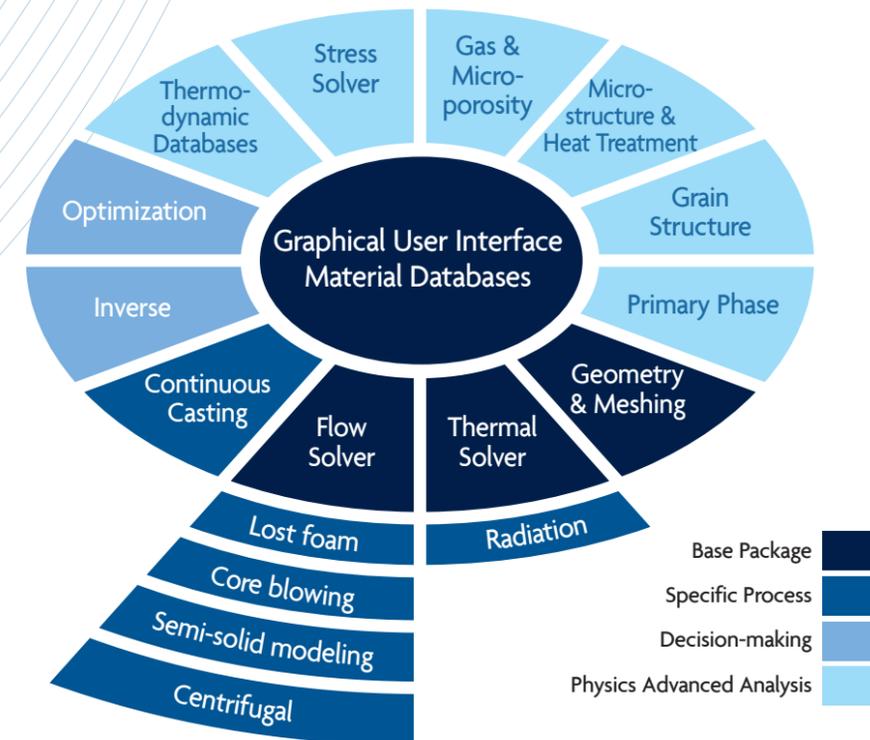
Solution

ESI simulation solutions assure our customers that each of these properties is maintained for maximum product performance and cost efficiency. Cast parts in critical locations must not contain porosities that can later initiate cracking. Components used in volume should be developed using the most cost effective processing to minimize cycle time, waste and scrap. ESI gives engineers the ability to see inside the casting process and deliver high precision components that meet the most demanding specifications for cost, weight and durability.

KEY FEATURES

- Solidification and phase change visualization
- Pouring, fill rate, and gating analysis
- Radiation with view factors
- Stress analysis and dimension control
- Large database of materials including Ni, Fe, Ti and Al
- Grain structure determination
- Microstructure modeling and mechanical properties as cast and after heat treatment
- Automated Gas Porosity identification
- Freckle indicator
- Shell creation
- Wax injection
- Optimization and process automation
- Now available in DMP versions to further reduce solution times

Casting Simulation Suite



BENEFITS

- A faster part and die design and improved stamping process quality
- Validated development methods produce production-ready dies the first time, thereby reducing costs and moving your designs to production quicker
- Springback compensation is included in the die development tools at the design stage to deliver high precision parts without expensive die compensation late in the production process
- Early feasibility checks and cost estimations can reduce business risks earlier in the sales and delivery cycle
- Material properties are tracked through the manufacturing process to ensure that product performance meets specification

Engine Components

Advanced materials and processes required due to the extreme conditions found inside aircraft engines

Because of the extreme conditions found in an aerospace engine, the components are often formed out of advanced materials, such as titanium. At the same time, the requirements for precision are high, and available space is limited, making the geometric shapes required very complex. Continuous demands for weight reduction mean that the components must always have the minimal material volume for the given task.

One of the more challenging manufacturing problems in every engine is the production of several complex connecting tubes. These tubes are often of highly complicated geometry and of advanced materials. Forming these tubes with the given specifications means risk of wrinkles and excessive thinning, while meeting the strict dimensional tolerances is inhibited by the springback behavior of the manufacturing process.

Solution

ESI virtual sheet metal forming tools can make sure that all your components produced meet high geometric precision and performance requirements with the minimum investment in tooling and prototypes. Difficult characteristics such as wrinkles and cracks can be eliminated and springback controlled at the tooling design stage, resulting in increased productivity, customer satisfaction and profits.

Airframe Components

Traditional stamping processes are often not applicable for the parts used in an aircraft

Highly complex geometrical shapes combined with advanced materials means the engineer has to look for alternative ways to manufacture these parts. Processes like super plastic forming, hot forming, stretch forming or rubber pad forming are often used to fulfill these requirements.

The difficulty linked to setting up these processes correctly includes finding a process design that works without tears, fractures, or wrinkles. Once that is achieved, optimizing material thickness, assuring uniform material distribution, and controlling springback during tool removal needs to be overcome.

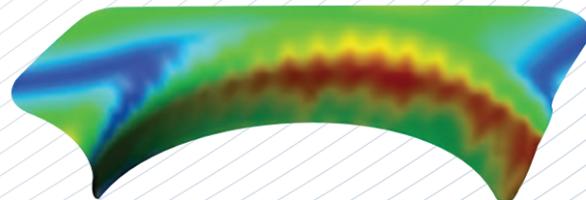
Solution

ESI virtual manufacturing suite can help the engineer find a feasible process setup, helping save time both in the design phase and in production. Validating the design virtually also reduces risk during later production and if problems do occur simulation can help resolve them quickly without costly trial and error methods on the shop floor.

KEY FEATURES

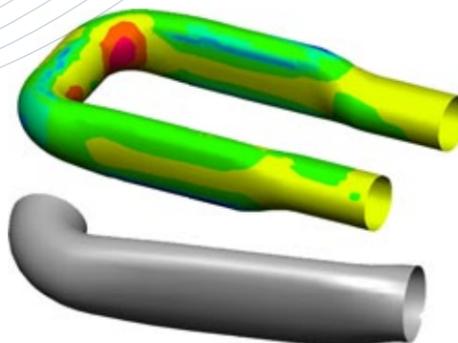
- Materials database includes Aluminium, Titanium, Dual Phase, Trip, Boron and many other advanced materials used in aircraft applications
- Dedicated die design tools, either standalone or in CATIA® environment
- Formability assessment features allow user to choose between speed and accuracy
- Reliable springback calculation and automatic compensation
- Supports for a wide variety of processes including hotforming, stretch forming, superplastic forming, rubber pad forming, tube forming etc
- Integrated optimization module
- Available coupling to performance evaluation simulation using the as-manufactured material properties

Stamping



Titanium Bracket - rubber pad forming with springback compensation

Hydroforming

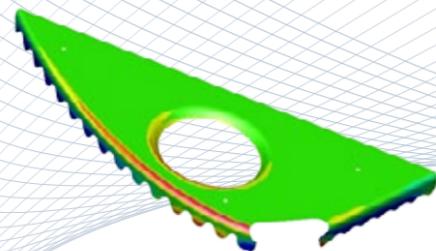


Complex tube hydroforming wall-thinning simulation
Courtesy: Fischer Hydroforming AG

Super Plastic Forming



Original 23-piece welded design (top) and 1-piece design optimized for SPF (bottom)
Courtesy: Superform USA



Aluminium D-Profile rubberpad forming with springback compensation

Lean Process Management For Manufacturing

ESI provides a flexible process modeling and execution platform for team collaboration

By using Lean Process Management Software from ESI, manufacturing data is automatically delivered as it becomes available according to the agreed process plan. The status is automatically tracked at the individual, team and project levels. The software provides real-time project management information and maintains traceability of the data from design all the way through final manufacturing and delivery. It can also be configured to allow remote program managers at your customers' sites to access the graphical environment for real-time updates through a simple web interface.



Automatically provide real-time project visibility for management and team members

"Vdot was invaluable in managing a development project with a very distributed engineering team, spread across several disciplines and development tools."

Roger Herdy
Qualis Corporation, Program Manager
NASA Marshall Space Flight Center



Screenshot from Vdot LPM program

ABOUT ESI GROUP

ESI is a pioneer and world-leading provider in virtual prototyping that takes into account the physics of materials. ESI has developed an extensive suite of coherent, industry-oriented applications to realistically simulate a product's behavior during testing, to fine-tune manufacturing processes in accordance with desired product performance, and to evaluate the environment's impact on performance. ESI's solutions fit into a single collaborative and open environment for End-to-End Virtual Prototyping, thus eliminating the need for physical prototypes during product development. The company employs over 800 high-level specialists worldwide covering more than 30 countries.



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