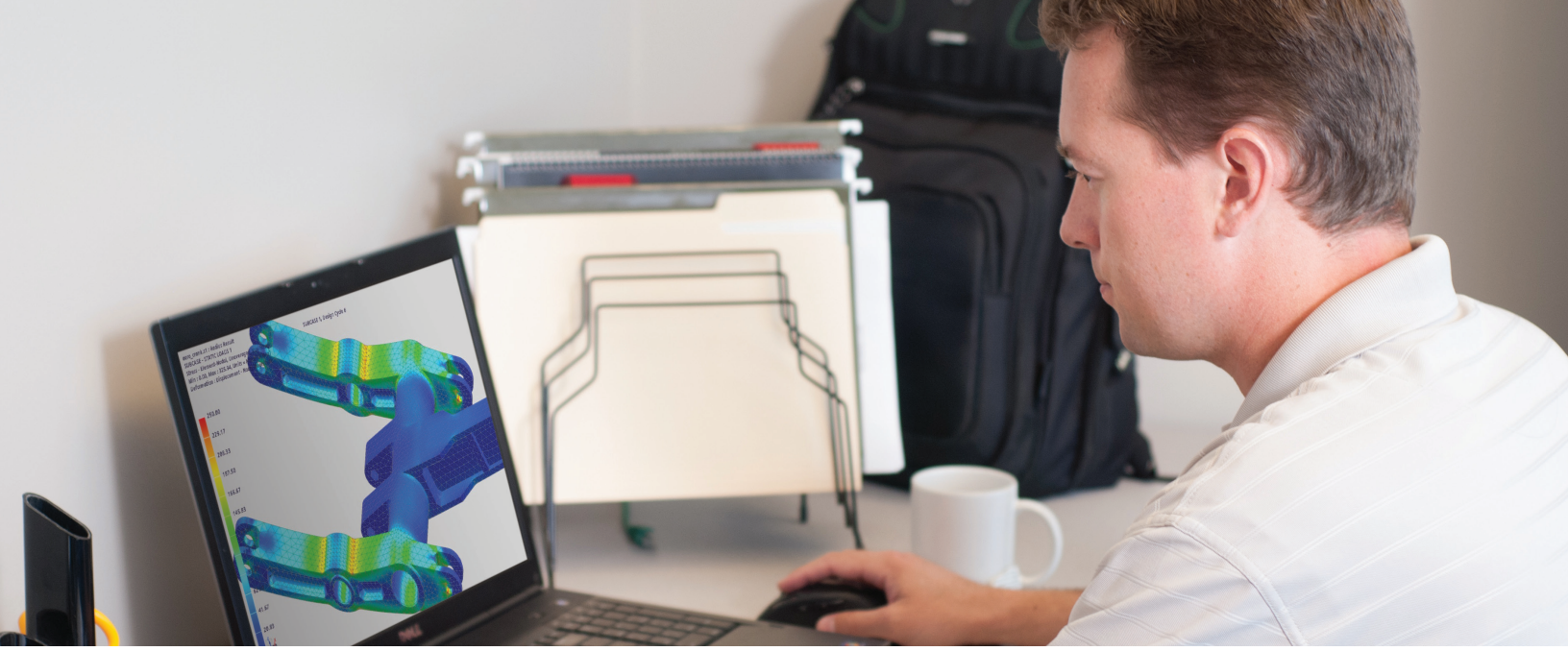


DIGITAL INDUSTRIES SOFTWARE

Simcenter 3D for generative engineering

Improving and optimizing product designs

Solution benefits

Discover a better design faster

Eliminate model simplification, model fitting or surrogates

Eliminate design overhead and achieve significant productivity gains

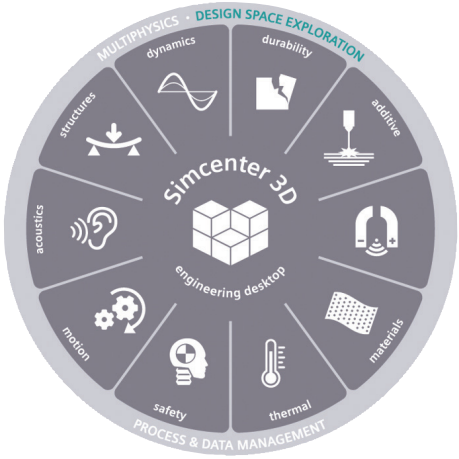
Reduce research time, product development costs and product design risks

Support design reviews by providing sensitivity to design variable

Simcenter™ 3D software optimization solutions relieve the burden of improving product designs by automating the iterative process. This enables you to compare your design's performance against specifications. It enables you to start at topology optimization and extend to design space exploration with more classical parametric optimization capabilities.

A platform for multidiscipline simulation

The Simcenter 3D design space exploration and optimization simulation solutions are part of a larger, integrated multidiscipline simulation environment with the Simcenter 3D Engineering Desktop at the core for centralized pre-/postprocessing for all Simcenter 3D solutions. This integrated environment helps you to achieve faster CAE processes and perform multidisciplinary optimization processes across physics domains, such as structural simulation,



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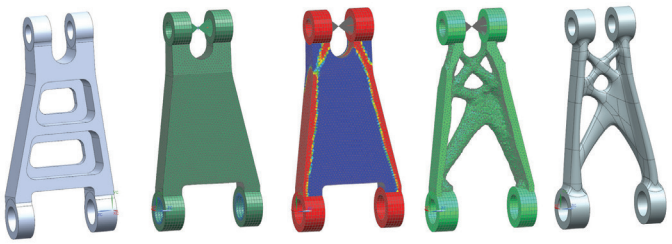
thermal simulation, fluid dynamics, multibody dynamics, electromagnetics, durability, dynamics, and acoustics simulation.

Automating the product performance process

Simcenter 3D optimization solutions streamline and automate that process by using sophisticated algorithms to search the entire design space and find the right combination of parameters that will yield optimal design and performance. To help the program know what you mean by optimal, you specify design and performance objectives for characteristics such as minimum weight, shape constraints and minimum stress or strain. Design parameters that you can vary include geometric, material and connectivity properties.



Reduce design risk and accelerate innovation

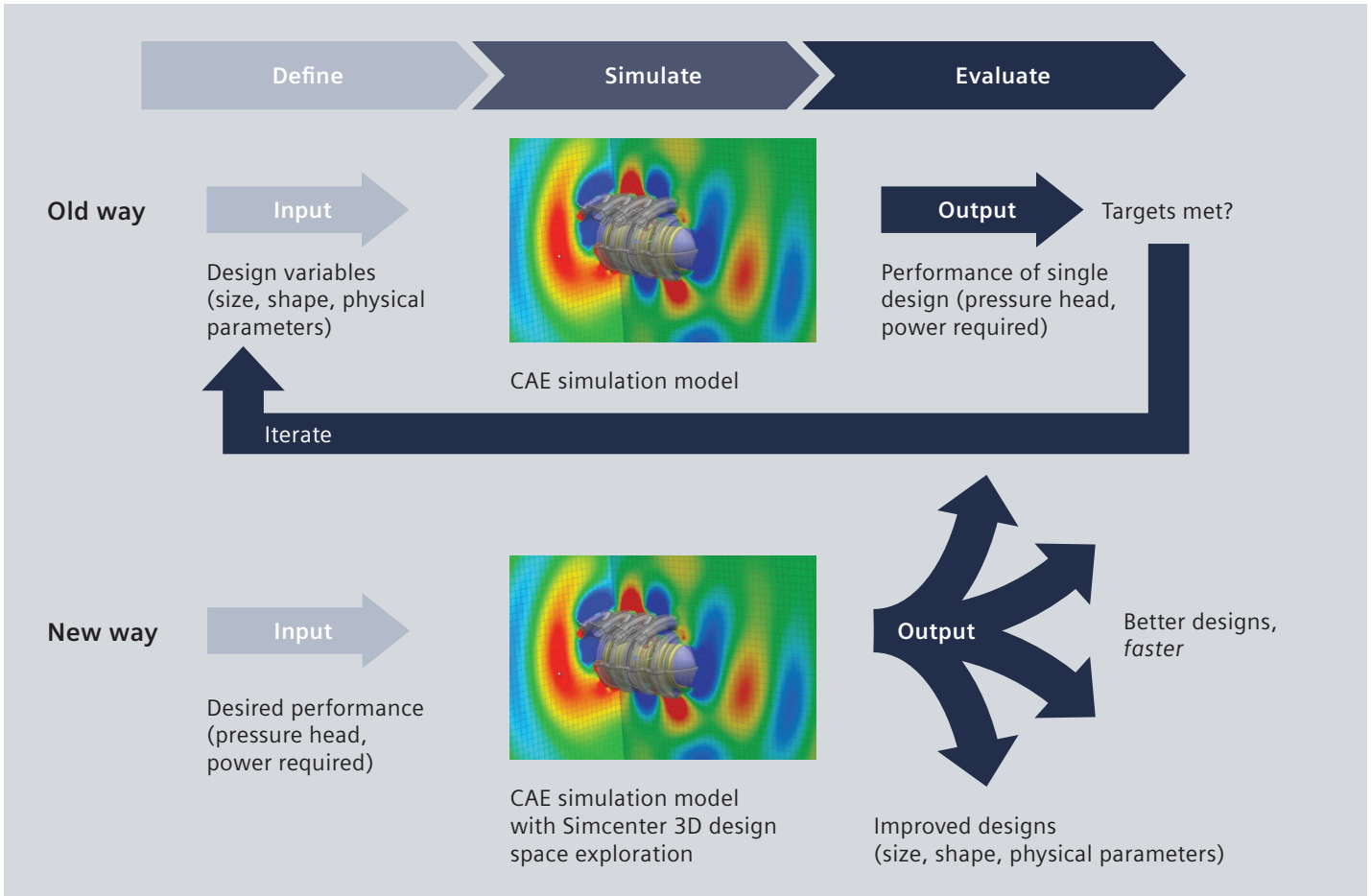
By better understanding the complex relationships among design parameters and how changes affect them, you can gather insight into product performance risk and accelerate innovation by determining feasible designs that satisfy all requirements.

Shorten time-to-market with confidence

Analyze your product performance deviations from specifications in a variety of operating conditions, and shorten time-to-market by automating thousands of simulations that would otherwise have to be performed manually.

Industry applications

The Simcenter 3D optimization solution can help designers in virtually any industry to achieve a better understanding of the complex relationships among design parameters and how changes affect these relationships. It can also help them realize a better design.



Aerospace and defense

- Airplane frame weight reduction and balancing attributes such as stiffness, modal frequencies, buckling loads
- Airplane wing weight reduction and balancing attributes such as stiffness, modal frequencies, buckling loads
- Airplane weight reduction and balancing attributes for composite airplanes (laminate/ply thicknesses)
- Satellite optimization for thermal stress and distortion, composites, modal frequency
- Launch structure weight reduction
- Aero engine fan shape optimization (compensation for centrifuge and other mechanical effects)
- Aero engine compressor weight reduction and performance balancing
- Aero engine turbine weight reduction and performance balancing
- Aero engine casing weight reduction

Automotive and transportation

- Body roof crush, panel strength, stiffness, frame durability
- Powertrain/driveline performance optimization, torque loads, thermal stress and distortion
- Chassis harshness loads, suspension deflections
- Suspension performance optimization and weight reduction
- Off-highway vehicles balancing weight reduction with strength, durability, rollover protection structure (ROPS), stability
- Manufacturing tool thermal stress and distortion, modal frequency, bolted stresses
- Support structure stability, stress

Marine

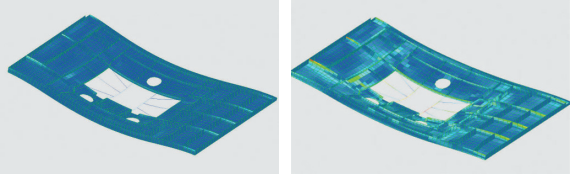
- Full ship stiffness, deformation, strength optimization, weight reduction

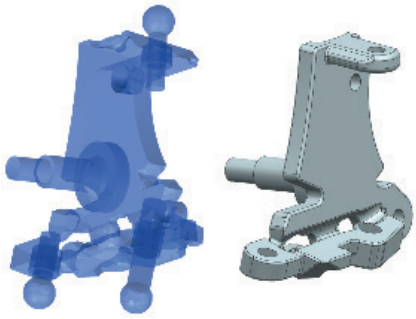
Consumer goods

- Packaging shape optimization

Simcenter Nastran
Optimization

Simcenter Nastran® Optimization software enables customers to establish design sensitivity based on simulated performance conditions and then synthesize and optimize designs. Efficient algorithms permit the use of hundreds of design variables and responses for the largest models. A broad range of robust optimization algorithms and approximation methods provide the backbone of a solution that allows numerous design variables and constraints to be more easily linked and rationalized to identify critical issues.





Module benefits

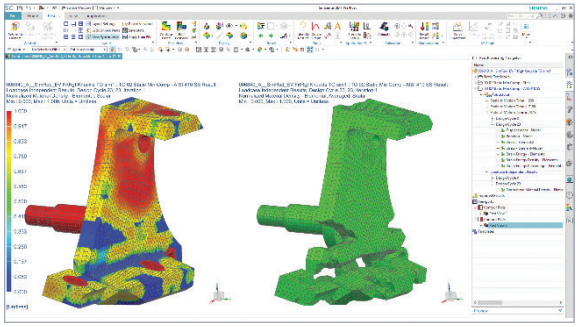
- Reduce design risk by better understanding the complex relationships among design parameters and how changes affect these relationships
- Improve confidence that your product will perform to specifications under a variety of operating conditions and manufacturing tolerances
- Accelerate innovation by determining feasible new designs that satisfy all requirements
- Shorten time-to-market by automating thousands of simulations that would otherwise have to be performed manually

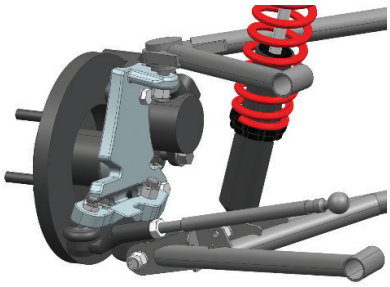
Key features

- Optimization of Simcenter Nastran models
- Constraints related to static, normal modes and buckling analysis
- Optimization capabilities associated with Simcenter Nastran Enterprise Advanced analysis types, such as superelements, dynamic response, modal frequency response, direct frequency response, modal transient response, acoustic analysis, static aeroelasticity and flutter
- Large scale optimization problems thanks to robust optimization algorithms and sparse matrix solutions
- There are hundreds of responses available for the objective and constraints
- Synthetic variables and responses can be created and combined with other responses in equations to responses for the objective and constraints

Simcenter Nastran
Topology Optimization

Simcenter Nastran Topology Optimization software offers the capability to optimize many different criteria in support of generative engineering. The solution enables the user to optimize the topology of regions defined as solids or shells and offers the capability to predict solid and lattice zones.





Module benefits

- Shorten time-to-market by directly starting from optimal topology for a large set of optimization objectives and constraints related to statics, modal, buckling, direct and model frequency analysis. Common examples include objectives to maximize stiffness, minimize mass, maximize mode, subject to mass, displacement, stress constraints
- Hosted in Simcenter 3D, enabling complete workflow from concept to final design
- Functional requirements are represented by shape control constraints, for example to support manufacturing, symmetry and size requirements
- Solid and lattice zone prediction

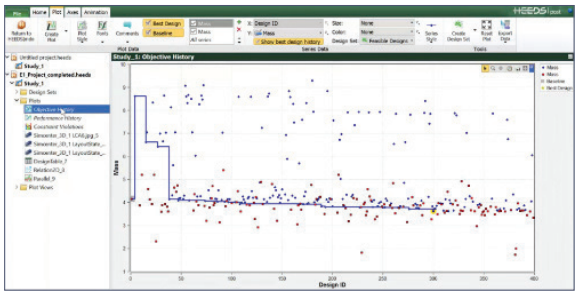
Key features

- Many methods are available to build the finite element (FE) model: orphan mesh, single computer-aided design (CAD) part and single finite element method (FEM), CAD assembly and single FEM or AFEM
- The design areas can be constructed using 2D shell or 3D solid elements and there can be multiple design areas with different materials representing different parts in an assembly, or homogenized meta-materials (lattices, varying density printed materials, etc.)
- Within a single topology optimization, the user can have any mix of analysis subcases selected from linear statics, normal modes, buckling analysis, direct and modal frequency
- There are hundreds of responses available for the objective and constraints
- Synthetic variables and responses can be created and combined with other responses in equations as responses for the objective and constraints

Simcenter 3D
Design Space Exploration

Simcenter 3D Design Space Exploration brings the power of parametric design space exploration to the desk of the user with low cost of adoption. It helps companies to move beyond standard use of simulation for validation, troubleshooting and basic prediction by automatically exploring broader design spaces to more rapidly discover much better designs.

The user can leverage smooth process automation, which simplifies the virtual prototype build process to exploit the distributed execution that accelerates virtual prototype testing. This enables the user to access efficient design search capabilities without the need for simplifying models. Additionally, the user has access to a complete insight and discovery interface that is a central part of virtual product development rather than an afterthought.



Module benefits

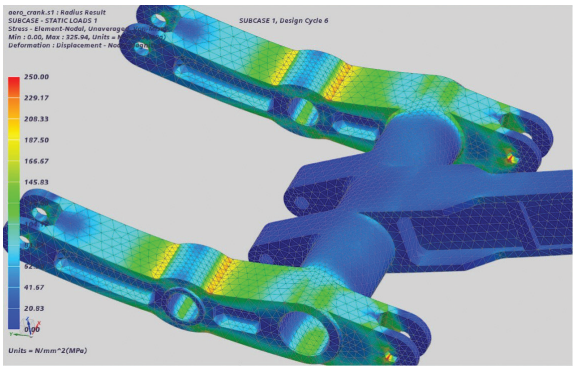
- Efficiently find good designs with many variables
- Selecting algorithms is automated and automatically tunes it throughout the design study
- The solution leverages all search strategies simultaneously
- Eliminates iteration and finds the best way to traverse the design space every time
- With an advanced algorithm and easy-to-use interface, the solution precludes the need for optimization expertise

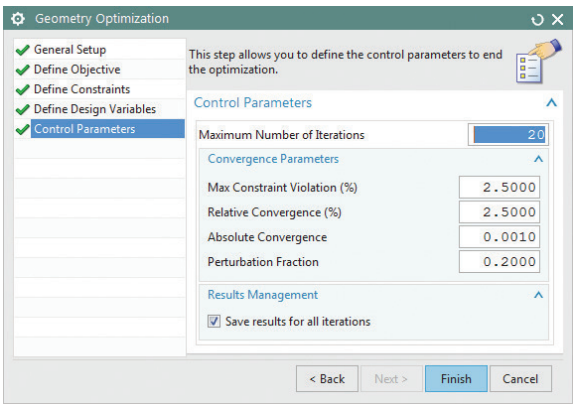
Key features

- Design space exploration and optimization for Simcenter 3D models
- Extensive support for Simcenter 3D model parameterization (including geometry, materials, finite element characteristics, solution parameters, etc.)
- Automates workflows, which streamlines data transfer across tools, eliminates errors in the process and significantly increases the efficiency
- Plethora of design-of-experiment (DoE) algorithms
- Cutting edge SHERPA optimization strategy, the advanced auto-tuning optimization strategy for single and multi-objective optimization
- Support for mixed continuous/discrete variable problems with multiple constraints
- A powerful but easy-to-use data analytics solution for gaining valuable insights into designs and design space
- Support for surrogate model creation and export

Simcenter 3D
Geometry Optimization

Simcenter 3D contains geometric and sizing optimization capabilities, all part of the standard Simcenter 3D Engineering Desktop. Simcenter 3D Geometry Optimization is a meta-solution process built on an existing solution. It provides classical capabilities for the selection of design variables and objective and constraint functions together with several optimization solution controls and postprocessing capabilities.





Module benefits

- Easily optimize geometry of element properties of Simcenter 3D models and the associated CAD models
- Reduce design risk by better understanding the complex relationships among design parameters and how changes affect those relationships
- Improve confidence that your product will perform to specifications under a variety of operating conditions and manufacturing tolerances

Key features

- Optimization of Simcenter 3D models and the associated CAD models
- Mixed CAD and FE geometry optimization: FE beam section properties, FE shell thickness, CAD model feature dimensions, CAD model sketch dimensions, expressions, including expressions that define an FE load
- Supported solvers: Simcenter Nastran, Simcenter 3D Thermal, Simcenter 3D Flow, Simcenter ESC, Simcenter SST, MSC Nastran, ANSYS, ABAQUS
- Types of responses for objective and constraints will vary depending on the solver. Examples include: weight, volume, temperature, mass flow, Joule data, radiation view factors, etc.
- FE result measures can also be used as responses; for example, max displacement, average Von Mises Stress. These can be measured globally or locally based on geometry distribution; for instance, on a face or along an edge
- Optimization solution data can be displayed in a spreadsheet

Capabilities chart

General capabilities	Specific capabilities	Simcenter Nastran Optimization	Simcenter Nastran Topology Optimization	Simcenter 3D Design Space Exploration
Integration with Simcenter 3D		•	•	•
Model parameterization	With associated CAD models	•	•	•
	Without associated CAD models	•	•	•
	Full Simcenter Nastran elements types suitable for analysis typ es	•	•	•
	Full Simcenter Nastran load and constraint types suitable for a nalysis types	•	•	•
	Other solver environments			•
Design volume	2D, 3D elements		•	
	Multiple design volumes		•	
	Different materials to present different parts and meta-materials (lattices, varying density printed materials, etc.)		•	
Variables	Every FE element in the design volume(s)		•	
	Element physical properties	•		•
	Composite element properties	•		•
	Connecting element properties	•		•
	Material properties	•		•
	CAD model expressions include feature and sketch dimensions, lo ad inputs			•
	Derived variables and formulas based on model responses			•
Materials	Isotropic, anisotropic, orthotropic	•	•	•
Analysis types	Linear statics	•	•	•
	Structural dynamics	•	•	•
	Buckling	•	•	•
	Acoustics			•
	Thermal			•
	Flow			•
	Coupled thermal/flow			•
Optimization objective	Single objective	•	•	•
	Single global or subcase objective	•	•	•
	Multi-objective			•
Optimization constraints	Multiple	•	•	•
	Multiple global or subcase objectives	•	•	•
	Relationships between variables			•
	Shape control constraints		•	
Optimization algorithms	Gradient	•	•	•
	Penalty laws linear, solid isotropic material with penalization (SIMP), rational approxi-mation of material properties (RAMP)		•	
	Lattice prediction based on lattice type characterization		•	
	Optimization controls and convergence parameters	•	•	•
	Design space exploration (DoEs, design sets)			•
	Auto-tuning optimization strategy - SHERPA			•
	Multi-objective auto tuning optimization strategy - multiobjective SHERPA			•

General capabilities	Specific capabilities	Simcenter Nastran Optimization	Simcenter Nastran Topology Optimization	Simcenter 3D Design Space Exploration
Simulation automation	Sequential simulation execution	•	•	•
	Parallel simulation execution			•
	Support for remote execution			•
Postprocessing	Optimization spreadsheet to summarize objective and constraint values per iteration	•	•	•
	Simcenter 3D postprocessing functionality	•	•	•
	Dedicated normalized material density display		•	
	Auto creation of post optimization verification model		•	
	Advanced postprocesssing (parallel plots, bubble plots, 3D functions, etc.)			•
	Response surface modeling			•
	Correlation plots			•
	Pareto plots			•
	Principal component analysis and influence analysis			•
	Analysis monitoring and control			•
Design geometry recovery	Update of CAD models			•
	Update of FE model	•		•
	Export of smoothed mesh back to CAD for design guidance in remo deling		•	

Legend:

• = included in module
+ = additional product required

Note: Simcenter 3D Engineering Desktop is a minimum prerequisite for all Simcenter 3D products. Other dependency or prerequisites may apply for individual products.

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For additional numbers, click here.

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