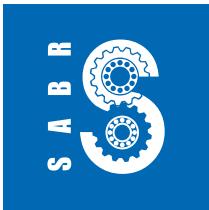# Ricardo Software
## Powertrain CAE Solutions

www.**software.ricardo**.com

What is SABR?

SABR is a proven shaft, gear and bearing concepting and design package developed to integrate into the design process and reduce product development time. It provides an intuitive graphical user interface, allowing all or part of the transmission system to be modelled at a level of detail appropriate to the current design phase. Additionally, it allows the performing of sensitivity studies to determine the effect of different geometric features, bearing types, gear positions etc., with immediate results. The solver is based on engineering standards as well as Ricardo's product design, manufacture and testing experience and is continually updated in line with real-world test and development programmes.
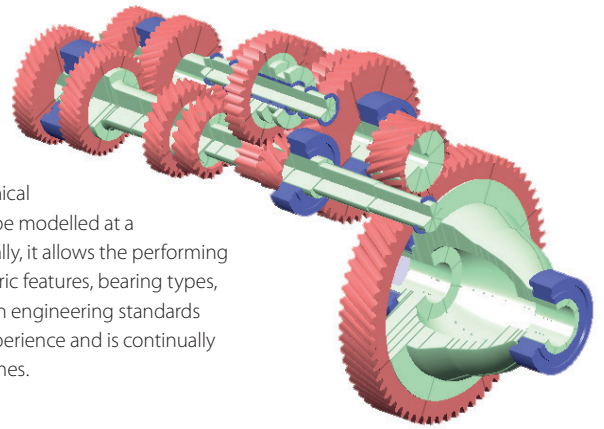
Key product features

- Simple and intuitive GUI
- Capability to model manual, DCT, automatic, complex planetary and bevel applications
- Hybrid and split path gearboxes can easily be modelled with any number of power sources, absorbers or auxiliary drives
- Gear design for balanced life and to achieve target NVH criteria

- Bearing analysis with life calculation and stress plots accounting for loading, roller profiling and misalignment
- Casing stiffness import from FE
- Shaft design and analysis
- Comprehensive results suite

Gear design

SABR's transmission assessment capabilities are enhanced by the integrated GEAR analysis software. Users can define initial gear sizes and rate parallel axis gears according to ISO6336 standard, including the effect of calculated gear misalignment. This powerful tool enables non-specialists to optimize gear geometry and determine the effect of misalignment on gear life. Immediate feedback is given to the designer of the change to input parameters both graphically and numerically without having to "run" a calculation.

Capabilities

- Powerful optimizer allowing the design of optimal geometry and balanced life gears
- Visual representations of key design attributes and clearances provide immediate feedback to the designer
- Direct import/export interface to SABR
- Detailed duty cycle function allows multiple loading regimes to be analysed to assess cumulative damage
- Export to Gearlab LDP and DONTYNE Load Analysis Model allows tooth contact analysis and transmission error calculation with macro geometry, duty cycle and misalignment information passing from SABR
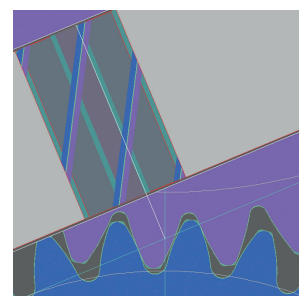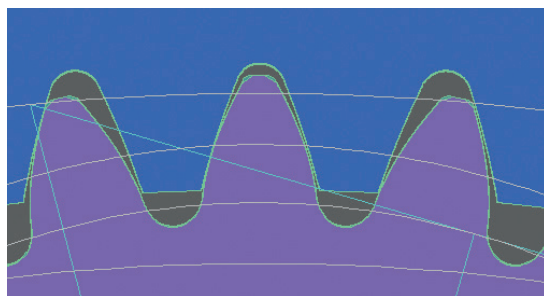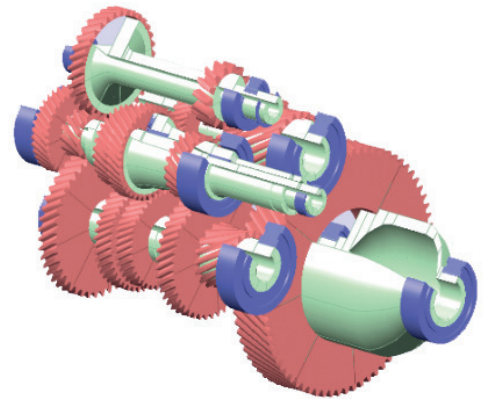
Bearing analysis

SABR is able to model deep-groove and angular-contact ball bearings, tapered, cylindrical and needle roller bearings that are casing mounted or encapsulated within two rotating components. The bearing life, misalignment and loading algorithms form the backbone of SABR and are based on bearing calculations that the main bearing design and manufacturing companies use, including ISO281 and ISO16281 standards. The close relationship between the bearing companies and Ricardo has advanced the evolution of SABR – as Koyo, SKF and Timken have their bearing ranges integrated into the package. SABR can calculate and visually represent the exact loading regime of the bearing, indicating the overall use of the bearing race as well as potential areas of excessive load.
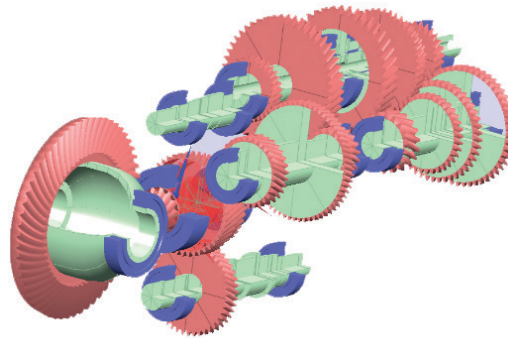
Capabilities

- Ability to analyse either standard or custom bearings of all the main types
- Life calculation, taking into account bearing misalignment, roller crowning and level of loading, preload and clearance
- Editable roller and raceway profiles allow full flexibility of bearing design and application
- Visual display of loading regime on the bearing raceways
- Preload assessment to understand stiffness, stress and life implications of applying preload as well as the bearing frictional loss
- Bearing positioning tool allows fast iterative assessments of transmission layout
- Integrated bearing catalogue and ability to define bespoke bearing catalogue
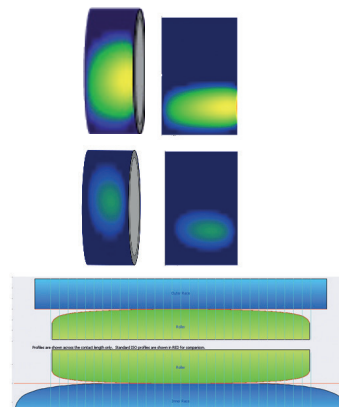
Shaft design and analysis

SABR allows the user to model transmission shafts, from single section shafts for initial concept sizing to complex multi-node arrangements for full and detailed system analysis, quickly and accurately. Stress concentration factors are automatically calculated and can include oil holes, circlip grooves and fillet radii at diameter steps. The effect of bores and tapered shaft arrangements can be modelled, assisted by an immediate sectional or 3D view of the shaft. Detailed output of the shaft analysis is given for deflections as well as key bending, torsion and axial stresses.

Capabilities

- Ability to assess all levels of shaft complexity
- Interactive 3D graphical user interface (GUI)
- Graphs of bending moment, shear force, torque application, and axial force
- Force direction shown in 3D GUI for quick and easy understanding of loading regime
- Numerical and graphical results showing principal tension and compressive stress, bending, axial, torsional and shear stresses
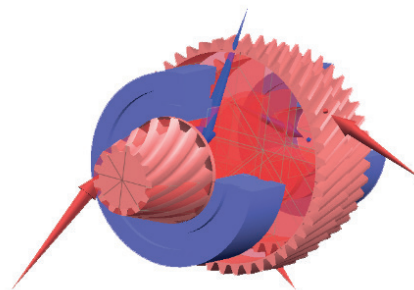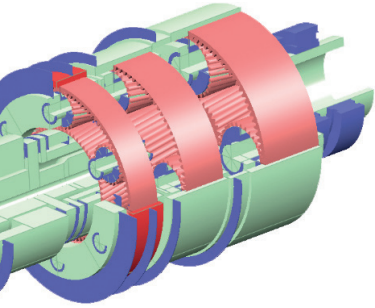
Duty cycle assessment

SABR can assess multiple load path regimes defined by time, torque and speed inputs. The setup of complex load paths across any number of gear sets is effortless for all transmission types including automatics, dual clutch, and hybrids. The analysis includes effects of any back-driven components.

The method of data input is straightforward, with a graphical representation of the transmission clearly showing the proposed load path from any number of power sources. The duty cycle can be exported with the gear geometry to allow representative gear design and life optimization.

Capabilities

- Ability to enter as many loading regimes as required
- Simple graphical interface, enabling precise and fast data entry
- Screen click-activated load path definition
- Hybrid power flows with any number of power sources
- Direct duty cycle export with gear geometry
- Duty cycle import from .csv format
- Duty cycle compression into smaller number of load and speed bins

Case study: World Rally Car

Objective
Provide the 4WD transverse transmission for a World Rally Car team

Concepting
- Basic clean sheet concepting performed to determine initial transmission configuration
- Initial bearing sizing determined from standard bearing catalogue
- Gears designed in order to meet the pre-defined duty cycle requirements using the integrated GEAR software

Intermediate design
- Shaft stress and bearing life assessed
- Bearing with lower than ideal life re-specified and results reviewed
- Model updated to represent assembly sequence and manufacturing information

Detailed design
- Shaft oil holes and detailed fillet radii modelled, resulting in automatic calculation of shaft stress concentration factors
- In parallel with the prototype test programme, a study was performed to reduce one area of high stress, as identified by SABR
- SABR-optimized shafts were phased in to replace the original design during the vehicle test programme

- As predicted by the SABR analysis, the original shaft failed during rig testing, with the optimized design meeting all durability requirements
- Further study performed to reduce mass without compromising stress

Result
- Class-leading gearbox reliability leading to a number of significant podium places and trophies

---

For further information about Ricardo Software products and services, contact us:

UK: +44 (0)1273 794444   **USA:** +1 (734) 394 3860

Email: rs_support@ricardo.com   www.**software.ricardo**.com

Delivering Excellence Through Innovation & Technology