Rolls-Royce

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Engineering and the Environment

Aeronautics, Astronautics and Computational Engineering

Prometheus: Embedding Knowledge & Best Practice Within CAD for Combustor Design Optimisation

UTC for Computational Engineering

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Prometheus project overview

The main goal of Prometheus is to develop an efficient and effective multi-disciplinary combustor design and optimisation system to reduce both the level of workflow complexity and rework by taking a more "geometry centric" approach to optimisation when compared to a traditional "optimiser centric" workflow. Special emphasis is given to the application of the Siemens NXOpen C/C++ Application Programming Interface (API) to efficiently automate various stages of the optimisation loop, including geometry generation, modification, identification, aero-thermal network generation, and mesh & CFD preparation. Developed using an object-oriented approach, Prometheus uses a series of feature based geometry recognition routines to allow geometry changes to be automatically reflected in any generated scripts for a variety of operations using embedded engineering knowledge and best practice. Figure 1 & 2 illustrate the traditional "optimiser centric" and Prometheus' "geometry centric" optimisation workflows respectively.

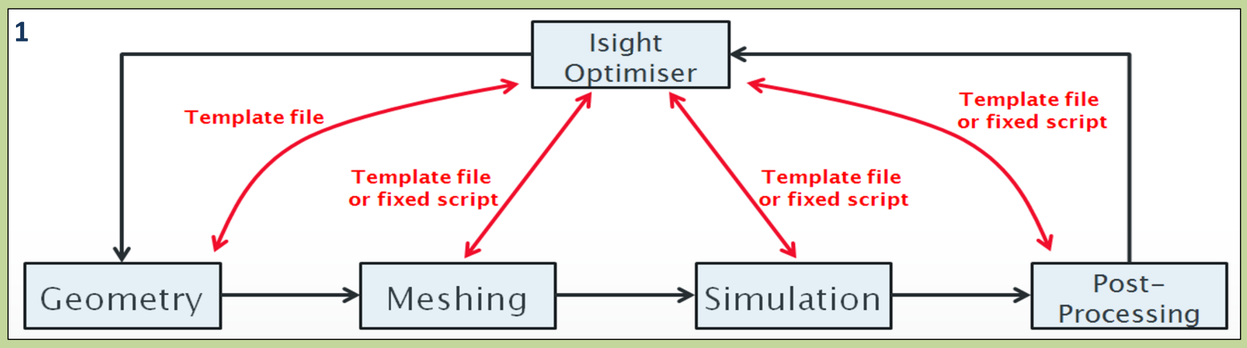

Figure 1: Traditional "optimiser centric" optimisation workflow

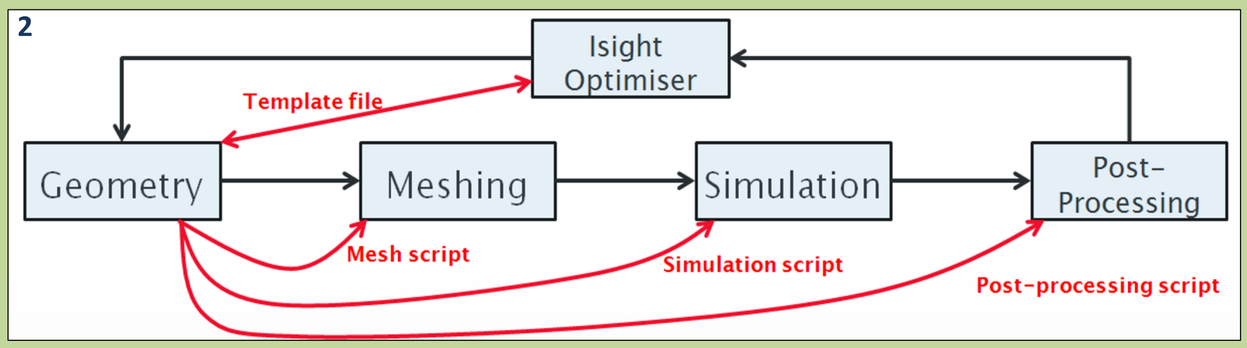

Figure 2: Prometheus "geometry centric" optimisation workflow

Current capabilities of Prometheus

The capabilities of Prometheus have been tested on a number of combustor geometries with various topologies, including ENTAPS, RB3036 and other modern combustors. With the latest development, Prometheus also provides the flexibility of integrating different CFD tools such as PRECISE-UNS or ANSYS Fluent.

Figure 3 demonstrates an example of Prometheus within a combustor design optimisation workflow. Data from Engine Preliminary Design System (EPDS) will be read in by Prometheus and used to manipulate the combustor geometry (Figure 3.a). Prometheus then automatically extracts an appropriate fluid volume for the particular combustor class (Figure 3.b), creates and solves an aerothermal network analysis (Figure 3.c), simultaneously creates scripts for meshing (Figure 3.d), combustion simulation and post-processing operations (Figure 3.e).

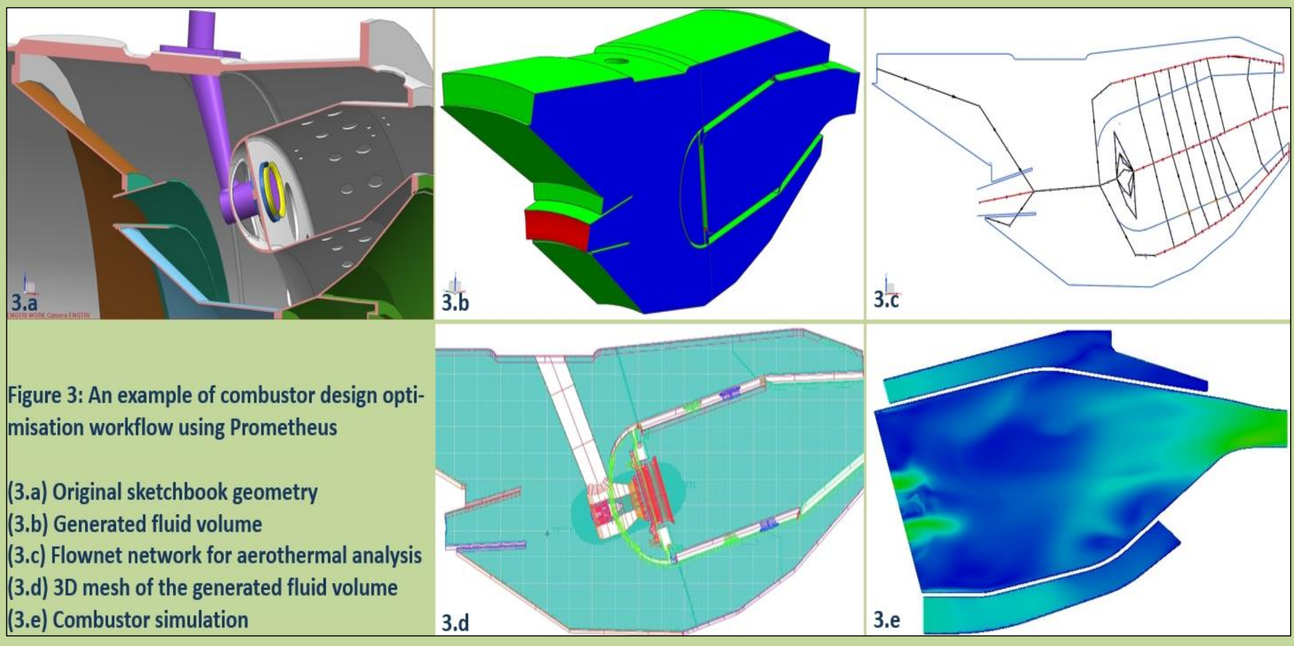

Figure 3: An example of combustor design optimisation workflow using Prometheus

(3.a) Original sketchbook geometry
(3.b) Generated fluid volume
(3.c) Flownet network for aerothermal analysis
(3.d) 3D mesh of the generated fluid volume
(3.e) Combustor simulation

Figure 4 demonstrates the results by running Prometheus on another combustor type (Figure 4.a). The latest development of Prometheus enables the user to create either single sector (Figure 4.b) or double sectors (Figure 4.c) periodic fluid volume for meshing and CFD simulation.

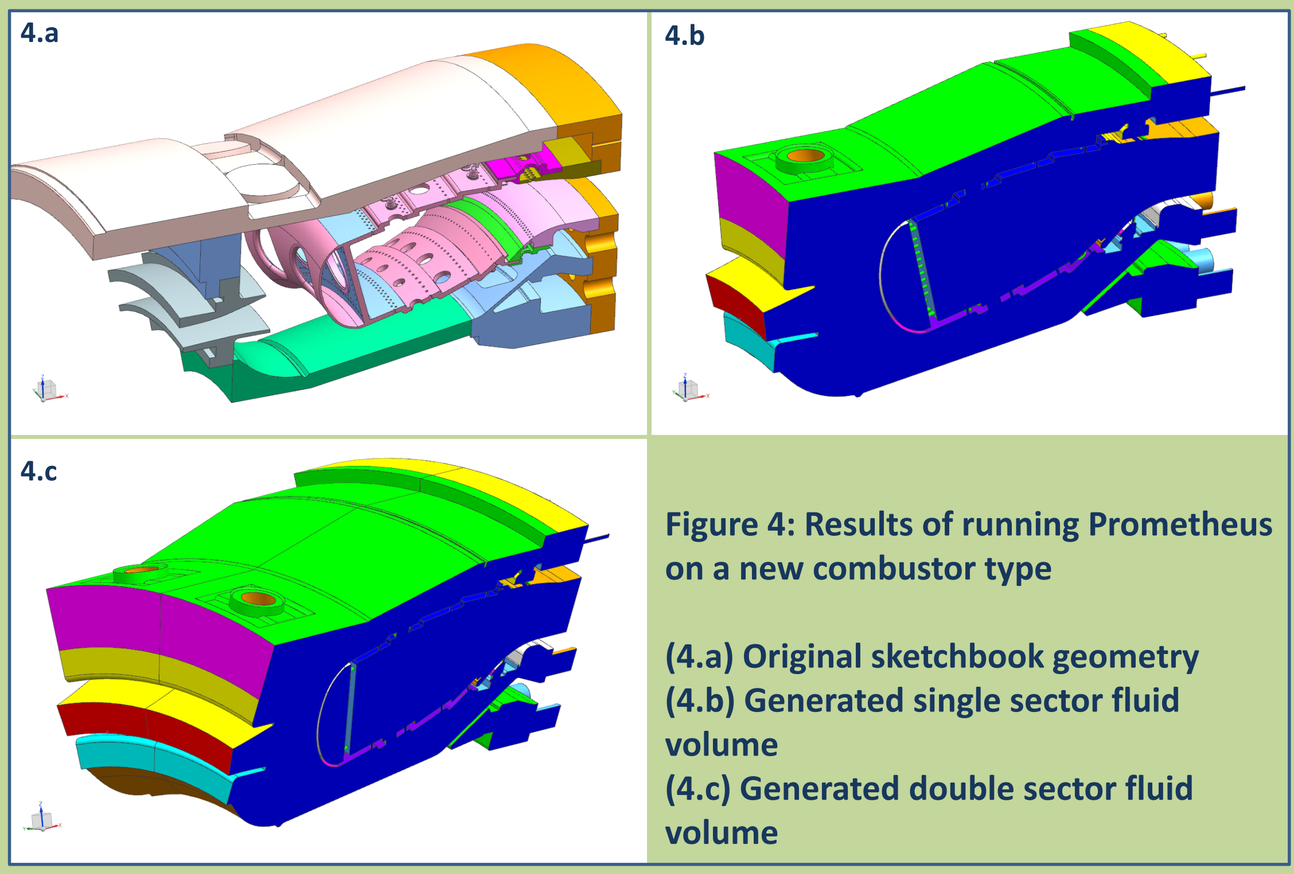

Figure 4: Results of running Prometheus on a new combustor type

(4.a) Original sketchbook geometry
(4.b) Generated single sector fluid volume
(4.c) Generated double sector fluid volume

Future work

Currently, Prometheus can perform fluid and aerothermal analyses but work is ongoing to extend its capabilities to a multidisciplinary combustor design optimisation system by applying it to modern and future combustion system architectures and including, for example, cost modelling, structural and aeroacoustic analysis.

Acknowledgements

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