

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

Xu Zhang, David Toal & Andy Keane, UTC for Computational Engineering, Faculty of Engineering & the Environment  
Chanti Charb, Victor Leyronas, Frederic Witham, Simon Stow, Mark Rogers, Steven Mills, Jon Gregory, Marco Zedda, Ron Bates, Rolls-Royce plc.

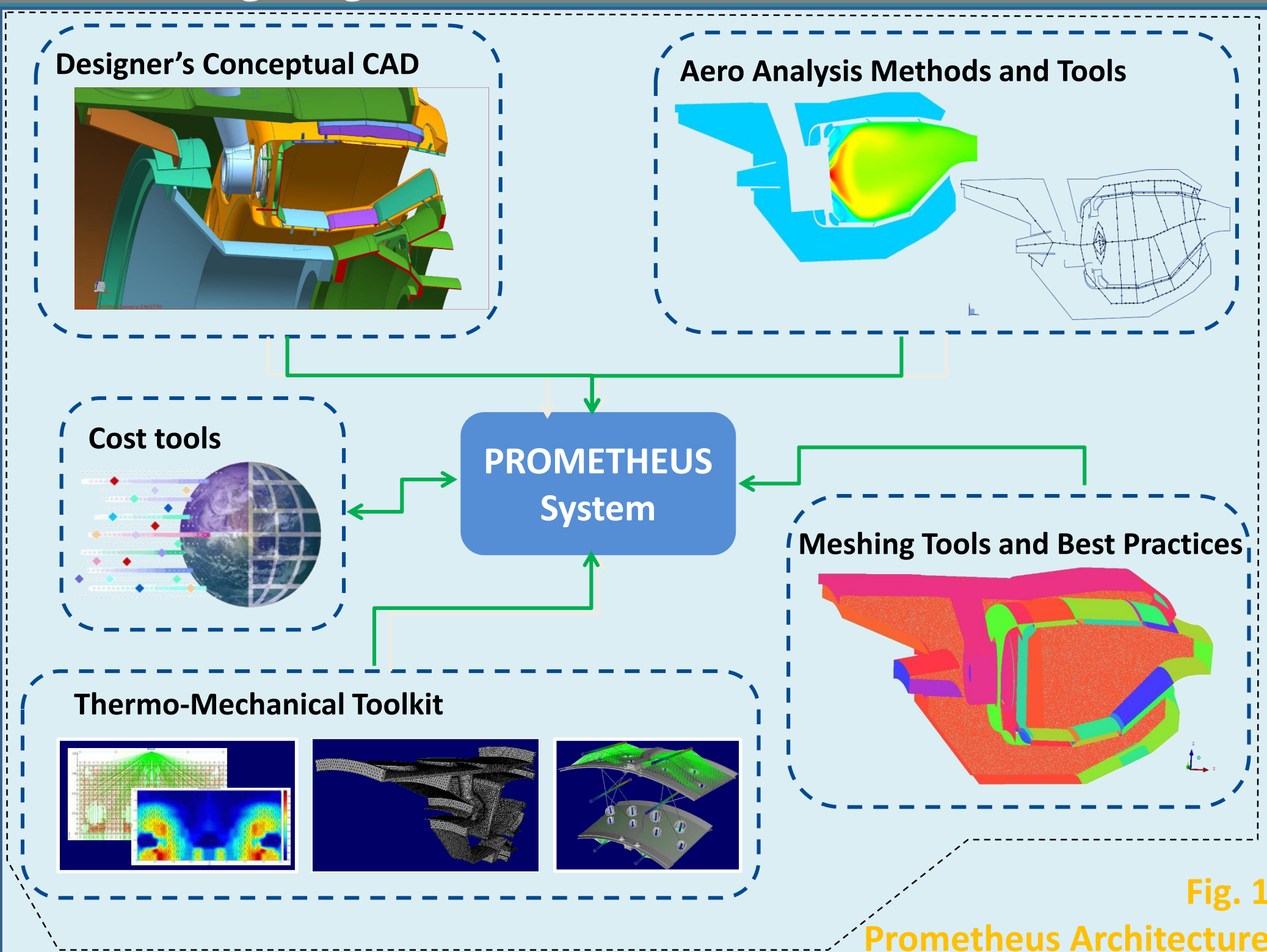


Fig. 1

Prometheus Architecture

Prometheus is an automated design system embedding knowledge & best practice within CAD for combustor design optimisation. The system architecture of Prometheus is shown in Fig. 1.

### Aero Analysis of Lean burn shown in Fig. 2.a – Fig. 2.e

Prometheus runs in a workflow. It starts with a lightweight “Sketchbook” CAD representation (2.a) and progressively adds details to its model according to the analysis in execution. During its workflow it prepares all scripts files needed and communicates with both commercial and Rolls-Royce proprietary packages automatically. Besides the generated the fluid volume (2.b), other tools used shown in the picture include the FlowNet network is used for 1D preliminary flow calculations (2.c), the ICEM mesher for computational meshing (2.d), the PRECISE solver for combustion CFD (2.e).

### DIET Integrated Thermo-Mech Analysis shown in Fig. 2.f, 2.g and Fig. 3

Recently, the latest development of Prometheus introduces the enhanced Thermo-mechanical analysis. Prometheus can now generate solid mesh in NX (2.f) and

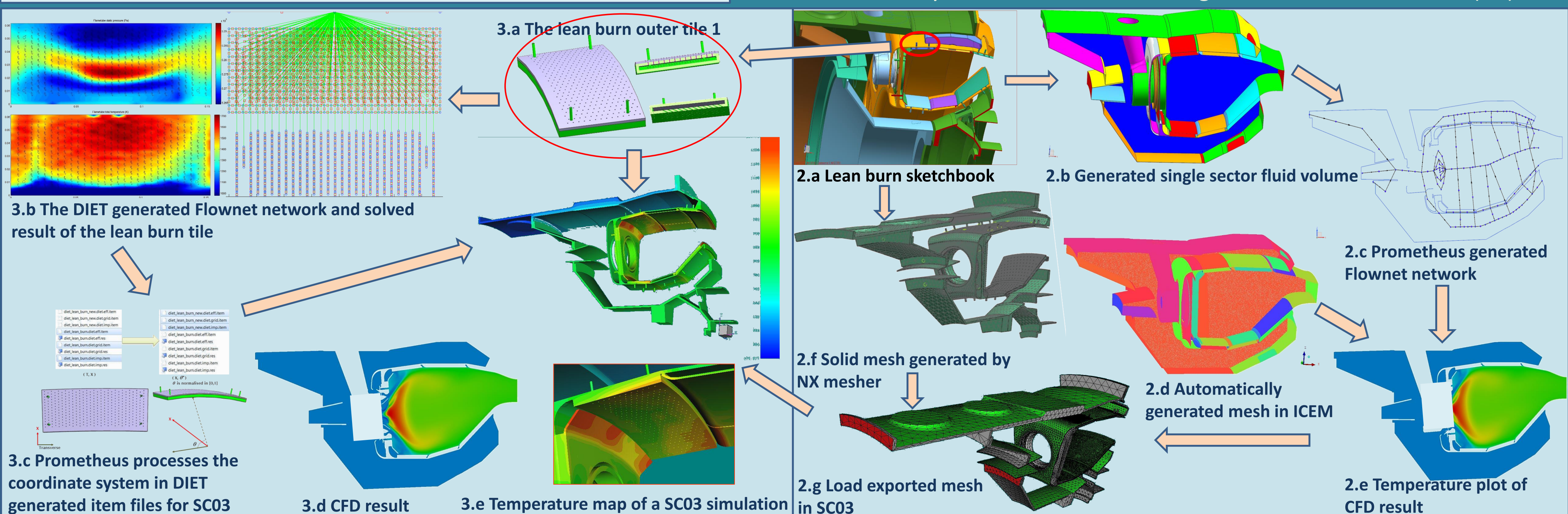


Fig.2 Aero Analysis of Lean burn Combustor with Effusion Tile

export the mesh to the well known SC03 finite element solver (2.g), the Rolls-Royce predominant thermo-mechanical simulation tool. All boundary conditions that have been set as face attributes will be extracted and saved as an executable file, which can be used to run in SC03 to apply boundary conditions automatically (2.g). At the mean time Prometheus extracts geometry information from the impingement effusion tile (3.a). Then it calls DIET to generated the network and solve it (3.b). The result graphical item files that will be used in SC03 are generated by post-processing step. Prometheus then processes the item files to transform the coordinate system to the format that suits SC03 (3.c). Along with other boundary conditions from CFD results (3.d), a SC03 simulation can be performed (3.e). The CD89 and SC77 libraries of thermal analysis have been utilised and the near future plans include the JB56 turbines cooling tool adapted for a combustion cooling and tailoring application. Significant benefit is expected from savings in air coolant mass flow by using it for dilution purposes, resulting in smoke and NOx reductions. Capability to iterate on the combustor cooling porosity is now getting implemented into Prometheus in order to meet the above targets.

Recently Prometheus has been used to perform a combat single skin rich burn combustor trade study. The study has currently performed hundreds of PRECISE simulations using Prometheus to investigate different length-depth ratios, numbers of injectors, porting arrangements and air-fuel ratios. It is estimated that an analyst would need 3 months to go through a number of designs the system visits in only 3 hours! It is also actively supporting the automated fuel spray nozzle design process in GEMinIDS project.

This work is carried out under GEMinIDS project.

