Computational Hypersonics @ UQ: in-house development and application

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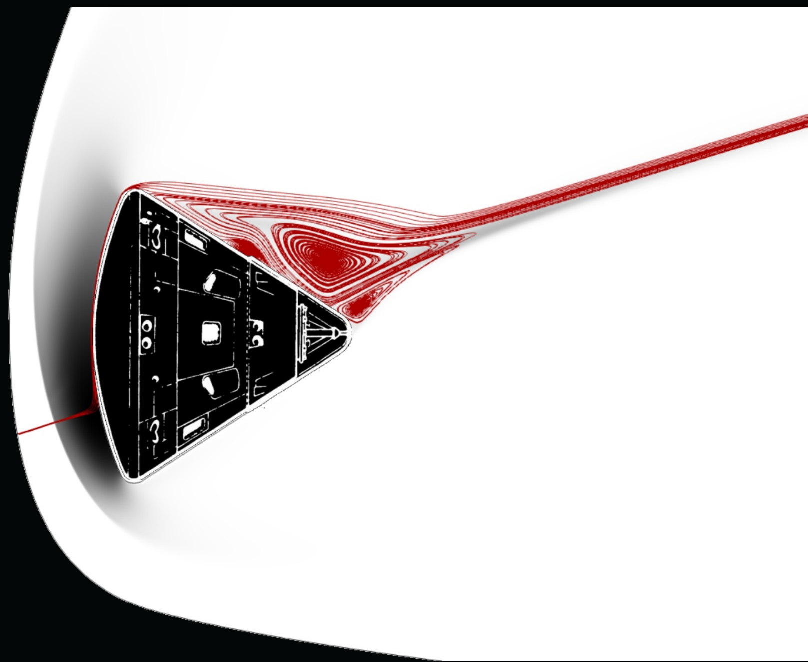
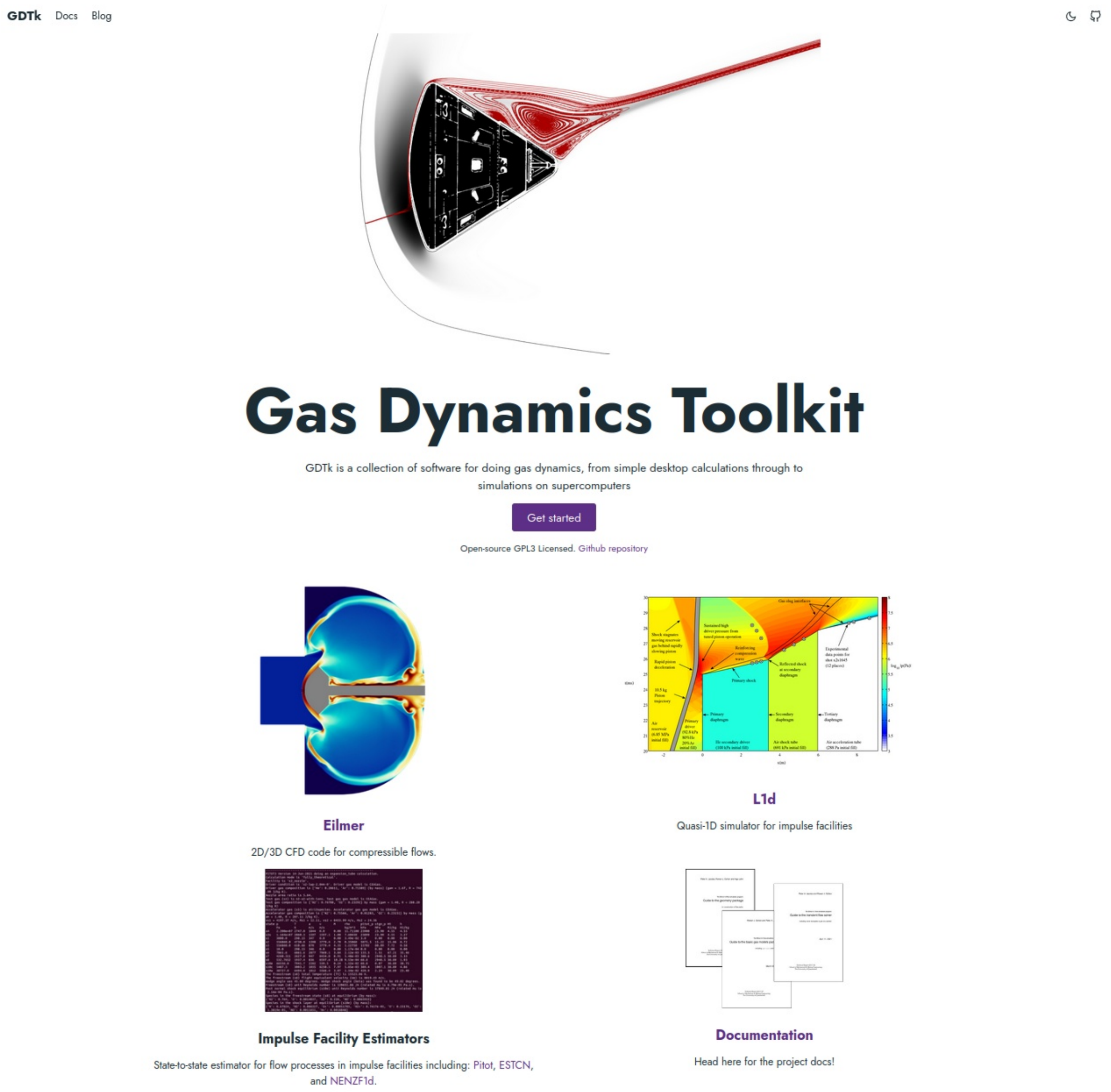


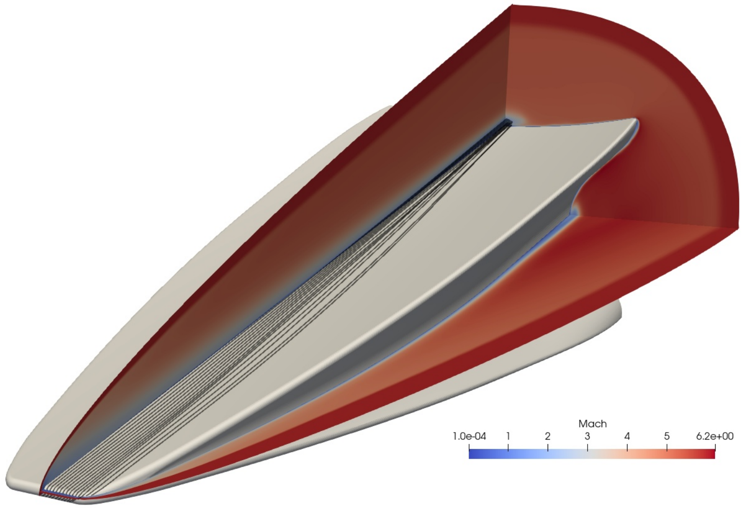
Hypersonic flow simulation tools: GDTk

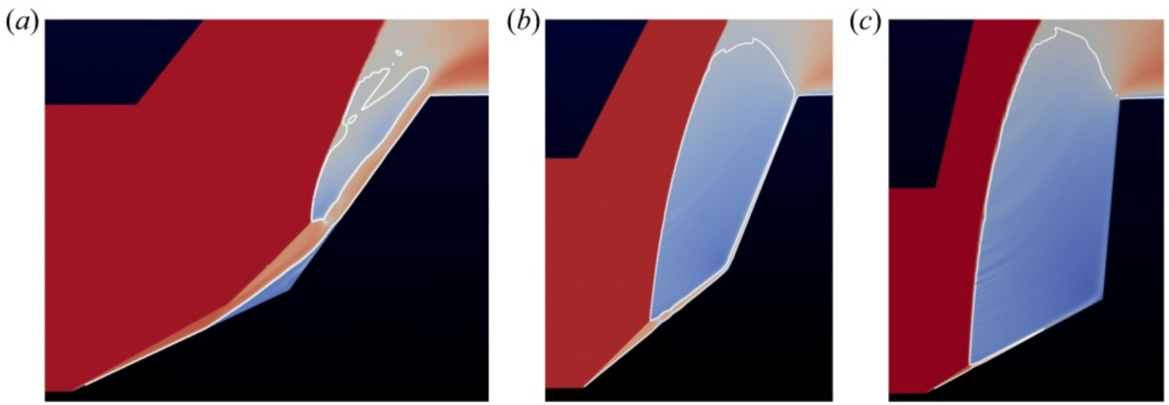


+ Simulation tools covering a range of fidelities
+ 30+ years of development, primarily at UQ
+ Development team:
  core of 4 developers + grad student contributions
+ User base:
  + local at University of Queensland
  + University of Southern Queensland
  + University of New South Wales
  + CalTech
  + Purdue
  + Oxford
+ User support:
  + monthly meet-ups
  + issue tracker
  + email (point-to-point with developers)
+ Documentation:
  user guides, reference manuals, technical notes, and catalogue of examples

Eilmer: UQ's in-house hypersonic flow solver

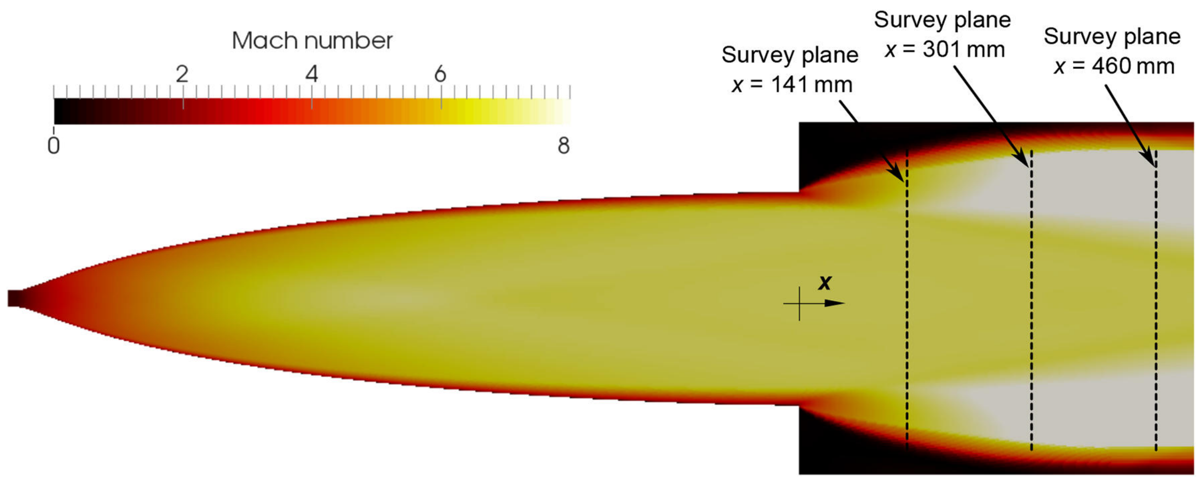
Experiment support
+ analysis of facility operation
+ analysis of test articles



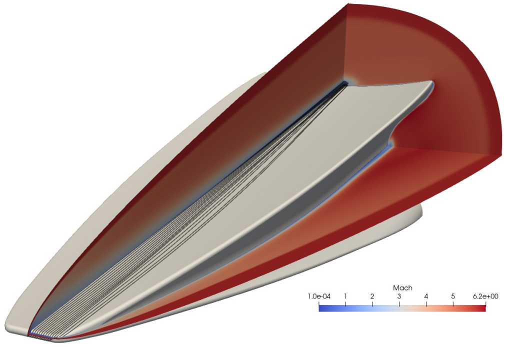


Flow physics investigation
+ as a wind tunnel substitute

Flowpath design and optimisation
+ impulse facility nozzles
+ aerodynamic shape optimization

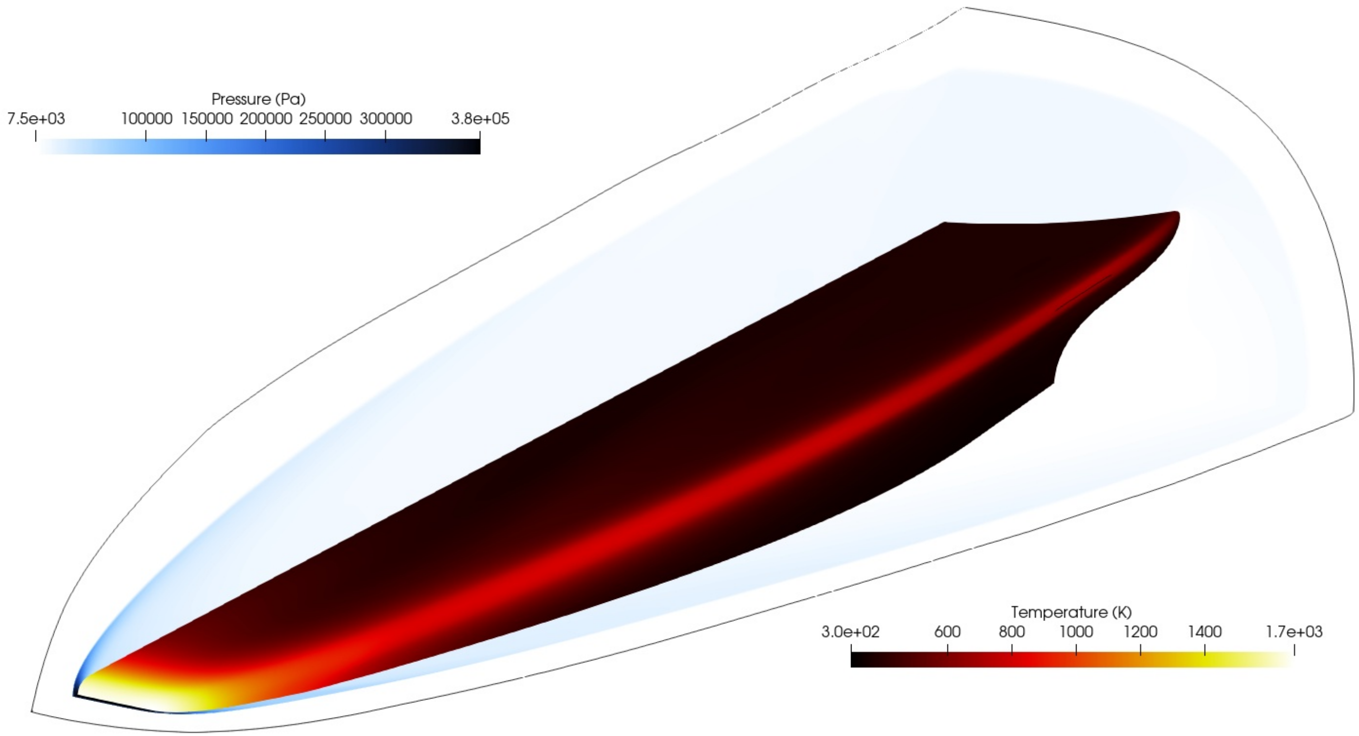


Eilmer for use in support of experiments



BoLT-II flight experiment (with ground testing)

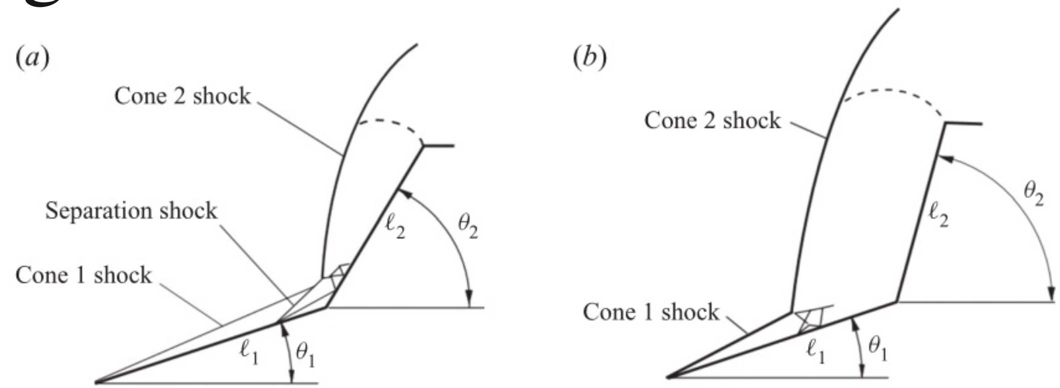
+ simulations of flow field to help with sensor placement
+ simulations of coupled heat transfer in fluid/solid domains to inform hot-wall testing

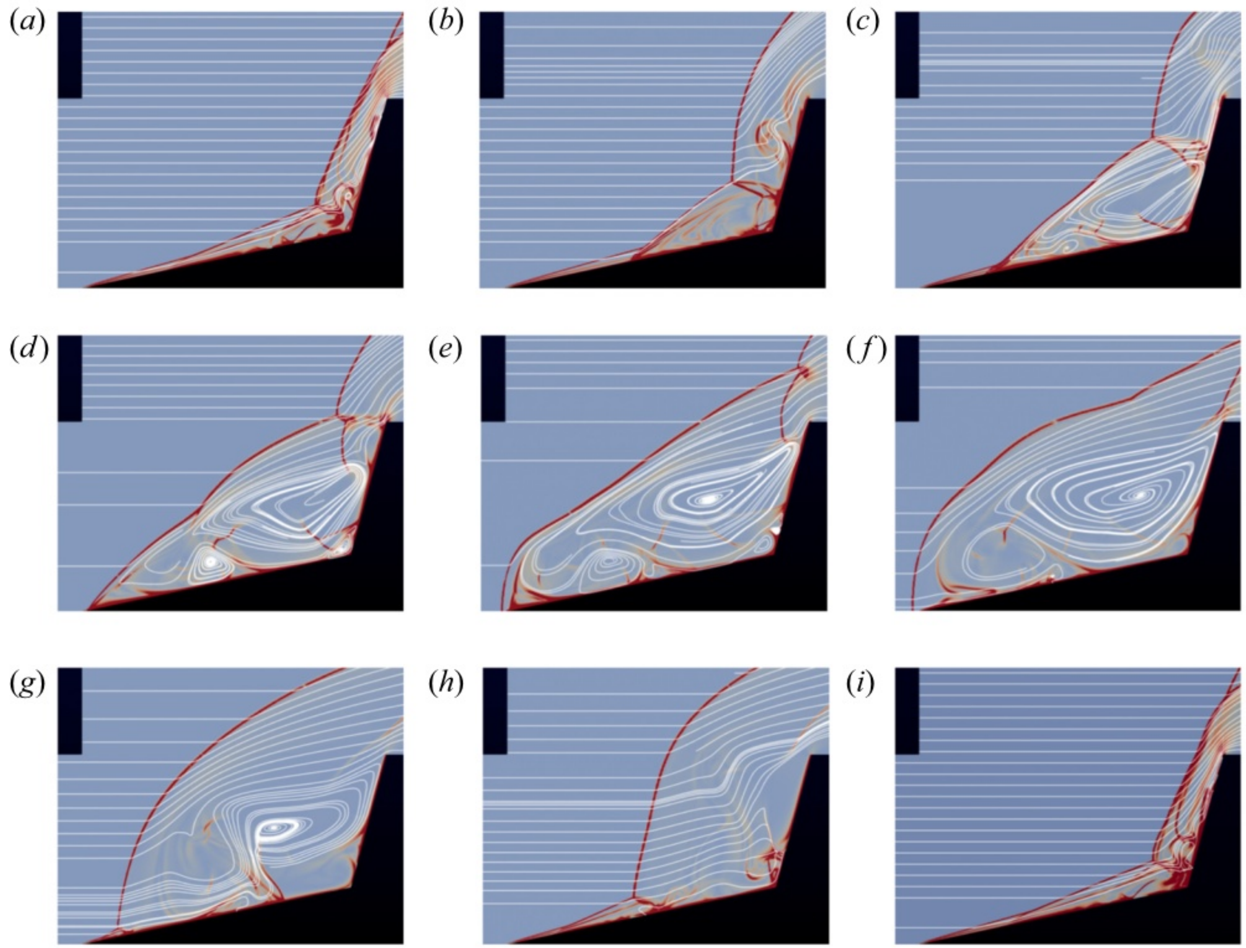


Eilmer for flow physics investigation

Steady and unsteady flow over double-cones

+ 300+ simulations to sweep geometric parameter space and flow conditions
+ aim to determine unsteadiness boundaries





Hornung, Gollan & Jacobs (2021) Journal of Fluid Mechanics, v.916

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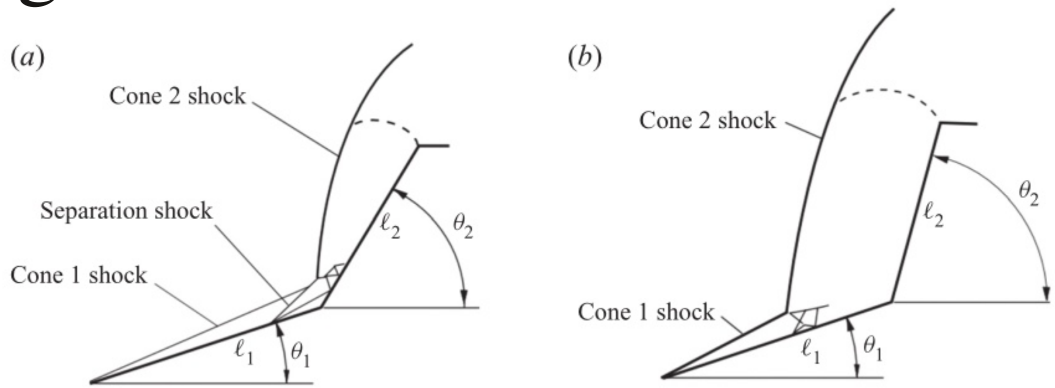

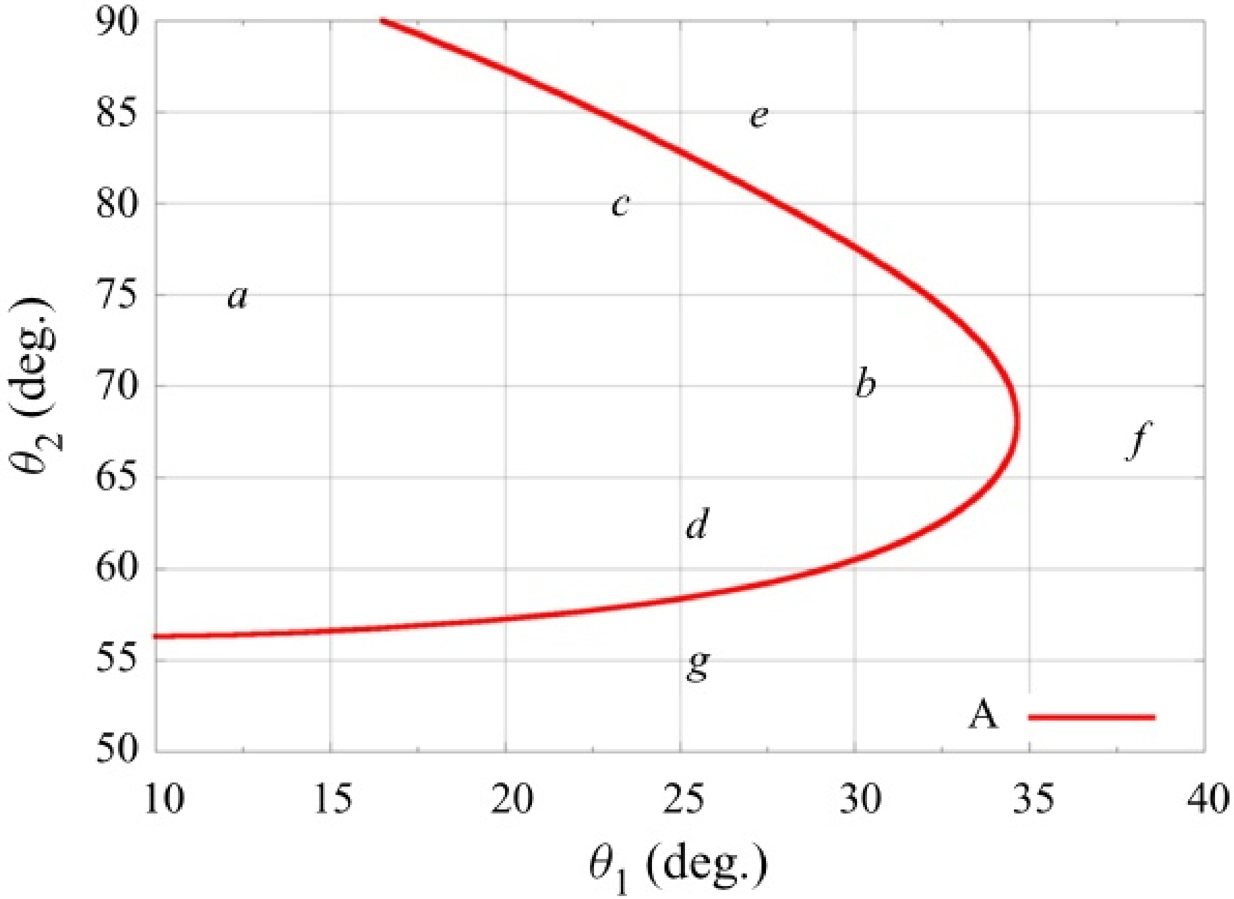

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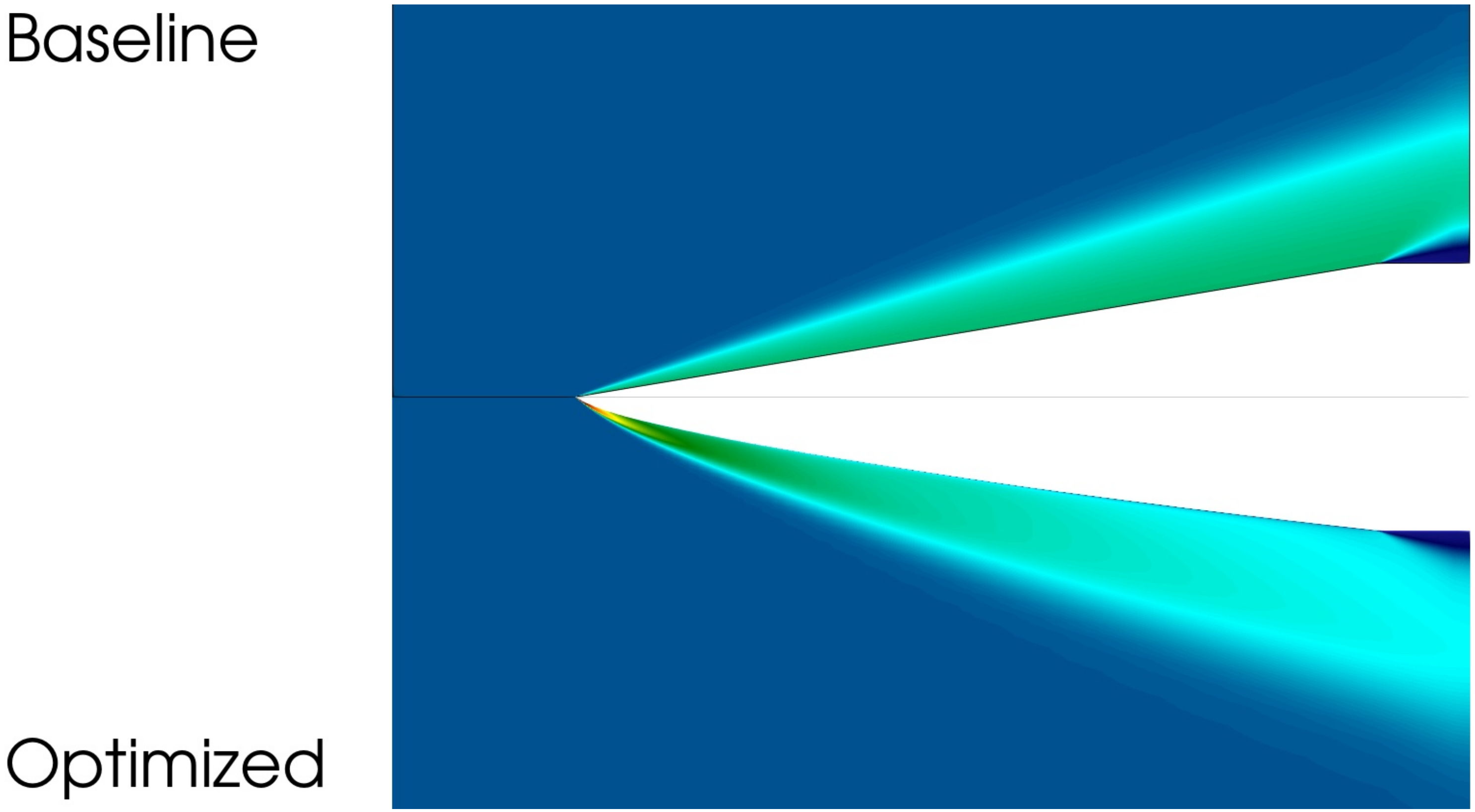
Eilmer for flowpath design

Efficient multi-parameter aerodynamic shape optimization
+ in-built state-of-the-art adjoint solver, allowing "open-box" optimization



Optimization target: minimum drag shape for given length and base diameter constraints

`Eilmer` for flowpath design

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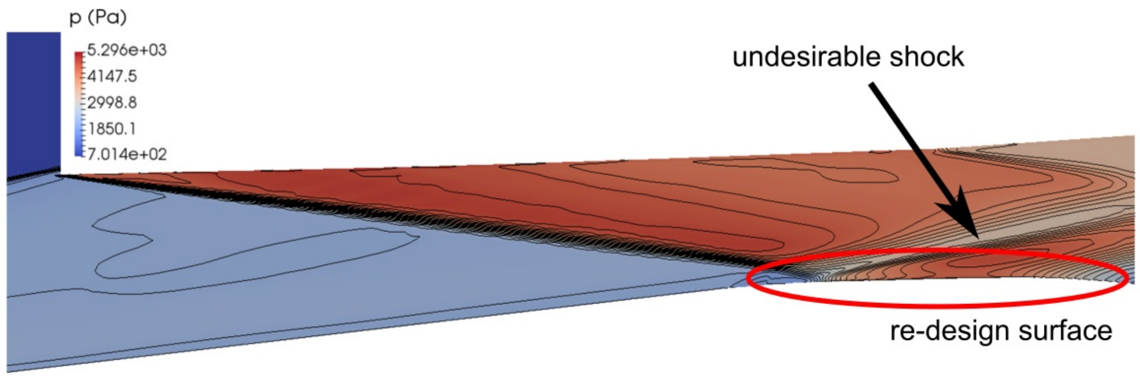
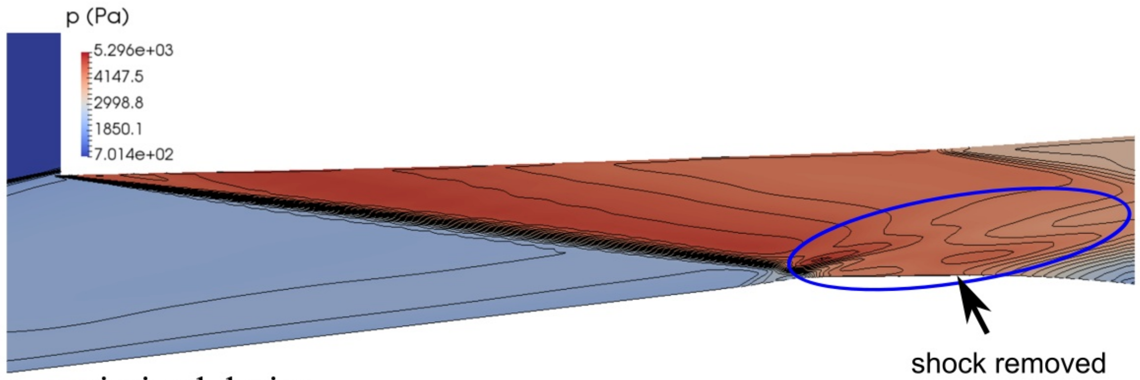
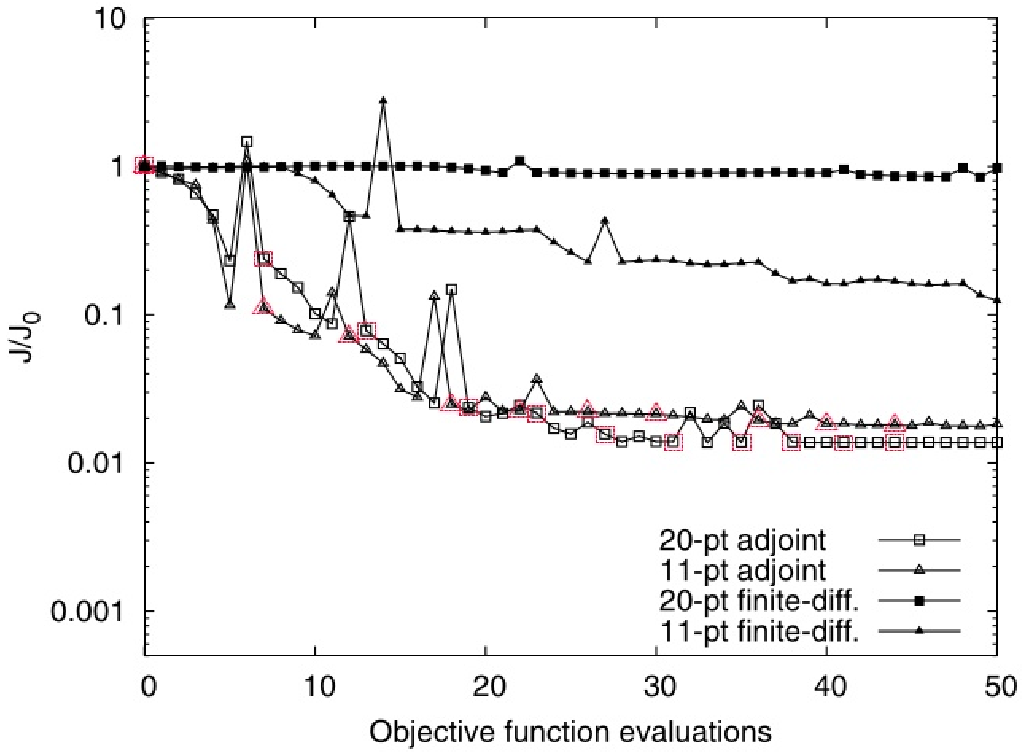
+ in-built state-of-the-art adjoint solver, allowing "open-box" optimization



a) original design



b) optimized design



Optimization target: minimum deviation from design pressure at inlet throat

Damm et al. (2020) AIAA Journal, 58(6)

Eilmer: features and capabilities

+ 2D/3D compressible flow simulation
+ Gas models include ideal, thermally perfect, multi-temperature and state-specific
+ Finite-rate chemistry
+ Inviscid, laminar, turbulent flows
+ Solid domains with conjugate heat transfer
+ User-controlled moving grid capability
+ Shock-fitting method for blunt body show layers
+ A rotating frame of reference for turbomachine modelling
+ Transient, time-accurate updates with Runge-Kutta family integrators
+ Steady-state accelerator using Newton-Krylov approach
+ User-defined customisations available for boundary conditions, source terms, and pre- and post-processing
+ Parallel computation using shared memory or distributed memory (MPI)
+ Multiple-block structured and unstructured grids
+ Native grid generation and 3rd-party import capability
+ Unstructured-mesh partitioning via Metis
+ Adjoint solver for efficient sensitivies evaluation