GDTk CHANGELOG 2025-q{:}

A newsletter for the GDTk Community

09 December 2025

This newsletter covers all of 2025, excepting the Christmas period. We'll catch you up on our southern hemisphere Summer-of-Code in the next newsletter.

Welcome to Jianshu Wu, new PhD student

A new PhD student, Jianshu Wu, joined the `Eilmer` team at the start of April, 2025. Jianshu joins us having completed a Masters degree at Chungnam National University in South Korea. Jianshu's PhD topic will involve a numerical study of near-wall influences on transition to turbulence in high-speed boundary layers. We hope to investigate tailored wall heating and/or injection of gases to influence transition.

Jianshu's project is part of a larger team working on the TUM-UQ International Graduate School for Science & Engineering project called HypRTTC (hypersonic roughness & temperature transition control).

Welcome Jianshu!
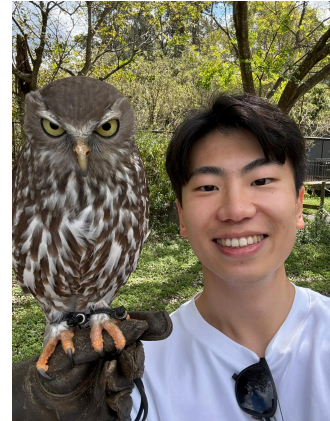
### *RJG gives keynote to UK Fluids Workshop on High-Speed CFD*

The UK Fluids Network has a High-speed CFD Special Interest Group. That group met for an online workshop on 16 April 2025. I was invited to talk on Australian high-speed CFD activities. I acknowledged that I would present a biased view of Australian activities in the simulation of high-speed flows, and spoke on some recent developments we have made with `Eilmer`. Those developments were a team effort and covered work by Nick, Reece, Rob, Kyle and Peter.

My talk covers a brief history of the gas dynamics toolkit (GDTk), the current features of `Eilmer`, and talks about our work on CFD-in-the-loop optimisation for aerodynamic design. A link to the slides is at right.

RJG presents in the Australasian Fluid Mechanics Seminar series

The Australasian Fluid Mechanics Society host an online seminar series once monthly to connect researchers across Australia and New Zealand (principally, but anybody can join the talks). As part of that seminar series, on May 28 2025, I presented on a multi-year effort led by Kyle Damm and Reece Otto to develop an adjoint-based optimisation capability for `Eilmer`. (See slides at right.)
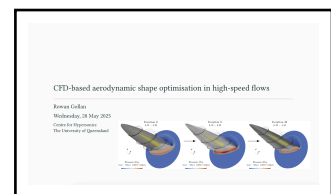
The talk can be found on YouTube at:
https://youtu.be/pKptyjbfbjU?si=D1z-MkiLcq52Icxs

Shock Waves Down Under, July 2025

The 35th International Shock Waves Symposium was hosted by the Centre for Hypersonics (CfH) at UQ's St Lucia Campus, with an excursion day to Moreton Island and a post-symposium workshop in Toowoomba at the University of Southern Queensland. The symposium ran from 5–14 July, 2025.

At UQ on the Saturday the 5th, members of CfH presented a short course on Hypersonic Shock Tunnel Experimentation and Modelling. Nick Gibbons and I covered the modelling part. Our slides are available here:

https://gdtk.uqcloud.net/pdfs/issw35-nng-rjg-short-course-2025-07-05.pdf

During the week, members of the `Eilmer` team presented work in the various technical sessions:

- NNG spoke about his modern rewrite of an equilibrium gas calculator for high-temperature gas compositions;
- RGW talked about simulations to investigate shock stand-off on spheres fired into chlorine; and
- RJG took the opportunity to open-source release Pingvin, which can be found on github: https://github.com/rjgollan-on-github/pingvin.

We were also fortunate to hear two members of the GDTk community give plenary lectures at the symposium. Hans Hornung gave the Ray Stalker plenary lecture and Vincent Wheatley gave a history of science and engineering development on high-Mach-number scramjet flowpaths at UQ. The timing of ISSW35 conveniently coincided with payday on a decade-long bet between Hans and Vince. The bet concerns the use of scramjet propulsion to deliver an object to low Earth orbit by 2025, with some technical conditions applied to that statement. Hans bet "no", Vince "yes". Hans collected a bottle of scotch at the conclusion of Vince's talk. Here we are enjoying Hans' winnings.

Figure 1. *(from left)* VW, HGH and RJG at the conclusion of ISSW35.

Rob Watt gives Final PhD Seminar in the CfH Seminar Series

On 14 August 2025, Rob Watt gave his final talk as a PhD student to the CfH group. Rob's thesis is about evaluating the effectiveness of electron transpiration cooling, and developing the high-temperature gas modelling to accompany that study. This means Rob has done a lot of work on blunt body simulations in his thesis and has learnt, as others have, how critical quality body-fitted grids that align with the bow shock are for estimating heat transfer.

To that end, Rob has been developing a shock-fitting mode for `Eilmer` that is compatible with the steady-state accelerator. Rob's final talk was on that work, and you can find the slides on the right. The image below shows the beautiful convergence of a shock-fitted blunt body, but you really should visit the slides to see the animation.
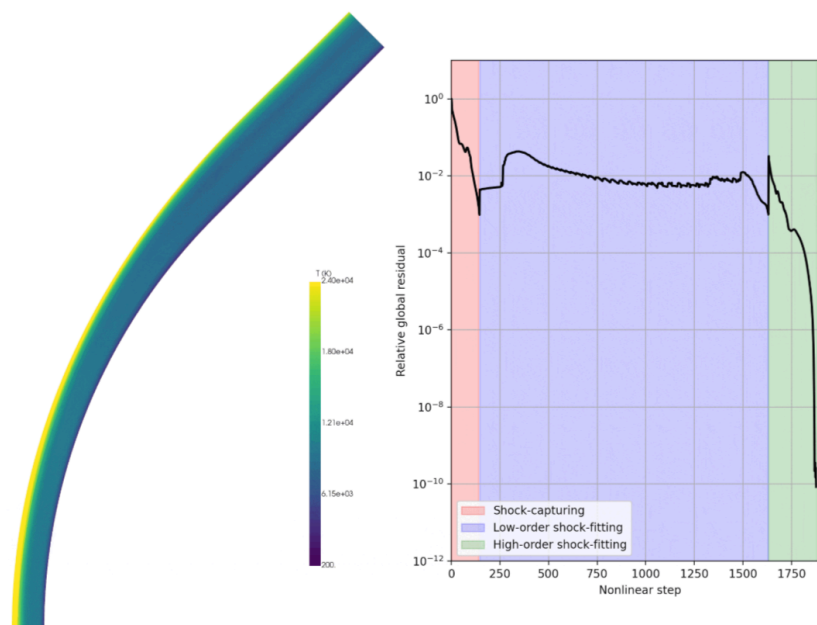

Figure 2. *left:* Flow field over the Hayabusa capsule; *right:* iterative convergence history in 3 stages: shock capturing, then shock-fiting with low order reconstruction, and finally moving to high order for final stage.

Rob also gave us a timely reminder about the value of physics-based simulation in a time when most of the world is going AI crazy. This image below captures some of the sentiment of working as a CFD developer in the current zeitgeist of "ML for everything!"

Eilmer presented at the Defence Supercomputing Summit

The Defence Supercomputing Summit brought together high-performance computing (HPC) specialists and enthusiasts from around the country for a meeting in Adelaide. On the 27th of August 2025, RJG presented to the summit on the uses of HPC for tackling simulations in hypersonics. The talk highlighted the role of `Eilmer` in Australian hypersonics simulation and focused on three classes of use case for HPC in hypersonics:

- flow physics investigation using large-scale parallelism;
- many-parameter studies/design space searches; and
- multi-physics simulation at long time scales.

Winter Lightning Talks

In the final days of winter, we held our Winter Lightning Talks. That was on Friday 29th August 2025, with Nick as schedule convenor. Here was our schedule of talks.

Schedule:

2:00pm	$(MAKE) it so	Shahzeb Imran
2:15pm	Implementing Kim and Jo's Model in Eilmer	Jianshu Wu
2:30pm	Laser Games	Seb van Oeveren
2:45pm	swft: A medium sized bird, superficially similar to the barn swallow	Nick Gibbons
3:00pm	Arm-chair computing	Peter Jacobs
3:15pm	Tea Break	
3:45pm	From Broke to Broker: Getting ChatGPT to Write an AutoTrader	Reece Otto
4:00pm	Using the Method of Characteristics to Solve a Flow Field	Carrie Xie
4:15pm	" " vs " "	Alex Muirhead
4:30pm	Untitled Duck Game 🦆 : Spring Cleaning ✨	Roshan Kurian
4:45pm	Trends in CFD for Low-Speed Aero: What Can We Learn?	Rowan Gollan
5:00pm	Are you down because your residuals aren't? Try this!	Rob Watt

Figure 3. Schedule for Winter Lightning Talks held on 29 Aug 2025.

GDTk team members at 4th HiSST Conference in Tours, France

In September, several members from the GDTk community went to the 4th International Conference on High-Speed Vehicle Science & Technology, held in Tours, France. We had two presentations from the `Eilmer` dev team: Reece Otto presented his results on optimising the lift-to-drag ratio on a hypersonic vehicle using adjoint-based aerodynamic shape optimisation; and Nick Gibbons presented work on physically-based one-di-

mensionalised scramjet flowpath estimator. (Nick's slides are linked in the next article; Reece's are to the right.)

The photos in Figure 4 were taken on the final day of the conference. We tried to round up the (remaining) Queensland contingent (both current and former researchers) for a photo in front of the banner. After the day's technical activities were done, we started our own symposium (look up the original definition) across the street to celebrate Reece's first presentation at an international conference.
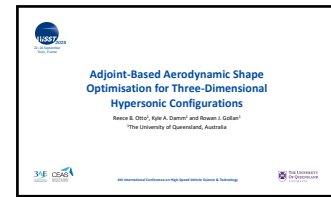

Figure 4. *left:* Queensland contingent at the conclusion of the 4th HiSST Congress; *right:* Post-conference celebration for Reece's first international conference presentation.

When in France (or is it when in Rome?), one should make the time to catch up with other present and past members of the GDTk community. So we did just that. On the Saturday night following the conference in Tours, we organised a group dinner in Paris so that we could reconnect with friends.

Figure 5. Reunion in Paris. *(clockwise from top left)* Eric, Jens, Reece, Rowan, Nick, Connie, Kyle, Pierre, and Ryan.

NNG gives talk at Technical University of Munich

Following the HiSST conference in France, Nick and I travelled across to Munich to visit the project team at the Technical University of Munich (TUM). In some sense, it was a kick-off meeting and we got to meet the new TUM PhD students on our UQ-TUM project as part of the International Graduate School of Science & Engineering. Our visit was on 30 Sep 2025.

While we were there, Nick presented a seminar about a quasi-1D approximator for 3D reacting flowpaths. This was an extended version of his talk the week earlier at HiSST.

Our time in Munich was in the midst of Oktoberfest, and I snapped a photo of a poster in the street (on right). Unfortunately, our time was too short in Munich to visit the Wiesen.

Lua celebrates 30 years and `Eilmer` helps it do so

We use Lua in the GDTk code collection as a scripting and configuration layer. Some members of the `Eilmer` development team are not super happy about the integration of the D code with Lua, and admittedly, when first inspecting the code base, there is a lot of D-Lua connection code. Others simply don't like Lua because it doesn't behave quite like Python (😉). So Peter and I set out to correct that thinking by writing a 16-page article on why Lua is a good choice for simulation software.

More seriously, our new article appears as part of a Special Issue in the Journal of Computer Languages to celebrate the 30th birthday of Lua as a programming language. We were invited to contribute our experience report on the use of Lua in our domain of physics-based simulation.

The article is published open access. You can get to it by clicking on the image to the right, and here is the abstract from the paper.

We describe our 15 + years of experience using Lua as part of the development toolkit for a physics-based simulation code, Eilmer. The code is specialised for the simulation of gas motions at high-speeds and the use of Lua aids to manage complexity and provide flexibility. We discuss our uses of Lua including: user-programmable input configuration, user-defined run-time customisation, for data description, and as a scripting layer to D language code. The paper presents both user and developer perspectives and experiences. We conclude with some lessons learnt about using Lua in the context of a physics-based simulation code, and close with a recommendation that the inclusion of Lua in our toolkit has been a net positive and fruitful decision.

Eilmer (online) Meet-ups

In 2025, we decided to reduce the frequency of Eilmer meet-ups. We're not sure we've landed on the right balance for meet-up frequency but we're adapting.

We held a February meet-up on 27 Feb 2025 at a US-friendly time. On June the 5th, our meet-up was at a Euro-friendly time. We'll finish the year with a US-friendly meet-up on December 11.

Eilmer announcements mailing list

We are starting an `eilmer-users` mailing list for the purpose of announcements from the dev team. We don't expect this to be a high volume mailer. Our intended use is: to mail out this newsletter; to announce `Eilmer` meet ups; and the occasional note about feature release or major change to code operation.

The advantage of using a list is that users can control their subscription. This reduces the confusion amongst developers of trying to hand around an up-to-date list of users. You can subscribe to the list here:

https://lists.eait.uq.edu.au/mailman/listinfo/eilmer-users

Eilmer tip corner

There is now an `lmr` Python module as part of `Eilmer` v5. It slices! It dices! and it cleans itself afterwards! Well, maybe the `lmr` module is not as full-featured as a TV home shopping cutting utensil, but we think it's pretty neat. It does in fact help with slicing of data.

Python uses garbage collection, so in a sense it does clean up after itself.

The idea of the module is to facilitate some user-directed advanced post processing of field data. The `lmr` module allows you to load in `Eilmer` field data and then perform some operations. You do all of this from a Python script. You import the module `gdtk.lmr` to get started.

Here is an example that does slice — using: `get_slice()` — which you can find in the code collection at:
`gdtk/examples/lmr/2D/sharp-cone-20-degrees/sg-minimal/estimate_shock_angle.py`.
It is used to estimate the shock angle on flow over a sharp cone.

python

```python
1 from gdtk.lmr import LmrConfig, SimInfo
2 import matplotlib.pyplot as plt
3 import scipy.stats.mstats as mstats
4 import math
5
6 lmrcfg = LmrConfig()
7 sim = SimInfo(lmrcfg)
8 snap_last = sim.read_snapshot(sim.snapshots[-1])
9
10 # Decide a trigger-level for detecting the shock.
11 xs, ys, ps = snap_last.get_slice(var='p', j=10)
12 p_min = ps[0] # Free-stream pressure
13 p_max = max(ps) # Post-shock pressure
14 p_level = p_min + 0.3*(p_max - p_min)
```

```
15
16 def locate_shock_along_strip(xs, ys, ps, plevel):
17     x = xs[0]; y = ys[0]
18     for i in range(1, len(ps)):
19         if ps[i] >= p_level:
20             frac = (p_level - ps[i-1])/(ps[i] - ps[i-1])
21             x = xs[i-1]*(1.0-frac) + xs[i]*frac
22             y = ys[i-1]*(1.0-frac) + ys[i]*frac
23             break
24     return x, y
25
26 x_loc = []; y_loc = []
27 for j in range(sim.grids[0].njc):
28     xs, ys, ps = snap_last.get_slice(var='p', j=j)
29     if ps[-1] > p_level:
30         x, y = locate_shock_along_strip(xs, ys, ps, p_level)
31         x_loc.append(x); y_loc.append(y)
32
33 result = mstats.linregress(x_loc, y_loc)
34 print(f"shock_angle= {math.degrees(math.atan(result.slope))} degrees")
```

Eilmer v5 release in 2025???

Yes, I think so. It has a nice ring to it to release Eilmer v5 in 2025.

The only thing holding back the release is a completed user guide. The code is in use and an automated test suite is active. The reference manual is up to date. There is a catalogue of examples and a tutorial guide.

I think I'm at peace with releasing Eilmer v5 with a not-quite-complete user guide.

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THE EILMER USER GUIDE

VERSION 5.0
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CENTRE FOR HYPERSONICS
SCHOOL OF MECHANICAL & MINING ENGINEERING
THE UNIVERSITY OF QUEENSLAND