UTS Rapido

Innovation through advanced 3D geometry processing

Bridging the gap between academia and industry

UTS Rapido applies advanced 3D geometry processing to solve complex engineering challenges across additive manufacturing, medtech, defence and advanced manufacturing.

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The role of 3D geometry processing

3D geometry processing is an interdisciplinary field focused on the representation and analysis of complex three-dimensional shapes in digital form. It enables engineers to convert physical objects and environments into accurate digital models that can be analysed, simulated and manufactured.

At its core, the discipline works with geometric representations such as point clouds, polygonal meshes and implicit surfaces. These models originate from sources such as 3D scanning, simulation, photogrammetry and CAD systems, and processed using advanced mathematical and algorithmic techniques.

Where it is used

3D geometry processing underpins many modern advanced engineering workflows, including:

- Additive manufacturing and advanced 3D printing
- Toolpath generation and build instructions for manufacturing systems
- Medical imaging and surgical planning
- Physics-based simulation and digital twin modelling
- Robotics and machine vision
- Infrastructure modelling and scan-to-BIM workflows
- Aerospace and automotive engineering
- Autonomous navigation and spatial mapping

Across these domains, geometry processing enables accurate digital representations of physical objects, allowing engineers to analyse, simulate and reproduce them with precision. UTS Rapido specialises in developing the algorithms and software systems that enable these workflows.

Why it matters for modern engineering

From surgical implants to satellite navigation, 3D geometry processing plays a central role in solving high-stakes technical problems.

It enables industries to move faster and with greater confidence, supporting better decisions, leaner production, and more accurate physical replication.

Whether reverse engineering legacy parts, simulating airflow around new aerospace designs, or digitising infrastructure for urban planning, well-processed 3D data provides the clarity and precision required for modern engineering applications.

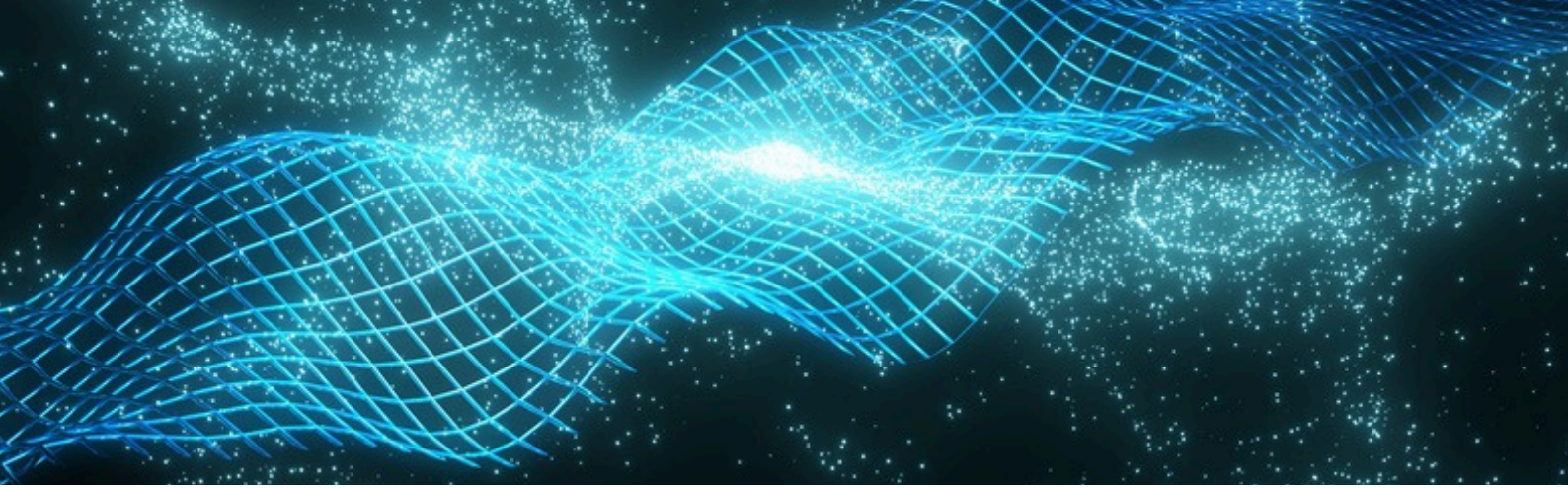
Experts in complex 3D challenges

UTS Rapido brings together one of Australia's most experienced teams in advanced 3D geometry processing, translating complex mathematics into deployable software systems for industry.

Our team draws on decades of experience across computational geometry, robotics, machine vision and applied mathematics, applying these disciplines to solve complex engineering challenges.

We deliver high-impact R&D projects across sectors including additive manufacturing, medtech, defence and autonomous and remote navigation.

Whether automating scan-to-print workflows, or enabling localisation in GPS-denied environments, our experts apply advanced geometric methods to deliver reliable, commercial deployable solutions.



3D geometry processing: real world impact

Across many industry sectors, 3D geometry processing helps bring digital and physical systems into closer alignment.

In aerospace and automotive, it supports aerodynamic simulation and design verification.

In medtech, it enables patient-specific implants, anatomical modelling, and surgical planning.

Construction and infrastructure projects rely on scan-to-BIM workflows and large-scale urban modelling.

Robotics, defence, mining and advanced manufacturing also rely on geometry processing to interpret spatial data, analyse complex structures and accelerate innovation across digital and physical systems.

Why 3D geometry processing is challenging

3D geometry processing draws on advanced mathematics, algorithm design and software engineering to analyse and manipulate complex 3D data.

Expertise across all three areas is not common. Developing geometric algorithms requires both deep mathematical knowledge and strong software engineering capability, while translating academic techniques into reliable industrial systems presents additional challenges.

The real difficulty lies in creating algorithms that operate reliably on imperfect real-world data and at an industrial scale.

UTS Rapido's software experts combine deep computational geometry expertise with advanced algorithm design and software engineering capability to translate complex mathematics into reliable systems for industrial and commercial environments.

Industry applications and use cases

Understanding the theory is only the beginning. Translating mathematical theory into robust, real-world algorithms is the real challenge. Our recent projects include:

Advanced manufacturing: Custom toolpath generation and lightweight structure optimisation for complex components.

Mining: Geometry-driven design and optimisation for large-scale spiral separators, validated through digital twin simulation.

Defence: Rapid reverse engineering and geometric reconstruction for field-deployable part replacement.

Maritime: Damage detection and automated planning for cold spray additive manufacturing (CSAM).

MedTech: 3D reconstruction from CT and MRI data for surgical planning and personalised implants.

Viewpoint - Hervé Harvard, Executive Director, UTS Rapido

The decision to build deep 3D geometry processing capability within UTS Rapido came from my direct experience in industry. I saw capable organisations struggle to advance complex physical and digital problems because the underlying mathematical expertise simply wasn't there.

Algorithms that accurately interpret, reconstruct and manipulate three-dimensional geometry sit at the harder end of applied mathematics and software engineering. They are rarely found in applied R&D teams at the depth serious commercial work demands.

As the founder of UTS Rapido, I have invested in that capability deliberately and consistently for nearly a decade, including securing grant funding to sustain it. The reason is clear in the work itself. SPEE3D needed it. Mineral Technologies needed it. Stryker's surgical planning platform needed it.

As a result, we have established ourselves as a leading partner in geometry processing expertise, supporting industry partners and broader organisations such as the AMCRC, where I sit on the Innovation Taskforce, and Standards Australia, contributing on the 3D Printing Committee.

Case study:
3D printing of precise, custom surgical implants

Stryker is a global leader in medical technologies, providing innovative products and services in Medical, Surgical, Neurotechnology and Orthopaedics that help improve patient and healthcare outcomes.

In partnership with UTS Rapido and the Digital Health CRC, Stryker set out to simplify the complex design process of patient-specific surgical solutions using 3D printing.

The collaboration aimed to front-load complexity into a digital environment, giving surgeons and technicians a valuable virtual planning tool.

Challenge

Previous research indicated that surgical implants designed and manufactured to precisely fit an individual's anatomy can reduce operation times and improve patient outcomes. However, the design of personalised surgical products is a complex and time-consuming process, involving highly skilled personnel and detailed surgeon input.

Our 3D geometry processing contribution

UTS Rapido has demonstrated its expertise in 3D geometry processing, creating precise 3D computer models of real objects using a combination of applied mathematics, computer science and engineering.

Technological impact

The project developed an automated software platform to streamline virtual surgical planning, enabling users to easily design patient-specific implants, and bone cutting guides for 3D printing.

Using 3D geometry processing and printing techniques, this solution reduces the burden on highly specialised overseas design personnel, and accelerates access to treatment for patients.

Outcome

Stryker now has a validated software platform to help plan and shape stock implants with greater precision and in significantly less time.

The solution supports better surgical outcomes, improves workflow efficiency, and helps move the industry closer to personalised, on-demand implants.

The rapid 3D printing of surgical implants that precisely fit individual patients is a step closer with new software to help with their design and manufacture.

The current findings and future iterations of this work have the potential for significant international impact.

The project also enabled Stryker to leverage matched funding through the Digital Health CRC.

Key 3D geometry processing activities

- Built a fully automated workflow that processes noisy CT scans into high quality 3D mandible models.
- Computed vector fields and centre-line paths optimised using surgeon-informed anatomical and mechanical criteria.
- Simulated with collision-aware algorithms and anatomical fit constraints.
- Developed real-time editing tools to allow minor adjustments by clinicians, supported by visual alerts and safety threshold indicators.
- Generated print-ready models and resin guides to optimise the surgical workflow.

Rob Wood, Senior Director of R&D, Stryker

This project makes an important contribution to the increased personalisation of patient-specific healthcare, where tools and treatments are individualised to achieve optimised outcomes for each patient.

By empowering surgeons and users with digital tools for design and planning, we can reduce the time to surgery and improve overall patient care. This is a key step toward more agile solutions in healthcare.

Sidewinder's bespoke 3D printing setup enables dual-material printing, real-time geometric correction and toolpath simulation, without the need for support structures.

Case study: Spiral printing at industrial scale

Mineral Technologies is a world-leading provider of gravity separation technology used in mineral processing plants across the globe.

Gravity spiral separators, typically constructed from polyurethane or fibreglass, are central to their operations. However, traditional mould-based manufacturing methods for these spirals can be inflexible, time-consuming and expensive.

Developing new designs requires extensive retooling and manual labour, slowing innovation, and increasing cost.

Challenge

Producing and refining spiral prototypes using legacy moulding methods was costly, slow, and offered limited design flexibility. Mould production delays add time and cost to each iteration.

Occupational hazards from resins and fibreglass dust also posed risks to workers. There was no effective pathway for rapid iteration or onsite manufacturing. Mineral Technologies needed to reimagine spiral manufacturing using 3D printing.

Solution

The goal was to design a large-scale 3D printer that could produce spiral prototypes up to 3 metres tall, without support structures and using dual materials for structural and wear-resistant layers.

UTS Rapido designed and built 'Sidewinder', a shipping container-sized 3D printer with dual robotic arms, a rotating pole, and an integrated scanning system. The printer produces spirals layer by layer with no support material. One robotic arm handles the structural layer. The other prints a smoother surface finish that enhances mineral separation.

Our 3D geometry processing contribution

At the core of the Sidewinder solution is a geometry-aware software pipeline designed to convert complex CAD models into precise, collision-free printing instructions.

Spiral separators present unique challenges due to their height, curvature and variable wall thickness, making conventional slicing approaches unsuitable for reliable large-format 3D printing.

To ensure accuracy, we integrated a 3D scanner on the robotic arm to detect eccentricity in the rotating pole. This live scan data is used to triangulate deviations and locally adjust toolpaths, maintaining tight tolerances across the full structure.

The system dynamically reorders printing sequences to minimise movement overhead and avoid defects caused by calibration drift or nozzle misalignment. We also implemented a full digital twin of the printer and print cycle, enabling simulation and validation of multi-hour jobs before committing materials.

Technological impact

This approach enabled a viable path to large-scale spiral prototyping without moulds or manual support removal. By combining non-planar slicing, live geometry correction, and real-time print simulation, the system demonstrated a new benchmark for precision and safety in additive manufacturing for industrial mineral separation.

Outcome

Accelerated R&D cycles, reduced reliance on hazardous chemicals, and enabled field-deployable 3D printing in the mining sector.

Mineral Technologies
A Downer Company

Key 3D geometry processing activities

- Developed a custom slicing algorithm optimised for tall, curved spiral structures.
- Created dynamic path adjustment logic to compensate for detected eccentricities in the build platform.
- Eliminated the need for support structures through optimised path planning and material flow control.
- Converted geometry into efficient robot-joint sequences with built-in collision avoidance.
- Simulated full print cycles via a high-fidelity digital twin, reducing test waste and improving reliability.

> **Dustin Pepper, Head of Products, Mineral Technologies**
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> Mineral Technologies continues to embrace innovation by leveraging cutting-edge technologies to enhance mineral processing.
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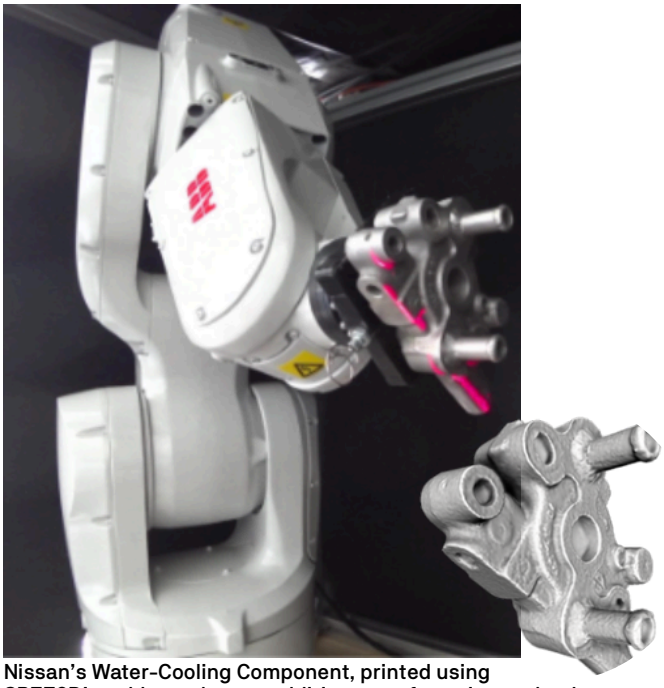
> Our commitment to exploring new approaches, such as advanced 3D printing, reflects a forward-thinking mindset that is shaping the future of mining operations.



Nissan's Water-Cooling Component, printed using SPEE3D's cold metal spray additive manufacturing technology

Case study: Reverse engineering in the field

SPEE3D

SPEE3D is transforming metal manufacturing through Cold Spray Additive Manufacturing (CSAM), a method that uses supersonic compressed air to bond metal powders without melting.

Its high-speed, field-deployable printers are used by defence forces for on-site production of robust, mission-ready metal components. Since 2017, UTS Rapido has partnered with SPEE3D under an IMCRC-funded research initiative, helping to advance SPEE3D's ability to replace critical components faster, more economically, with reduced operational risk.

Challenge

Mechanical failures in defence and mining environments can halt operations for days. Replacement parts are often unavailable, and delivery delays put mission readiness and safety at risk. Most components have no existing digital twin, and conventional reverse engineering is too slow and error-prone to meet field demands. Without a viable digital-to-physical workflow, on-demand part production isn't possible.

Solution

UTS Rapido developed a fully automated 3D scanning system that enables SPEE3D to replace broken parts in hours rather than days. The system integrates a high-precision scanner with an industrial robotic arm and advanced path-planning software. It automatically adjusts the scan path in real time to maximise surface coverage, avoid collisions and generate high-fidelity digital models ready for printing.

Technological impact

This approach replaces static, pre-set scan paths with active decision-making based on local geometry. It eliminates the need for part repositioning or multiple rescans, ensuring fast, accurate capture of complex surfaces in rugged, real-world conditions.

Our 3D geometry processing contribution

At the core of the solution is an intelligent scanning algorithm that dynamically guides the robotic arm to capture complete geometry, regardless of complexity.

Instead of following a fixed path, the algorithm makes real-time decisions based on point cloud density, local geometric features, and surface gaps. Each scanning movement is planned and executed only if collision-free, enabling operation within the confined build chambers of SPEE3D printers.

We also developed the full communication and synchronisation layer between the robot, scanner, and the high-level software controller, ensuring smooth, autonomous execution across the system.

> **Byron Kennedy, CEO, SPEE3D**
>
> We knew we had to tap into the research ecosystem to access the skills and resources we didn't have in-house. By partnering with IMCRC and UTS Rapido, we have been able to develop something we wouldn't have been able to do on our own.

Key 3D geometry processing activities

- Developed an intelligent scan-path algorithm that adapts in real time based on point cloud density and local geometry.
- Enabled dynamic, collision-aware planning for full surface coverage, even in confined printer chambers.
- Integrated scanning logic with robot motion control and high-resolution STL generation for print readiness.
- Created the communication interface between scanner, robot arm, and user interface, ensuring seamless execution.

Outcome

SPEE3D can now digitise and reproduce critical metal components in hours instead of days. This can be done on site, in the field, and without manual intervention.

The result is reduced downtime, increased operational autonomy, improved reliability, and a fully closed-loop workflow, from scanning to printing, in remote environments. This creates a faster, more resilient manufacturing process that supports both expeditionary deployments and OEM clients.

Originally developed for defence and cold spray additive manufacturing, our reverse engineering solution can now be applied in other industries such as oil and gas, aerospace, and field service, under separate IP arrangements.

UTS Rapido: Expertise, integration and delivery

Experts on hand

- One of Australia's most experienced software teams in 3D geometry processing
- Deep cross-disciplinary integration with UX, robotics, mechatronics and additive manufacturing
- Trusted R&D partner for defence, medtech and mining sectors
- Proven capability in developing novel algorithms for real-world deployment
- IP-aware, commercially minded and industry focused

Key capabilities

- Point cloud acquisition, cleaning and 3D reconstruction
- Mesh simplification and curvature estimation
- Topology optimisation
- Robotic path planning and collision-aware trajectory generation
- End-to-end scan-to-print CAD pipeline development
- Geometry-based simulation and digital twin frameworks

How we work

We collaborate closely with clients to:

- Define clear technical objectives and commercial goals
- Identify high-value R&D opportunities
- Scope feasible development pathways
- Rapidly prototype, test and iterate solutions
- Deliver deployment-ready systems for industrial or regulated environments
- Manage IP considerations to support commercial deployment

Our national impact in additive manufacturing R&D

UTS Rapido is one of 14 research partners in the newly established Additive Manufacturing Cooperative Research Centre (AMCRC), a $271 million national collaboration between industry, government and universities.

Through this initiative, UTS Rapido contributes expertise in advanced software, geometry processing and AI-enabled optimisation for next generation additive manufacturing systems.

Guido Ranzuglia
Principal Software Engineer, UTS Rapido

Expert spotlight: Guido Ranzuglia, Principal Software Engineer

Guido is one of Australia's leading experts in 3D geometry processing, with more than two decades of experience developing advanced algorithms for mesh and point cloud analysis.

As a core contributor to MeshLab, an open-source platform widely used for 3D model processing, he has contributed to influential projects focused on mesh simplification and curvature analysis, as well as co-authoring research on GPU-accelerated geometry algorithms.

His work spans both academic research and industrial applications, focused on robust computational methods for analysing and processing complex geometric data.

At UTS Rapido, Guido develops advanced geometry processing pipelines and algorithms used in applications ranging from surgical planning to robotic scanning and additive manufacturing.

His work underpins several of UTS Rapido's most technically demanding projects, including automated scan-to-print workflows, robotic 3D scanning systems and software platforms for personalised medical implants.

Technical contributions

- Developed precision algorithms for mesh simplification, smoothing and curvature analysis.
- Led implementation of advanced scan-to-print workflows across surgical, industrial and defence projects.
- Developed scalable software tools that translate complex geometric theory into practical industrial systems.

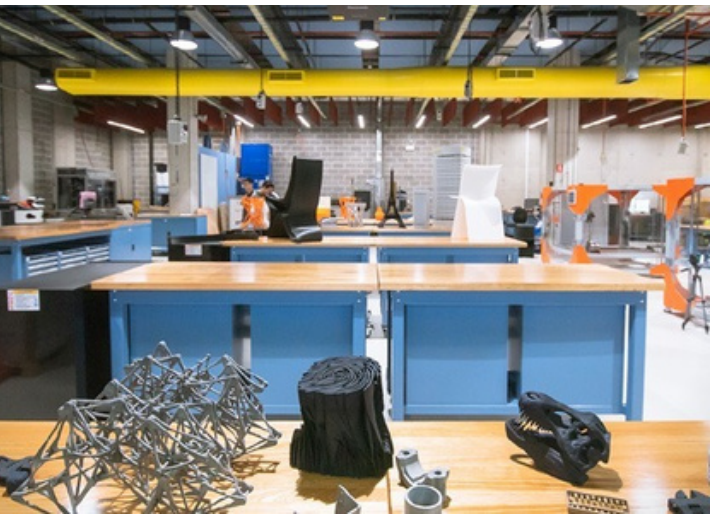
Guido's expertise in 3D geometry processing sits at the core of some of UTS Rapido's most advanced software projects.

His ability to translate complex mathematical ideas into robust industrial software is a major asset for our partners.

Raj Calisa, Principal Delivery Manager, Software - UTS Rapido

Access the UTS R&D ecosystem

UTS Rapido sits within the broader UTS innovation ecosystem. We lead projects with our own engineering and digital expertise, while drawing on specialist researchers, facilities and laboratories across the university when required.



UTS ProtoSpace: your gateway to prototyping excellence

UTS ProtoSpace is our on-campus additive manufacturing facility. It houses state-of-the-art industrial printers and fosters collaboration with industry partners and researchers. It's home to Australia's largest collection of additive manufacturing technologies, powering hands-on education, breakthrough innovation, and industrial delivery.

ProtoSpace enables our team to prototype and validate innovations rapidly, supported by high-performance equipment and expert technical staff. It anchors UTS Rapido's work in physical product development, allowing us to translate advanced software algorithms into real-world prototypes.

Turning complex geometry into practical engineering solutions

UTS Rapido works as an extension of your innovation team, combining software, mechatronics, additive manufacturing and UX expertise to progress ideas through structured development stages. We build and test what matters, then hand over prototypes, data and production-ready artefacts so you can proceed with confidence.

Partners with industry

- Projects range from end-to-end solutions to targeted engagements that fill specialist capability gaps
- We collaborate with industry partners and apply research insights within world-class facilities
- Professional R&D solutions for complex engineering and technology challenges
- Industry expertise spanning AgTech, biomedical and health, manufacturing, mining, retail, technology and transport
- Industry partners typically retain ownership of intellectual property generated through the projects they fund

Rapido Social Impact

- We support purposeful organisations working to address complex societal challenges
- Engineering and technology solutions delivered on a low-bono basis

Whether you're a start-up, SME, large corporation or not-for-profit organisation, UTS Rapido provides access to world-class engineering expertise, facilities and R&D capability to develop advanced products and technologies.

CONTACT US

Ready to discuss a project or partnership?
Contact us to learn more about our R&D expertise, labs and facilities: rapido@uts.edu.au / rapido.uts.edu.au

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