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The LTU-SPORTC approach to get better glide on narrow skis (XC & biathlon)

A popular-science guide for ski technicians, service personnel and ambitious cross-country and biathlon skiers (SPORTC)

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Abstract

This article examines gliding on narrow skis as a scientifically analyzable tribological system rather than a “mystical” craft. Since friction is a multiscale phenomenon, factors ranging from the macro- to the nanoscale must be taken into account. The most significant factors are ski selection, as well as preload and stiffness, which determine pressure distribution and thus heat generation in the contact area. Only then do base preparation and structures come into play, regulating the meltwater film: While a thin film acts as a lubricant, too much water creates braking suction effects. In the post-fluorine era, the focus is increasingly shifting toward these mechanical processes and systematic preparation. This approach replaces guesswork with precise measurements – such as via tribometers or contact pressure measurement – to make variables controllable.

The invisible opponent under your ski

In cross-country skiing and biathlon, the decisive fight often happens where nobody can see it: in the few square centimetres where ski and snow meet. This ski-snow contact is a tribological system, i.e., a moving interface in which pressure, temperature, the micro-scale ski-base texture, and a constantly evolving snow surface determine how much energy you lose to friction.

Elite teams now treat gliding as an engineering problem: quantify what happens at the interface, choose the right ski for the skier and the day, and then design the ski-base texture and surface treatment to manage contact area, water, dirt, and snow crystals. The same logic applies to ambitious skiers, where small improvements in glide translate into less fatigue, better pacing, and a more enjoyable race.

Friction is multi-scale

One reason glide preparation feels 'mystical' is that friction is multiscale in nature. At the macro-scale, your body mass and technique load the ski and shape the pressure distribution along the base. At the meso- and micro-scales, the base grind and rill create channels that can guide meltwater and reduce suction. At micro- and nanoscale, the polymer base, waxing and other surface treatments, and dirt contamination influence wetting and shear at the interface.

For elite-level service personnel, this is well known, and for others, it is good news, indicating that there are controllable levers that can and should be prioritised. In practice, the order of impact typically is:

- ski choice and camber/stiffness (pressure distribution),
- base grind and rill (contact area and water management),
- surface treatment (fine-tuning and contamination control).

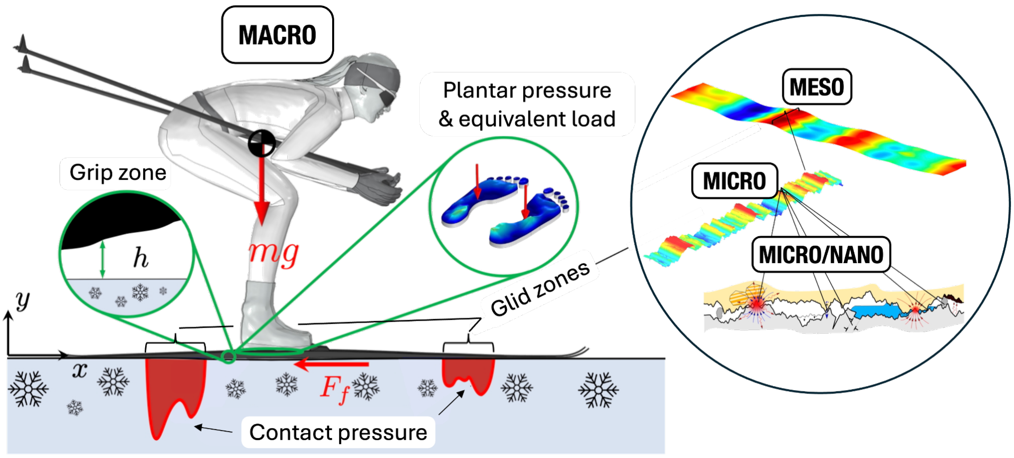

Fig. 1: Multi-scale view of the ski–snow system: macro loading and pressure distribution linked to base texture and interface processes.

Water film: friend and enemy

A thin meltwater film can reduce friction by separating parts of the base from sharp snow asperities (a lubrication effect). But in warm, wet or transformed snow, too much water becomes a problem: the ski can experience suction and viscous drag, especially if the water cannot escape the contact fast enough.

This is why structure matters so much. Near 0 °C, the ski-base texture acts as micro-drainage. A good structure creates pathways for water to flow out of the contact, keeping the film thin and preventing 'sticking' in low-speed sections. Conversely, an inappropriate structure (too smooth, clogged, or wrong pattern) can trap water and increase drag. In cold, dry snow, the texture controls the contact area. An area that is too large will raise 'dry' friction, while a too small area, or an overly aggressive structure, increases the risk of the ski base ploughing into the snow.

Camber and pressure distribution

Questionnaires comparing experts and non-experts indicate a consistent pattern: experts place more emphasis on camber/span and pressure distribution than non-experts do. The logic is straightforward. Pressure distribution controls where the ski contacts the snow, how quickly frictional heat is generated, and how much local melting occurs. It also changes how the structure actually functions: contact area and structure aggressivity must be optimised so that it minimises dry friction, does not sink into or plough the snow, and drains excess water from contact zones to avoid suction and viscous drag.

For technicians, this reinforces a practical rule: before debating wax chemistry, ensure the ski fits the skier and the conditions. The 'right' ski makes everything else easier as it produces a contact that can be tuned with structure and surface preparation.

A practical complication is that non-experts rarely have a "quiver" of many pairs. Most ambitious skiers have only a few skis to choose from—sometimes just one cold pair and one warm pair, or even a single all-round pair. That does not make camber irrelevant; it changes what "optimisation" means. Instead of selecting the perfect ski for every condition, the goal becomes to (i) understand what each ski is best suited for, and (ii) tune the contact with the tools that are still available.

For amateurs, the order of levers is typically:

- choose the best of your available skis for the day (even a small camber mismatch matters),
- adjust loading and contact position where possible (technique, binding position/plate systems),
- use grind and rill to manage dry friction and ploughing versus water drainage,
- use wax and surface treatment products as the final fine-tuning step.

In other words, elite teams often "solve" the contact problem by ski selection; amateurs more often "solve" it by understanding their limited ski set and then compensating with binding position, structure choice and disciplined preparation. The 'right' ski still makes everything easier, but even with only a few pairs, a "contact-first" approach produces better, more repeatable decisions than starting with wax chemistry.

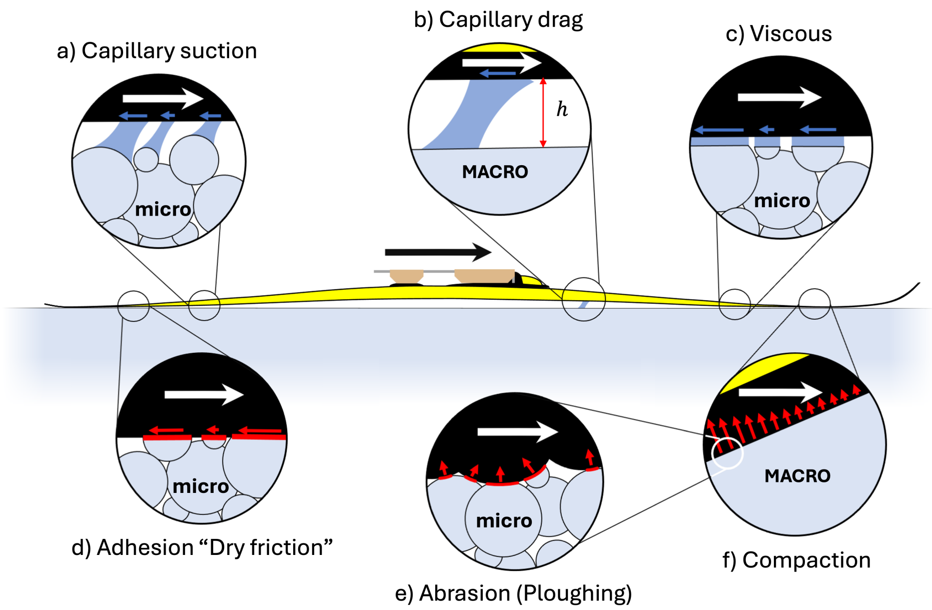

Fig. 2: Schematic overview of ski–snow friction mechanisms across scales in both dry and wet regimes.

Post-fluoro reality

With the flour-ban restrictions, glide performance shifts from relying on fluorocarbon compounds' extreme water repellency to a robust system: careful ski selection, in combination with the base grind and rill, and systematic preparation routines. The winners are the teams (and amateurs) who treat testing as a controlled process rather than a circumstantial one.

For ambitious skiers, that can be simplified to: (i) picking a ski that matches your weight and technique, and the track and snow conditions, (ii) keeping the structure open and fresh, and (iii) avoiding overcomplicating the final step. The 'last 5%'

still exists, but it is only meaningful after the first 95% is done well.

From craft to measurement

SPORTC's research direction is to reduce uncertainty by combining tribology theory with measurement in realistic conditions. That includes field monitoring (e.g., high-precision positioning to connect speed changes to terrain and decision-making) and tribometer concepts that can resolve small differences in friction during controlled gliding tests. Complementary sensor approaches, such as plantar pressure, ski/pole accelerometery and force measurements, help connect technique and loading to the contact outcome.

For service personnel, the takeaway is not that every club needs a research lab. The takeaway is the mindset: measure what you can, repeat tests, change one variable at a time, and log conditions carefully.

Practical takeaways

- Match ski to skier and day. Camber/stiffness controls pressure distribution; it often dominates glide potential.
- Structure is contact area and water management. Near 0 °C, focus on drainage (appropriate grind/rill). In cold, dry snow, an overly aggressive structure can increase 'dry' friction.
- Cleanliness is key. Dirt and old layers can clog the structure and ruin water-repellency (hydrophobicity). Clean bases so the structure you already have can do its job.
- Test like an engineer. Use short, repeatable test runs; rotate skis; change one factor at a time; record temperature, humidity, snow type and contamination.
- Keep expectations realistic. Differences can be small and noisy. The goal is reliable decisions, not perfect certainty.

Looking ahead

Better friction models and more accessible measurements will make glide decisions more reliable: from World Cup teams to ambitious amateurs. The "invisible opponent" won't get easier, but it will get more predictable when we treat glide as an engineered system rather than a superstition.

Literatur

Further reading can be found in [1–8].

About the Author

Andreas Almqvist is a professor at Luleå University of Technology, where he has been conducting research and teaching in the field of tribology for over 20 years. He earned his PhD in Machine Elements/Tribology at the same institution and has received numerous awards, including recognition for his doctoral thesis, best scientific publications, and other academic prizes.
His current research focuses on the tribology of skiing, particularly the gliding properties of cross-country skis. He applies his expertise in continuum mechanics, mathematical modeling, and programming to understand and optimize the interactions between snow, ski base, and wax.

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