

World Metrology Day 2020 - Virtual event Q&A

Questions and Answers from the World Metrology Day virtual event on 20 May 2020. To review the recording of this event please [click here](#).

- Q. **MSL New Building** - What has been the biggest challenge of this project?
- A. **Cliff Hastings** - In New Zealand building physics laboratories is not something that's done on a regular basis. There aren't a lot of examples to look back at to see how others have completed the process. Physics laboratories, and in particular, metrology laboratories are unique in many of the very tight specifications required. For the building design and construction team, this meant many hours of effort spent assessing how the laboratory building could be constructed to meet specs. This included designing an HVAC system capable of maintaining a 20 degree +/- 0.1 temperature, introducing 'clean' power and ensuring separation between the building steel frame and the reinforcing bar used in the concrete slab (quite a challenge with the amount of rebar used in the slab).

We've been fortunate to be able to work with a great team from our Gracefield Innovation Quarter Programme team (the team responsible for the redesign and development of the Gracefield site). As a result of the great relationship with this team, MSL has been able to have strong input into the building design and ultimately it's performance. This has meant, while challenges have certainly come along, we've had the right team in place to deal with them.

- Q. **MSL New Building** - When do you think we might have a fully operational building and be able to invite visitors in?
- A. **Cliff Hastings** - Moving all our equipment into the new laboratory is a time-consuming process. This isn't something we want to rush. Maintaining the integrity of our equipment and traceability is vital to our ongoing success. That means we have a very deliberate move plan in place. We aren't expecting to have all temperature and electrical standards equipment moved in and fully operational until mid-2021.

Having said that, the new building will become an operational laboratory very quickly as equipment is moved in and set up and we begin conducting research and calibrations with that equipment.

Depending on our move progress we could be in a position where we can allow visitors in to see parts of the building from late 2020

Q. **MSL beyond the SI redefinition update** - what do you mean when you refer to the role of angle when talking about improving the rigour of the SI?

A. **Murray Early** - The existing treatment of angle in the SI is unusual – for example, angles are required to be in radians but are then considered dimensionless. So if you obtain an angle in degrees you need to first convert it to radians and then remove that unit for it to be used in an SI-consistent expression. Various people have suggested adding angle as an SI base unit ([see Quincey and Brown, Metrologia vol 53, pp 998-1002, 2016](#)) but it would come at the cost of rewriting many of the equations of physics.

An illustration (from this paper) of the problem is highlighted by considering the famous Planck-Einstein formula $E = hf$ where the Planck constant h has units of J s and f is in s^{-1} , so the product as expected is in J. It is common to recast this expression using an angular frequency ω where $\omega = 2\pi f$ and the quantum of energy becomes $E = \hbar \omega$. Here the reduced Planck constant $\hbar = h / 2\pi$ also has units of J s and ω is in s^{-1} . However, if the unit of angle was now included \hbar would have to be in units of J s rad^{-1} and ω would be in $rad s^{-1}$, so that \hbar and h would have different dimensions (undesirable); alternatively the equation could be modified as $E = \eta \hbar \omega$, where $\eta = 1 rad^{-1}$. It would be difficult to overhaul established equations of physics to accommodate this change!

Note that if the angle unit was fully included in the SI, then the dimensions and units of torque and energy would no longer be the same since energy = torque x angle (the unit for torque would go from N m to N m rad).

Q. **MSL beyond the SI redefinition update** - Does MSL plan to build an optical clock?

A. **Murray Early** - Not at the moment, but if and when optical clocks have been developed as commercially available instruments (and the SI unit second has been redefined) the case would certainly be compelling. Historically MSL hasn't been involved in any research around the development of new clocks but has rather focussed on methods to disseminate time and frequency for New Zealand users. However, we now have a slightly larger team in the area, and some related work is beginning in the possible use of frequency combs. We also have a developing relationship with the NZ Dodd Walls Centre of Research Excellence in quantum technologies who have relevant research interests and expertise. It would be fantastic if there was some future collaboration related to this relentless development of ever improving clocks.

Q. **The MSL Apprentice programme** - Nina what's the coolest thing you've learnt at MSL?

A. **Nina Wronski** - One of the coolest things I have learned so far at MSL has been building knowledge in geometric dimensioning and tolerancing (GD&T), I believe this is mostly because my mentor Lenice has a passion for GD&T which she has

passed on to me. Quite often I get to be involved and watch measurements Lenice makes on the coordinate measuring machine (CMM), and I find it really interesting. I hope to learn more and be more involved in this in the future, especially operating a CMM and reading engineering drawings.

Q. **The MSL Apprentice programme** - How do you select apprentices?

A. **Lenice Evergreen** - The process of selecting the first apprentice started with a brainstorm of the personal attributes we thought were important. Skills can be taught, but attitude is a big indicator of success! We short-listed and then phone-interviewed applicants that showed these attributes and then interviewed the final four to find our apprentice.

Q. **The MSL Apprentice programme** - Where did recruiters get the shortlist for the Apprentice through, was this a job Advert?

A. **Lenice Evergreen** - We advertised the position as a normal vacancy at Callaghan Innovation including job sites like Seek. We also publicised the position to local high schools and polytech's.

Q. **The MSL Apprentice programme** - How do you find the job market when recruiting for calibration technicians for Air New Zealand?

A. **Paul Biddick** - Recruiting is never easy as the pool of calibration Engineers is very small in NZ and people don't tend to move around very much. We have managed to find experienced calibration engineers but many of our staff have come from either electrical or mechanical backgrounds and we train them across all the areas of calibration – a process that takes approx 2 years.

Q. **The MSL Apprentice programme** - When will MSL start the process of recruiting the next apprentice and will there be overlap with Nina?

A. **Lenice Evergreen** - We've planned for an overlap between Nina and the next apprentice so she can pass on what she's learned, so we'll start recruiting for the next apprentice later on this year.

Q. **The MSL Apprentice programme** - What MSL technical team will host the next Apprentice?

A. **Lenice Evergreen** - The next MSL apprentice will likely be in a different technical area of MSL, but there's a whole lot of basic metrology knowledge and skills that will be the same..

Q. **The MSL Apprentice programme** - What has been the biggest challenge getting the Apprentice programme up and running?

A. **Lenice Evergreen** - The biggest challenge has been allocating enough time to keep the apprentice busy as well as keeping up with the regular work. We've learned that it's really important to have plenty of projects ready to go.

Q. **The MSL Kibble project update** - So when will the MSL Kibble balance be fully operational and realising NZ's kilogram standard?

A. **Yin Hsien Fung** - I think there are two parts to this question:
To enable individual realisations of the new kilogram for individual NMIs, internationally, there is still more work to do. For example, resolving the discrepancies between realisations, improving and establishing the long term stability of these realisations from around the world. To do this, there will be several international comparisons between experiments in the next decade or two before dissemination of the unit of mass by individual realisations can take place. Basically, it is a long term international effort. This leads me to the second part of the question which is about when is it going to be fully functional. In my view, maybe we can say that it is “fully” functional when we are able to take part in the international comparison, for that we need to achieve an uncertainty of at least 100 parts per billion. For the first phase of the project, we want to show that our novel unique “no cookbook recipe” Kibble balance can work and produce some sensible numbers with uncertainty of a few parts per million, that will be our first step, so we hope maybe sometime next year. But then again, since it is a metrology research project, if we take care of every component carefully enough, understand each component well enough, then we will be surprised that actually, we can get better results beyond what we had expected.

Q **Data Metrology** - What do you think the appetite is for moving to digital calibration certificates?

A. **Blair Hall** - There seems to be a pull from European industry driving this development overseas, but I am not aware of any local interest and certainly no local appetite. However, if anyone is reading this and thinking “but I would quite like a fully digital, machine readable, calibration certificate”, please get in touch. We might be able to help.

Q. **Data Metrology** - It seems that Data Metrology is a very rapidly evolving field so is MSL keeping pace with the rest of the world in terms of research?

A. **Blair Hall** - We have been publishing relevant research for more than twenty years. We have also taken the initiative to bring this topic into an international conference, which is happening next month. So, no problems with the pace of research. However, in terms of “development” (i.e., the D in R&D) there is a huge challenge. The European projects we refer to in the talk have many more staff than the whole of MSL. There are also supporting European digital-government initiatives that underpin these developments. We cannot expect to keep pace with the technological developments.

Q. **Data Metrology** - Will MSL be working with IANZ to ensure all reported CMC's follow the same format? At present it can be difficult to compare labs when some use uV/V some % and some a combination?

A. **Blair Hall** - Yes, of course. We have a close working relationship with IANZ and are ready to offer them assistance at any time. The particular problem of CMC definition and format is a big international puzzle. The MII group in the NCSLI, that I mentioned, have devoted quite a lot of energy to it, but I don't think there is a recognised solution to this issue yet. It appears that the German authorities may impose strict formats in the context of their digital projects, but I don't have any detail about that yet.

- Q. **Data Metrology** - Data Metrology is something that will be important for all NZ Cal Labs, will MSL be holding workshops and writing Technical Guides to help with this in the future?
- A. **Blair Hall** - Yes, of course. We do not yet know how international trends will affect New Zealand. The best thing local labs can do right now is train their staff up in basic measurement principles. This is the best way to prepare for change.

The MSL course "Measurement, uncertainty and calibration", is excellent for this (<https://www.measurement.govt.nz/training/measurement-uncertainty-and-calibration-workshop-2/>). I strongly recommend this course, because it explains the foundation for what will be coming soon in data metrology.