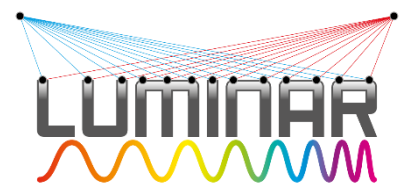


LUMINAR workshop
18-19 May 2016

Wrap-up and discussion

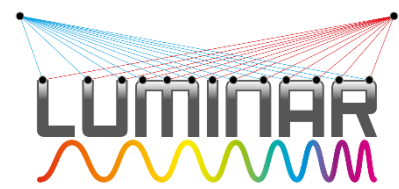
2012: challenges coming from end users



- Novel technology solutions with **cost** and **performance** between **photogrammetry & laser trackers**, ideally operating within **10 m x 10 m x 10 m** volume to **50 μm** accuracy.
 - ✓ FSI and InPlanT systems (new concepts)
 - ✓ Compensating 3D laser meter
 - ✓ Compensating telemeter
 - ✓ Digital CENTRAX, refraction network

Additional new concepts ?

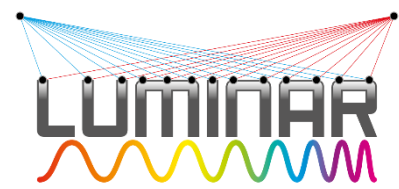
2012: challenges coming from end users



- Show how absolute distance meters (**ADMs**) can be made directly **traceable to the SI**, for example, through the use of quantum reference standards.
 - ✓ FSI HCN cell
 - ✓ Compensating 3D laser meter (iodine reference)
 - ✓ Compensating telemeter (frequency reference)

Other systems requiring traceability provision e.g. laser radar, photogrammetry.

2012: challenges coming from end users

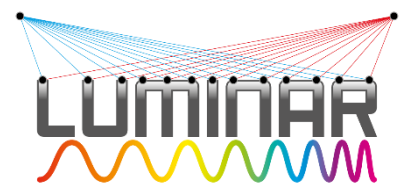


- **Reference algorithms/software** for the analysis of 3D networks of points/point cloud data that are robust, fast, verified, and provide metrologically sound outputs with rigorous **uncertainties**.

Not yet tackled.

Still valid issues.

2012: challenges coming from end users

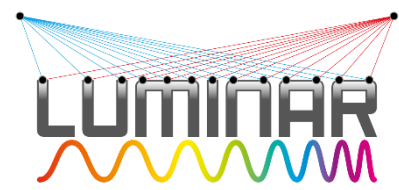


- Understand and predict the behaviour of **multi-component assemblies** in varying **industrial environments**, e.g. target of 5 m structures; 5 °C temperature deviation (temporal and spatial).
 - ✓ Hybrid model developed in LUMINAR
 - ✓ Continues in Light Controlled Factory

Additional complexity needed.

Tolerance stack up needs to be designed-in.

2012: challenges coming from end users

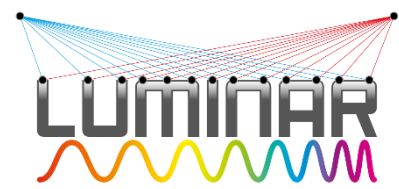


- **On-line** compensation for **refractive index effects** in ambient air in industrial environments ideally to 10^{-7} , over typical factory spatial volumes (e.g. 10 m x 10 m x 5 m).
 - ✓ Compensation in 3D laser meter
 - ✓ Compensation in telemeter
 - ✓ Refraction built into photogrammetry network
 - ✓ Digital CENTRAX and multi-spectral imaging

Simultaneous 3D over entire volume – not yet.

And high accuracy will be needed (but some systems not sensitive).

2012: challenges coming from end users

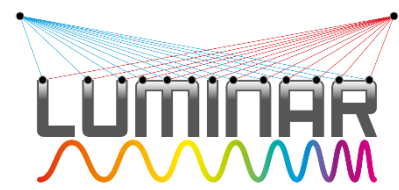


- Better understanding and methods for **performance verification** of LVM tools bringing **traceability** through rigorous uncertainty evaluation, including the use of **Virtual instruments**.

Not yet tackled.

Still valid.

2012: challenges coming from end users (2/2)

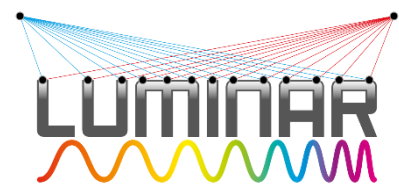


- Understand the **dynamic behaviour** of LVM tools and provide new methods/tools which can be used to improve the dynamics of time consuming processes.
 - ✓ Research work from Thomas at KIT on laser trackers

Understanding other systems needed.

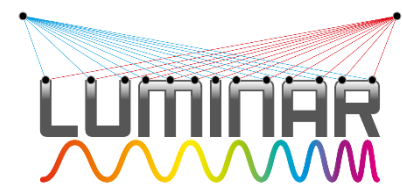
Feedback into processes & process control.

New/other challenges



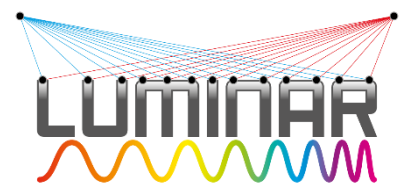
- The following slides are a capture of the discussions at the workshop.

New/other challenges



Importance of temperature distribution in measurement

- Distribution of temperature in volume important
- Develop image based i.e. optical based solutions for length metrology rather than surveying, e.g. room sized refractive index and refraction compensation
- Previous research e.g. Williams at NPL, could be re-visited
- Alternatively, refine the spectroscopic technique used in SIB60 by MIKES for shorter range
- Acoustic techniques?
- Refraction modelling and updated refractive index data and equations



New/other challenges

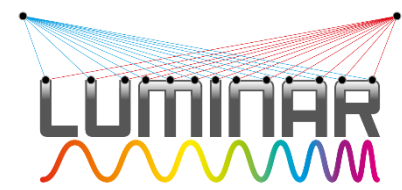
Linking & improving of networks

- Richer network adjustment with bigger redundancy
- Helps to include more instruments
- Compatibility of data between instruments (including uncertainties and covariance matrices)
- Adding of ambient information (conventional and optical environmental sensors)
- Different types of devices as parts of the network including FEA modelling

Software

- Reference software e.g. network solvers
- Virtual machines (Monte Carlo)
- Instrument position optimisation for line of sight issues

New/other challenges



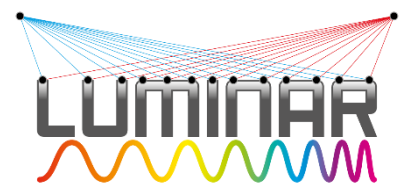
Equipment

- Many techniques relying on $n=2$ glass balls
- Difficult to obtain in small quantities
- Consolidated product ordering, alternative targets
- Switch to targetless metrology
- Laser radar not achieve critical mass unlike trackers (similar birthdays)

Expectation management of EMRP

- Extremely difficult to develop new ideas to working prototype in 3 years
- Bigger impact takes longer to achieve
- Longer projects better

New/other challenges

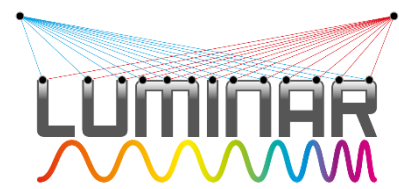


Inter-disciplinary sharing of knowledge

- Surveying, machine tool, robotics, LVM – all solving similar problems
- However, previous '1D project' showed these were difficult to combine
- Need to share solutions not issues

Targets

- Auto target finding & coping with line of sight issues
- Look again at targets in photogrammetry – passive vs emissive
- Coding: wavelength, radiation pattern, structured beams, fluorescent to give temperature at surface



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