CFARS and Other Remote Sensing Initiatives

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CFARS, 27th March 2018

De l'audace,
encore de l'audace,
toujours de l'audace
et la Patrie sera sauvée!

George Danton
Assemblée Legislative, Paris
2nd September 1792

introduction

- Other initiatives include:
  - Normative
    - IEC 61400-12-1:2017
    - IEC 61400-50-2
    - IEC 61400-50-3
  - Informative
    - IEA Wind Task 32
    - Carbon Trust OWA Recommended Practices
- Challenges include:
  - Objective acceptance criteria based on evidence
  - Description of circumstances in which demonstrated performance is considered transferable (complex terrain issue)
  - Broader context (digital convergence)

IEC

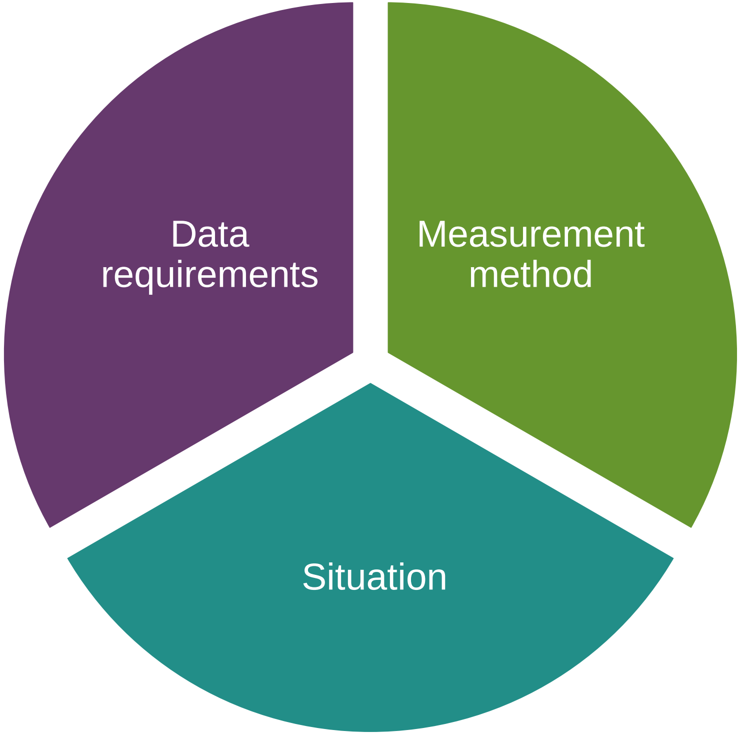
- Other initiatives include:
  - Normative
    - IEC 61400-12-1:2017
      - Limited to simple terrain
      - Describes calibration procedures but not acceptance criteria
    - IEC 61400-50-2
      - Content of Annex L in a separate standard due to re-organisation of IEC 61400-12 series of standards with use case elements separated for easier maintenance (e.g. measurement methods in 50-1/2/3, evaluations that fulfil data requirements remaining in 12-1
    - IEC 61400-50-3
      - New standard covering nacelle mounted lidar

use cases

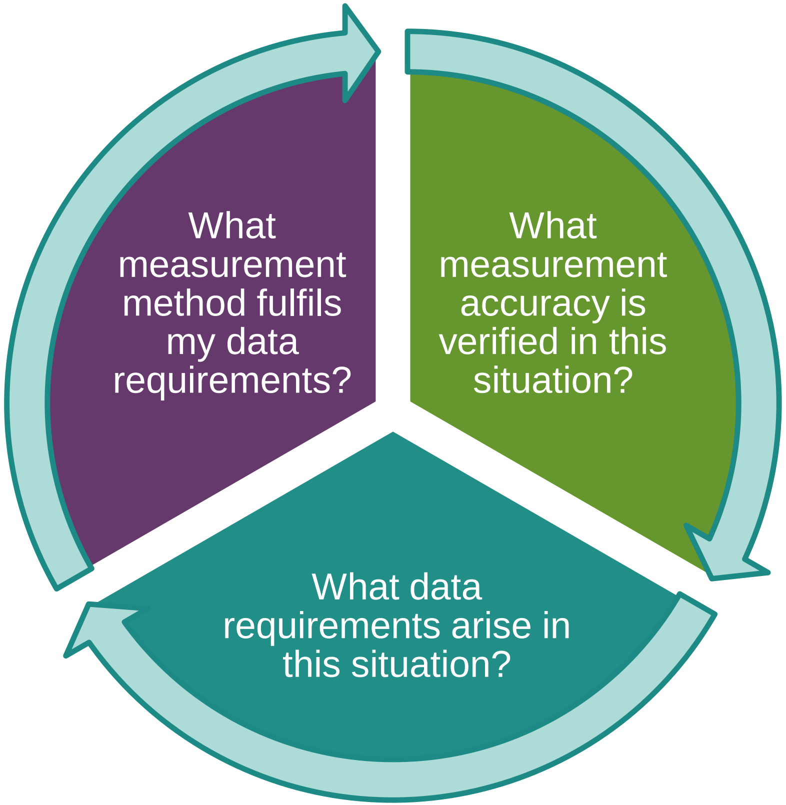
- The IEA Wind Energy Task 32 has adopted a "use case" framework for describing the application of lidar in wind energy assessments to ensure well-documented measurement techniques applied in a manner that is fit-for-purpose with the degree of consistency required for investor confidence.

- A use case considers three things:
  - **Data requirements**: articulated without reference to the capabilities of the possible methods that are available to fulfil them.
  - **Measurement method**: there are multiple options available whose suitability depends upon the data requirements that are being fulfilled.
  - **Situation**: the performance of a particular method may depend upon the circumstances in which it is deployed.

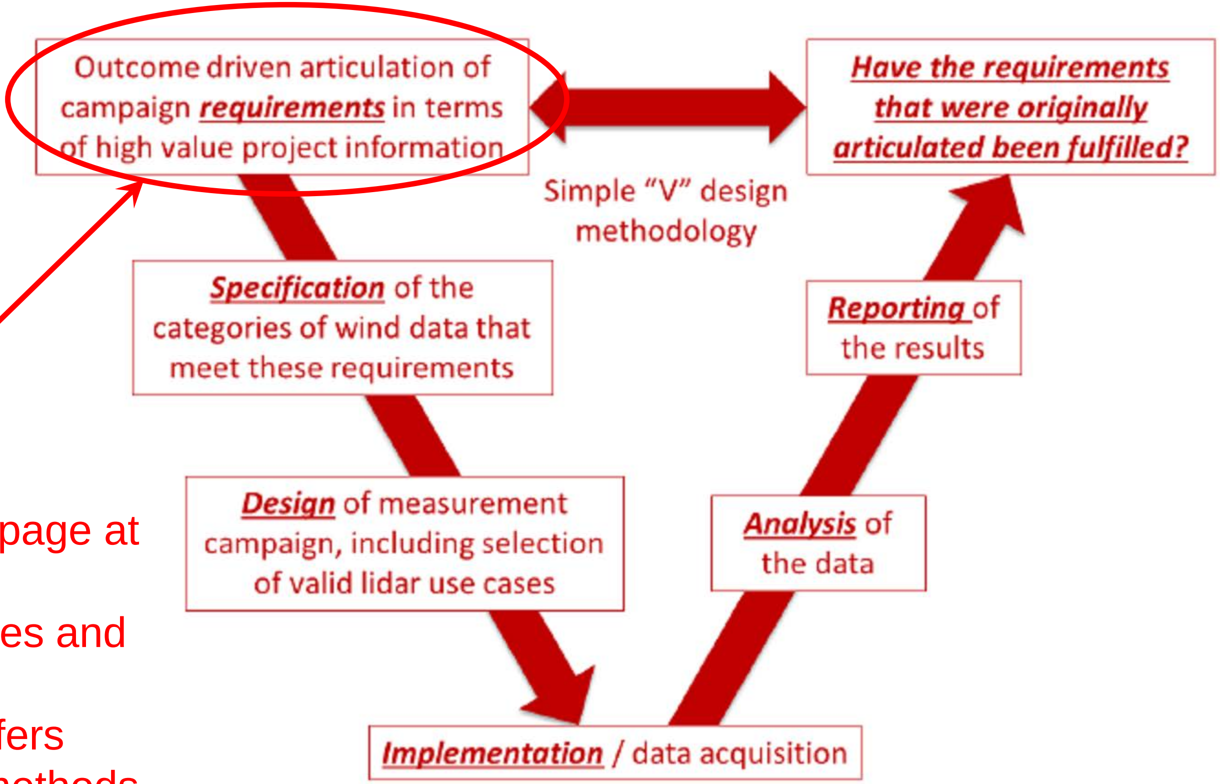
use cases



use cases


What measurement method fulfils my data requirements?
What measurement accuracy is verified in this situation?
What data requirements arise in this situation?

measurement and analysis campaign design



- Get everyone on same page at earliest opportunity
- Only possible if objectives and methods are clear
- Understand what RS offers compared to previous methods

3rd generation measurements

- **1st generation: *extrapolation***
  - Mast mounted sensors and remote sensing vertical profilers
  - Direct, intuitively understandable data, e.g. wind speeds and directions, are acquired at a point in space, or representing conditions at a specific location
  - These are then extrapolated using various modelling techniques to represent a larger area, incurring significant uncertainties

3rd generation measurements

- **2nd generation: *inference***
  - Scanning lidars implementing use cases that entail PPI, RHI and compound scan geometry measurement methods to conduct wake studies, complex flow studies, etc.
  - Inference of wind conditions from data acquired in multiple locations throughout the area of interest using scanning devices
  - Data not intuitively understandable, e.g. measurements radial velocity vector components relative to the location of the scanning device, but requires expert knowledge and interpretation
  - Trade-off required between time- and space- resolution: a scan geometry providing grater details in space takes a longer period of time to iterate

3rd generation measurements

- **3rd generation: *direct observation***
  - Wind parameters of interest are all directly observed within the entire domain of interest
  - Measurement is intuitive: all that is required to interpret the measurement is knowledge of its purpose rather than instrument-specific expertise.
  - Direct observation of measurements in all locations of interest analogous to measurements obtained at a single location by 1st generation devices
  - Example: multiple synchronised lidars fulfil at least some of the requirements of a 3rd generation system
  - No trade-off between time- and space-resolution: direct measurements obtained instantaneously in all locations.

challenges

- Evidence base
  - Articulate acceptance criteria for a specific use case in relation to the evidence base for that use case and IEA use case validity criteria
  - Objective evidence based evaluation of TRL (Technology Readiness Level) of RSD system with respect to a use case replaces subjective guidance associated with the Stage 2 to Stage 3 transition
  - Define evidence base criteria, e.g. a specific number of validated campaigns with a variety of means of validation
  - Individual units should also be calibrated / validated in accordance with existing procedures for each use case in which they are deployed
  - Acceptance of a specific project data set relies on conformance to the grounds on which the system, unit and use case are valid and verified
  - C.f. IEC PT 61400-50-3 Zero Classification discussions

challenges

- Terrain complexity
  - The relationship between the measurement situation, as required by the use case, and the measurement method, in terms of the performance under those circumstances, should be transferable from the calibration site at which it has been established to the project site
  - The basis for this transferability requires the terrain to be equivalent in all respects that influence performance
  - Terrain complexity is not currently assessed in a manner conducive to establishing equivalence between sites
  - There is an urgent need for a working group to settle the problem of characterising terrain complexity in an objectively useful and quantitative manner.

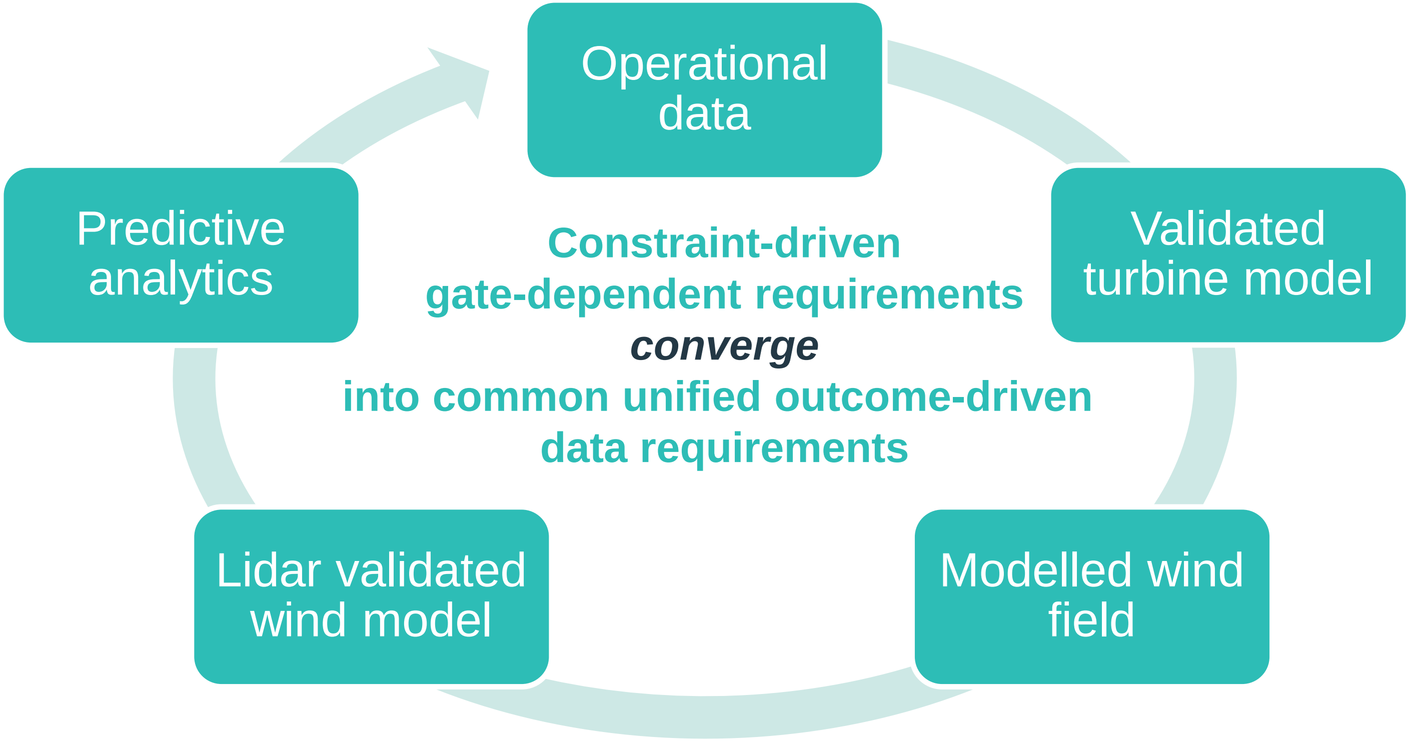
challenges

- Calibration and testing
  - The uncertainty arising due to calibration is dominated by the uncertainty associated with the reference instrument.
  - We should consider new testing techniques, e.g.
    - Separation of intermediate values based on primary measurement and final values based on Wind Field Reconstruction (WFR)
    - Multiple references, to isolate contribution from individual sources of error
  - Uncertainty budgets are inherently incomplete because there is no way to ensure all relevant influences on measurement outcomes are considered. Must distinguish between
    - Absolute likelihood of an outcome
    - Extent to which an outcome is expected on the basis of our current knowledge
  - This should motivate us to improve our understanding of fundamental measurement processes

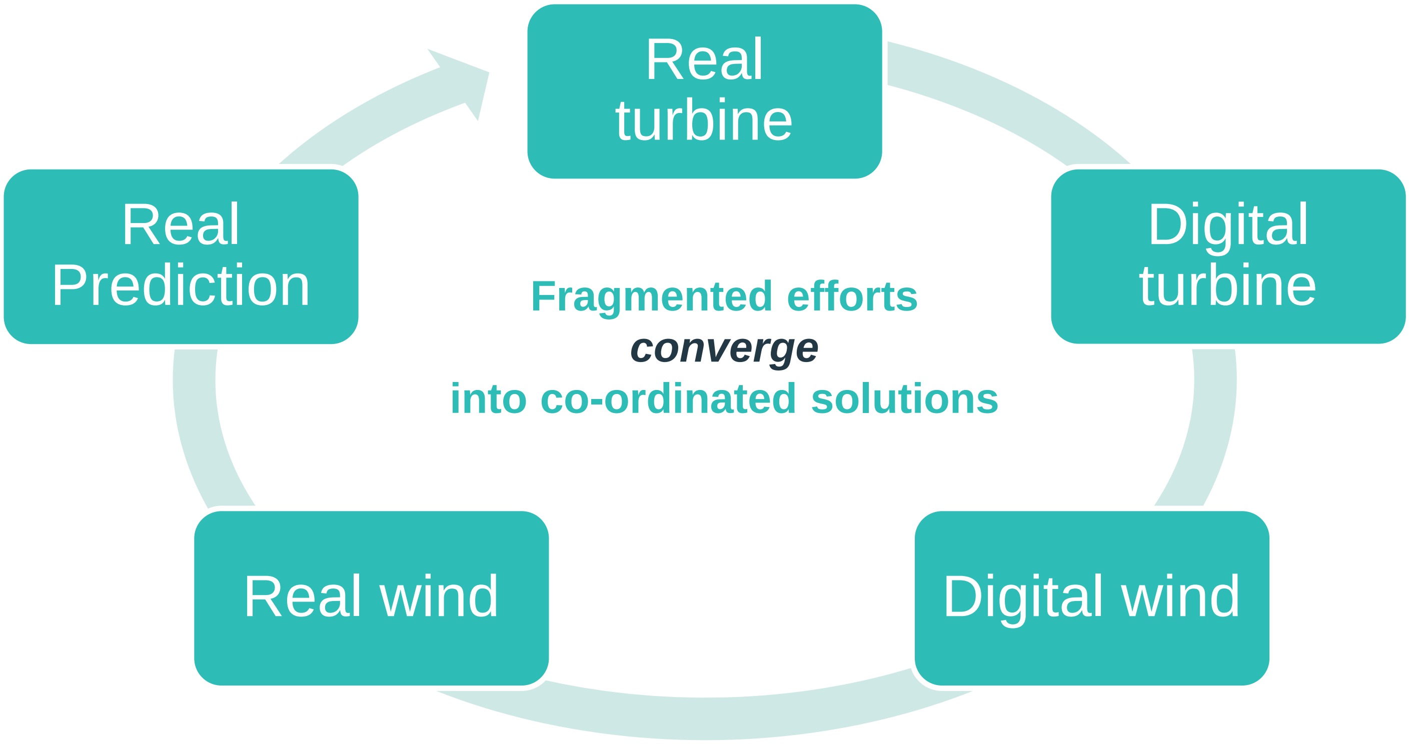
challenges

- Transformative impact on wider practice
  - The capabilities of remote sensing make available datasets that are richer than was previously the case, e.g.
    - Model validations, wind shear extrapolation etc. all benefits
    - A number of approximations, heuristics and rules of thumb are well past their use-by date
  - It is becoming possible to “close the loop” in wind energy procedures and achieve “digital convergence” on common data requirements and shared understanding of the fundamental processes
  - We remain aligned to these developments if we adopt an outcome-driven rather than constraint-driven approach, e.g.
    - Understanding and reducing the *real* uncertainties,
    - Remaining focussed on what is correct rather than merely convenient
  - Common understanding allows earlier planning with everyone on the same page

the digital convergence opportunity



the digital convergence opportunity



the digital convergence opportunity