

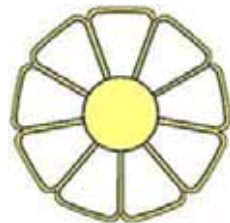
Blade-Integrated Overspeed Protection for Small Wind Turbines

Lawrence D. Staudt

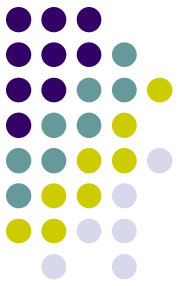
Niall M. McMahon

Centre for Renewable Energy at
Dundalk Institute of Technology (CREDIT)

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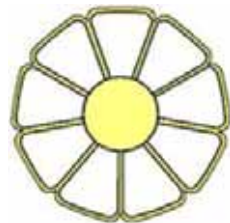


Wind Turbine Overspeed Limitation



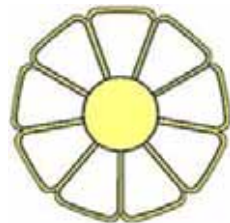
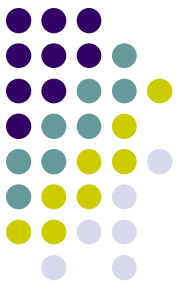
- “Small” wind turbines typically have fixed pitch for cost and simplicity reasons
- Rotor-based overspeed control is desirable
- How to implement without variable pitch?
- Done in the 1980s when companies such as LM and Alternegy offered standard lines of wind turbine blades with integral overspeed control
- Will this market re-appear?

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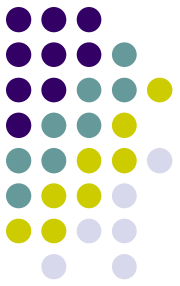


Wind Turbine Overspeed Limitation

- Flip tips
- Tip brakes
- Furling tails
- Ailerons
- ...



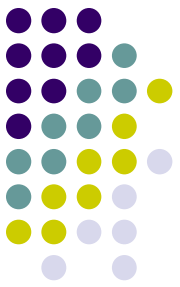
Wind Turbine Overspeed Limitation



- How about deforming the leading edge of the blade to limit overspeed?
- Possible with advances in materials
- Potentially low cost, simple, reliable
- Our research attempts to:
 - Determine what deformations might work
 - Show what deformations actually work
 - Implement a solution

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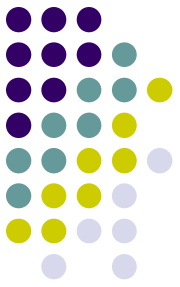
Leading-Edge Deformation

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We have:

- Found that a great deal of work has been done on deformed leading edges
 - Mostly in the aerospace industry, but also in the wind industry (e.g. ice studies, insect studies)
 - Deformation generally viewed as undesirable
- Discovered that leading edge deformation can in practice be used to limit wind turbine rpm
- Patented this concept

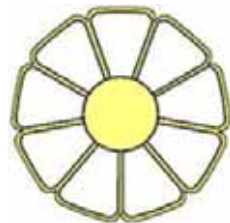




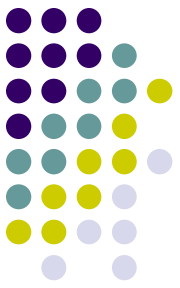
Leading-Edge Deformation

- Theoretical and practical approach
- Literature review
- Design based on evolving theory (XFOIL, JavaFoil, FlowWorks, OpenFOAM, etc.)
- Experimented with various leading-edge shapes

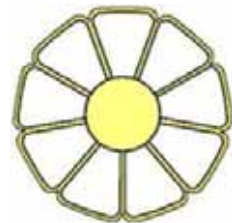
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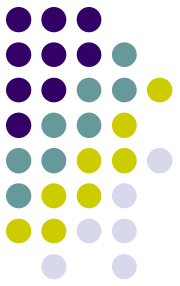


Leading-Edge Deformation



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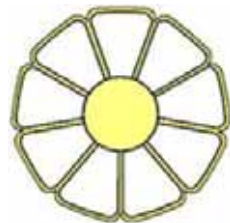




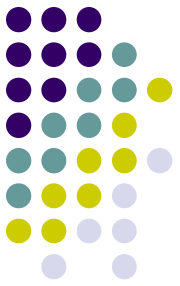
Leading-Edge Deformation

- We tested the undeformed airfoil in the runaway condition (carefully!)
- Subsequent deformed airfoils were compared with this and with theoretical predictions

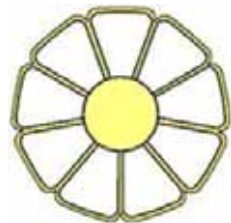
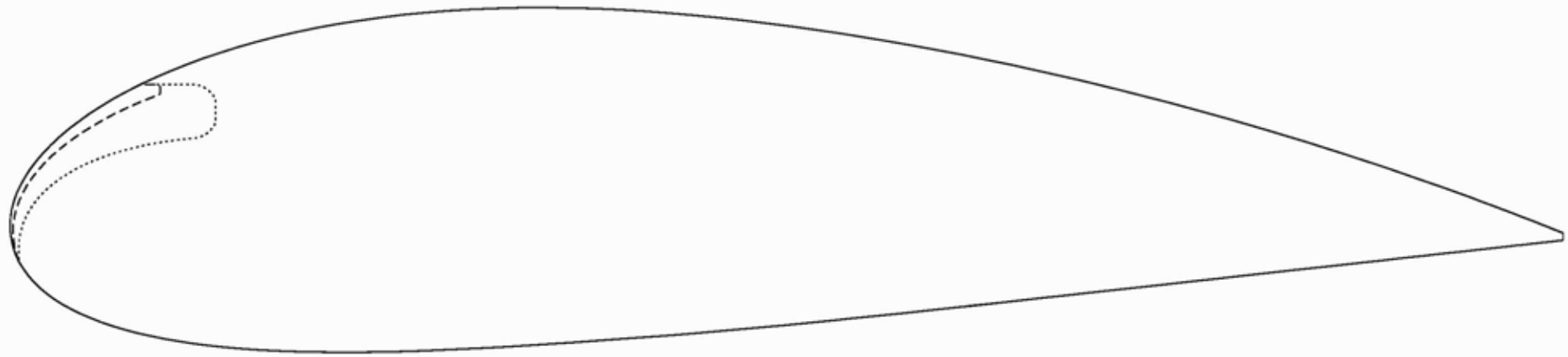
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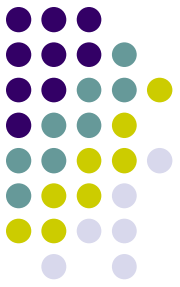
Leading-Edge Deformation



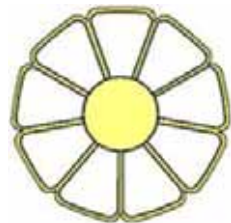
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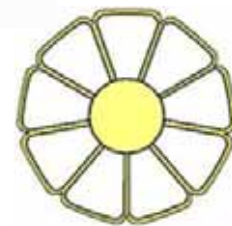
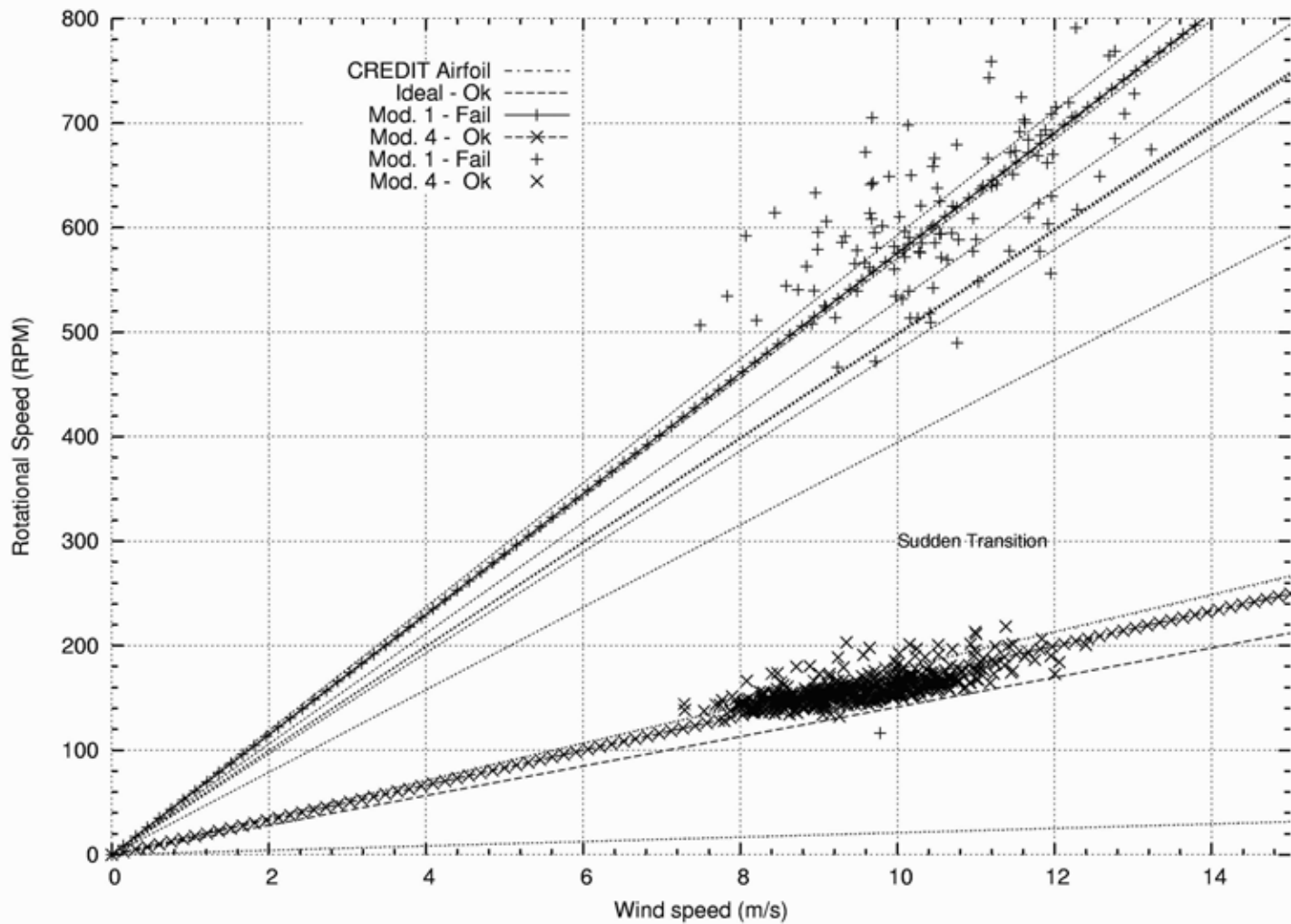


Sample Results



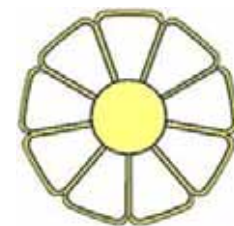
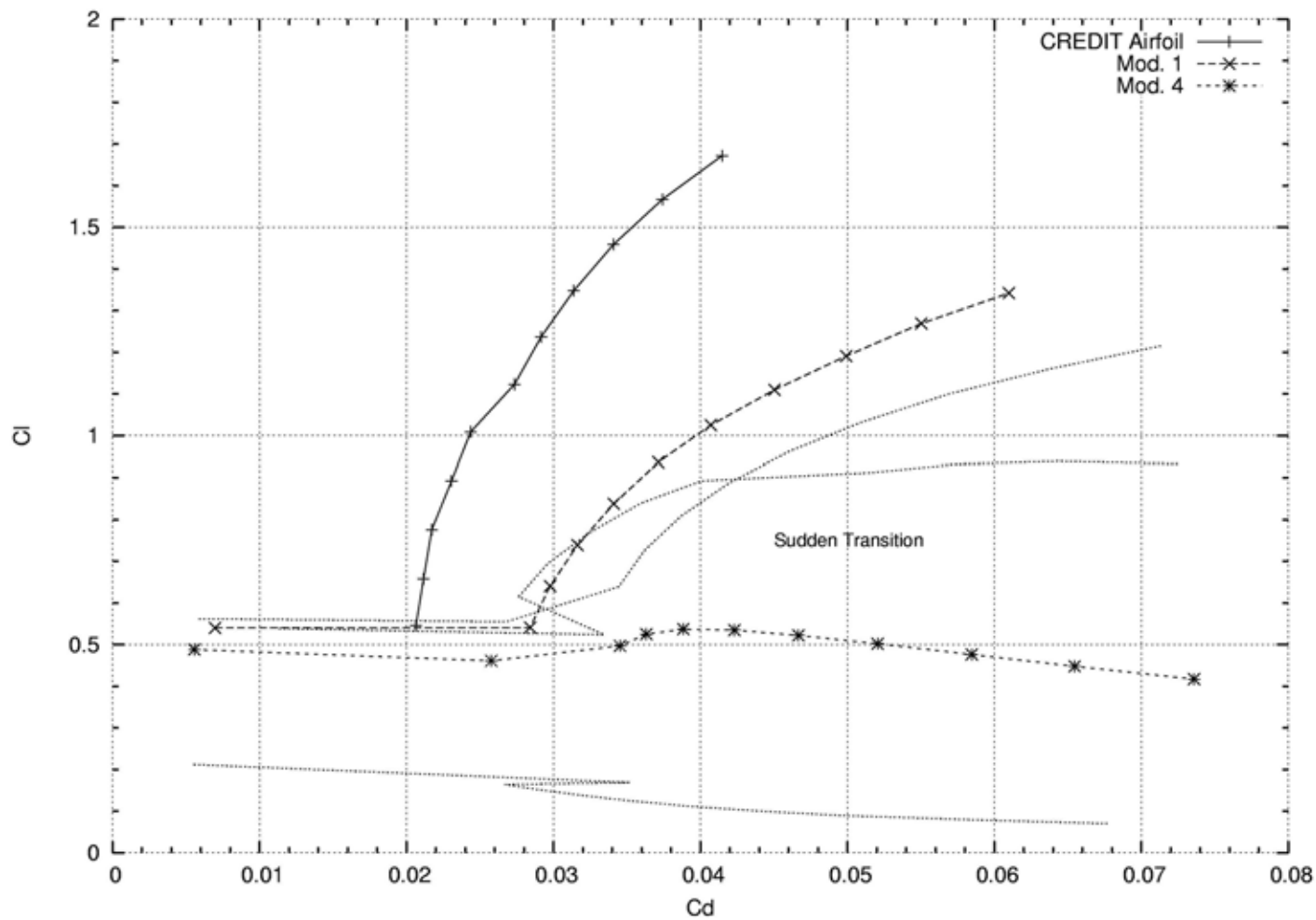
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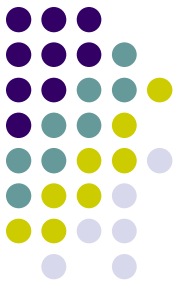


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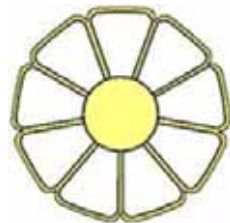


Sample Results

- Very little middle ground in the results i.e. a given profile does or doesn't work
- Sharp protrusions useful in initiating separation
- Protrusion needs to be fully exposed to incoming flow

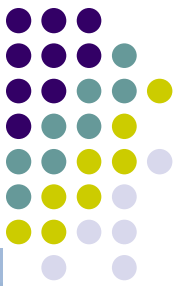


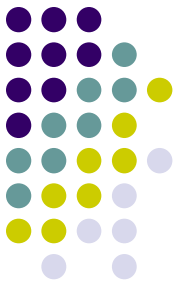
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Further Work

- We have designed and built a 4m wind turbine for testing production prototypes of the LET concept
- We continue to validate models to allow rapid design adaptation to all airfoils
- It appears the concept is scalable to up to ~20m rotors





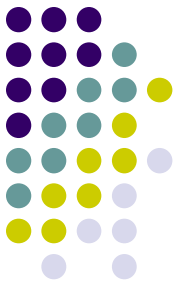
Conclusions

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- Using leading edge deformation appears a valid way of providing rotor-based limitation of rotor speed on fixed pitch wind turbines
- We continue to develop the theory and practice of this concept
- We plan to make this technology available to interested parties



Thank You! Any Questions?



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