

Applications of Concurrent Engineering (CE) in Wind Turbine Design

**John Leahey
Composite Design Engineer
Vestas Turbines R&D**

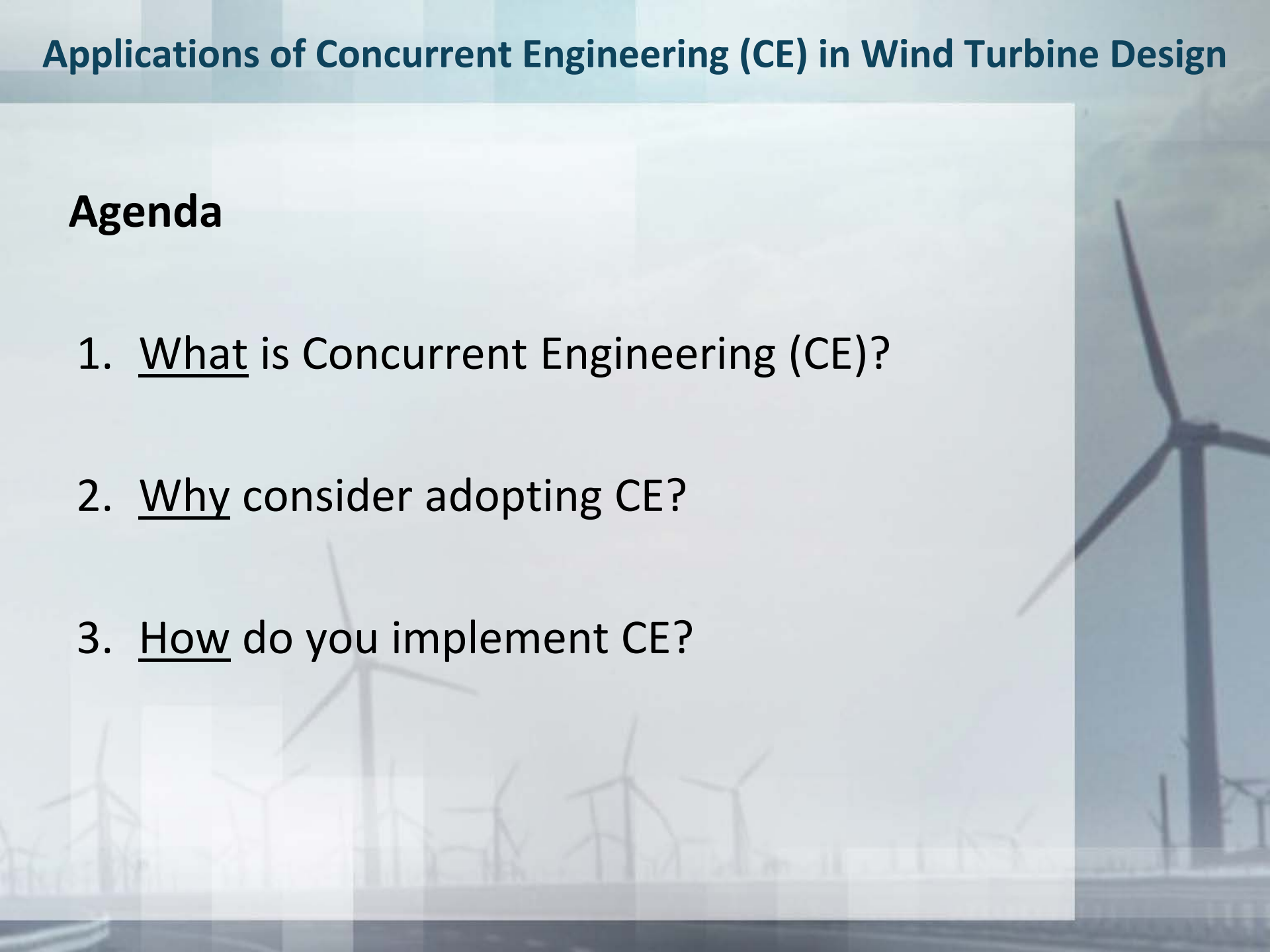
Leahey.John@gmail.com



Applications of Concurrent Engineering (CE) in Wind Turbine Design

Agenda

1. What is Concurrent Engineering (CE)?
2. Why consider adopting CE?
3. How do you implement CE?

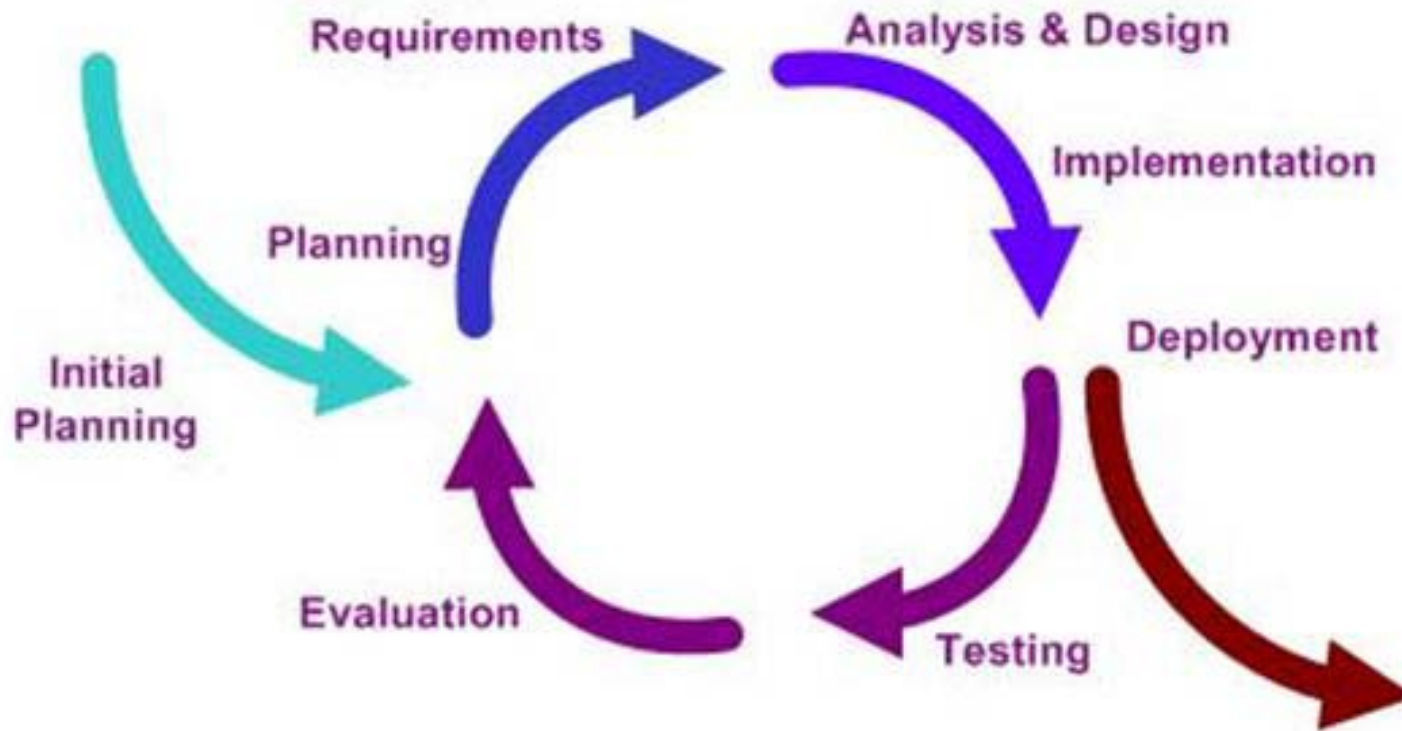


A background image showing a field of wind turbines under a cloudy sky. The turbines are dark in color, and the sky is a mix of light and dark clouds. The overall tone is somewhat muted and atmospheric.

What is CE?

What is CE – Holistic Design Process

Concurrent Engineering: The integrated design of products and processes, including manufacture and support.



What is CE – Holistic Design Process

Concurrent Engineering: The integrated design of products and processes, including manufacture and support.

Historical Examples → Naturally Concurrent

- Small, integrated teams
- Broadly experienced leadership



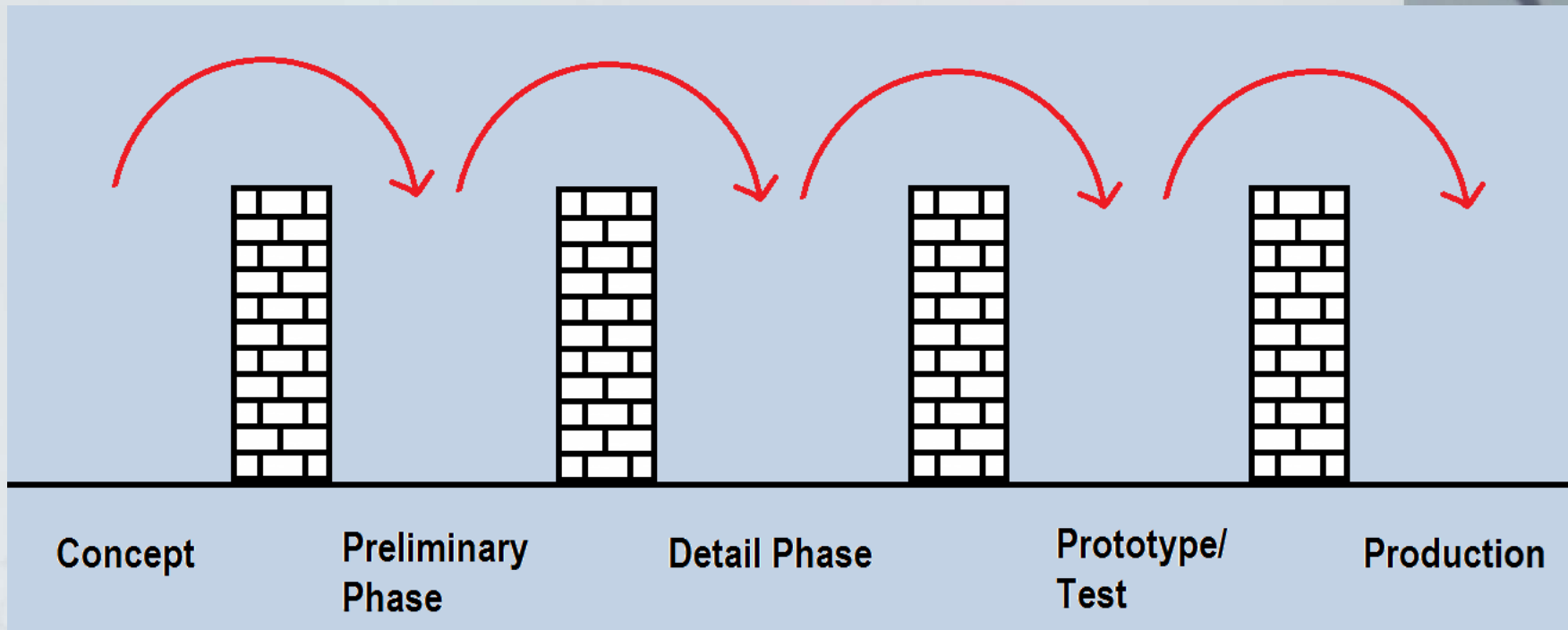
CE versus Typical Methods

“Over-the-wall” Engineering

- Sequential Engineering (SE), Serial Design, Waterfall Engineering

Why Sequential Engineering?

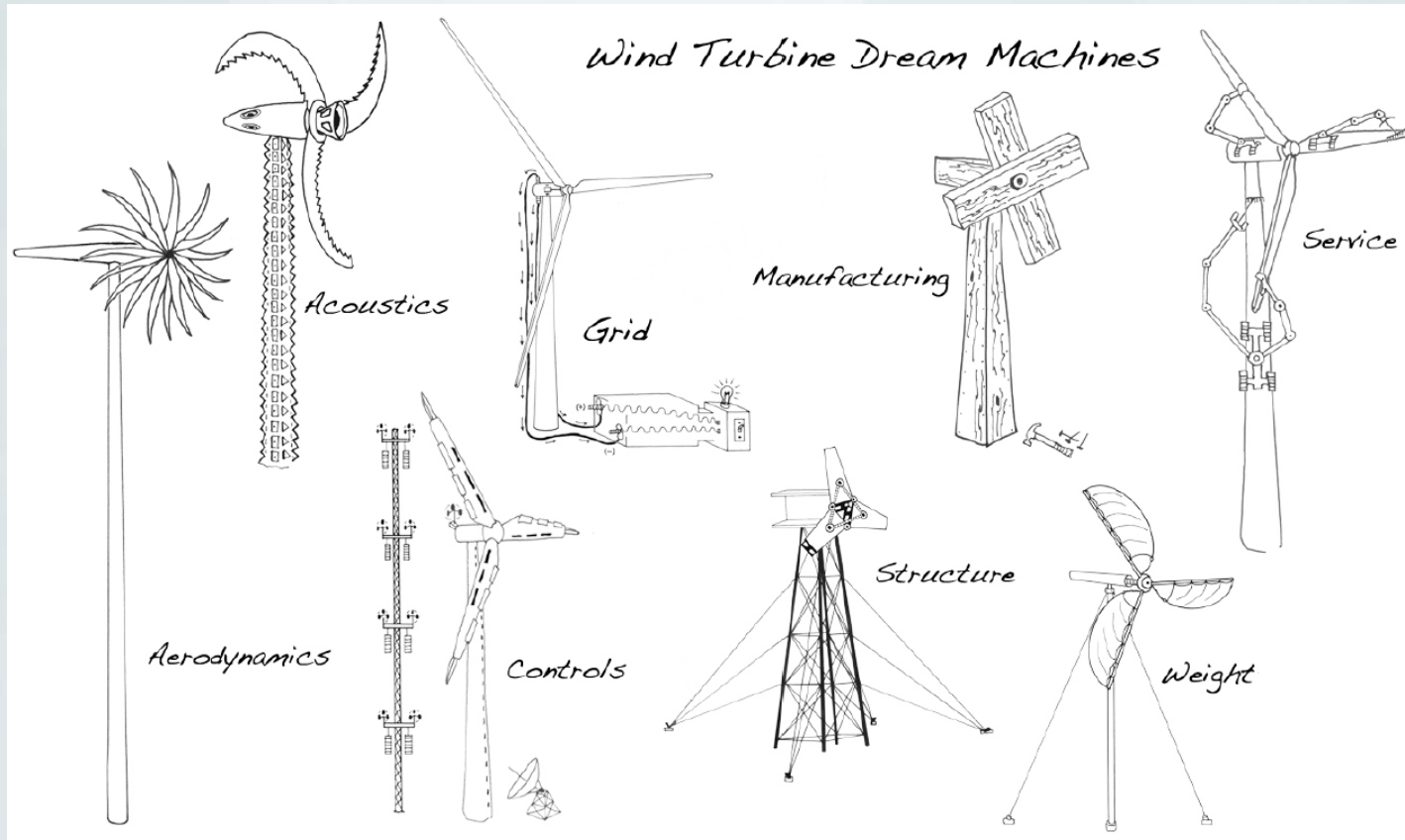
- Dispersed Supply Chain → Drift to SE methods in Post WWII era



CE versus Systems Engineering & MDAO?

Systems Engineering – Can be Serial or Concurrent

- Can “fall down” at sub-assembly or component design



MDAO (Multi-Disciplinary Analysis & Optimization) – CE Subset

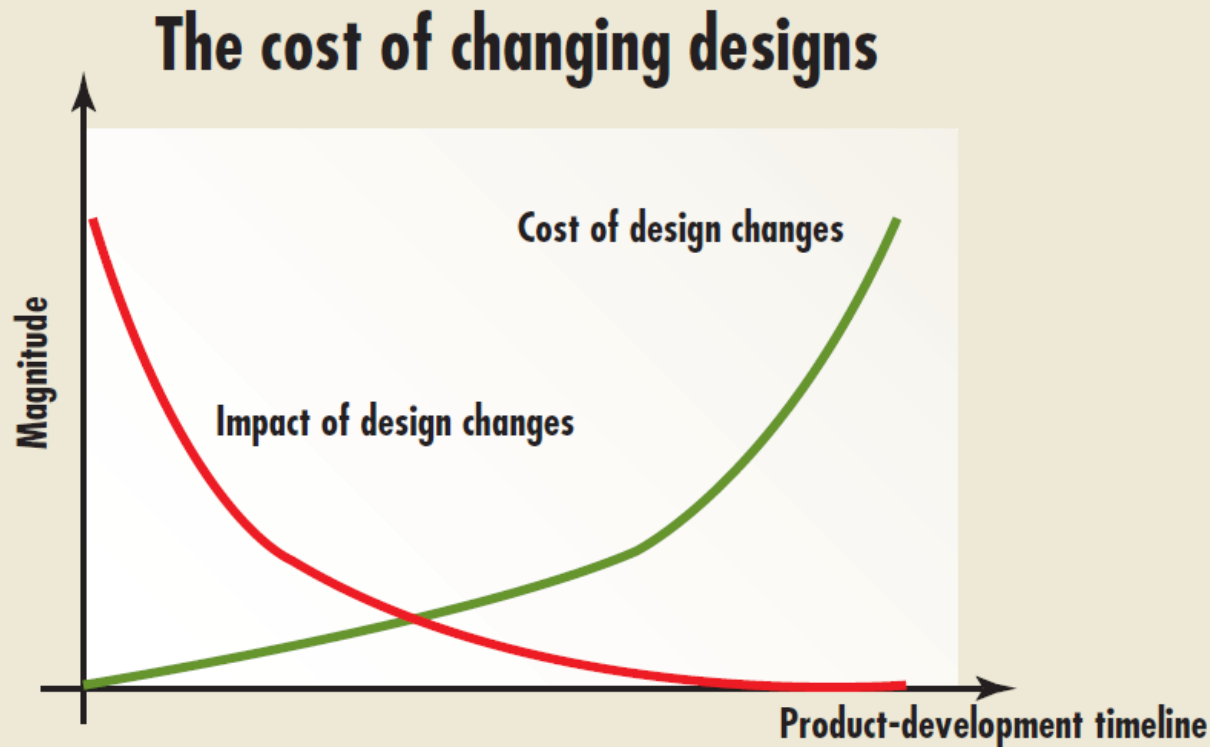
- Stitches together multi-disciplinary tools
- What about people?

A background image showing a field of wind turbines under a cloudy sky. The turbines are silhouetted against the light sky, and the overall scene is slightly hazy. The text "Why consider CE?" is overlaid on the left side of the image.

Why consider CE?

Why CE – Costs Committed Before Design Understood

Sequential Engineering Problems



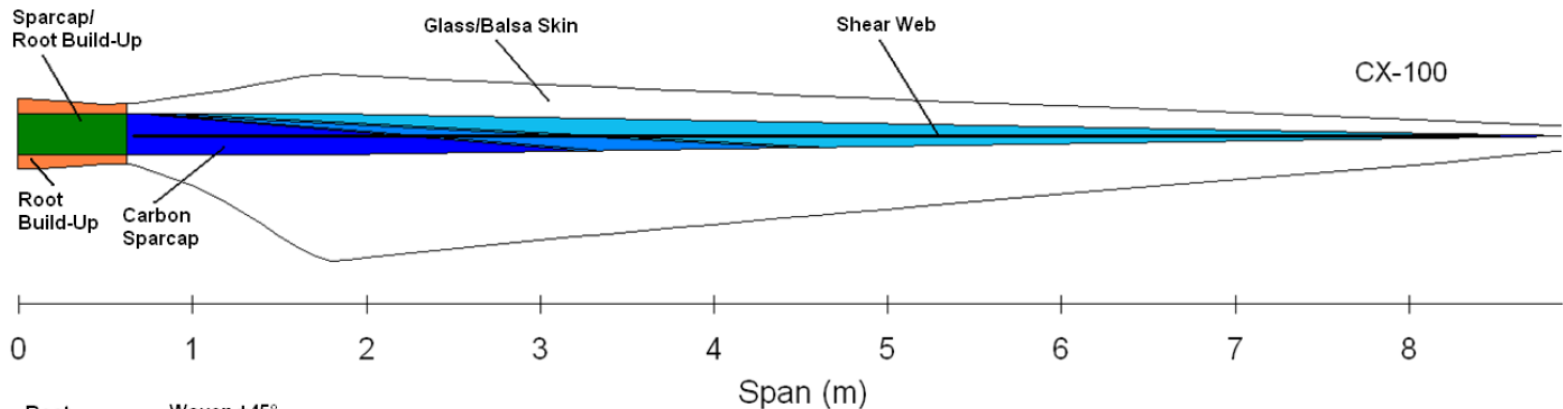
Most design costs are committed during preliminary design, even though little is typically known about a design at this stage, according to a study by Boeing during the 1960s. As design moves from concept towards production, redesign costs skyrocket while flexibility plummets.

Why CE – BSDS Blade Example

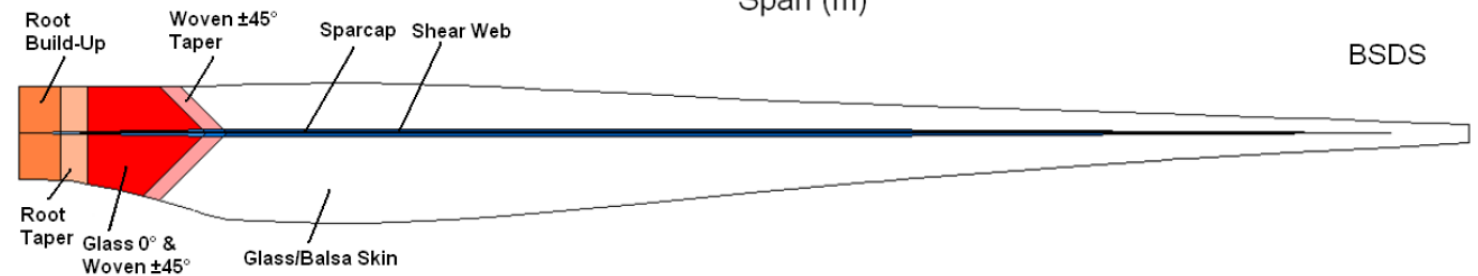
BSDS – NREL/Sandia Blade System Design Study

- http://energy.sandia.gov/?page_id=3057#BSDS

CX-100 Sequential Design



BSDS Concurrent Design

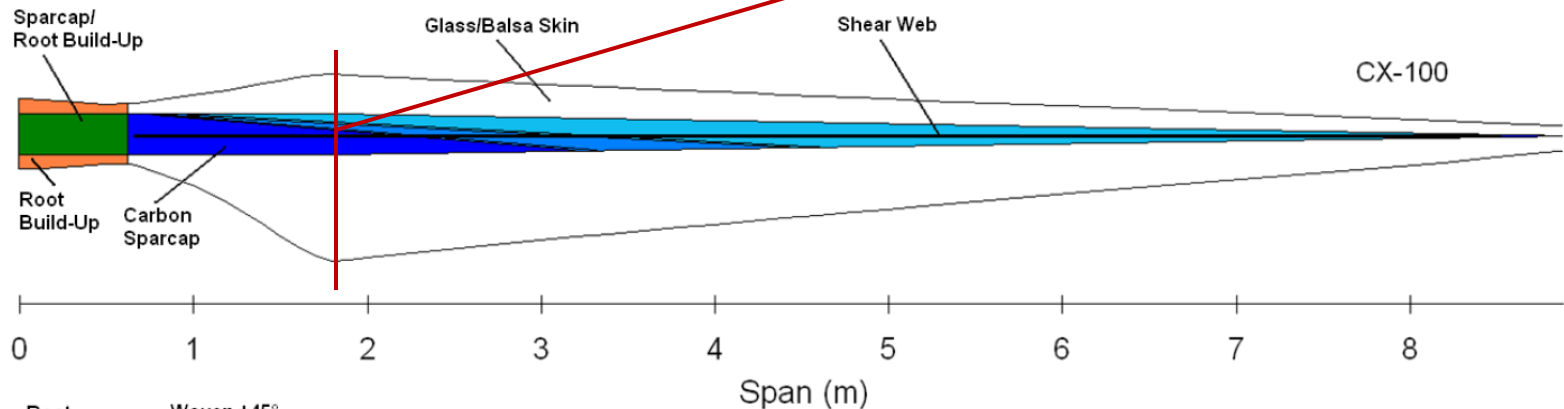


Why CE – BSDS Blade Example

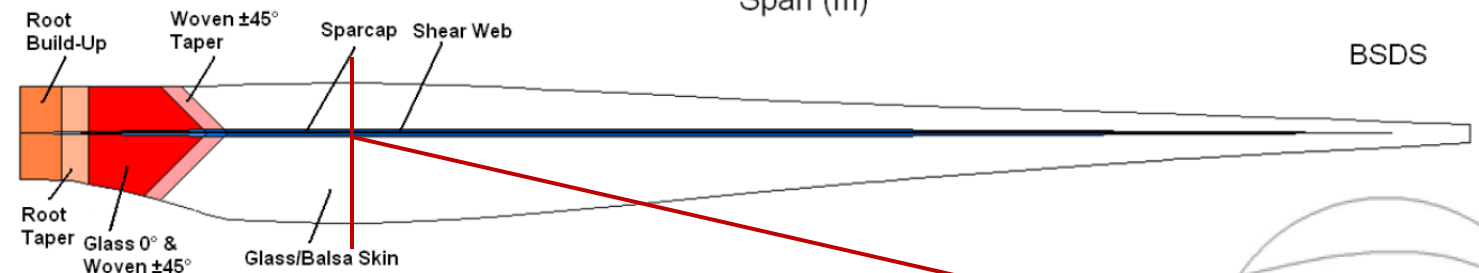
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CX-100 Sequential Design

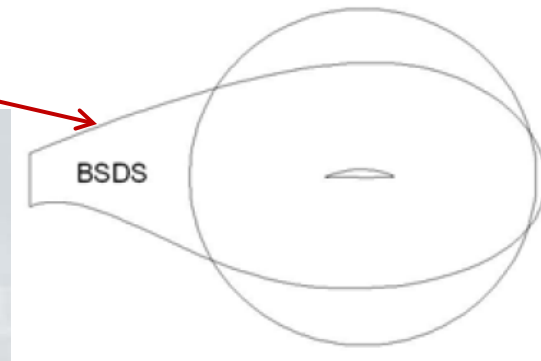


BSDS Concurrent Design



Concurrent Design Result

- Balancing Aero/Structure/Manufacturing yields
 - Aerodynamically and Structurally efficient Flat Back airfoil
 - Manufacturing friendly constant thickness sparcap

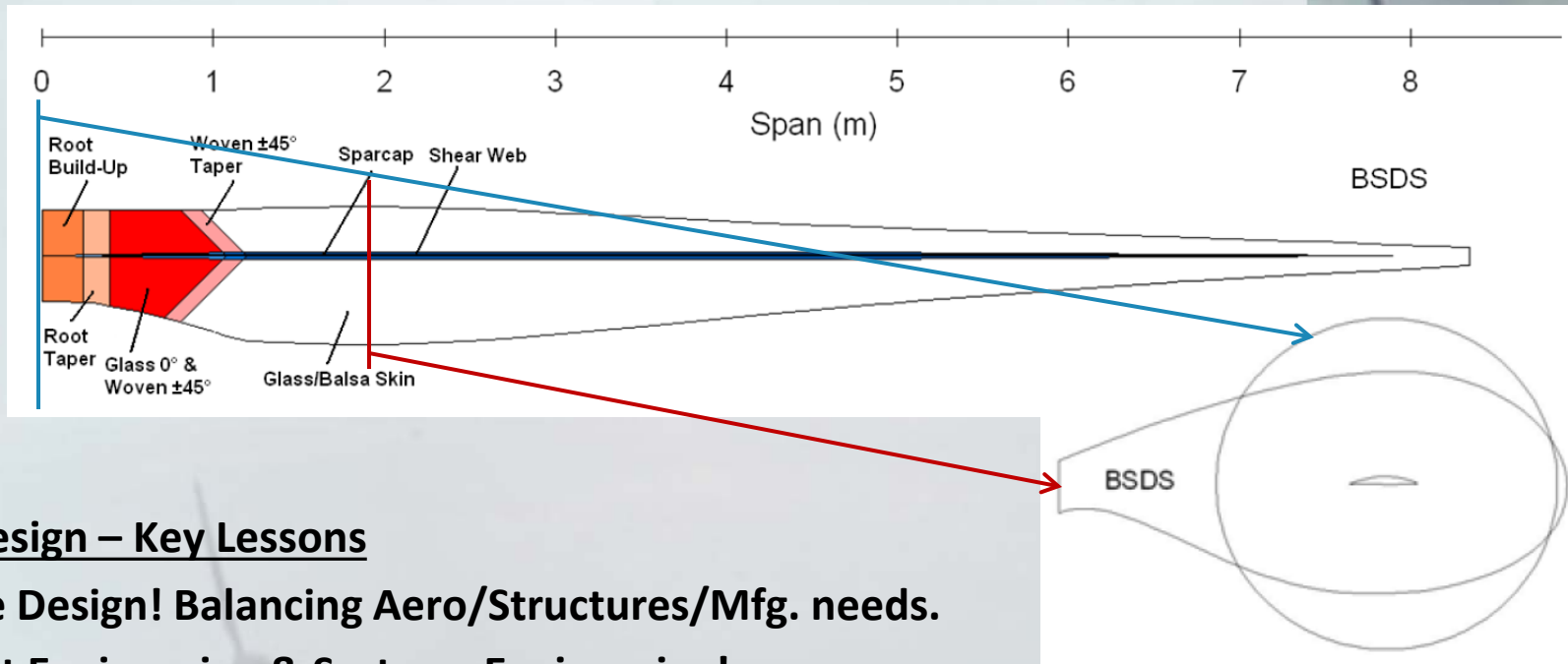


Why CE – BSDS Blade Lessons

BSDS – NREL/Sandia Blade System Design Study

- http://energy.sandia.gov/?page_id=3057#BSDS

BSDS Concurrent Design



Concurrent Design – Key Lessons

- Innovative Design! Balancing Aero/Structures/Mfg. needs.
- Concurrent Engineering & Systems Engineering!
 - Blade Root Diameter Increase
- Importance of Research (Internal, Academic, National Labs, etc.)!
 - Availability of Flat Back Airfoil

A background image showing a field of wind turbines under a cloudy sky. The turbines are dark in color, and the sky is a mix of light and dark clouds. The image is slightly blurred, giving it a soft, atmospheric feel.

How to deploy CE?

How deploy CE – Lessons from Success



- **Collaborate!**
 - Organizational Paradigm Shift
- **Communicate**
 - Collocated, Cross-Functional Teams
- **Cross Train Silos**
 - Broadly experienced leadership

How deploy CE – Collaborate

- **Paradigm Shift – Allocate more time for conceptual design**
 - Typical Program Management wants to speed past early design phases
 - Crucial Stage for Concurrent Engineering!
- **Cooperate, don't Compete!**
 - Silos leads to “hoarding” margin



How deploy CE – Communicate

- **Q: What do these have in common?**



How deploy CE – Communicate

- **Q: What do these have in common?**
- **A: Complex Multi-disciplinary Design**



How deploy CE – Communicate

- Q: What do these have in common?
- A: Complex Multi-disciplinary Design
- Cross-Pollinate: Design Charrette



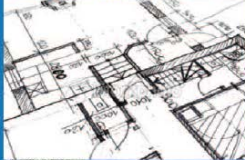
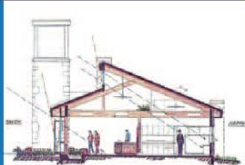
National Renewable Energy Laboratory
Innovation for Our Energy Future

A Handbook for Planning and Conducting Charrettes for High-Performance Projects

Second Edition

Gail Lindsey • Design Harmony, Inc.
Joel Ann Todd • Environmental Consultant
Sheila J. Hayter • National Renewable Energy Laboratory
Peter G. Ellis • National Renewable Energy Laboratory

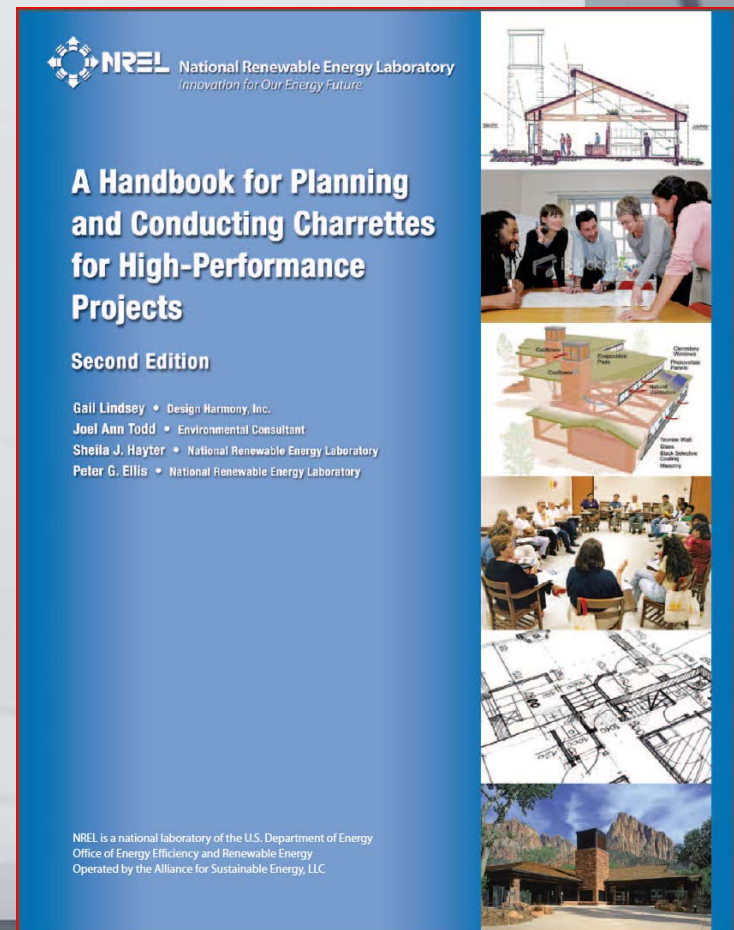
NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC



How deploy CE – Communicate

Design Charrette – Communication & Collaboration Strategy

- **Focused, multi-day workshop with collaborative approach to create realistic, achievable designs**
 - Develop early consensus about project priorities
 - Create project vision & design goals
 - Initiate an integrated design process
 - Form a strong, inclusive project team
 - Agree on project schedule and budget



<http://www.nrel.gov/docs/fy09osti/44051.pdf>

How deploy CE – Communicate

- **Collocate if possible**



How deploy CE – Communicate

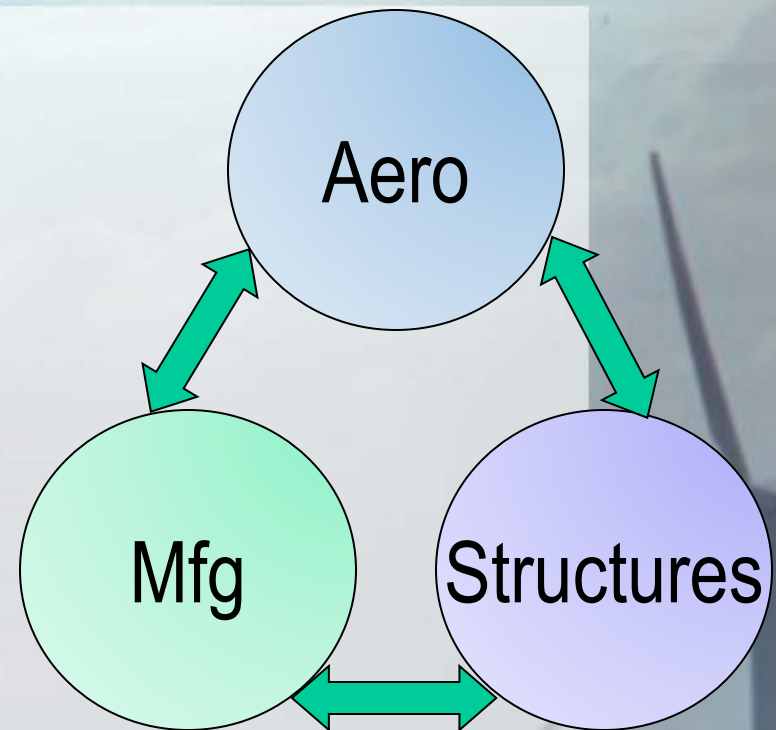
- **Collocate if possible**



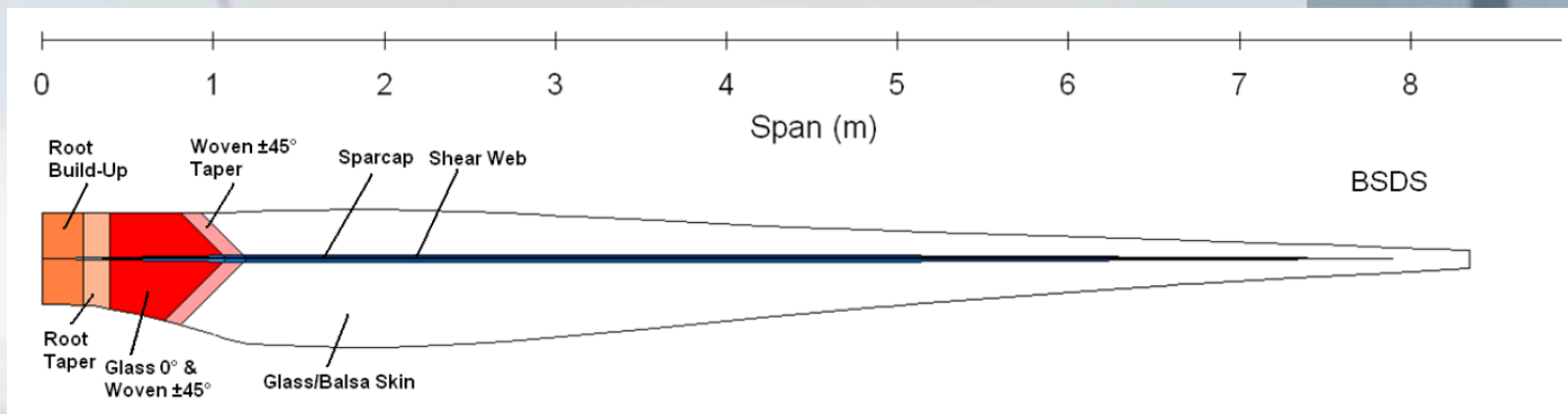
- **Leverage IT – “Virtual” Collocation**
 - VOIP, Videoconference, Skype, etc.

How deploy CE – Cross Train “Silos”

- **Historical Examples**
 - Broadly experienced leadership
- **Learn about other “Silos”**
 - Understand each others pain
- **Benefits of Cross-Training**
 - Improves Collective Intuition!

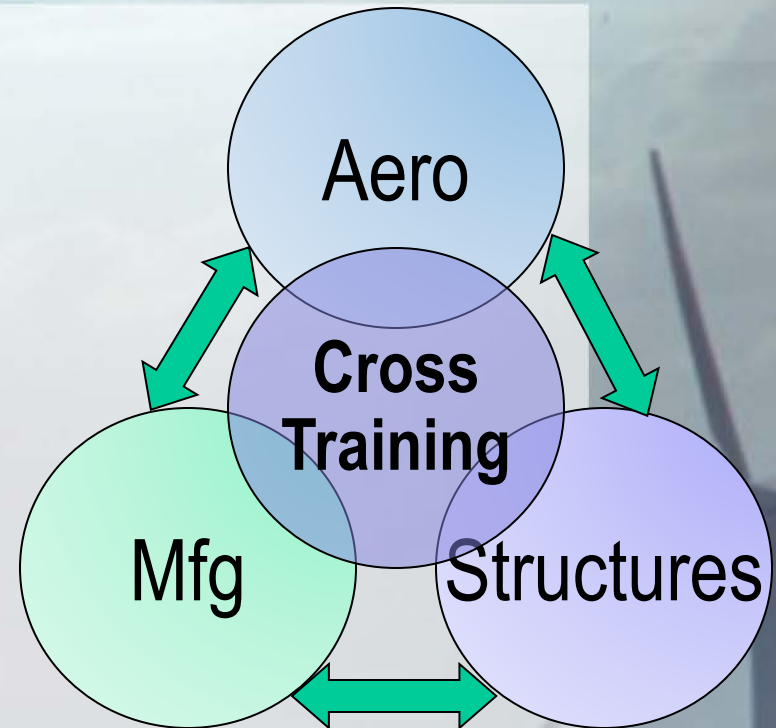


BSDS
Concurrent
Design

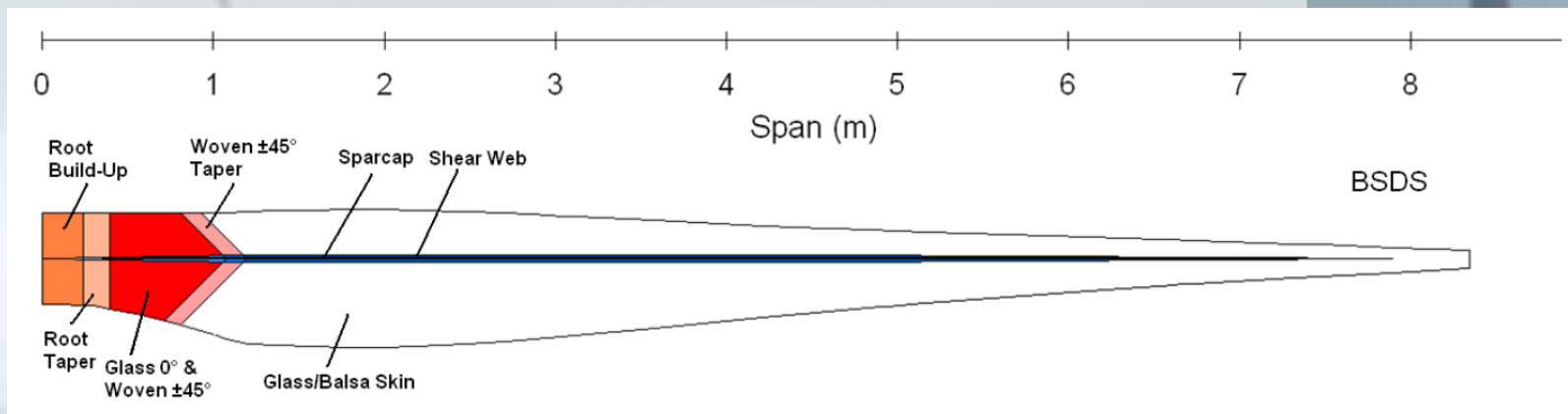


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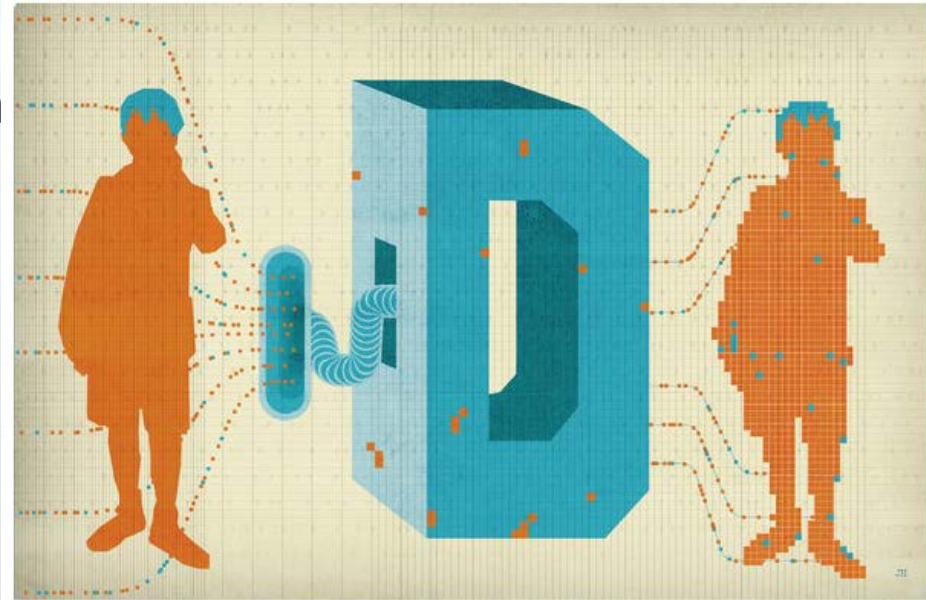
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Sure, Big Data Is Great. But So Is Intuition.



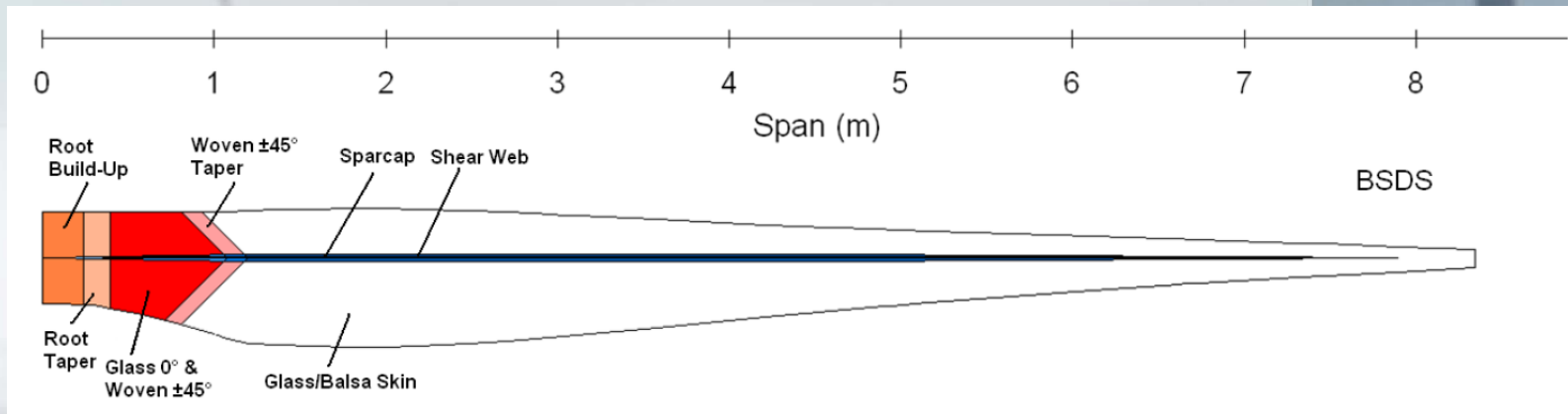
The New York Times

By STEVE LOHR

Published: December 29, 2012

John Hersey

BSDS
Concurrent
Design



How deploy CE – Resources

- **NREL/Sandia BSDS**
 - http://energy.sandia.gov/?page_id=3057#BSDS
- **Concurrent Engineering Links**
 - **CE Journal**
 - <http://cer.sagepub.com/>
 - **Integrated Concurrent Engineering (ICE)**
 - <http://web.mit.edu/~tcoffee/www/docs/lai-cet-rsp-ICEToolsStudy-tcoffee-8a.pdf>
 - **CE Deployment Strategies**
 - <http://www.revistaproducao.net/arquivos/websites/32/v06n2a02.pdf>

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Thank You!

John Leahey
Composite Design Engineer
Vestas Turbines R&D

Leahey.John@gmail.com