



**RDECOM**



**Presented at**  
**8<sup>th</sup> STAR Meeting**  
**Braunschweig, Germany**  
**Sep. 10-11, 2012**

## ***High Advance Ratio***



*Approved for public release; distribution unlimited.  
Review completed by the AMRDEC Public Affairs Office*

**TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.**

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**Presented by:**

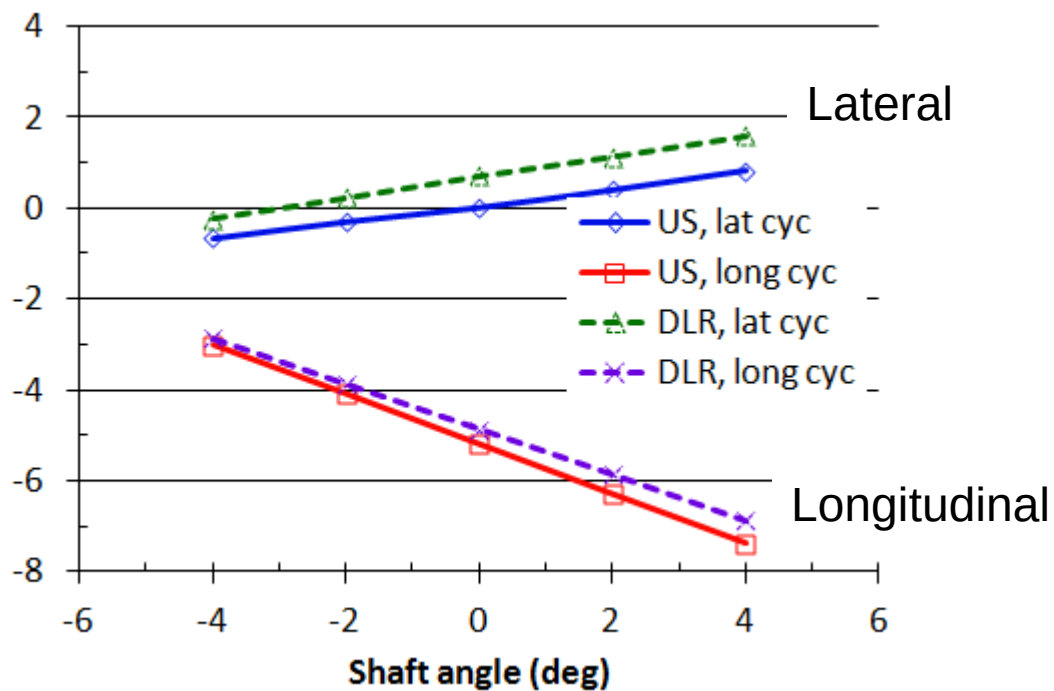
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Moffett Field, CA

- **CAMRAD II**
- **Prescribed wake (rollup model)**
- **Trim condition**
  - Cyclic flapping angles at the blade root = 0
  - Collective is fixed at 4 degrees
  - Wind speed at 76m/s (speed ratio = 0.70)
  - Shaft variation of -4, -2, 0, 2, and 4 degrees
- **Control law**
  - 500V amplitude, 0/rev actuation (0 and 180-degree phase)
- **Objectives**
  - Performance improvement
  - Vibration
  - Noise reduction

Solid line: US

Dashed line: DLR

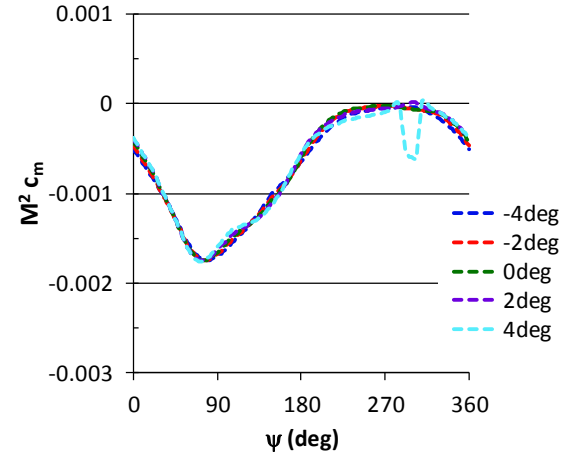
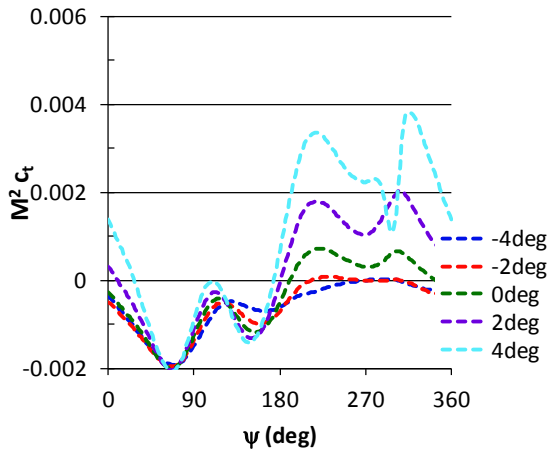
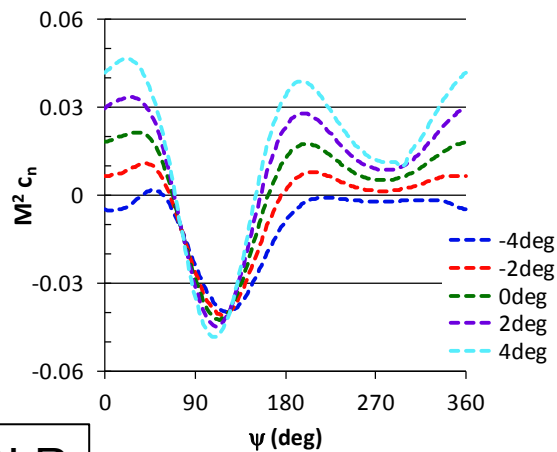
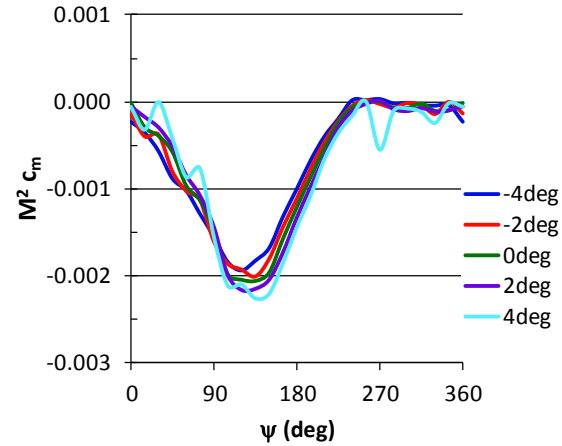
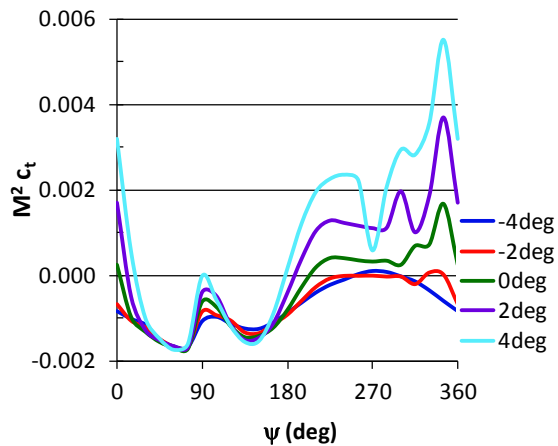
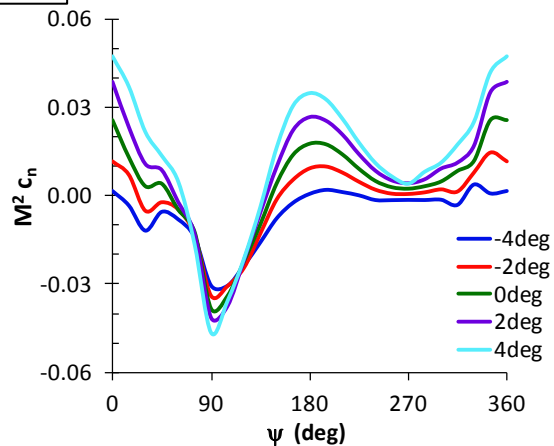


US

normal force

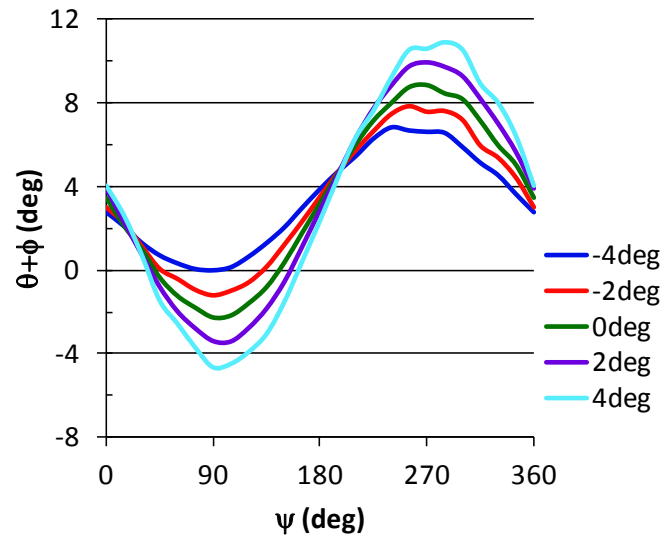
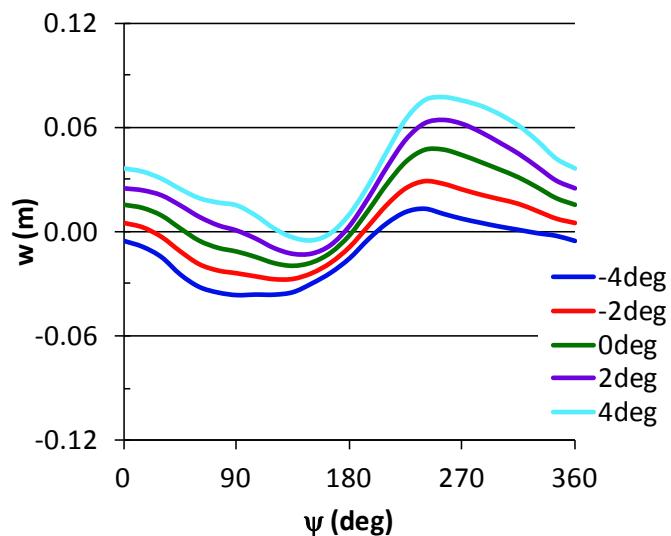
chord force

moment

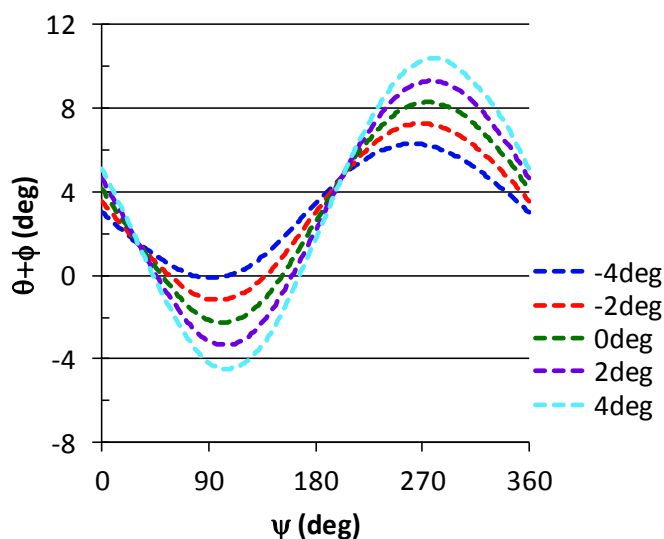
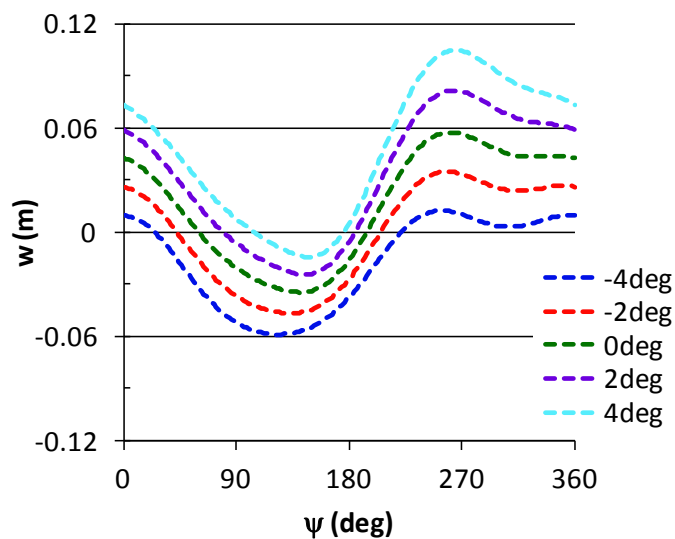


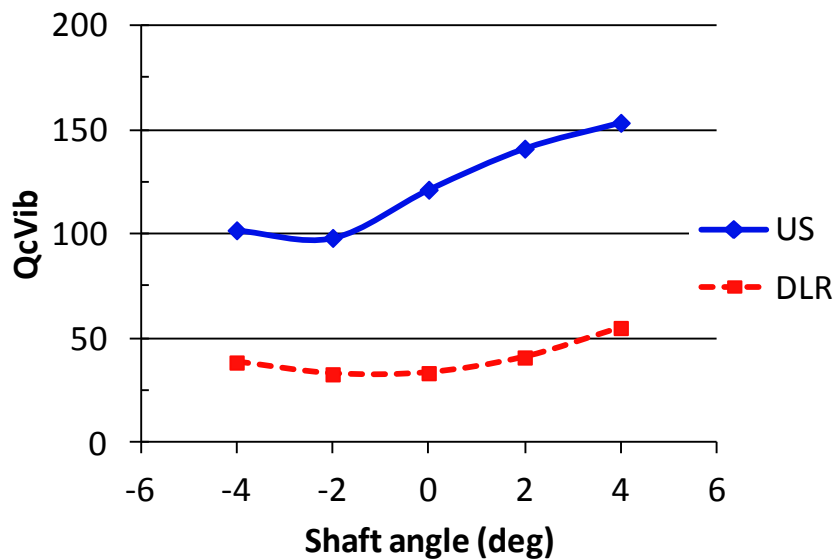
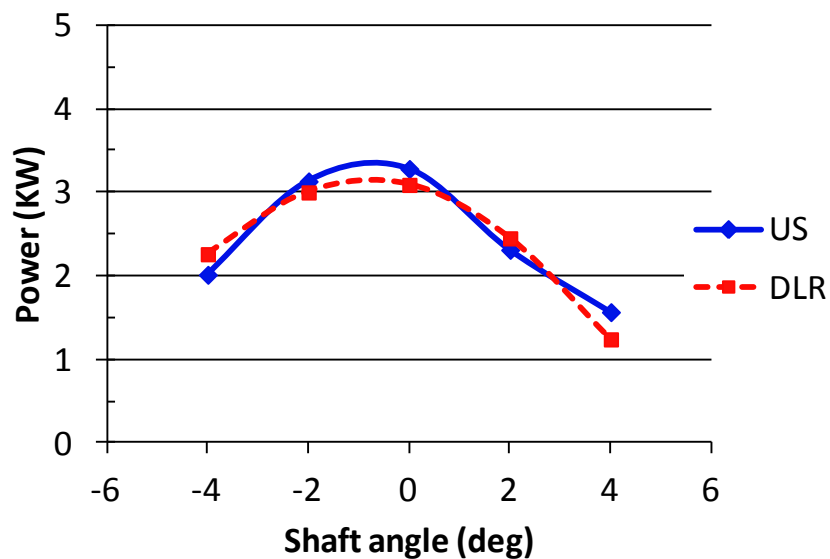
DLR

US



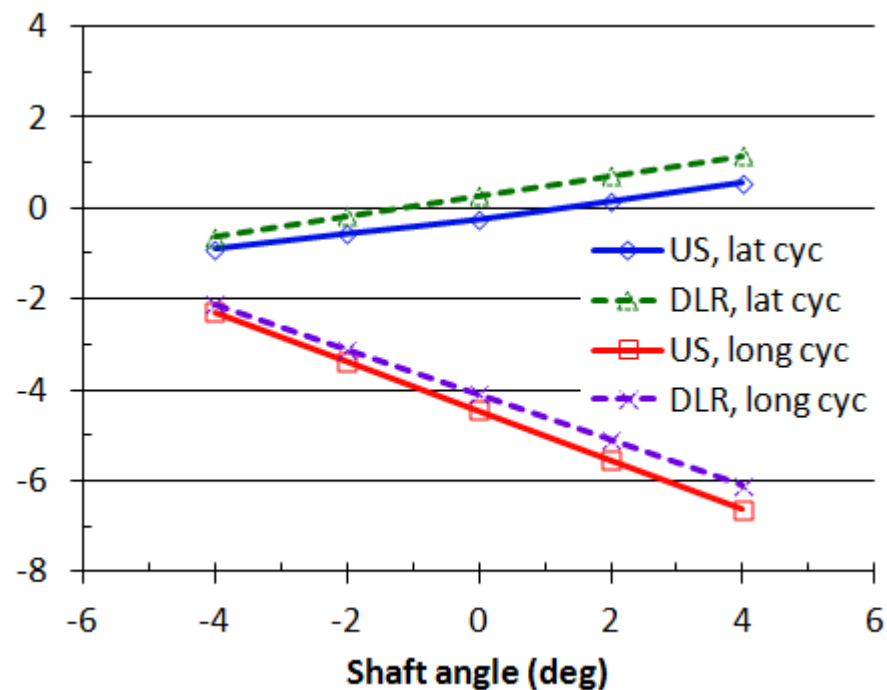
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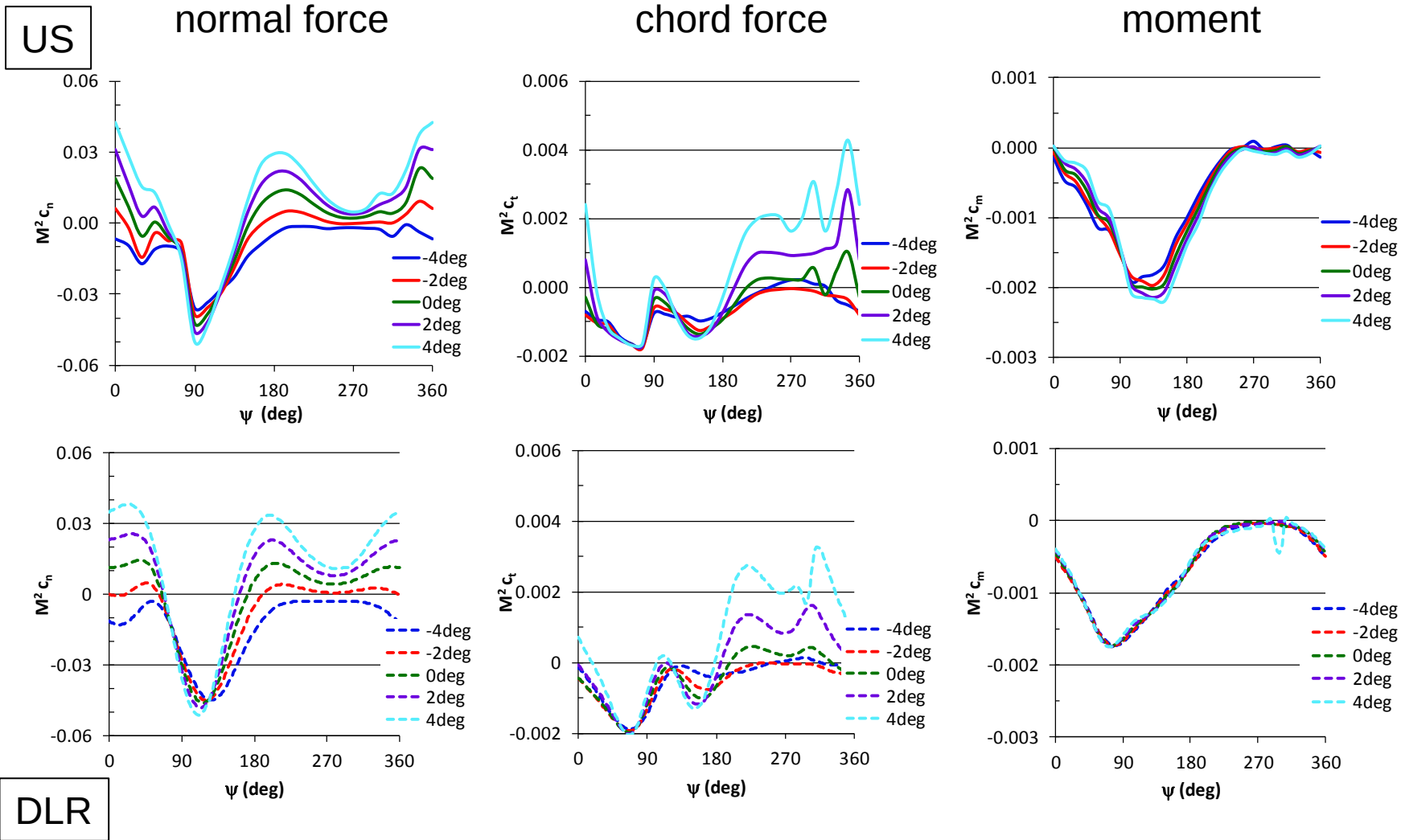


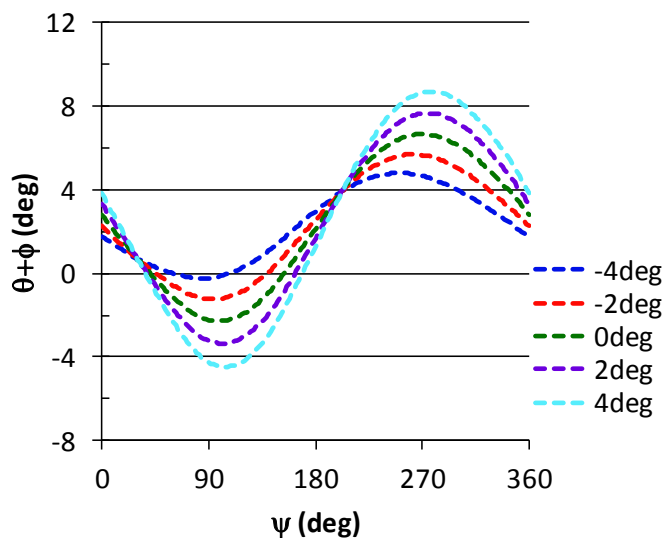
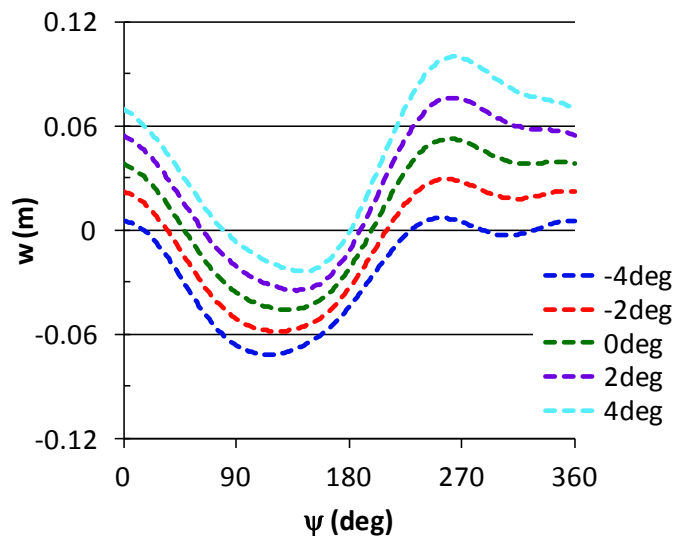
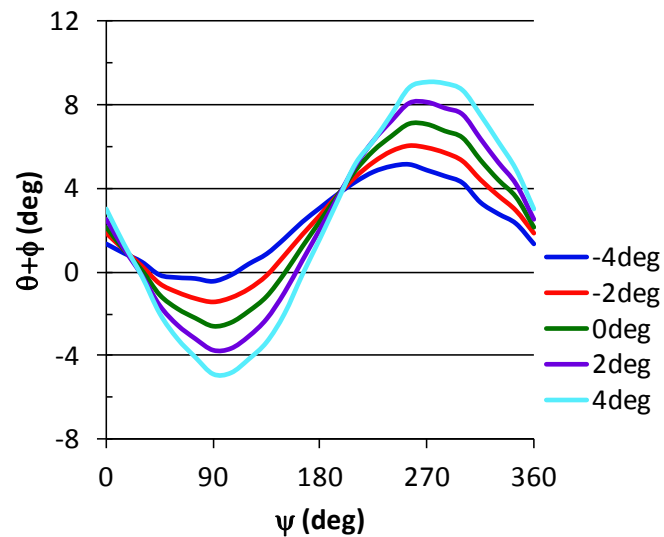
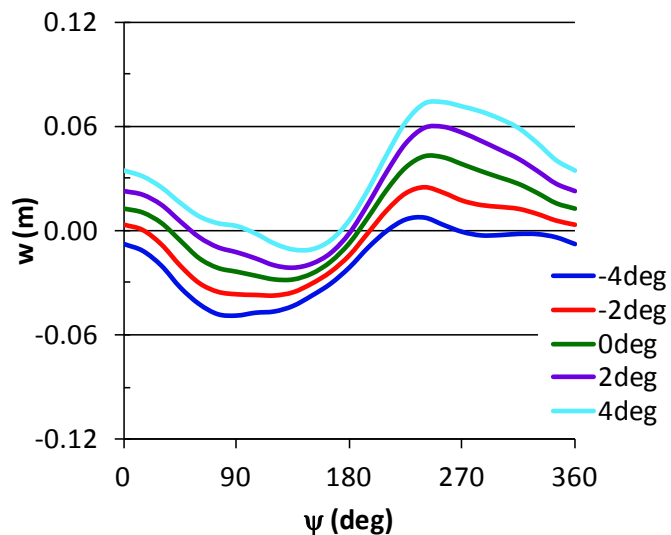


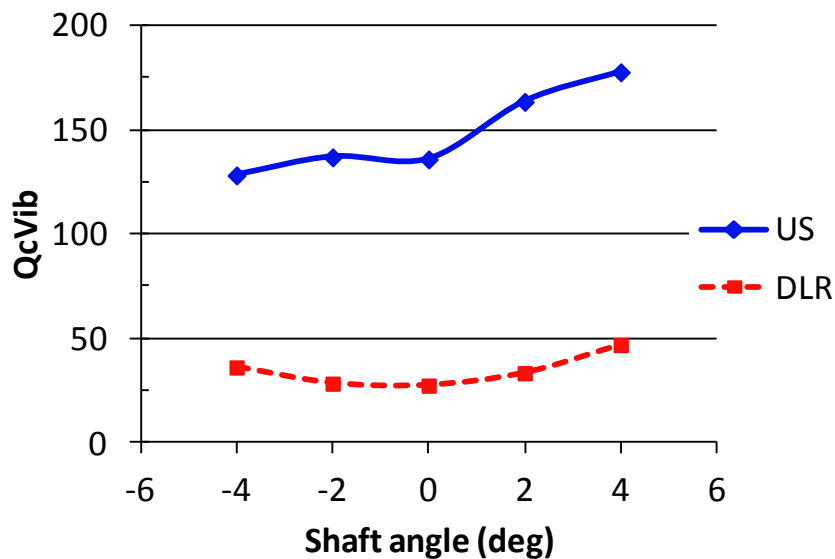
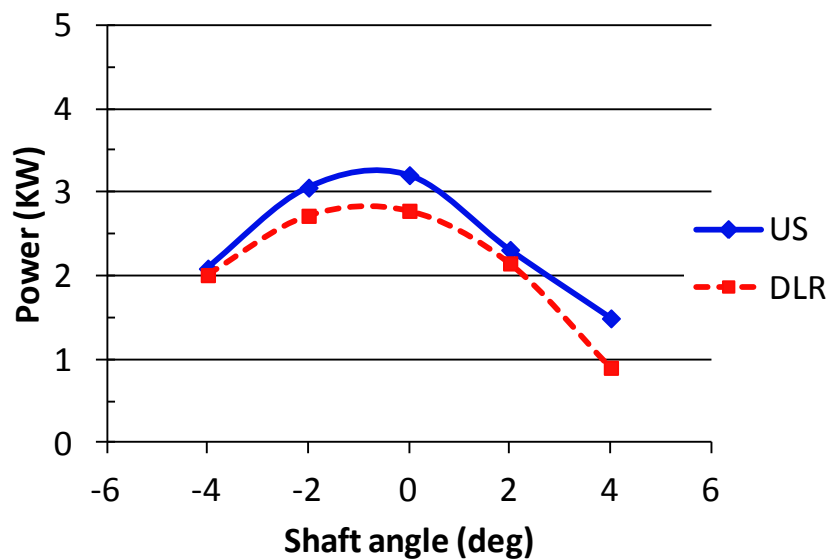
**Solid line: US**

**Dashed line: DLR**



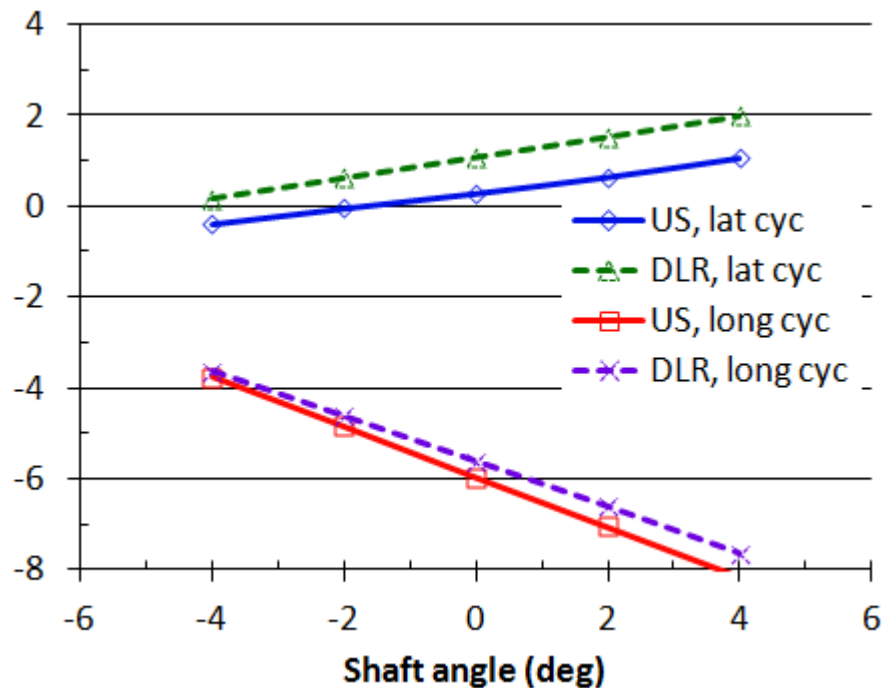




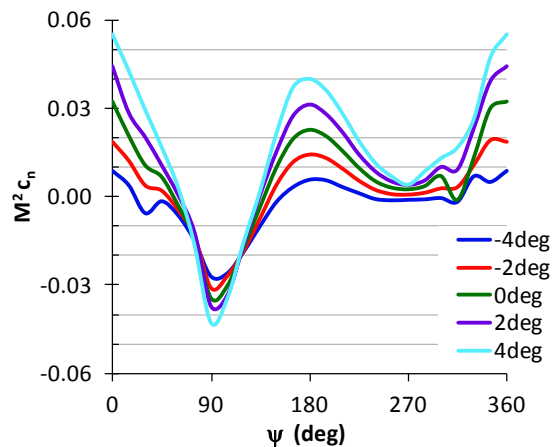


Solid line: US

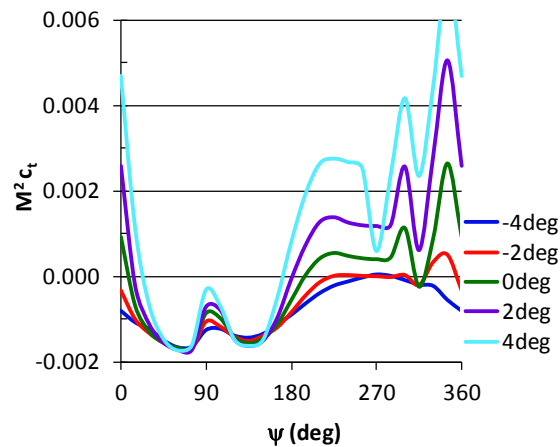
Dashed line: DLR



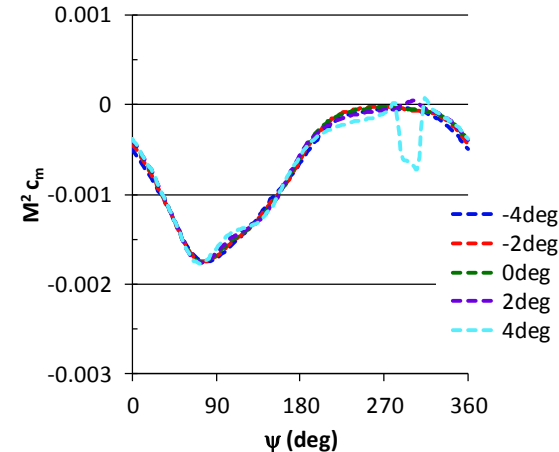
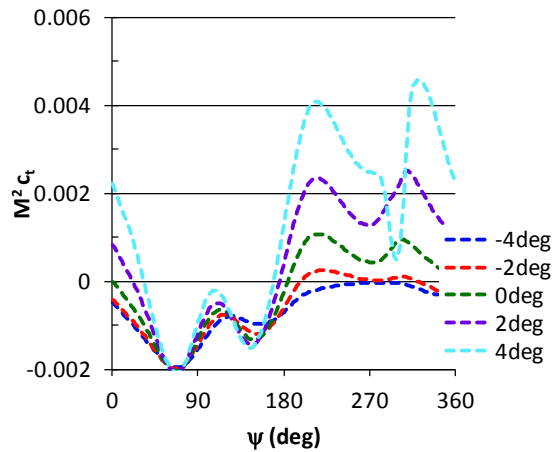
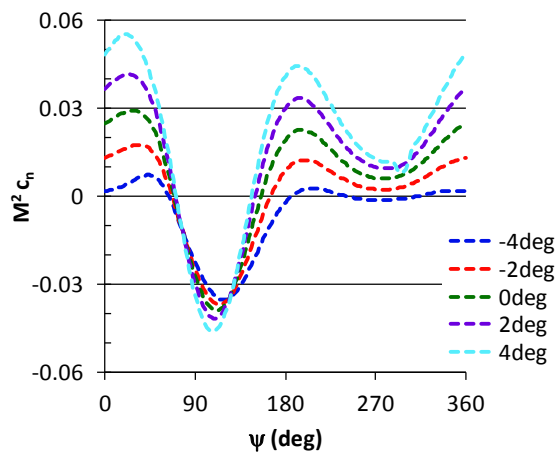
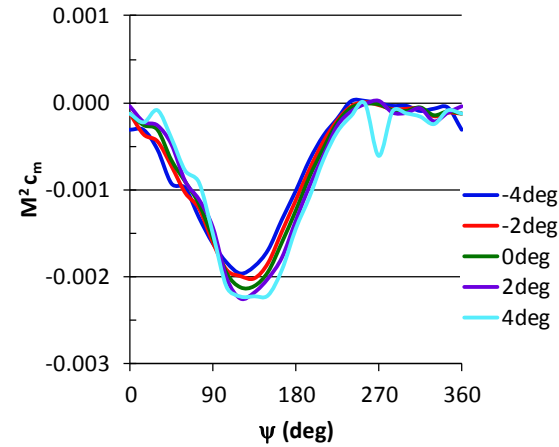
normal force



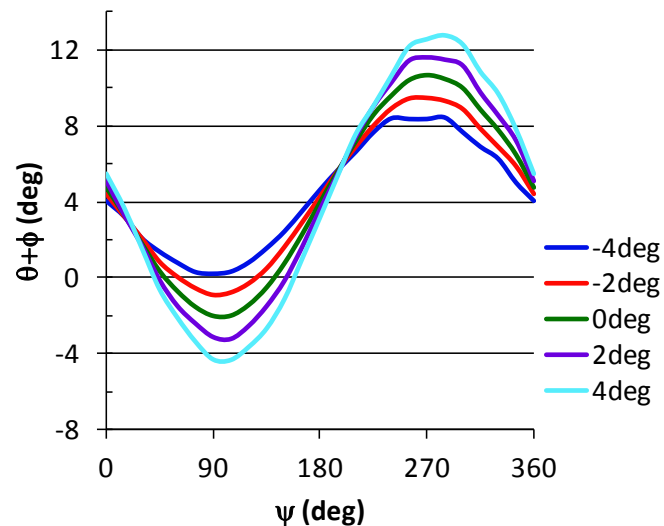
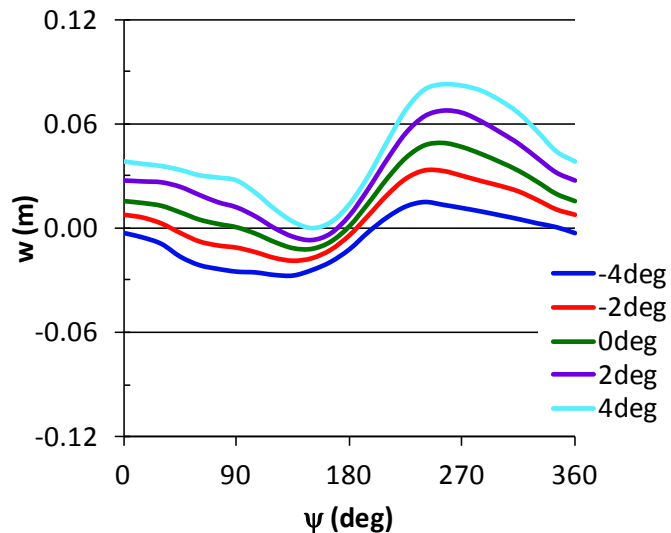
chord force



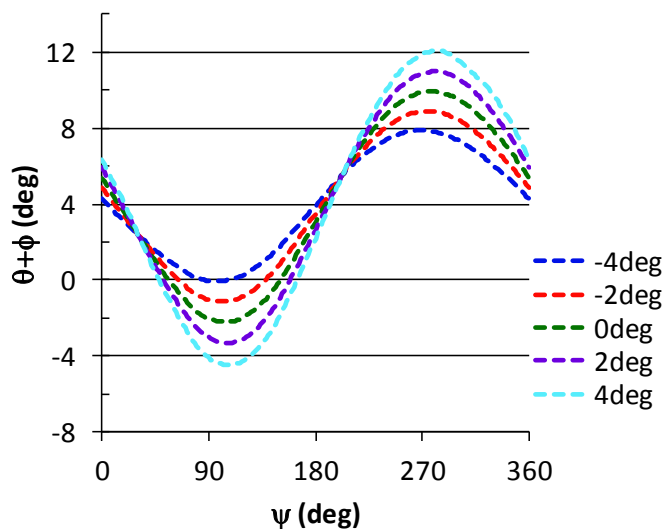
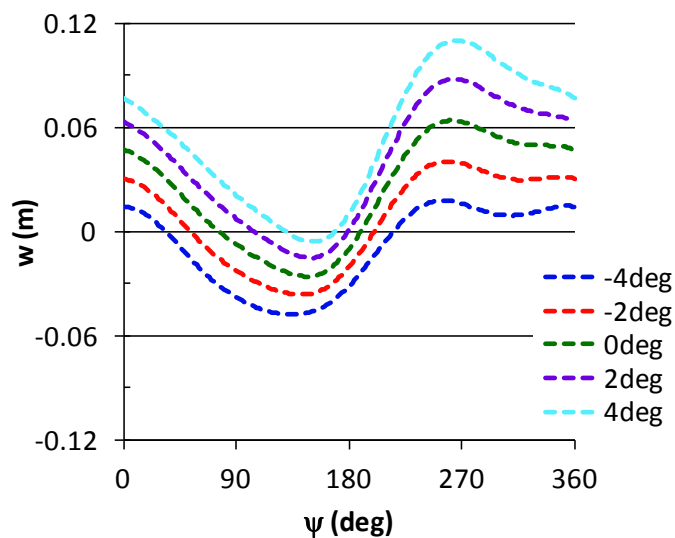
moment

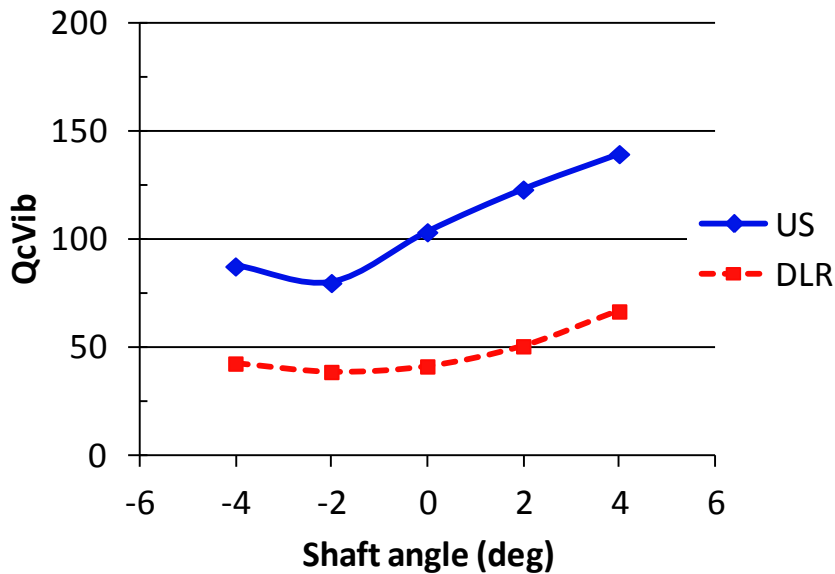
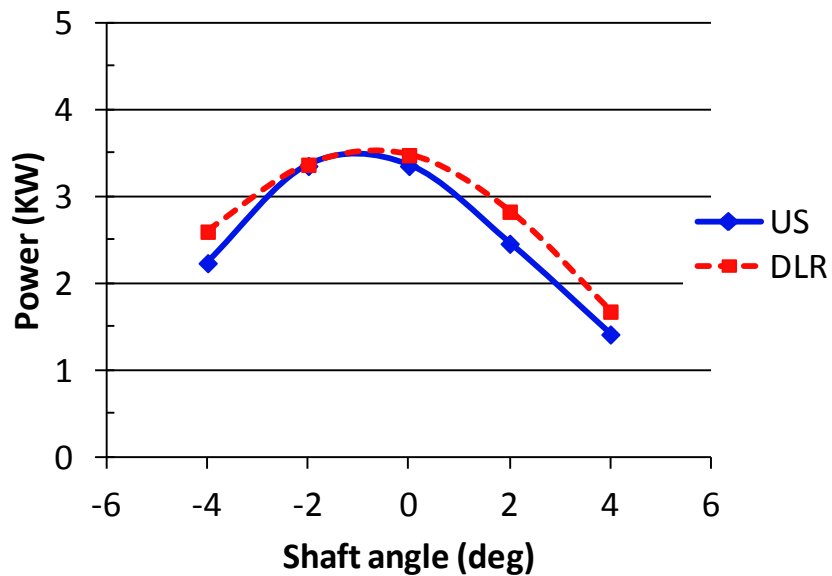


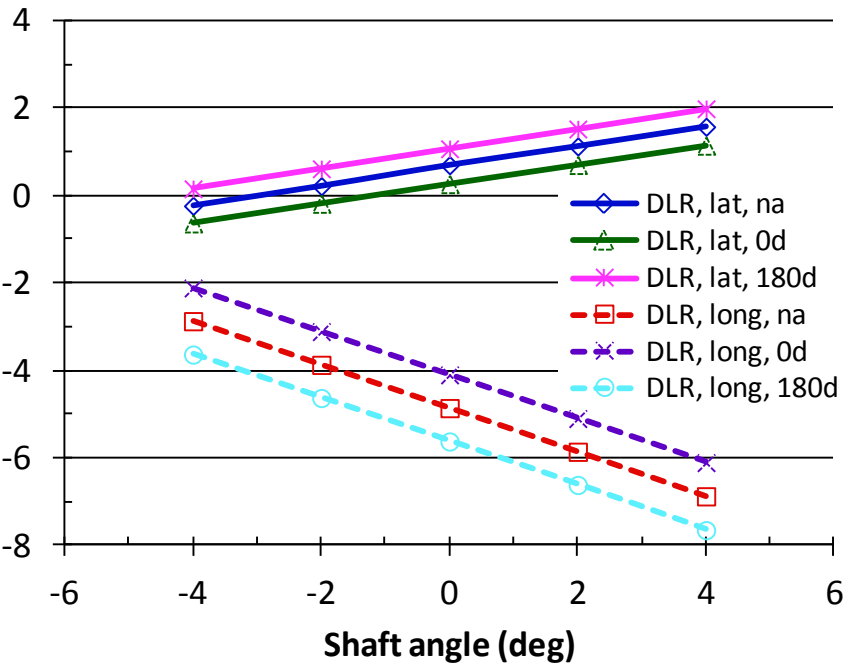
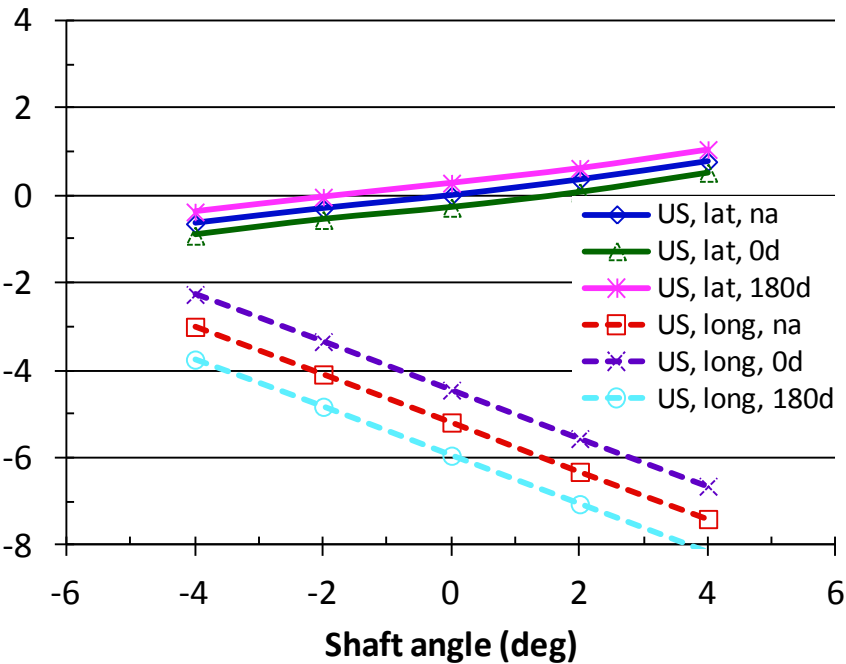
US



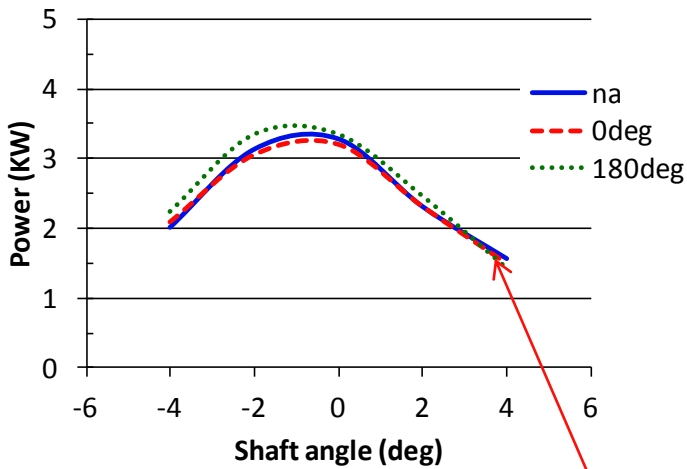
DLR



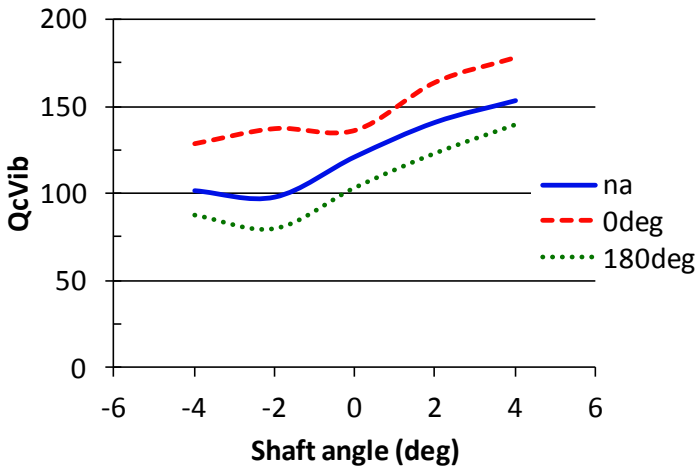




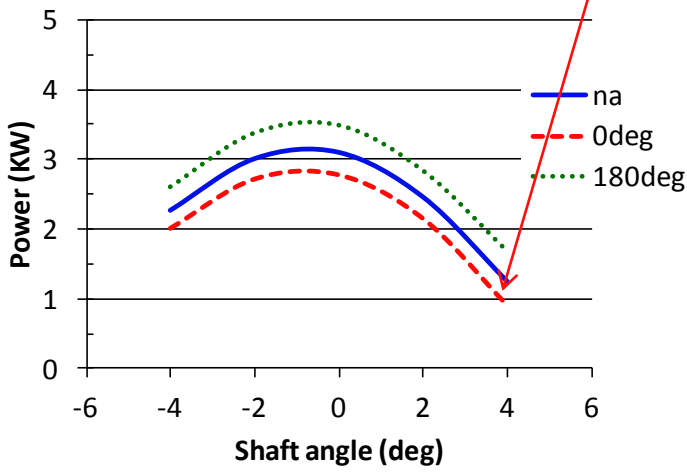
Power: US



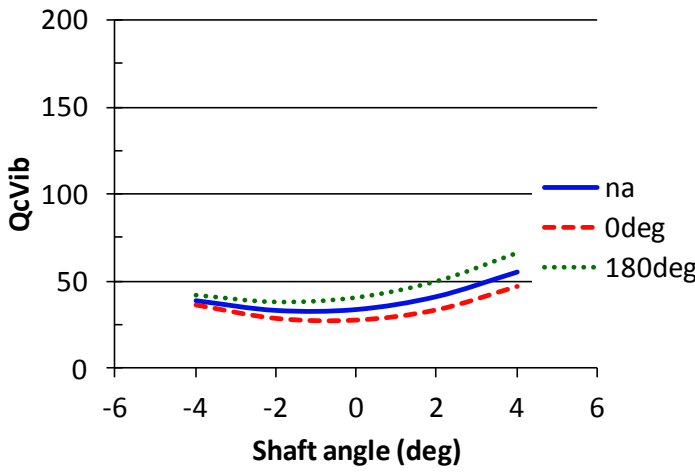
Vibration: US



Power: DLR



Vibration: DLR



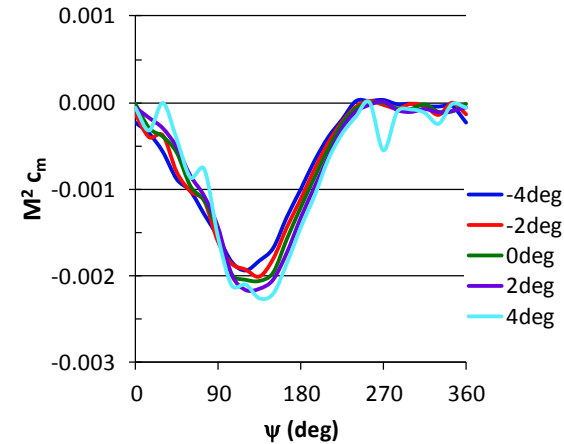
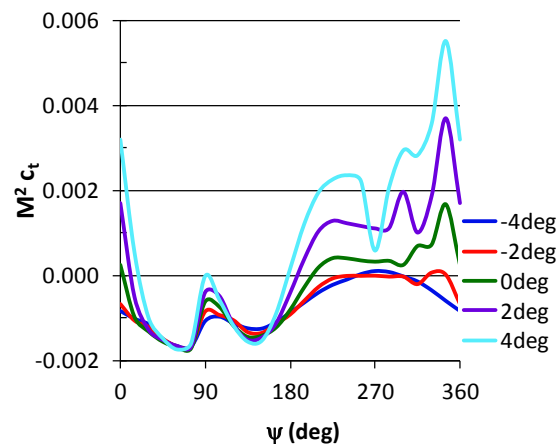
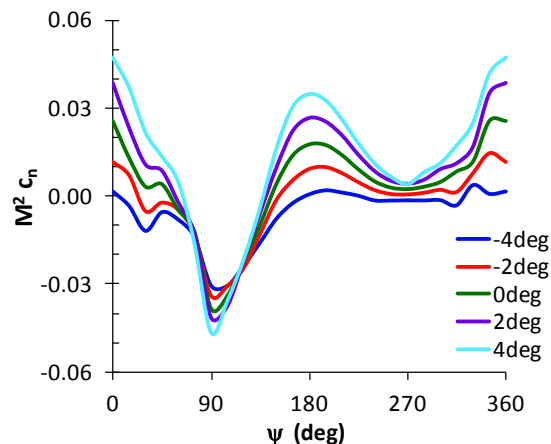
80% amplitude

Rollup

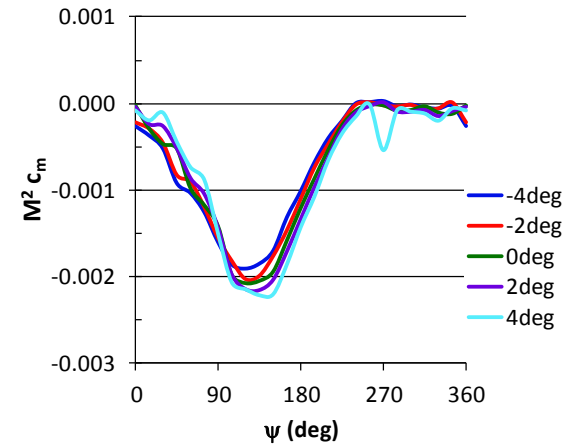
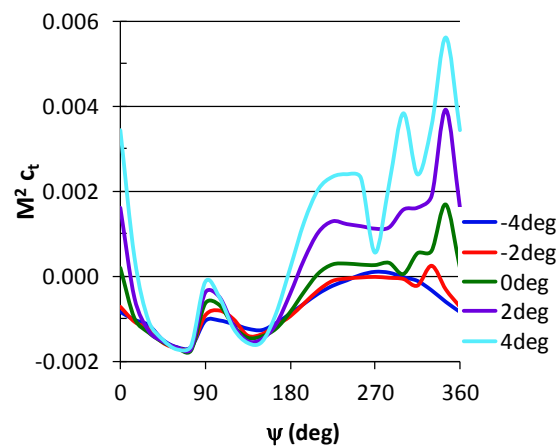
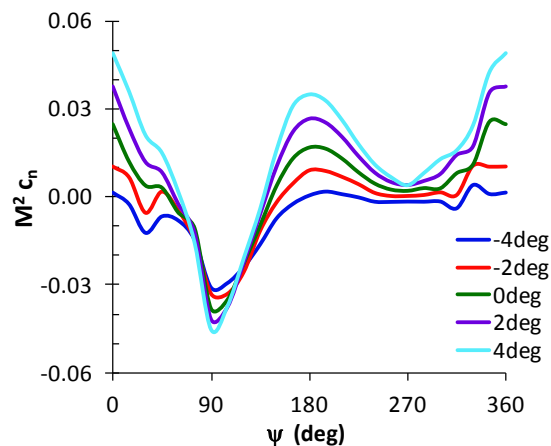
normal force

chord force

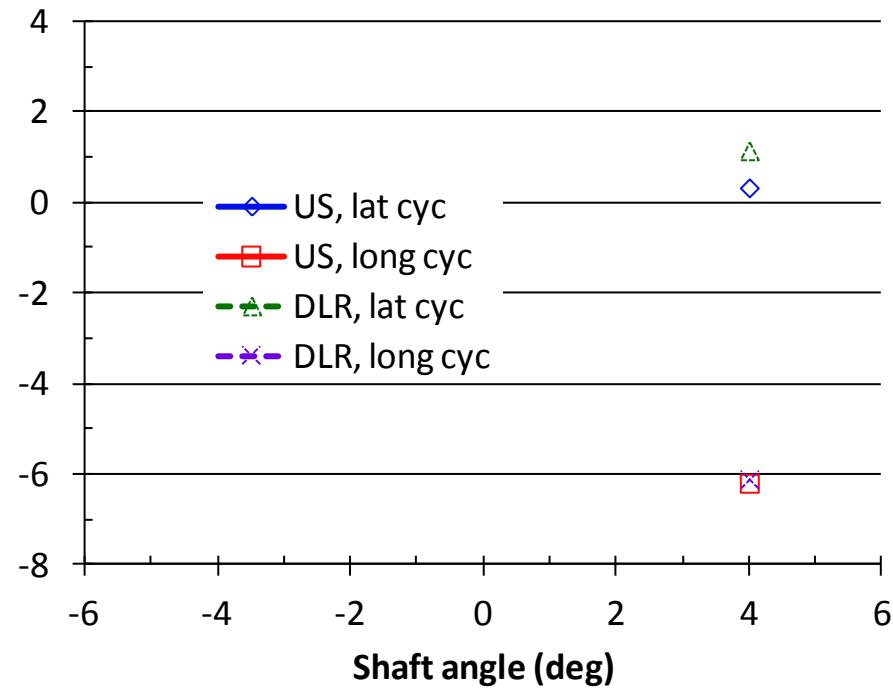
moment



8 multiple trailers



- 80% actuation, 0P, 0-deg phase
- Shaft angle of 4 degrees



# Airloads

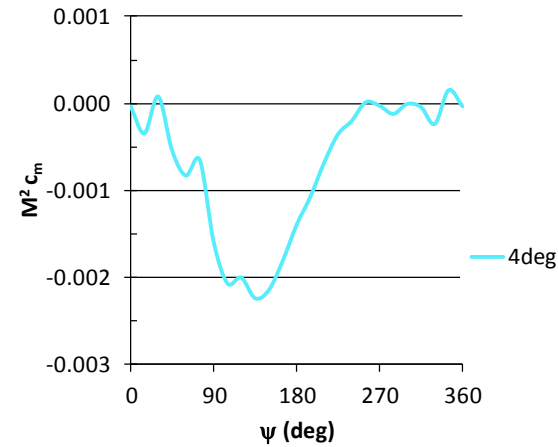
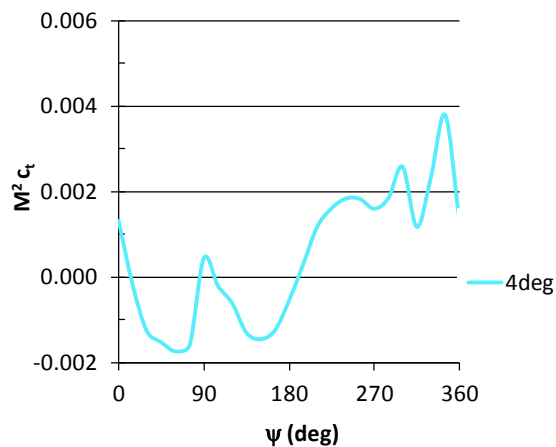
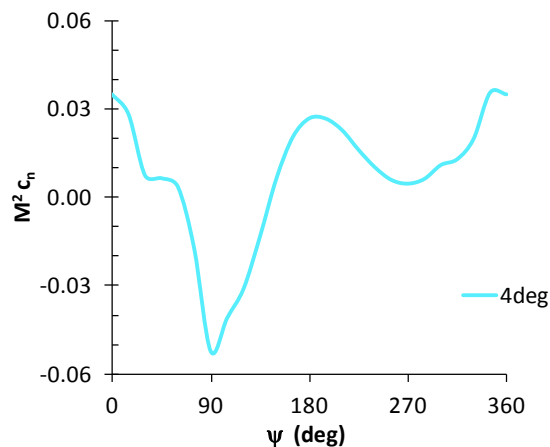
## 80% Actuation, 0P, 0-deg Phase

normal force

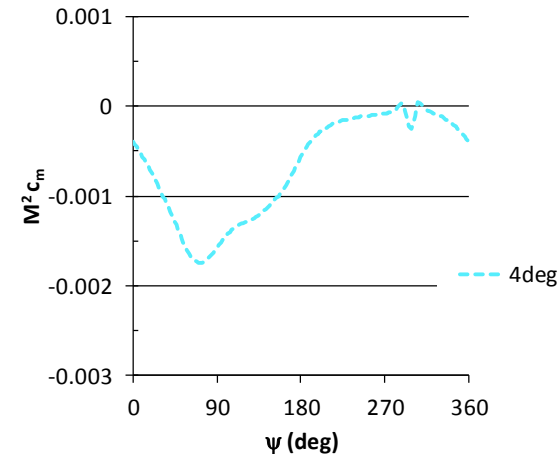
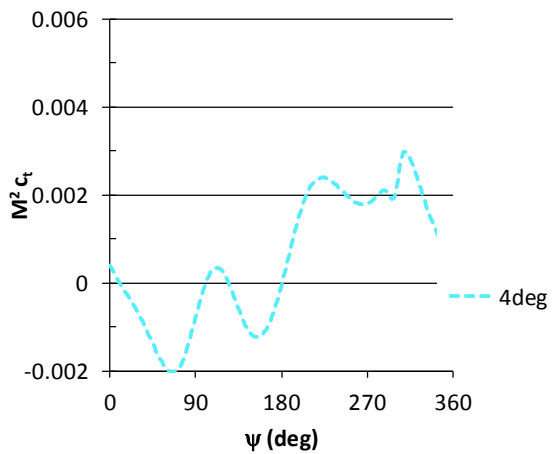
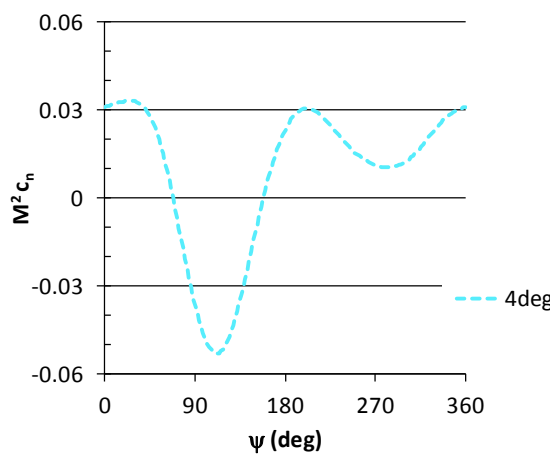
chord force

moment

US



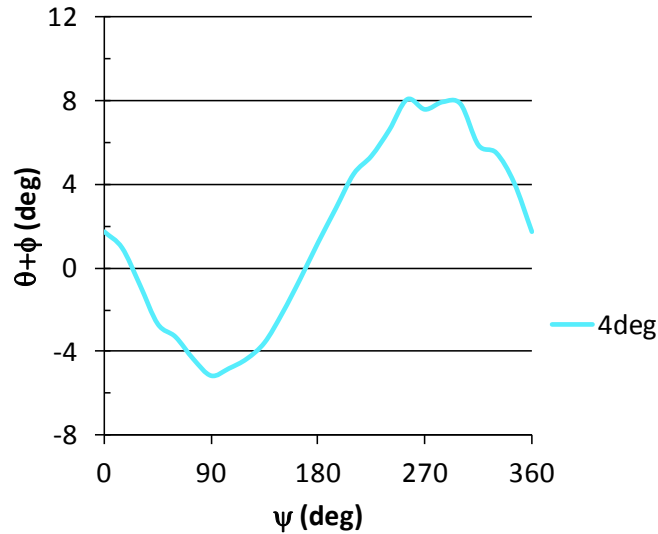
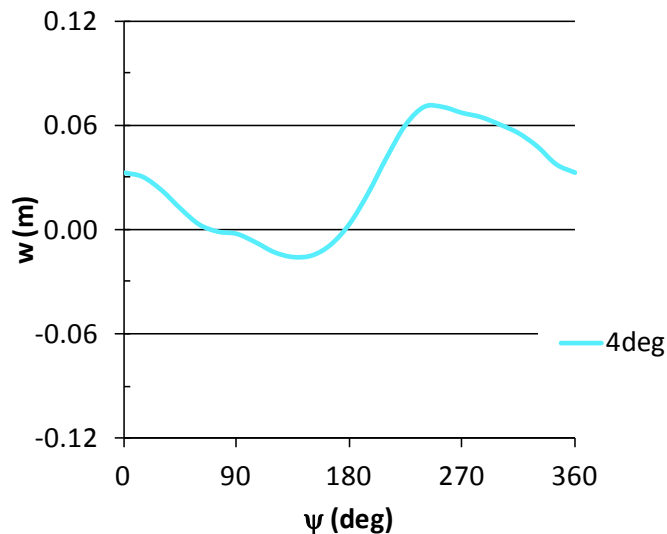
DLR



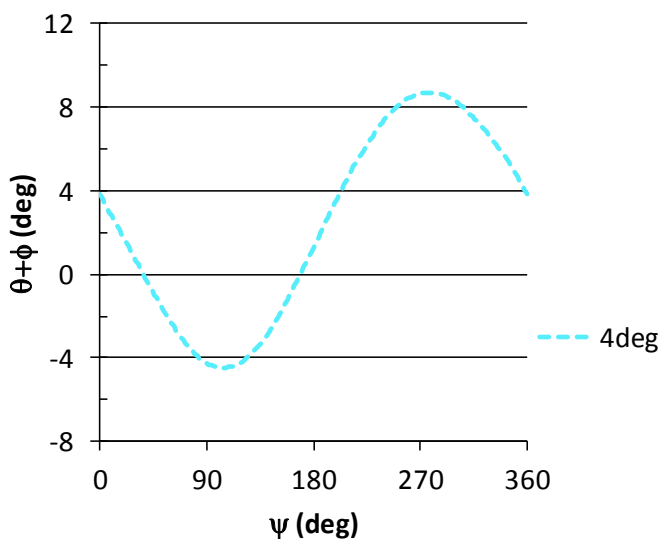
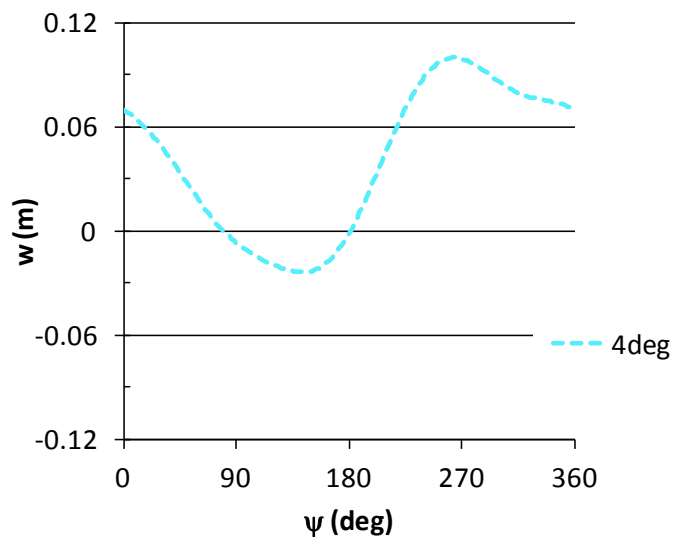
# Blade Tip Responses

## 80% Actuation, 0P, 0-deg Phase

US

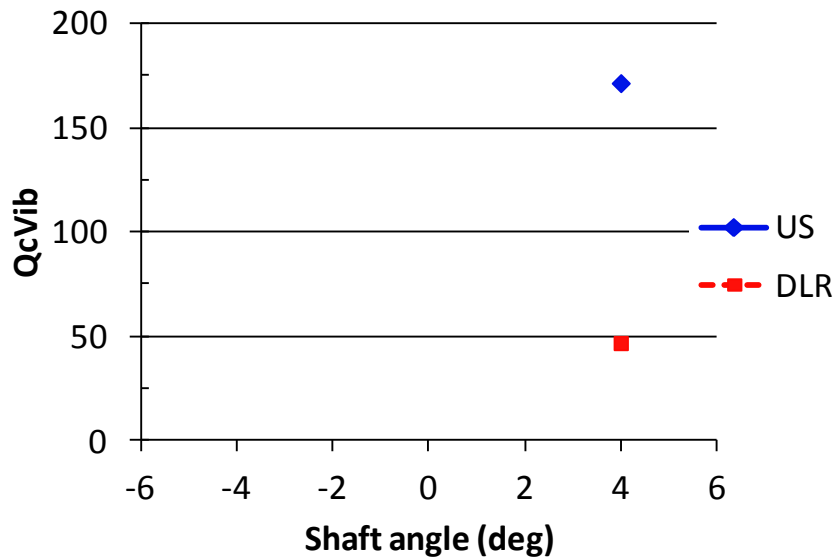
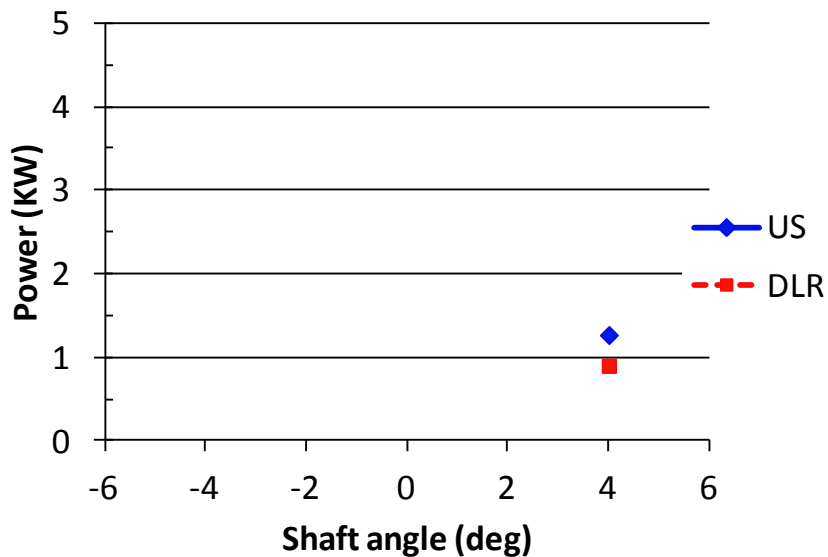


DLR



# Power and Vibration

## 80% Actuation, 0P, 0-deg Phase



- **Airloads and blade deflections agree well between US and DLR results**
- **Power and vibration index were not as close as airloads**
- **For the 80% amplitude (best phase and best shaft angle), the following are obtained compared with the NA case:**
  - (Vibration) US: 12% increase, DLR: 15% reduction
  - (Power) US: 19% reduction, DLR: 27% reduction
- **The performance improvement was made with the 80% amplitude actuation by a mere 0.5-1.0% power reduction from the nominal value (60KW)**