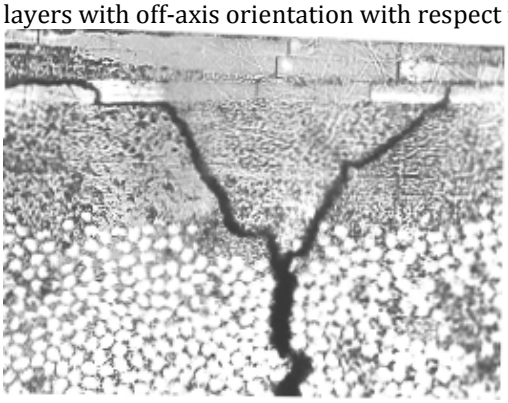
DocMASE Project Proposal 2013-02

Project Title	Fatigue Mechanismus in Composites for Aerospace an Wind Turbine Applications
Main University and Advisor	Luleå University of Technology / Prof. Janis Varna
Second University and Advisor	Université de Lorraine - EEIGM / Prof. Zoubir Ayadi
Associated Partner(s) (if applicable)	Texas A&M University, Dept. of Aerospace Engineering USA Prof. Ramesh Talreja
Project Description (with **image**, if applicable)	Laminated composites are widely used in substructures and components of wind turbine blades and in most recent airplanes like Boeing 787. In contrast to metallic ellements where single crack growth is the main fatigue mechanisms, in fiber composites subjected to fatigue loading the damage is dispersed and many microdamage modes can be observed before the damage localization at the end of the fatigue life. The first damage modes usually appear in layers with off-axis orientation with respect to the main loading direction, see Fig. 1.  Fig. 1. Intralaminar crack in off-axis layer causing fiber breaks in the adjacent layer Still the fatigue life of the laminated composite depends on the primary damage mechanism: fiber breaks connected with debonds in the main load bearing layer. The intralaminar crack which is relatively harmless by itself is the reason for high localized stress concentrations in the load bearing layer resulting in multiple fiber breaks in the intralaminar crack tip region. During the following cyclic loading fiber/matrix interface crack (debond) propagates from the fiber break along the fiber. A multitude of debonds in a certain cross-section leads to weakening of this cross-section and fatigue failure of the component. The objective of this project is to study these mechanisms experimentally (cyclic mechanical loading, SEM , optical microscopy, X-ray tomography, etc) on the edges of real specimens as well as designing model experiments where the same phenomena can be observed in a single fiber composite or with a group of fibers embedded in a matrix. An important part of the work is finite element calculations of the stress state in the damaged region with the goal to use fracture mechanics to simulate damage growth in cyclic loading.
Previous Publications	• Pupurs A, S. Goutianos, P. Brondsted and J. Varna, Interface debond crack growth in tension–tension cyclic loading of single fiber polymer composites, Composites: Part A, 44, 2013, 86-94. • Pupurs A., Varna J. Unidirectional composite in mechanical fatigue: modelling debond growth from fibre breaks, Plastics, Rubber and Composites. - Vol. 39. pp. 128-136, 2010.
References	• J.Varna, L.A. Berglund, R. Talreja and A. Jakovics, *"A Study of the Crack Opening Displacement of Transverse Cracks in Cross Ply Laminates*", International Journal of Damage Mechanics, 1993, Vol.2, 272-289. • J. Varna, F. Paris, "*The Effect of Crack Face Contact on Fiber / Matrix Debonding in Tensile Transverse Loading* ", Composite Science and Technology, 1997, vol.57, No.5, 523-532 • Sun Zuo , IM Daniel, JJ Luo, Modeling of fatigue damage in polymer matrix composite, Materials Science and Engineering, A361, 2003, 302-311.
Requirements of the candidates / Requirements during the doctoral programme.	To receive Swedish PhD degree the candidate in addition to 3 years of research work has to accumulate about 60 ECTS credits in courses. Since this corresponds to 1 year of studies, the expected length of doctoral studies is 4 years. About 15 of the required ECTS points will be obtained during the common activities of the DocMASE project. The fourth year will be financed by the Lulea University of Technology.