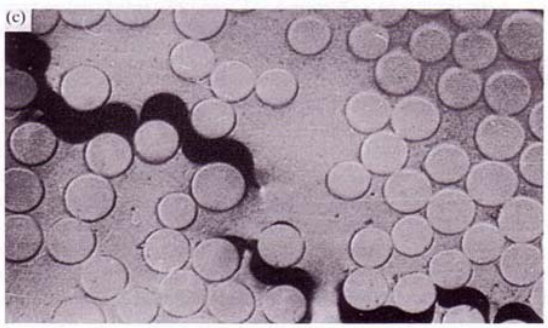
DocMASE Project Proposal 2015-04

Project Title	**Mechanics of extreme thin composite layers for aerospace applications**
Main University and Advisor	Université Lorraine - EEIGM Prof. Zoubir Ayadi
Second University and Advisor	Lulea University of Technology Prof. Janis Varna
Associated Partner(s) (if applicable)	Swedish Institute of Composites and University of Sfax, Tunisia
Project Description (with **image**, if applicable)	A very surprizing observation on damage in laminates was made for about 30 years ago: the transverse tensile strength value of unidirectional composite determined loading to failure is NOT APPLICABLE for thin layers inside a laminate, see ref [1,2]. The real transverse strength (called in-situ strength) is significantly higher. Reasons for this phenomenon were analysed theoretically using fracture mechanics, among others, also by researchers at LTU [1-3]. The potential of the "thin layer approach" was not utilized because large scale manufacturing techniques for thin layers were not available. Now, when 3-4 "actors"-manufacturers in EU have the technology to produce fibre reinforced layers of thickness 40-60 micrometres, all airplane producers (Boeing, Airbus) have large interest in understanding the mechanics of transverse cracking (intralaminar damage) to utilize damage resistant thin layers in lightweight structures. Earlier studies were dealing with propagation of existing cracks, which is more difficult in thin layers. Optical and SEM analysis of damaged laminates has shown that not only the crack propagation but also its initiation (coalescence of matrix and interface defects/imperfections to form crack) depends on the thickness of the ply. To analyse the initiation, non-uniform statistical distribution of fibres has to be analysed. The thesis work will be mainly computational using FEM with designing of model experiments and microscopy observations of damage phenomena. Focus will be on transverse tensile loading of thin plies, but mixed (shear/transverse) and compressive loading will also be addressed.  Figure: Transverse cross-section of unidirectional fibre reinforced composite showing initiation of crack by coalescence of fibre/matrix debonds.
Previous Publications	1. Varna J., Modeling Mechanical Performance of Damaged Laminates, J of Composite Materials, 47 (20-21), 2013, 2443-2475. 2. Varna J., Quantification of damage and evolution modeling in multidirectional laminates, Proc. of the 27th RISÖ International symposium on material science, Roskilde, Denmark, 2006, p.349-356. 3. Berglund L.A., J. Varna, J. Yuan, *"Effect of Intralaminar Toughness on the Transverse Cracking Strain in Cross-Ply Laminates,"* Advanced Composite Materials, the

	Official Journal of the Japan Society for Composite Materials, Vol. 1., No. 3, 1991, 225-234. 4. Huang, Y., J. Varna, R. Talreja, Statistical Methodology for Assessing Manufacturing Quality Related to Transverse Cracking in Cross Ply Laminates, Composites Science and Technology,95,(2014),100-106.
References	1. Parvizi A, Bailey J.E. On multiple transverse cracking in glass fibre epoxy cross-ply laminates. Journal of Materials Science, 1978; 13:2131-2136. 2. Flaggs D.L. and Kural M.H., Experimental determination of the in situ transverse lamina strength in graphite/epoxy laminates, *J. of Composite Materials*, 16, (1982), 103-115. 3. Nairn J. and Hu, S., Matrix microcracking . In: Pipes R.B, Talreja R, ed. *Comp. Mater*. series, vol. 9. *Dam. Mech. Comp. Mater*. Amsterdam: Elsevier, (1994), 187-243.
Requirements of the candidates / Requirements during the doctoral programme (courses, seminars, etc.)	This project is in collaboration between French and Swedish universities. Swedish requirements (which are more rigorous) with respect to credit points for courses will be followed. The student will pass courses in the amount of 60 ECTS, which correspond to one additional year of studies (3 years reasech + 1 year courses, evenly distributed). The fourth year will be financed by Lulea University of Technology. 15 ECTS of the 60 will be obtained in common courses, workshops and summer schools organized by DocMASE