## Project Interim Progress Report(Rapport d’avancement de project intérimaire)July 1, 2016 - January 31, 2017Please submit by January 16, 2017(Attn: Joanne O’Connor management@nserc-canrimt.org)

## Instructions

*This progress report, updated milestones**and the Form 300 are required as a condition of research funding support from the sponsors of the NSERC CANRIMT.* ***Please report for activity in the current reporting period only.***

**SUMMARY**

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| **THEME III: Machining of Composite Parts** | **Leader/ Chef:** *(S. Park )* |
| **PROJECT III.5:** ***Numerical Simulation of the Damage and Failure Mechanisms in Composites during Machining*** | **Leader/ Chef:** *(R. Vaziri/Y. Altintas, UBC)*  |
| **PROJECT DURATION/DURÉE DU PROJET : 5 years** |
| **STATUS/STATUT:** *(****Milestones*** *to be updated by each Project Leader)* |
|  **Ahead of Schedule** |  | **On Schedule** |  |  **Delayed** | **X** | **Cancelled** |  |

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| **PROJECT DESCRIPTION/ DESCRIPTION DU PROJECT** (*Brief description in point form, including role of project in Theme.)* |
| The numerical modeling of damage and failure mechanisms that fibre-reinforced composite materials (e.g., CFRP) undergo during their machining require considerable research will be studied.  |

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| **PROJECT OBJECTIVES & METHODOLOGY/ OBJECTIFS DU PROJET & MÉTHODOLOGIE** *(Include alignment with Network objectives.)* |
| The objective of the project is to model the composite machining process, and simulate it in digital environment to predict the most optimal – damage free cutting conditions. The complex and gross levels of damage that occur locally in the neighbourhood of the tool-workpiece (composite) interface consist of fibre breakage, fibre/matrix debonding, matrix cracking, as well as more global damage, such as delaminations. This latter damage is initiated at the local level but propagated on a macroscopic scale in stacked configurations of dissimilar materials (laminates) requiring different types of computational treatment. A damage method will be developed and embedded to ABAQUS FE for simulations.  |

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| **1. RESEARCH TEAM/ ÉQUIPE DE RECHERCHE** *(Summary for the current reporting period)* |

**1a: Research Personnel (Supervisors, Co-Supervisors, Collaborators)/
Personnel de recherche**

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| *Name, given name/Nom., prénom* | *Organization/Organisation* | *Sup./Co-Sup./* *Collaborator* | *E-mail/Courriel* | *Phone No./Téléphone* |
| Vaziri, Reza | UBC | Supervisor | reza.vaziri@ubc.ca | 604-822-2800 |
| Altintas, Yusuf | UBC | Co-Supervisor | altintas@mech.ubc.ca | 604-822-5622 |

**1b: Students, Postdoctoral Fellows, Research Assist./
Assoc./Eng., Technical/Professional, Guests** *(from outside Province; from outside Canada)***/
Étudiants, Boursier de recherches postdoctorales, assistants, techniciens et invites** *(invite hors Province; hors Canada)*

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| *Name, given name/Nom., prénom* | *Position* | *Organization/Organisation* | *Name/Nom.(S) or /ou (C)\** | *Start/Début* | *End/ Fin* | *CANRIMT Salary/Moincl ben.* | *Extern.fundingamount* | *Externfundingsource* |
| **Malena Shulz** | **Master** | **UBC/WZL Aachen** | **Vaziri (C), Altintas (C)** | **Jul 2016** | **Aug. 2016** |  |  | ***DAAA*** |
| **Xiaoye Yan** | **Ph.D.**  | **UBC/** **Northwestern Polytechnical University, China** | **Vaziri (C), Altintas (C)** | **Sept. 2016** |  |  | **$18000** | **China Scholarship**  |
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***\*(S) – Supervisor
 (C) – Co-Supervisor***

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|  **TOTAL #** | **BASc** | **MASc/** **M.Eng.** | **Ph.D.** | **PDF** | **Res. Asst.** | **Res. Assoc.** | **Res. Eng.** | **Tech./ Prof.** | **Guests/outside Province** | **Guests/outside Canada** |
|  |  | **1** | **1** |  |  |  |  |  |  | **2** |

**1c: Partners & Contributions/
Partenaires et Contributions**

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| --- | --- | --- | --- | --- | --- | --- |
| *Organization /Organisation* | *Acronym/Acronyme* | *Contact*  | *Cash/Espèce* | *In-Kind/ Nature* | *Overhead/Frais généraux* | *Total* |
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| **2. RESEARCH PLAN FOR THE CURRENT PERIOD/PLAN DE RECHERCHE POUR LA PÉRIOD ACTUELLE** *(Please list both the technical objectives, methodologies and milestones as stated in the previous report.)* |
| To model the local mechanisms and physics of the problem at the CFRP/tool interface, different discrete and meshless modeling methodologies (e.g., the discrete element method [141], smoothed particle hydrodynamics [142], and Peridynamics [143]) will be employed to overcome complications from singularities and element distortions that arise when continuum- (finite element) based approaches are used to model fracture/damage at microscopic scales. The regions modeled using discrete or meshless methods will then be tied to the zones modeled using continuum elements in a process referred to as concurrent coupling approach. In this combined micro/macro-mechanical approach the effects of manufacturing-induced residual stresses at the fibre-matrix interface, as well as the two-way coupling effect between the temperature and mechanical/chemical behaviour of the CFRP will be taken into account for a more accurate and physics-based prediction of damage/failure of CFRP undergoing machining operations. The numerical model will be utilised in subthemes III.2 to III.4. |

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| **3. ALIGNMENT OF RESEARCH PROJECT WITH NETWORK OBJECTIVES/ALIGNEMENT DU PROJET DE RECHERCHE AVEC LES OBJECTIFS DU RÉSEAU***( Please comment on the alignment of the research project with the overall Network objectives.)* |
| Aerospace industry uses composite materials significantly in light weight structures, and their machining is a challenge. This project is intended to model the process physics to simulate the composite machining operations in digital environment, which is the general objective of the network.  |

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| **4. PROBLEMS and RESOLUTIONS/ PROBLEMES ET SOLUTIONS PROPOSÉES***( Please summarize any problems arising during the current reporting period and their resolution or plans for resolution.)* |
| *Problem/ Problème: UBC does not have composite machining test facility, which hinders our research.* *Resolution / Résolution: UBC can contribute better to design smart tools that can be used in machining composites. As a result, Altintas recommends scientific committee to allow UBC to design an ultrasonic vibration assisted tooling system to assist fracture of fibres at high frequency. Preliminary feasibility study is underway and will be submitted to scientific committee.*  |

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| **5. RESEARCH PROGRESS and RESULTS/ PROGRÈS DE LA RECHERCHE et RESULTATS:***(Summarize progress and results below.)* |

**5a: MILESTONES/ÉTAPES**
*Summarize progress on milestones – including % completed – as outlined in the Research Plan for the current reporting period and any modifications since the last reporting period.* *(Milestones document also to be updated for each project.)*

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| **MILESTONE/ ÉTAPE:** |
| **Progress: Behind the schedule** **Modifications:** *UBC does not have composite machining test facility, which hinders our research. UBC can contribute better to design smart tools that can be used in machining composites. As a result, Altintas recommends scientific committee to allow UBC to design an ultrasonic vibration assisted tooling system to assist fracture of fibres at high frequency. Preliminary feasibility study is underway and will be submitted to scientific committee. In parallel, numerical simulation of cutting CFRP s will continue as proposed but with visiting Ph.D. students until experimental facility is installed at UBC. There is no funding at the moment to establish a costly facility.* **% Completed/ Rempli** |
| **Tasks** | **% Completed** |
| Literature review | **80** |
| Modeling the mesh generation of composites | **10** |
| Fiber failure criteria in FE simulation of cutting | **10** |
| Simulation pf orthogonal composite machining with various fiber orientations | **10** |
| Drilling simulation for composites | **0** |
| Experimental validation | **0** |

**5b: PUBLICATIONS and PRESENTATIONS / PUBLICATIONS ET PRESENTATIONS**

*Please list all publications directly arising from Network-funded research during the current period. Do not include abstracts.*

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| ***A: REFEREED CONTRIBUTIONS - ARTICLES****Include articles in refereed publications – please specify whether the article has been submitted (S), accepted (A) or published (P).* |
| Last Name, Initial | *Year* | *Title, Journal, Volume* | *Status* |
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| ***B: REFEREED CONTRIBUTIONS - OTHER****Include papers in refereed conference proceedings, letters, notes, communications, review articles, monographs, books, book chapters and government publications.* |
| Last Name, Initial | *Year* | *Description* | *Status* |
|  |  | Conference Title, Location and Date (Status: Invited, Not invited) |  |
|  |  | Journal/Book/Publication Title (Status: S-submitted; A-accepted; P-published) |  |
| ***C: NON-REFEREED CONTRIBUTIONS****Include papers in non-refereed conference proceedings, papers, letters and review articles.* |
| Last Name, Initial | *Year* | *Description* |
|  |  | Conference Title, Location and Date  |
|  |  | Journal/Book/Publication Title  |
| ***D: SPECIALIZED PUBLICATIONS - PRESENTATIONS****Include theses, presentations, industrial/technical reports, internal reports, discussions of abstracts and symposium records.* |
| Last Name, Initial | *Year* | *Description* |
|  |  | Thesis or Conference Title, Location and Date  |
|  |  | Journal/Book/Publication Title  |
| ***E: PUBLICATIONS – Not originally funded by NSERC CANRIMT but continuing or completed with Network funding***  |
| Last Name, Initial | *Year* | *Description/Title* ***(include start date of NSERC CANRIMT funding)*** |
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| ***F: PUBLICATIONS –Not funded by NSERC CANRIMT but related to the Network research focus***  |
| Last Name, Initial | *Year* | *Description/Title* |
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**5c: PATENTS and LICENSES/ BREVETS ET LICENSES**

*Non-disclosure agreements signed, patent applications filed, patents issued, copyrights, licenses under negotiation, licenses granted, etc.*

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| *Category* | *Owner* | *Description* |
|  |  |  |

**5d: OTHER COMMUNICATIONS, AWARDS/ AUTRES COMMUNICATIONS, PRIX**

*Provide information on additional communications related to your work, such as awards and distinctions, news stories, interviews, public forums, press releases, etc. for the current reporting period (please provide copies or links.)*

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| *Name, given name/Nom, prénom* | *Details* | *Date* | *Link or copy attached* |
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| **6. TRAINING/ FORMATION** *(Describe the extent of cross-network and partner involvement in training for the current reporting period.)* |
| **So far, one master student from Germany has been trained and a visiting Ph.D. from China is under training.**  |

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| **7. RESEARCH PLAN FOR NEXT 6 MONTHS/ PLAN DE RECHERCHE POUR LES 6 PROCHAINS MOIS***(Describe Planned Research Activities for the next 6 month period and include any modifications made during the current reporting period.); also please list both the technical objectives and milestones.)* |
| **Model the fiber fracture along straight 2D tool paths. Predict the forces and compare against the measured forces to validate the approach.**  |

**8. OPTIONAL – Comments, Questions and/or Feedback/
OPTION – Commentaires, questions et/ou des commentaires**

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| *Include any supplemental comments or questions pertaining to the Network here.* |
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**9. NETWORK EVENTS ATTENDED or SUGGESTIONS /
ÉVÉNEMENTS RÉSEAU ONT ASSISTÉ ou SUGGESTIONS**

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| *Please list any Network-related events attended and include comments and suggestions for events which may be helpful and informative for Network members to attend in future.* |
| *Event* | *Comments/Suggestions* |
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**The fibers are oriented with diferent angles in ABaqus, and failure mechanism has been developed to shear the material. The cracks seen in** Figure 1 **are difficult to handle due to complexity of the process.**



Figure 1 FE modeling of composite machining.