Preface

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Biographical notes: Stephen C-Y. Lu is permanent holder of the David Packard Chair in Manufacturing Engineering at University of Southern California (USC). He Heads the Master of Science in Product Development Engineering program at USC. He is the founding Director of the Improving Productivity via Advanced Collaboration Technology (IMPACT) research laboratory at USC. As a pioneer of the Engineering Collaboration via Negotiation (ECN) paradigm, he has published over 300 technical papers and served on many journals' editorial boards and keynote speaker in the fields of collaborative engineering. He is the Chief Editor of the *International Journal of Collaborative Engineering*. His current research interests are in design thinking, collaborative engineering, and technological innovation.

Collaboration is the activity in which many individuals work together interdependently to achieve a higher goal than is possible for any individual to accomplish alone. The collaboration activity is as old as our civilisation. The development of human potential in any society depends on our ability to collaborate with one another; and no advancements can be possible without it. In today's highly-connected global society, collaboration has become the true fabric encompassing our personally and professional life and a ubiquitous activity underlining the success or failure of everything we do. Examples range from small projects for intellectual and business pursuits, to large-scale international efforts such as space exploration and anti-terrorism activities.

Although the concept has long been established, collaboration is often misunderstood, overlooked and poorly accomplished in practice because the scientific understanding of human collaboration remains largely incomplete. We can often recognise instances that have resulted from successful collaborative practices, but our ability to learn, teach and recreate good collaboration principles in other contexts is very limited. In spite of the rapid developments of communication and information technologies to support local and remote collaborations, we lack fundamental knowledge about the sciences of human collaboration in various professions. This limitation is especially apparent in the engineering world, where demands for more functions, higher quality, lower costs and faster deliveries increase rapidly. To remain competitive in today's global markets, companies must rely on the best collaborative engineering practice to support project teams across disciplinary, geographical and temporal boundary. Despite its importance, there is very little scientific knowledge available from research to guide engineering collaborations in industries. Experiences still play an important role in collaborative

engineering practice today; and much of these experiences are acquired and passed on in an ad-hoc manner.

The type of tasks for which collaborative engineering is most needed, and can be most beneficial, is always complex and diverse due to the following characteristics:

- The tasks are ill-defined. Their solutions depend on task formulations; hence, there are often disagreements about how to define the given task assignment.
- Due to various resource and knowledge limitations, the tasks are open-ended and characterised by technical complexities and/or scientific uncertainties.
- The stakeholders have diverse interests, expertise, and access to information about the assignment; hence, they often perceive the tasks differently.
- Several stakeholders have a vested interest in the task outcomes, and they are interdependent of each other in resources and expertise for the solutions.
- Unilateral efforts based on traditional methods to deal with the tasks have proved insufficient and have typically produced less than satisfactory outcomes.
- These stakeholders are not organised in a structured way, and they often have a disparity of power and/or resources for dealing with the task assignment.
- These differing perspectives often result in, at least initially, incompatible (or even adversarial) opinions and positions among the stakeholders.

When faced with these challenging tasks, members of collaborative engineering teams must proactively participate in making group decisions, so that everyone will have a say as well as an ultimate stake in the final outcomes. This is especially important when the task is assigned with some high-level goals only – the team must first explore and weight various opportunities to jointly define a specific problem with clear objectives and criteria to solve. Often, creative thinking and innovative proposals are needed from everyone on the team to generate new options and solutions that are beyond the experience and knowledge of any single member.

Collaborative engineering is an emerging discipline that integrates social teamwork and technical task-work to improve the quality and efficiency of group decisions by engineering teams. It is a socio-technical activity with the purpose of maximising the synergy between social interactions in teamwork and technical decisions in task-work. However, because engineering collaboration is still more of a practiced art than a scientific discipline today, teamwork and task-work integration is very hard to achieve in practice. A major road-block to the study of collaborative engineering and improvement of its practice is the lack of understanding of the socio-technical nature of group decisions in engineering teams. While traditional engineering is concerned with technical decisions by individuals, collaborative engineering must focus on group decisions by teams. Social interactions in the team will alter members' perspectives toward the given assignment, which, in turn, will change the technical decisions that members will make. This results in a highly dynamic socio-technical cycle, making group decisions in collaborative engineering teams difficult to manage and accomplish.

To overcome the challenge of group decisions, collaborative engineering teams must systematically pursue teamwork and task-work in tandem. Teamwork involves social interactions among multiple stakeholders, who have complementary backgrounds and different interests, to jointly explore various proposals, discourse their merits, and choose

a decision opportunity. Relevant social reality issues of the given assignment must be addressed collaboratively in teamwork to achieve collective rationality among interested stakeholders. This kind of problem has been studied extensively in social choice research as the multi-stakeholder choice problem. The decision opportunity chosen in teamwork then defines a decision problem, with specific objectives and criteria, which must be solved by the team in task-work. Task-work is a technical activity in engineering, in which the team must find solutions for the decision problems defined by the decision opportunity that they jointly chosen in teamwork. Relevant brute reality knowledge must now be brought into task-work for team members to find optimal solutions to complete the task assignment. For complex and diverse tasks, the decision problems to be addressed often have multiple objectives with different evaluation criteria. Therefore, task-work in collaborative engineering frequently involves multi-objective optimisation to obtain global optimality for group decisions. This type of multi-objective optimisation problems has been researched extensively in the engineering optimisation community.

The above teamwork and task-work process highlights the interdisciplinary challenge of collaborative engineering research. Both social realty, based on human preferences, and brute reality, according to domain physics, are needed. Social sciences principles are indispensible to guide teamwork with the constructionist thinking; and natural sciences knowledge is needed to accomplish team-work with the deterministic philosophy. Social interactions must be considered as an integral part of technical decisions, rather than treated as a separate management function, in order to maximise the benefits of teamwork and task-work integration in collaborative engineering. Knowledge from many disciplines outside the traditional scope of engineering, such as organisational behaviours from management, social cognition from psychology, social choice from economics, and negotiation analysis from decision science must to be synthesised to establish a scientific foundation for collaborative engineering. Scholars from these broad disciplines must be brought together with engineering researchers to pursue rigorous research and development of this emerging human-centred engineering discipline at the intersection between social and natural sciences.

The *International Journal of Collaborative Engineering* provides an intellectual platform for scholarly exchanges of ideas and results among researchers and practitioners working in the interdisciplinary areas of collaborative engineering. Its ultimate goal is to transform collaborative engineering from a black art practiced by the few today to a rigorous discipline understood by the many tomorrow. We hope that the interactions enabled by this new journal will stimulate new ideas, spearhead exciting research and generate useful knowledge so that collaborative engineering can be taught systematically at university and practiced effectively in industry in the future. We invite you to actively support, contribute and participate in this collaborative endeavour.