Aspect-Oriented Thinking

An approach to bridging the disciplinary divides

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Shayne Russell Flint
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I declare that the work in this thesis is entirely my own and that to the best of my knowledge it does not contain any materials previously published or written by another person except where otherwise indicated.

Shayne Russell Flint
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Abstract

Engineering is often described as the application of scientific and technical knowledge to solve problems. In this thesis, I support a more general view that engineering should be treated as a continuous process of learning and action that aims to make well understood improvements within dynamically complex environments of co-evolving social, man-made and natural systems. I argue that this can only be achieved by adopting an approach that systematically develops, manages and integrates the knowledge and expertise of many disciplines to conceive, develop, modify, operate and retire systems. A novel implementation of such an approach, called *Aspect-Oriented Thinking*, is presented.

Aspect-Oriented Thinking begins with the development and verification of a set of *Domain Models*. Each *Domain Model* represents knowledge about a separate, autonomous and possibly discipline specific concern or view within a given context. *Domain models* are developed by engineers, scientists, sociologists, psychologists, lawyers, philosophers, economists and others, using languages and techniques with which they are familiar. Knowledge captured in a set of *Domain Models* is then *woven* together, in accordance with a set of separately developed patterns and rules, to construct, modify, operate and retire systems, including models, hardware, software, processes and simulations. This is a continuous process which, in the first instance, involves those systems used to learn about a given context and to make decisions regarding required changes. Later, the process involves those systems used to implement and evaluate the impact of these decisions.

The significance of *Aspect-Oriented Thinking* lies in its broad applicability to any situation in which the expertise and knowledge of diverse disciplines is required to understand and make improvements within complex multifaceted environments such as those that involve sustainable development and national security.

A proof-of-concept within the context of software engineering is provided to demonstrate the mechanics and viability of *Aspect-Oriented Thinking*. The results of this demonstration are used to support an argument for future experimentation aimed at evaluating the effectiveness of *Aspect-Oriented Thinking* in a more general interdisciplinary environment.

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Preface

The research reported in this thesis started when, after 15 years experience in the software and systems engineering industry, circumstances allowed me to take an extended break from work. With support from Dr Clive Boughton, my current supervisor, I decided to use this break to undertake a post-graduate research project that would aim to improve, in some way, software and systems engineering practice.

After enrolling in a PhD program at the Australian National University I was able to embark on a long and broad exploration of what could be done to improve the ability of software-intensive systems projects to deliver the capabilities expected by stakeholders. My investigations started with the widely held view that problems related to requirements are a major cause of project failure. I studied the requirements engineering literature covering topics such as specification, modelling, measurement and capability maturity, and concluded that requirements engineering process improvement may provide a way to improve software and systems engineering practice. While considering what it meant to *improve* a process, I explored systems theory, system dynamics, decision making, organisational learning and change, socio-technical systems and ethics. I also revisited my early career as a junior engineer and military officer to reflect on success and failure within the complex socio-technical environment of modern defence.

From these explorations it became clear that industrial practice could be improved by developing and using software and systems engineering approaches that help ensure the development of capability that has well understood impacts (both positive and negative) throughout a defined environment and over time.

As these ideas formed, I was offered and accepted a position at the Australian Defence Science and Technology Organisation (DSTO). Whilst at DSTO I worked in a multi-disciplinary group headed by a linguist and comprising social scientists, psychologists, computer scientists and myself - an engineer. From this experience I realised that a multi-disciplinary team was required to fully understand the broader impact of existing, new and modified systems. Any software or systems engineering approach that focused on the development of capability with known impacts in time and space would therefore need to be interdisciplinary in nature.

It was from this milieu of exploration and experience that *Aspect-Oriented Thinking* emerged.

Shayne R. Flint
Canberra, Australia