The Multi-Disciplinary Aspect of System Development

Observations from Daily Life

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Within our daily professional lives, many of us feel that multi-disciplinary cooperation and development is a crucial aspect of the system development process in which we participate, and consider it of vital importance to the success of the developed products. In this article, I will report some observations on multi-disciplinary development from my own daily practice.

Multiple disciplines

In my current role as technology manager and project architect of the Volumetric Imaging product at the Cardio Vascular Product Management Group of Philips Medical Systems (PMS), I cooperate on a regular basis with people from the following disciplines:

- software (engineer, architect, team leader, test manager, configuration manager)
- system design (technology managers, architects, designers, norm compliance)
- image quality
- project management
- product management (neuro vascular, cardio)
- clinical science (neuro vascular, cardio, workflow), clinical application
- system engineering
- mechanical engineering
- service innovation
- pre-development (developers, group leaders)
- research

In the architectural roles I fulfill, multi-disciplinary cooperation and negotiation is daily work. More than others, architects are involved in multi-disciplinary cooperation. Even so, multi-disciplinary cooperation is regarded as something so common by many people within the organization, that it is usually not looked upon as a separate entity or activity. It is simply embedded in the organization, and naturally present in daily working life.

Multi-disciplinary cooperation

In my daily working situation, the many different disciplines cooperate via common-sense communication and negotiation. In order for different disciplines to communicate effectively, they use a shared 'language': *a language consisting of concepts, terminology, and principles that they share and understand, and that covers the topic at hand*. Typically, the shared language is naturally developed while talking about a specific problem; it is built up from concepts originating from the disciplines participating in the discussion. The developed concepts end up in specifications and designs, and thereby become the language of the team. Everyone in the team, but especially the architect, has the responsibility to keep the shared language simple and understandable for all involved disciplines. Often, drawing pictures helps in supporting the multi-disciplinary documentation or discussion. Personally, for multi-disciplinary communication, I strongly believe in the power of artistic

free-style pictures. I'm convinced that in most situations free-style pictures are more powerful than standardized (e.g., object-oriented) diagrams, especially because the free-style pictures allow you to artistically express the concepts at hand, and because standardized semantics are only remembered by experts from software development.

I often experience that people from other disciplines are very much willing to present their views in simple and understandable terminology. I remember visiting Prof. Moret, one of the world's top neuro radiologists. While Prof. Moret was at work, a colleague neuro radiologist commented on Prof. Moret's work. He used terminology he knew we would understand - similarities between plumbing and Prof. Moret's life-saving work were regularly made. I'm convinced that people who really know what they are talking about, are also able to express their ideas in simple down-to-earth terms. Keeping it simple is a key to success.

In general, in system-level requirements documentation and corresponding discussions, I try to keep everything understandable for all involved disciplines. I thereby avoid having to actively maintain different views on the same topic for different stakeholders - this reduces maintenance work, reduces inconsistencies, and stimulates discussions between the involved disciplines.

Uni-disciplinary cooperation

Nearly all the decision making teams in which I cooperate consist of people from different disciplines. However, even in case people belong to the same discipline, they typically have a different area of expertise, or they play a different role in the development process. For example, in our software team, we have experts in the following areas of expertise: platform, processing, and viewing. All three areas have their own concepts, terms, and corresponding technologies. So, even though all three areas of expertise are represented by architects from the same discipline, i.e., software, the area of expertise differs significantly. Consequently, for me, as project architect, the cooperation with these three software architects has many similarities with true multi-disciplinary cooperation.

Avoid walls between disciplines

It is of importance that the different disciplines do not create isles of isolation. They have to be open to each other, and depend on each other. As an architect, you sometimes notice signals of isolation; at that point stimulating the multi-disciplinary communication is important. Furthermore, the project organization can have a major impact on inter-disciplinary communication. Often, projects are organized as a collection of subprojects, one for each discipline. In many situations it would be preferable to organize projects according to the components defined in the system architecture, thereby grouping disciplines working on the same component in one team. This has been illustrated in Figure 1.

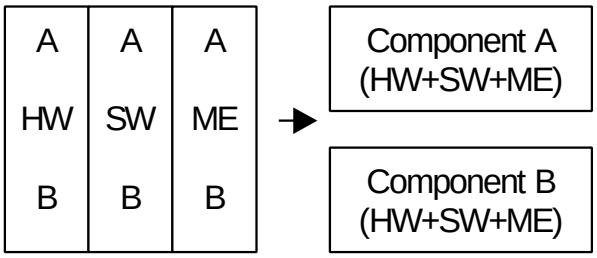

Figure 1: Reorganizing projects from a discipline-oriented structure to a component-oriented structure.

Experts on key technologies

For many products, including most of the medical systems that PMS develops, the success of a product often depends on achieving excellence in a few key system aspects. These system aspects usually are of a multi-disciplinary nature. Cardio Vascular uses an organizational structure in which individuals, called Technology Managers, are assigned to carefully selected key aspects of the system. I fulfill this role for all technologies related to Volumetric Imaging. This approach works well: it leads to focus in the organization and stimulates multi-disciplinary development in key success factors of the product family. On a smaller scale, we use the same approach. We have, for example, a team that specializes itself in 3D image quality and builds up multi-disciplinary knowledge on a critical system aspect.

Multi-disciplinary design methodologies

Even though, in my daily work, I cooperate with people from many different disciplines, I must say that we do not use any structured multi- disciplinary design methods. This is not surprising - in our team, one *development* discipline dominates: software. Teams in which multiple development disciplines (hardware, mechanics, software) coexist, and in which success depends on intensive and carefully balanced interaction between the parts developed by the different disciplines, could very well benefit from such techniques. However, I'm not aware of any development team that uses design methodologies tailored for multi-disciplinary development in practice. Some opportunities in this area might be:

- **HW/SW co-design and implementation**
  During my period at CERN, I ran into Handel-C, a programming language and toolkit enabling hardware/software co-design and implementation. It allows easy migration of code between software and FPGA firmware.
- **Multi-disciplinary modeling and simulation**
  For mechatronical designs, I can imagine that modeling hardware, software, and mechanics in a single simulation model would allow for even more advanced systems to be designed, and to be tested beforehand. Considering the pressure towards more and more integrated systems, I expect that such approaches will be picked up in the near future.

Conclusions

Summarizing, I see that:

- Multi-disciplinary cooperation occurs via simple down-to-earth negotiation and cooperation.
- The language understood by all disciplines, consisting of concepts, terminology, and principles, grows together with the product.
- Uni-disciplinary cooperation can have strong similarities with multi-disciplinary cooperation when the areas of expertise differ significantly.
- Avoid isles of isolation. Consider reorganizing projects to combine cooperating disciplines to component oriented teams.
- Assign people to multi-disciplinary key aspects of your product line.
- Multi-disciplinary design methodologies are little used. They will become more important.

About the author

Dr. ir. Marcel Boosten MTD is Volumetric Imaging Technology Manager at the Cardio Vascular Product Management Group of Philips Medical Systems. In this role, he is responsible for the technological aspects of one of the key success factors of the Cardio Vascular business. Since 1994, Marcel holds a M.Sc. in computing science from the Eindhoven University of Technology. In 1996, he finished the post-master program in software technology (OOTI). He holds a Ph.D. in software design for work performed at CERN, Geneva, Switzerland. Since 2000, he works for Philips Medical Systems.