

Business plan for Infofusion 2014–2019

Attachment to UMIF Annual Report 2012

Infofusion is a research program in Information Fusion that has been active at the University of Skövde since April 2005. This document describes the achievements of the program so far and the long-range Vision of where we want to be with the research program for 2019, with some goals to achieve for 2014 to move in this direction. The achievements section is followed by a bulleted list of achievements within Marketing (Impact), Scientific, Financial, Collaboration, and Organizational Integration headings.

Summary

As more and more data and information becomes available in strategic areas like business intelligence, public security, health care, food production, and energy management, the ability to turn unlimited amounts of available data and information into selective situation pictures for decision support is becoming a prerequisite as well as a success factor. *“Information fusion is the study of efficient methods for automatically or semi-automatically transforming information from different sources and different points in time into a representation that provides effective support for human or automated decision making or analyses thru provision of understanding.”* Initial funding from the Knowledge Foundation for a research profile in the period 2005 to 2011 and for the research profile+ UMIF in 2011 to 2014 has created the foundation for establishing an Infofusion Center of Excellence for High-level Information Fusion, with a vision of being among the world leading centers by 2019, with a focus on a broad range of decision support applications in *strategic civilian as well as defense and security domains*. Core research areas within the center include *anomaly detection, uncertainty management, interactive visualization, and situation/impact assessment*. We believe that a step toward this goal can be taken with an application for a multi-disciplinary TEMA project in the Knowledge Foundation Center. Such a TEMA has multiple information fusion activities, where all activity partners contribute to the shared TEMA area.

INFOFUSION 2005-2012 ACHIEVEMENTS

The University of Skövde applied, in close collaboration with 15 companies and in response to a call from the Knowledge Foundation, in 2004 for a funded research profile (*forskningsprofil*) in Information Fusion. The application was approved and the profile project was scheduled to run between 2005 and 2011.

The Executive Committee of the Infofusion program immediately decided that the scope of its work should extend beyond the approved profile project, and focus on developing the entire research area of information fusion. The implication of this decision was that several other activities related to the information fusion area were coordinated by the executive committee. The term “The Information Fusion Research *Program*” was adopted to acknowledge this extended scope, and the program was later given the short name Infofusion.

In 2011, a funding application was made to the Knowledge Foundation for a Research Profile+ project called “Uncertainty Management in High-Level Information Fusion” (UMIF), dnr 20100320. Funding of MSEK 10 was granted for 2011-10-01—2013-09-30, with an extension of certain activities in the project until 2014-03-31.

The UMIF project consists of ten work packages (WP), corresponding to the “UMIF task concept” mentioned in the UMIF project contract. The first of these was the

pre-study work package (WP0: UMIF pre-study), which was completed in 2011-10-01—2011-12-31. During the pre-study, which included a project-wide workshop, the remaining work packages were defined. Three of these are research area oriented (WP1: Uncertainty Management Methods; WP2: Visualization & User Interaction; and WP3: Impact analysis and Anomaly Detection), corresponding to the three research areas mentioned in the UMIF project contract, page 4. The intersection of these research areas define the research questions of UMIF, to be studied in concert with each other and each of the industrial application domains.

Four of the work packages are application domain oriented (WP4: Threat Evaluation; WP5: Assisted Driving; WP6: Anomaly and Situation Detection for Traffic Safety; and WP7: Model-Based Optimization), and are carried out in close cooperation with our partner companies. The final work packages are a research prototype (WP8: Demonstrator Platform), and a dissemination work package (WP9: Dissemination), where the latter is integrated with each of the other work packages.

Thanks to the investment from the Knowledge Foundation, senior researchers at the university, from various backgrounds not necessarily associated with information fusion, have contributed to a more integrated understanding of the information fusion problem in collaboration with research staff at partner universities. The Skövde perspective on information fusion is a broader application of high-level information fusion models and techniques to a wider range of application problems compared to the traditional approaches in this field. Our innovative approach has enabled us to identify two white spots in the field of information fusion. First, the research in high-level information fusion is relatively immature compared to the more established low-level sensor-data fusion. That implies that systems currently can identify interesting objects and track their behavior over time (low-level fusion), but that translating this behavior into understanding of situations and possible future impacts is hard (high-level fusion). Besides, the large majority of applications are still defense oriented. We include defense oriented and civilian projects in our project portfolio to enable learning from the latest trends in the field, and our interest is to widen these methods and techniques into other applications like business intelligence, health and elder care, transport, security and safety, education, sports, agriculture, automotive engineering or energy management.

The research profile budget was approx. 20 million SEK per year, with one third of the budget from the Knowledge foundation, one third from participating companies and one third from university funding. The budget of the research profile+ UMIF is around 8 million SEK per year, with almost two thirds from the Knowledge foundation and one third from participating companies and university combined.

The research profile generated 14 PhD degrees in information fusion, and an additional 3 PhD students are about to get their PhD degrees in associated projects. These young talented researchers are a key resource in the further development of the research program into a successful Center of Excellence.

The program contains both basic research oriented projects and application oriented projects. Some of earlier projects have had problems in either identifying a clear business value when applying information fusion or in realizing the applications in practice due to a lack of prerequisites (e.g. availability of data, quality of data, and availability of technological infrastructure). These cases have been insightful to grasp the complexity of the information fusion problem as well as to inform the design of future projects. The advisory board has repeatedly signaled that the ambitions of the program are high with respect to the available resources. Good achievements have been made within most projects and within each scenario, but that the integration between them in the form of derivation of general lessons learned has been tough. In all application scenarios and

projects the main human resources have been PhD students. They have performed well within their respective projects and almost all of them plan to finish their dissertation on time. However, it is hard for junior researchers to contribute to the derivation of general lessons learned across scenarios and projects, especially in the early stages of their projects. Senior researchers have been mainly involved in supervising PhD students, managing the program and attracting future funding.

Infusion is not yet a world-leading international Center of Excellence, but we are confident that we can become one within the coming 6 years. Some of the identified success factors for continuing growth are a larger participation of senior researchers in combination with PhD students and post-docs, and a stronger relation between research goals of individual projects and the overall research program. The fact that we have attracted two adjunct professors, have recruited two assistant professors and are recruiting one (or more, if funding permits) additional assistant professors in Informatics with specialization in Information Fusion should strengthen this outlook.

Infusion achievements 2005-2012 in bullets

Marketing (Impact) achievements

- Members of the program have continuously presented ambitions and achievements of the Infusion program in their own organizations, for Swedish industry, for the general public and for the international research community.
- Infusion is recognized as a key element in the research strategy of the University of Skövde.
- The program director is a Member of the ISIF Board of Directors, where ISIF is the International Society for Information Fusion organizing the annual Fusion conference.
- Several UMIF members of “The Evaluation of Technologies for Uncertainty Reasoning Working Group” (ETURWG), an official working group of the International Society for Information Fusion (ISIF) since 2011. The group provides a forum to address issues and coordinate with researchers in the area, and to evaluate techniques for assessing, managing, and reducing uncertainty.

Scientific achievements

- The Infusion research program has produced 241 publications in journals and conferences during 2005–2012 (2 book chapters, 33 journal articles, 14 theses, 183 international conference papers, and 9 other reports), including 38 papers in the ISIF flagship International Conference of Information Fusion (Fusion 2005–2012).
- There are currently 6 PhD students involved in the program, and 14 PhDs in information fusion have graduated from the program so far. Of the currently enrolled PhD students, 2 are late hires in the profile and 4 have recently been hired in associated projects. Of these students, 3 are expected to finish in the near future.

Financial achievements

- The total budget of the program has been MSEK 120 for the research profile and MSEK 16 for the research profile+ UMIF. For the research profile, one third of the budget came from the Knowledge foundation, one third from participating companies and one third from university funding. For the research profile+ UMIF, almost two thirds came from the Knowledge foundation and one third from participating companies and university combined.
- Additional external funding of approx. MSEK 68 has been secured for Infusion Associated Projects, with an average of MSEK 14 per year in the 2-year period from 2012 to 2013 (see chart “Infusion Funding Prognosis” at the end of this

document). Applications for an additional MSEK 56 in external funding have been submitted, and additional substantial funding applications are planned in 2013.

Collaboration achievements

- Collaboration with 15 companies at various times has been realized.
- Through intense participation in the annual Fusion conference and the organization of our own yearly SWIFT conference relations with international research groups and Swedish research institutes are developed.
- When writing and submitting research funding proposals contacts with collaborating companies, Swedish research institutes and international research groups are utilized. In most of the applications external parties participate.

Organizational Integration achievements

- Information fusion is an integral part of each of the three main Research Centers at the University of Skövde and as a result a major element in the Knowledge Foundation Center (*KK-miljö*) at University of Skövde

VISION FOR 2019

The University of Skövde is establishing an Infusion Center of Excellence for High-level Information Fusion, with a vision of being one of the leading European center of excellence within high-level information fusion and perhaps among the world leading centers by 2019, with a focus on a broad range of decision support applications in strategic *civilian as well as defense and security domains*. Core research areas within the center include *anomaly detection, uncertainty management, interactive visualization, and situation/impact assessment*. The center includes public and private partners, nationally and internationally, that have a strategic interest in applying information fusion methods and techniques, and is a virtual collaboration entity beyond the organizational borders of the individual participating partners. Researchers within the excellence center conduct basic and applied research. The center is among the ‘first to call’ for organizations in Europe that face high-level information fusion problems, and is involved in a European consortium of such fusion centers of excellence. Researchers from the excellence center are ‘first to cite’ on the five key research areas. The center is self-sustainable both in form of human resources (producing new PhDs and attracting students and faculty externally), and financial resources (attracting so much attention and funding that projects naturally want to become part of it). In other words, the center has attained “critical mass” and with sustained growth. Strategic collaboration with other world leading high-level information fusion research centers exists by means of regular exchange of key researchers, common research strategies, collaborative funding applications, collaborative research projects and collaborative publications.

The Infusion Center of Excellence for High-level Information Fusion at the University of Skövde is a central element of the university’s research strategy. The center can either be a virtual entity with members from different participating organizations (e.g. University of Skövde, Gothenburg Science Park, Linköping University, FOI, Fraunhofer-Chalmers Research Center, Fraunhofer FKIE, and CMIF as well as the participating companies) hosted by the University of Skövde or organized as a research center within the University of Skövde.

GOALS FOR 2014

In 2014, when the UMIF project ends, we want to be one step closer to a leading Infusion Center of Excellence for High-level Information Fusion. This implies utilizing our main achievements and reaching for the ambitions that not yet have been achieved in

the first 8 years of the program. One path to achieving this is as a TEMA application. A multi-disciplinary TEMA project in the Knowledge Foundation Center would have multiple information fusion activities, where all activity partners contribute to the shared TEMA area. This funding strategy allows us to include activities with funding from other funding agencies and still be a major player in the Knowledge Foundation Center.

The TEMA application continues the successful research work of the Infofusion profile and the UMIF profil+, and will be applied for in June 2013 within the Knowledge Foundation Center. Activities in the TEMA consist of Knowledge Foundation financed activities such as HÖG projects and ProSpekt, Strategic recruiting, Expert competency for innovation (e.g., a prestudy), a SIDUS project currently applied for (Internet of Sports) and industrial PhD students (within ApplyIT industrial research school), but also with projects in the information fusion area with other types of funding, such as existing projects and applications with partner companies in NFFP, FFI, and FORMAS. An interesting feature of the TEMA concept is that all activity partners in the information fusion activities contribute to the shared TEMA area, with 10 – 50 % of their project budget. This means that the funding agency the university, and the partner companies contributes and share in the TEMA area to the same extent, and need to judge the value of participating.

The research direction of the Infofusion research program is primarily connected to the prioritized collaboration area “Development and use of decision support technology”, but is also connected to the prioritized collaboration areas “Serious games and Gamification”, “E-health and assisted living” and “Manufacturing”. In general, our goal is make Information Techniques more known and to widen the use of IF to new problem areas, leading to new knowledge and methods in Information Fusion.

The most prioritized goals for 2014 are:

- The core research areas in high-level information fusion that our center will focus on are further refined. Position articles for each area should be published in international journals.
- The number of companies actively involved is increased from the current research program.
 - The satisfaction and interest in continued collaboration has been sensed with a web-based questionnaire, and will be followed up by direct contact with current and past, as well as some new, industry collaboration partners.
- Each key research area and each application domain include at least two senior researchers who are at least 40% of their time actively participating in research (besides supervising PhD students and managing projects/scenarios/program).
- In each key research area there should be a minimal amount of basic research (one PhD project), besides contributions from application scenarios.

From a scientific perspective the coming year are crucial in positioning ourselves. Having gathered numerous experiences from basic research projects and application research projects we have the material to point out where we are unique with respect to the international information fusion community. In 2014 we need to have refined and positioned our key research areas clearly by means of describing Skövde’s unique contribution compared to other international research groups and by identifying challenges in a future research agenda with a focus on a broad range of decision support applications in strategic civilian as well as defense and security domains. To strengthen our scientific position in the core research areas within the center (including anomaly detection, uncertainty management, interactive visualization, and situation/impact assessment), we aim to publish two positioning articles concerning each of them.

From a marketing perspective the goal is that relevant local companies as well as the major companies in Sweden in 2014 know what High-level information fusion is, and what benefit it can have for their business. From a recruiting perspective, it is important that we continue and upgrade the Information Fusion course for PhD students, including an advanced version. From a marketing perspective, this shows that Skövde is the place to study Information Fusion and to assure a supply of future researchers.

From a financial perspective the main goal is to have guaranteed funding for the amount of senior researchers as stipulated earlier in this chapter. Besides, it is very important that a new generation of at least 8 PhD students be funded (at least 1 per research area and 1 per application scenario), as well as post-docs or a proper mix.

Next, we aim to have 'letter of intent' agreements with the major actors in (high-level) information fusion in Sweden and centers of high-level fusion internationally on long term strategic collaboration. As the exact form of this collaboration may need to be developed towards 2019, a good relation should have been established by 2014.

Some final action points are to continue work on the SWIFT workshop on Information Fusion Topics (SWIFT 2013) and consider starting a series of "Critical Issues in IF" workshops, with a focus on Scandinavian participation or perhaps a Northern European focus, at the suggestion of IFAB (this may be achieved by including more government/funding and industry involvement in SWIFT). Further to identify and build a relationship with strategic partners in Scandinavia (to join the excellence center) and internationally (for strategic collaboration on high-level information fusion research agenda), to take advantage of the unique research building "Portalen" that gives us close-up access to Gothenburg Science Park and employees in companies in the science park within a creative and supportive environment.

Infusion Funding History and Prognosis for 2013 – 2020

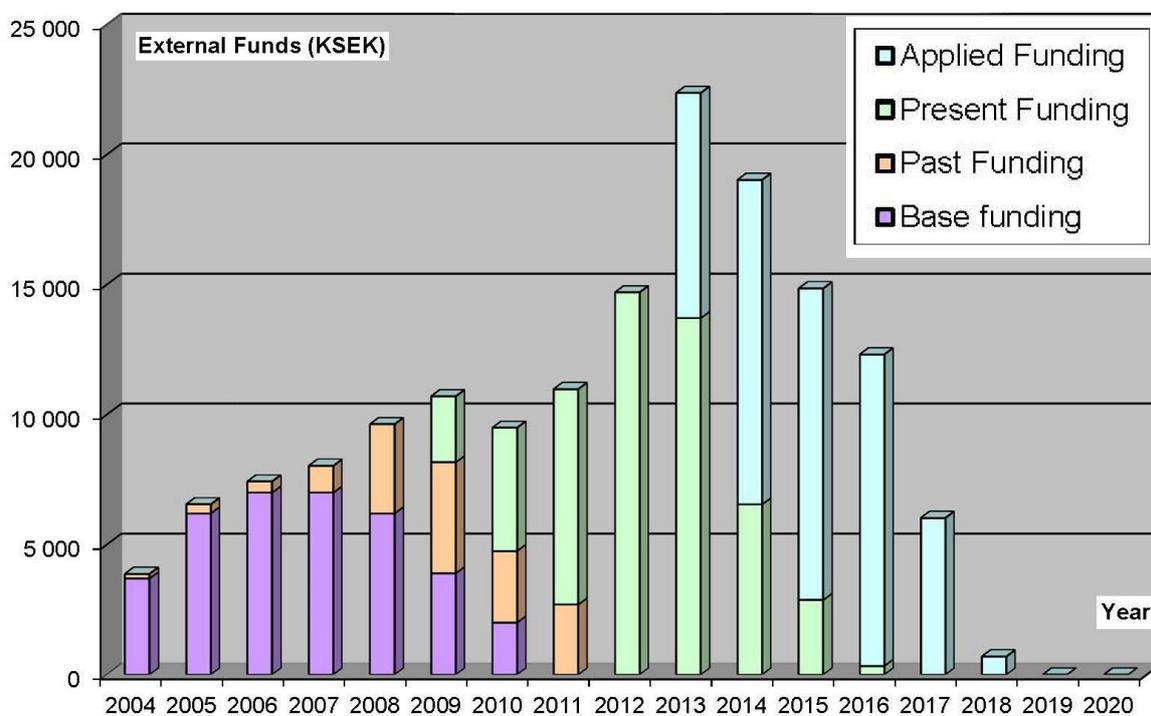


Figure 1: Prognosis based on secured (green) and submitted funding applications (blue)