

# Data Intensive Applications (DIA+) — Project Plan

## 1 The focus of DIA and the addressed scientific and industry-related needs

The research school Data Intensive Applications (DIA, [lnu.se/en/dia](http://lnu.se/en/dia)) addresses current and future challenges of smarter industrial and business systems focusing on data intensive core sciences, and their applications in system and software engineering. Mastering these challenges requires cross-disciplinary research and development (R&D) of experts in the core sciences (data science, statistics, mathematical modelling, simulation) and in (mechanical, system, and software) engineering. It also requires cutting edge research competence and practical experience and know-how at the same time. To this end, DIA brings together mathematicians and data scientists with engineers, academic researchers with developers and managers in industry, and research methods with concrete real-world challenges, (big) data, and practical experiences. Thus, DIA leads to excellent applied, multidisciplinary research and outstanding product, service, and system development. Neither side can achieve this alone and in isolation: our applied researchers need data and challenging application cases to validate their theories, while our industry partners benefit from R&D divisions extended by academic researchers contributing to and exploiting the relevant research frontiers.

### 1.1 The main focus of the existing industry graduate school DIA and its progression

**The main focus of DIA** Cyber-Physical Systems (CPS) are interconnected systems of physical assets and computational capabilities. CPS, the internet of things (IoT), and cloud-computing have resulted in a ubiquity of sensor, computing, network, and storage systems and give access to previously unprecedented amounts of data. Artificial Intelligence (AI) turns it into actionable knowledge and machine processable information to build resilient, self-adaptive, self-optimizing, self-aware systems, i.e., smarter systems. Integrating smarter systems in production, logistics, and decision making, in products and services has significant economic potential and will disruptively change industry and business, but also adds new challenges to system development, maintenance, and operation. DIA contributes to this change addressing the connected challenges in concrete cases of our industry partners making real world systems smarter and advancing the state of the art as well as the industry capacities in the relevant data intensive core technologies, especially, in IoT, Digital Twins (DT) and simulations, deep and statistical machine learning (DL, ML), computer vision (CV), natural language processing (NLP), and visual analytics (VA).

**Progression of DIA** Ph.D. modules constitute the core of our research. They consist of a Ph.D. student employed at a partner company, supervisors from that company, and a cross-disciplinary supervisor team from the research groups of the Linnaeus Center of Data Intensive Sciences and Applications (Lnuc DISA, [lnu.se/en/disa](http://lnu.se/en/disa)). The on-going R&D efforts explore data intensive technologies and methods and exploit them in the (engineering of) smarter systems owned by our industry partners. At *Combitech*, we develop virtual ecosystems for smart sustainable neighborhoods. At *SKF*, we get closer to a smart, fully automated factory producing 24/7 without human supervision by (i) calibrating quality measurement using unsupervised ML, (ii) visual quality assessment using supervised DL and CV, and by (iii) developing a generic server-based ML and Operations (MLOps) infrastructure. At *Softwerk*, we make wood production chains smarter by recognizing log end fingerprints and by predicting properties of logs using DL and CV. At *Virtual Manufacturing*, two Ph.D. modules contribute to smarter automated production lines by developing DT as a service, and by exploring their prediction and optimization for lean productions (tested and applied in Scania's production lines). At *Volvo Construction Equipment (CE)*, two Ph.D. modules develop smarter CE with AI based software applications for (i) estimating mechanical damage in CE using DTs, (ii) giving feedback on the behavior of CE to drivers based on sensor data, and (iii) recognizing clogging in the exhaust gas system of CE. Also, we analyze maintenance protocols using NLP for (iv) smart predictive maintenance and (v) optimal selection and usage of CE on customers sites. At *Electrolux Professional*, we use NLP to analyze service requests and maintenance visits for smarter maintenance of industrial washing machines to (i) decide if a technician needs to be sent, (ii) predict the needed equipment and qualification, and (iii) help with the diagnosis. At *HL Design*, we develop a multi-shop concept, that finds DTs of existing Web shops to extend the decision basis and to avoid the cold start problem in smart recommendations. DIA even hosts two Ph.D. modules in e-health not funded by KKS but by Region Kalmar who (i) develop smarter systems in e-health to automatically generate ML features from medical quality registries for quality analysis and (ii) investigate the effect of digital anamnesis and e-triage on the quality of the patient-carer relations. Altogether, the collective outcome of our R&D projects advances the state of the art in data intensive applications and validates fundamental results of data intensive core sciences.

*Formal admin:* Starting in Mar. 2020, DIA enrolled 4 Ph.D. students in fall 2020, 4 in fall 2021, and 1 in Dec. 2021. We signed agreements with the partner companies and KKS and set up Individual Study Plans (ISPs) for all Ph.D. students who are progressing as planned; we updated and approved their ISPs annually.

*Organization:* We built the organizational structure as planned, cf. Section 4, and established recurrent meeting series for internal communication on all levels. We routinely run the recruitment and on-boarding processes with new partner companies and Ph.D. modules. In addition to their own equipment in the partner companies, DIA Ph.D. students have now access to DISA's experimental hardware labs: the IoT lab and the High-Performance Computing Center (HPCC) to test results and ideas in controlled environments.

*Events:* We routinely run the planned activities, cf. Section 3.2.

*Curriculum development:* DIA developed the first structured Ph.D. curriculum at the Faculty of Technology (FTK) at Lnu, which is taken by our industry Ph.D. students as well as by regular Ph.D. students, cf. Figure 1.

*Course development:* DIA offers 3rd cycle courses comprising 100 ECTS credits, cf. [lnu.se/en/dia](http://lnu.se/en/dia).

*We consider DIA to be a good way towards a permanent industry graduate school with excellent applied research (education) in smarter systems (engineering) funded by Lnu, companies, and public organizations.*

## 1.2 Added value that DIA+, the second intake, contributes to DIA

**For the industry** *DIA+ will make the difference between successful individual Ph.D. projects and a sustainable change of the R&D strategy of the industry utilizing Lnu as a natural partner for their strategic growth and development, which is crucial for the evolution and the prostration in and beyond the Linnaeus region.* In general, technical and product-oriented R&D facilitate renewal and the companies' long-term competitive conditions.<sup>1</sup> Thus, DIA+ amplifies, extends, and adds value to industry R&D in smarter systems (engineering). We always strive for a maximal alignment of the research focus in the individual Ph.D. modules with the R&D objectives of the respective partner company, which adds a clear practical value to the industry partners. We showed that co-produced, applied research can effectively contribute to their own efforts and goals. This will continue to lead to many additional collaborations beyond DIA+. Moreover, we observe great synergy between the participating companies, e.g., direct business relations, common courses of PhD-students and their industry supervisors, and common conference visits. This is of great value for in-house competence development. Finally, we observed in the recruitment process, applicants more qualified than R&D positions in industry usually attract. This complements in-house competence development. Several companies of the first intake are interested in extending their engagement with new modules in DIA+. This confirms the envisaged and experienced added value for our partner companies.

**For Lnu** *DIA+ will establish the prerequisites for Ph.D. modules funded by industry as a fundamentally new Lnu financing strategy complementing research funded by faculty and national and international organizations. This will generate excellent applied research results and trigger further external funding and, thus, making Lnu a very attractive academic environment for the future recruitment of excellent researchers.* DIA+ adds values by (1) more applied research that generates real impact on society, (2) a stronger consortium of partners that know each other and have a high level of trust. This leads to (3) more relevant research topics, (4) research proposals with intense collaboration between academia and industry, which in turn leads to more external funding opportunities, and (5) a growth of research without additional public funding. For our junior researchers, (6) being involved in the Ph.D. modules gives them experiences in supervising Ph.D. students and collaborating with industry, which in turn helps them to grow as researchers. The second intake will also give us the opportunity to (7) further develop and refine our processes and methods for coordinating an industry research school and to (8) strengthen the general research education at FTK.

**For both sides** *We believe that DIA+ will make the difference between successful but timely limited projects in data intensive applications and a permanent and institutionalized industry graduate school in smarter systems (engineering).* DIA+ will raise the maturity level of industry leading to a continuous intake of new industry Ph.D. students fully financed by companies. It would be a win-win for both industry and academia. Industry would continue building up competitive competences in-house. For academia, it is a new way to sustainably fund applied research. Hence, a second intake would be a steppingstone towards building a permanent industry research school.

<sup>1</sup><https://www.vinnova.se/en/publikationer/strategiskt-fornyelsearbete-inom-svensk-industri/>

### 1.3 Changes of the main focus in connection to a second intake

Data intensive sciences, technologies, and methods constitute the core of the applied research within DIA. This continues to hold even for a second intake and beyond. However, DIA observed already in its first intake a broadening of the application areas, from smarter CPS to *general smarter systems* supporting industry, business, and even e-health. Due to common core technologies, we observe good synergies between the Ph.D. students, the academic supervisors, and the company supervisors. The common ground are these shared technologies. Different application areas contribute rather to inspiration than to misunderstanding and confusion. This is a learning from the discussions at the Big Data conference series and on the DIA advisory board and became most evident during our AI for managers course which has also been taken by several company supervisors. Therefore, we will continue focusing on the data intensive core sciences and technologies applied to smarter systems (engineering) but, we will not enforce CPS as the sole type of systems to apply them to. Broadening the verticals of the companies that participate will lead to unexpected synergies, cross-organizational learning between companies widening their perspectives. This will benefit the development of the individual companies, DIA, DISA, and Lnu, as well as their Ph.D. students, researchers, developers, engineers, and executives.

Also, Lnu DISA built stronger research collaborations nationally and internationally and will continue to do so. DIA's Ph.D. modules will benefit, especially from the national DISA collaborations by including senior researchers from other Swedish universities and RISE in the supervisor teams to supplement the competence of Lnu's supervisors, but also to build stronger networks for both the Ph.D. students and their industry and academic supervisors.

### 1.4 Contributions of stakeholders and their complementary competencies

**Lnu** The researchers and supervisors at Lnu contribute with multidisciplinary supervisor teams providing the appropriate competence and scientific tools and methods that the Ph.D. modules need to address the industry R&D challenges and goals in a scientific way and applied to the specific context in their respective company.

*Courses and curriculum* provide structured 3rd cycle education, in the foundations of data intensive sciences and technologies, in (engineering of) smarter systems, in research methodology and methods, information search and retrieval, writing scientific texts, reviewing etc. DIA's cohesive curriculum for this education, cf. Figure 1, guarantees quality of and progression between individual courses. Lnu developed and will further develop missing courses of the Ph.D. curriculum; cf. the original DIA proposal for the "Short description of courses that will potentially be developed". This work and the Ph.D. program are embedded in the academic and administrative infrastructure at Lnu. Also, Lnu provides the formal 3rd cycle education program and examination rights and the administrative structure for developing, approving, and quality assuring Ph.D. courses and individual study plans, meeting rooms, lecture halls, etc.

*Research and development:* Lnu contributes with senior research and supervisor competence and concrete collaboration in the industry Ph.D. projects. Ph.D. students are supervised by multi-disciplinary supervisor teams from Lnu. Researchers/supervisors collaborate in the industry Ph.D. projects and contribute to data intensive core technologies, e.g., in deep machine learning, and to application domain specific competence, e.g., in mechanical engineering. They guarantee an embedding in larger research groups and are responsible for the scientific relevance of the individual research questions and the scientific quality and publication of the results. This benefits the individual Ph.D. modules and increases the attractiveness of Lnu for companies seeking research collaboration.

*DIA as a permanent research school:* With DIA+, Lnu will create the organizational and financial prerequisites to continue DIA even beyond the period of direct funding from KKS.

**Partner Companies** have different business areas, interests, and focus, but they share many similar basic issues, challenges, and goals that lead to synergies, either indirectly via the supervisor teams or directly through dialogue and collaboration between the Ph.D. students and their industry supervisors of different companies.

*Courses and curriculum:* Our industry partners lead the joint work of defining needs for competences and contribute to the joint work of defining and developing missing courses and putting them together to a curriculum. They contribute with complementary lectures and seminars both as part of the Ph.D. curriculum and outside reaching students and researchers outside DIA and the general society. This is closely connected and synced with the KKS Expert Compe-

tence project Smart Industry where the competence needs of companies are turned into courses for a broader group of professionals. These courses are also taken by DIA Ph.D. students or their supervisors in industry.

*Research and development:* Our industry partners define problems and contribute with the resources needed to conduct the development in the projects, guarantee relevance, and establish them firmly in their respective organization. This includes resources needed to prototypically implement research project results, define operational goals, and evaluate them in real-world settings and on real-world data. It also includes engineering and management competence in their respective industry. Every Ph.D. student is supervised by at least one supervisor from the respective industry partner. They are responsible for the industry relevance of the individual project goals and the applicability of the results.

*DIA as a permanent research school:* We observed great commitment of DIA partner companies in the recruitment of new partners during the first intake but also before this application; we expect this to continue. Spin-off projects and other initiatives contribute to a constant need of new industrial Ph.D. students and a permanent industry grad school.

**Ph.D. students** Senior employees at the company and newly recruited talents contribute with their unique competences to interesting *courses and to the curriculum*. They constitute the core workforce in successful *research and development* projects. As a result of the Covid pandemic, the recruitment of Ph.D. students was delayed. Smaller groups that started their studies at different times demonstrated positive effects of a continuous enrollment: those who have started earlier supported those who came in later with tips, advice on courses, balance between academic requirements and direct benefit to the company etc. This formed our ideas of organizing *DIA as a permanent research school* with continuous annual intakes.

## 2 Expected results and effects

DIA positively impacts the involved organizations (Lnu, partner companies) and the careers of their employees (researchers, developers, engineers, Ph.D. students, executives). DIA contributes to short- and long-term goals of Lnu and will remain relevant for the partner companies throughout and beyond DIA+.

### 2.1 Goals for the university

**The Linnaeus University Center<sup>2</sup> for Data Intensive Sciences and Applications** (Lnuc DISA) was reviewed by independent external and internal reviewers after five years (in 2021) and granted continued funding for (at least) another five years (in 2022). In both the review of results and the next five-year plan, DIA is central to DISA's applied research (education) in smarter systems (engineering). DIA is the link between research and education and between academia and industry, for DISA as well as for Lnu's Knowledge Environments Digital Transformation<sup>3</sup> and Green and Sustainable Development<sup>4</sup>. The consolidated research performed by DIA's Ph.D. students also advances the state of the art in smarter systems. It will open new avenues for future research and raise new research questions. DIA sets prerequisites to continue generating more high-quality scientific publications, more collaborative research projects with high industry relevance, and more external funding.

For the fundamental research in smarter systems (engineering), DIA and its industry projects provide an invaluable source of real-world data and scenarios to validate the theoretical research that otherwise only could have been validated under lab conditions. It also leads to closer collaborations between the DISA core departments Computer Science (CS) and Mathematics (MA), and the DISA engineering departments in Mechanical Engineering (ME), Forest and Wood Technology (FWT), and Building Technology (BT). Moreover, DIA increases the maturity of researchers at Lnu in collaborating with the industry, in long-term commitments to Ph.D. projects with commonly supervised Ph.D. students. This leads to a better understanding of R&D needs in industry and their practical constraints.

*Operational goals:* Successful DIA+ research will lead to one level 2 plus around five level 1 journal or conference publications for each of the 11 new Ph.D. modules by the end of 2028. Each Ph.D. module will generate at least one externally funded research proposal by the end of 2028 and at least 1 M.Sc. thesis per year under 2023–2028.

<sup>2</sup>Research environments of the highest quality, both nationally and internationally recognized, are designated Linnaeus University Centres.

<sup>3</sup><https://lnu.se/en/meet-linnaeus-university/knowledge-environments/digital-transformations>

<sup>4</sup><https://lnu.se/en/meet-linnaeus-university/knowledge-environments/green-sustainable-development>

**Faculty of Technology** DIA extended the Ph.D. level course offering of the CS and MA departments and improved and structured their research education. A common research education in smarter systems (engineering) is clearly in line with the visions and strategy of Lnu and its Faculty of Technology (FTK). DIA provides the first structured, cohesive third cycle education curriculum at FTK and DIA+ will develop it further. Also, the DIA curriculum provides a research continuation for the 5-year's M.Sc. programs<sup>5</sup> in Software Technology and in Technical Mathematics. DIA triggers direct collaborations between researchers of all FTK departments, especially CS, MA, ME, FWT, and BT.

*Operational goals:* DIA has enrolled 20 (incl. 11 DIA+) industry Ph.D. students by the end of 2023. FTK has approved the general study plan (ASP) for doctoral studies in Computer Science with a specialization in data intensive smarter systems by the end of 2024. 4 Ph.D. students defend their thesis by the end of 2025, 5 by the end of 2026 (all from the first intake), and 11 by the end of 2028 (from DIA+). DIA is funded and continues as the institutionalized graduate school of DISA and the CS department after 2028.

## 2.2 Relevance for partner companies

**Research and Development:** Industry partners are facing similar challenges in exploiting data intensive sciences and technologies for building smarter systems in a smarter way. It is their overarching R&D goal to address them, individually in the respective Ph.D. projects and altogether in DIA. More specifically, DIA is relevant for:

*Competence:* Partners explore and adopt technologies, such as digital twin, predictive maintenance, and scientific ML, for solving concrete problems in the development, maintenance, and operation of their smarter systems.

*Strategy:* They put together individual projects, solutions, and improvements to a common strategy towards smarter systems (engineering); define and get started with concrete pilot projects, set expected outcomes, define a structured systematic roadmap, and continuously implement it and adjust it to new challenges and opportunities.

*Results:* They create new services, products, platforms, and ecosystems basing on and exploiting smarter systems.

**Full exploitation of opportunities offered by Lnu:** By mastering these industry challenges in the research modules, DIA increases the relevance of academic applied research in smarter systems for our industry partners. DIA concentrates and formalizes collaborations of the participating companies with Lnu and puts the numerous smaller activities with them on a more sustainable strategic basis. This way, DIA simplifies the relationship management between Lnu and the partner companies. This amplifies the knowledge exchange with Lnu and between the participating companies. Moreover, the collaboration gives mutual access to the respective national and international networks.

Additionally, DIA Ph.D. students inspire their colleagues to work with their own competence development. Aligned with the KKS Expert Competence project Smart Industry, DIA offers courses related to smarter systems to Swedish companies and their employees (beyond DIA). This way, DIA helps promote competence development in smarter technologies even beyond the partnership of DIA. This increases the attractiveness of the DI(S)A for other potential industry collaboration partners and lowers the entry bar of common R&D projects.

*Operational goals:* 50% of the partner companies continue collaboration in externally funded research projects overlapping with DIA+ or directly thereafter. The other partner companies continue collaboration by other means. The CS and ME departments agreed on strategic research and education partnership documents defining collaborations even beyond DIA with all DIA partner companies in '24. For Combitech and Volvo, CS/ME have started research collaborations with their main national R&D centers in addition to the collaboration with the units in the Linnaeus region by the end of '23.<sup>6</sup> 10 new companies beyond the DIA partnership collaborate with DISA researchers by '26.

**For the industry Ph.D. students:** DIA creates challenging scientific questions in data intensive sciences and technologies and their applications in smarter systems with high relevance for the industry. This way, DIA contributes to industry centered and research-based Ph.D. education with clear links to solutions and innovations in crucial fields of society. DIA contributes with challenging educations and complements them with applied research and societal embedding. It increases the number of available Ph.D. level positions, students, and courses. It increases the employability of graduates in industry and academia and, hence, opens new career paths for them. It strengthens the individuals in providing direct meaning and value in the application of otherwise theoretic knowledge and results.

<sup>5</sup>Civilingenjörsutbildningar at Lnu

<sup>6</sup>DIA succeeded already with Electrolux Professional: their corporate R&D headquarters will co-supervise their second Ph.D. module in DIA+.

*Operational goals:* 9 Ph.D. students defend a Ph.D. thesis by the end of 2026; 11 by the end of 2028; zero dropouts.

**Soft goals** of our industry partners expressed in initial workshops that DIA continues to positively contribute to:

- Recruitment of highly qualified talents that are already familiar with the company challenges and culture.
- In-house development opportunities for employees that otherwise would seek new challenges elsewhere.
- Access to and evaluation of cutting-edge research results and easy adoption of solutions relevant for reaching own R&D goals. Senior researchers contribute directly to solutions relevant for the industry.
- Long-term relationship building with relevant research and education environments.
- Exchange of experiences on common challenges and approaches with other partner companies.
- Positioning and competence development of the collaborating regional sites in their globally operating group, e.g., better dialogue with the central research units and higher relevance of the collaborating regional sites.
- Training of staff with skills needed to tackle relevant and challenging end-to-end problems: from problem definition and solution creation to realization and validation.

### 3 Implementation of the project

#### 3.1 Integration of DIA and DIA+ and new development

The main goal of DIA+ is to build one permanent industry graduate school. To this end, DIA+ will benefit from all already established successful DIA processes, the infrastructure, the curriculum, and the organization. DIA+ will also serve as a stress test of these existing structures and trigger change where needed.

Due to the pandemic, some Ph.D. students started during 2020 and others only in 2021, at different points in time. We found this continuous enrollment successful and would like to apply this to the second intake (and beyond): all new Ph.D. modules will start in 2023 but spread out throughout the year; some few might even get enrolled only at the beginning of 2024. This helps integration by (i) giving them more individual and personalized on-boarding, (ii) creating occasions to build up peer relations with the Ph.D. students that started shortly before who give practical advice, and (iii) making it less stressful for the individual Ph.D. student if their pace is faster or slower than average; Ph.D. studies in general are not expected to have constant progression. The DIA curriculum will anyway be followed in smaller groups due to the different prerequisites of the Ph.D. students, ranging from mid-aged, company internal employees with a Swedish M.Sc. education to young talents from Asia with a major in mathematics.

Not only are we integrating DIA+ in DIA, but also in the regular research education in CS: industry Ph.D. students take courses and participate in other joint events together with our regular Ph.D. students, including the students working in externally funded projects and the Lnu Knowledge Environments, i.e., industry Ph.D. students take part in many regular general Ph.D. activities (informal meetings, seminars, workshops, hackathons, reading groups, paper review groups, study visits, etc.) in addition to the DIA specific activities. As the group of all DIA Ph.D. students and their supervisors from both academia and industry will be very large, some of these activities will be held in smaller groups. Their selection might be based on the intake, but it can also be based on progression, research topic, or industry vertical. The value for the individual Ph.D. module, the company, and the activity goal will determine the target group.

DIA+ builds a stronger national collaboration network of researchers in our field, as an added value for the individual Ph.D. student, the partner companies, and the researchers at Lnu. Starting points are the external networks of DISA and Digital Transformations including the VR infrastructure InfraVis, the RISE Digital Manufacturing Cluster, AI Sweden, Swedsoft, and Lnu's European Digital Innovation Hubs (EDIH): Health Data Sweden and DigitHub Sweden. We invite co-supervisors from other universities or research institutions with complementary competences that we find beneficial to strengthen collaboration with, e.g., AI ethics or real-time systems. Some of our industry partners work with several universities and research institutions and have asked us to work more closely together with them; they see us as complementary collaboration partners rather than competitors.

Internationally, DIA+ will also integrate in the EU action ENTRUST<sup>7</sup> that brings together 16 leading research

<sup>7</sup>HORIZON-MSCA-2021-DN-01 "Next Generation of Trustworthy Agri-Data Management"

institutions and enterprise from 5 different countries across Europe to establish a doctoral network of 11 Ph.D. students who are supposed to become a new generation of data executives. Lnu will be the host of 2 such positions, where one of them is industrial Ph.D. with Södra. Moreover, with the affiliated Ph.D. modules in e-health, DIA+ will align with Lnu's contributions to the European University for Well-Being (EUniWell, [euniwell.eu](http://euniwell.eu)), especially, to EUniWell's AI working group and seed projects.

For social integration and better group cohesion, we will offer joint trips to conferences, study visits, and inspiration days both nationally and internationally. We have learned from other ongoing and previous industry graduate schools that these types of activities are very appreciated by all parties, both to get to know each other better, to find synergies, and to get new inspiration and knowledge.

### 3.2 Plans for DIA

**Recruitment of doctoral students** Most partners see DIA as an opportunity to recruit competences that they lack today. We will apply the joint DIA recruitment process that has been established in collaboration with the HR and R&D divisions of the partners and at Lnu. It covers all steps from defining the profile, over announcement and selection, until the candidate is formally enrolled as a Ph.D. student and employed by the company. The process worked very well for all parties and will continue to be applied. For partner companies with employees to be enrolled in DIA+ as part of their competence development, e.g., Volvo CE, the process reduces to formally enroll the Ph.D. students.

**Joint activities** We keep the approved and appreciated activities developed during the first phase of DIA and add a few new (in bold face).

*Annual joint kick-off day* inviting all supervisors from the industry and Lnu, Ph.D. students and company and Lnu representatives to officially start the school and generate a common loyalty towards DIA.

*Annual one-day DIA workshop collocated with DISA's annual Big Data conference.* At these workshops, Ph.D. students document their achievements both internally and externally. They are an occasion to bring together DIA Ph.D. students and Lnu supervisors, other DISA researchers, company supervisors, and other interested company representatives with researchers and students at Lnu as well as interested companies and organizations in society in general. In December 2022, we organize the 8th annual Big Data conference, where we already welcome the industry supervisor and confirmed Ph.D. students of the second intake and inform about DIA.

*Bi-annual one-day doctoral seminar* At these seminars, Ph.D. students defend their achievements and next steps internally in front of the joint supervisor staff both from the industry and Lnu, and their fellow Ph.D. students. These seminars are a central tool for DIA for achieving several objectives. They serve as a platform for DIA internal R&D related discussions. They train the presentation and public speaking skills of the Ph.D. students, preparing them for conferences and the thesis defense. They correct lesser promising suggestions of the supervisor team by making use of the intelligence of the many. Finally, they motivate the Ph.D. students and set informal deadlines that help structuring the long-term venture of Ph.D. studies.

**Joint trips to conferences, study visits** etc. both nationally and internationally will be organized as a means of getting to know each other, building new knowledge, and as networking activities.

*Ph.D. curriculum and course development* are central activities in DIA. Course development is demand driven where industry and Lnu supervisors define needs and opportunities of competence areas. A new course on **Paper and proposal reading and peer-reviewing** supervised of senior researchers will be developed. Curriculum development is driven by individual courses prerequisites and a general progression over the curriculum.

*Ph.D. courses* are the main means of formal Ph.D. education and knowledge transfer, but also an opportunity for the Ph.D. students to meet their peers from DIA and related Ph.D. programs.

**Quarterly Ph.D. meetups** are only for Ph.D. students and give them a way to get to know each other better, bring up current challenges, needs or questions. **They will integrate the different intakes.**

*Bi-annual steering committee meetings* for strategic discussions with the executives and formal decisions.

*Monthly executive board meetings* are scheduled in connection to the monthly DISA meetings for operational discussions and decisions.

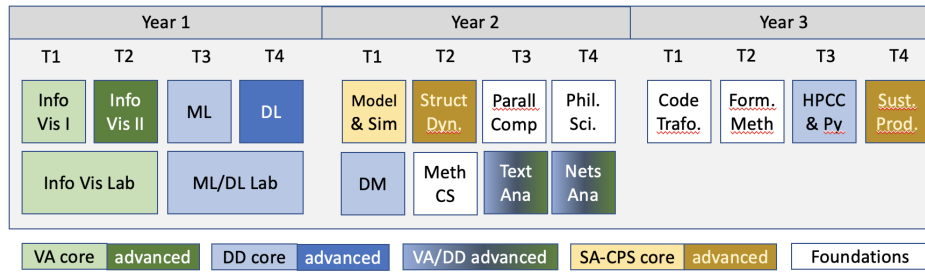


Figure 1: DIA curriculum.

*Continuation efforts* aim at maintaining DIA beyond 2028: formalizing and documenting processes; **from 2025 on recruitment of new partners for the institutionalized graduate school.**

*Weekly supervisor meetings* as detailed below.

**Organization of supervision** As in the first intake, each Ph.D. module consists of a Ph.D. student with an industry research project, one main supervisor from the industry and one main supervisor from Lnu. A supervision group of a Ph.D. module may incorporate other experts from Lnu, other universities, and the industry if needed, e.g., for adding expertise in mechanical engineering and forest, wood, and building technologies. The Ph.D. research project is jointly defined by the two main supervisors to guarantee both the relevance for the companies' R&D and scientific quality.

Weekly meetings with the Ph.D. students and the supervisors proved to be a working instrument to organize supervision. They bring up questions, resolve practical problems, and provide feedback. They check the progress on micro-level to keep the participants of the module in sync with the latest development and with each other. Co-publications are discussed and initiated in these meetings.

Ph.D. students meet in common courses to exchange experiences and support and encourage each other. This part of the supervision is informal but nonetheless invaluable. It is expected and encouraged that the Ph.D. students find further interaction channels, e.g., slack groups and common informal meetings. DIA will continue to fund such activities when needed but, we expect the Ph.D. students to take the initiative.

Ph.D. students and their supervisors also meet in the annual doctoral seminars and at the annual one-day DIA workshops. These activities are an essential part of the official supervision; they encourage summarizing, presenting, discussing, and opposing intermediate results. It puts the focus and sets deadlines on the scientific work progress and prepares the Ph.D. students for conferences and Licentiate and Ph.D. disputations.

**Curriculum and courses** The ASP of CS research education at Lnu comprises at least 90 ECTS credits. For the first intake, we developed a curriculum worth altogether 100 ECTS. The selection of courses depends on research needs and prior qualifications and is decided together with the examiner and the main supervisors.

Courses are grouped into the three CS areas that constitute the core groups of DISA and are central to build smarter systems: Self-adaptive Cyber-Physical Systems (SA-CPS), Data Driven Technologies (DD), and Visual Analytics (VA), complemented by foundational courses, cf. Figure 1 for the current curriculum and [lnu.se/en/dia](http://lnu.se/en/dia) for course syllabi. In DIA+, we will adjust the curriculum and develop more courses on demand. We aim for more courses than there are teaching slots in the curriculum framework. This is necessary because of the heterogeneous background and needs of the Ph.D. students.

Common courses will be given on site and on-line in hybrid learning mode, exploiting the experience of developing flexible forms of education during the pandemic and in the KKS "Expert Competence for Innovation" project. By supporting these courses with modern learning management systems, we create the foundations for aligning professional and educational activities and for spreading the content even beyond DIA.

**Publication strategy** Every year, FTK and Lnu assess the individual researchers to set their faculty research funding level for the coming year. The assessment uses the number of publications and the quality of the publication channels according to the "Norwegian Register for Scientific Journals, Series and Publishers". In the past, the active researchers



at the CS department produced ca. two publications per year and researcher. 6% of the publications are at the highest quality level (level 2), which includes high-impact journals and conferences. 85% of the publications are at level 1. This level includes journals and conferences with somewhat lower impact and even some highly ranked symposia. The remaining level 0 publications, typically in workshop proceedings, account for less than 9% of the total production. The (informal) publication requirement for a Ph.D. thesis to be accepted in CS is one level 2, alternatively two level 1 journal publications, plus around five level 1 conference publications. DISA's goal is to increase the number and relevance of publications: on average 4 publications per researcher (excl. Ph.D. students) and year, and 20% level 2 publications. DIA+ will contribute to this goal and, thus, actively works for an increased amount of publications with high impact and relevance by (1) Setting individual quantitative publication goals and assessing the number and the quality of publications as part of the ISP updates. (2) Encouraging early publications in the first year even at level 0 and funding travel costs and workshop fees; discouraging level 0 publications later in the subsequent years and not funding connected costs. (3) Adjusting the publication requirement for a Ph.D. thesis to one level 2 journal plus around five level 1 journal or conference publications.

**Internationalization strategy** Within DIA internationalization is important and gives both the researchers and the partner companies an added value. Researchers understand industry trends, solutions and needs, not only from the perspectives of an individual company but also on a national and international level. Our industry partners learn about relevant research and development trends and results in an international context. Both broaden their respective perspectives. For researchers, the international context is crucial to keep their research relevant and in the forefront. DIA includes this perspective in their industrial Ph.D. students' third cycle education from the beginning and throughout their whole Ph.D. program. Therefore, strategic internationalization activities include: (1) Researchers/supervisors and Ph.D. students participate in and present results at international conferences. DIA actively motivates and financially supports their Ph.D. students to present early results at smaller international venues. Later, DIA encourages publications at the highest quality level, which means in an international context, cf. to DIA's publication strategy. (2) In collaboration with the Grants and Innovation Office (GIO), DIA provides seminars, workshops and other activities for researchers, industry partners and Ph.D. students to learn about international funding opportunities and acquire the know-how to write competitive project applications. (3) DIA is active in EDIHs, EUniWell, and other international networks that Lnu is a partner in to meet and share knowledge with universities and industry from all of Europe and beyond. (4) DIA motivates and financially supports the Ph.D. students to attend international courses and summer schools in order to broaden their horizons and build international networks of their own. (5) DIA's researchers/supervisors and Ph.D. students and industry partners engage in international projects (proposals), such as the EU action ENTRUST, with research addressing and complementing the DIA research challenges in smarter systems. (6) DIA makes smarter systems research relevant for collaboration with the international R&D centers of our partner companies in the cases where we do not have them yet in the consortium.

## 4 Leadership and organization

Although the staff has partially changed (due to people who left and joined Lnu) the leadership and organization structure has been established as planned for DIA and is supposed to remain stable even for DIA+.

**The Steering Committee** is responsible for the governance of DIA, its strategic development, and its quality assurances. The steering committee meets twice a year. It consists of at least three company representatives, two academic representatives (the FTK Dean and the Head of the ME Department), and one Ph.D. student. Additionally, the project manager and the project coordinator are affiliated with the steering committee. There is only one steering committee for both intakes. The names and affiliations of the current members can be found here: [lnu.se/en/dia](http://lnu.se/en/dia).

**The Executive Board** is responsible for the operational leadership of DIA and for program and research coordination. Also, it runs the daily business, coordinates activities, plans the program, handles formalities, follows up on the Ph.D. students and their projects, supports the participating industries, and handles the administration of DIA. The executive board remains the same as for the first intake and consists of the DIA director, coordinator, program coordinator, and research coordinator.

**The Director** Welf Löwe, Professor (CS), leads DIA and the executive board. He is supported by the board members with their respective responsibilities and controlled by the steering committee. He will be ultimately responsible for budget and result, the quality, the scientific coordination of the Ph.D. modules, for successful curriculum and course development, and the operation of the Ph.D. education according to the curriculum. He is the formal point of contact towards KKS.

**The DIA coordinator** Diana Unander will coordinate activities and stakeholders. She is responsible for scheduling meetings and other activities, requesting and putting together formal reports, relationship management with companies, supervisors, researchers, and Ph.D. students. She is the point of contact towards the Lnu administration and the customer relationship manager towards the participating companies.

**The Program coordinator** Morgan Ericsson, Assoc. Professor (CS), assures that the curriculum guarantees quality and progression of skills and knowledge. He defines the requirements for the syllabi so that they fit together in the curriculum of DIA. Syllabi submitted by the course responsible researchers must be checked against the requirements and approved by the program coordinator. Finally, he schedules the courses.

**The Research coordinator** Mauro Caporuscio, Professor (CS), supports the recruitment of Ph.D. students to meet to academical and industry needs. He also organizes the match making of Ph.D. students and supervisors. For enrolled Ph.D. modules, research coordination monitors the progress of the students, approves and (if necessary) adjusts the ISPs and discusses problems in the executive board. Research coordination also organizes support from academia to industry for supervision mentoring of companies if needed.

**Supervisors** from the industry and academia have the main responsibility for the Ph.D. students and their ISPs in close dialogue. They give advice regarding the content of DIA courses and the development of new courses in close cooperation.

**Researchers responsible for courses** report to the program coordinator, define and adjust course syllabi, conduct the courses, and examine the Ph.D. students.

**Industry Ph.D. students** conduct the research and co-production in the Ph.D. modules, suggest, discuss, and agree on ISPs and follow them.

## 5 Company participation

Each company participating in DIA+ contributes to one Ph.D. module with a Ph.D. student, a supervisor, a research topic, and the required co-funding resources. Each company contributes to the joint activities including but not limited to course and curriculum development. Additionally, Combitech, Electrolux Professional, Sigma Technology, Scania, Virtual Manufacturing, and Volvo CE contribute to the formal self-organization of DIA and lead and contribute to the Steering Committee. Below the summaries of the companies already committed to DIA+ (in lexicographic order), their visions and goals as well as their research needs and benefits. As in the first intake, this information was jointly developed with the partners companies in individual workshops and the summarized by the companies themselves.

### 5.1 Electrolux Professional – Enhance and prolong machine lifetimes by using AI to detect issues and prevent breakdowns

Electrolux Professional is one of the leading global providers of food service, beverage, and laundry solutions, serving a wide range of customers globally, from restaurants and hotels to healthcare, educational and other service facilities.

**Vision and goal:** To be customer obsessed is one of the guiding principles of Electrolux Professional and this means to be focused on the customer and deliver customer value. At Electrolux Professional, our customers are at the heart of everything we do. Our mission reflects our drive to continuously create better experiences for customers to elevate and enrich their everyday' s work-life. We take pride in knowing our customers' needs fist-hand and are committed to always adopting a customer-first approach to deliver value.

**Research needs and benefits:** To better understand the customer, Electrolux Professional has launched a massive program to collect machine data from its installed base from around the world with the aim of remotely monitoring usage and identifying behaviors and needs. The company believes that the analysis and visualization of the collected data can help Electrolux Professional to improve its devices and allow its customers to optimize their use by extending their equipment's lifetime and performance while reducing their carbon footprint and potentially guide them in the choice of the next-generation equipment when needed. Electrolux Professional believes that creating a Predictive Maintenance data product can better serve customers and allow the company to grow its identity as one of the leaders in the professional market. By having an in-depth understanding, Electrolux Professional aims to create benefits both for customers and stakeholders. This means to (1) keep the customer's equipment always at the best performance and to be able to prevent breakdowns by identifying potential future issues, improving up-time for end-customers using our products, (2) offer a careful and personalized maintenance program through AI and ML reducing operating costs, (3) extend the range of service by offering more advanced solutions, such as a water-energy-saving program as a service, (4) increase the company's value and get closer to the customer's need and to help them grow their business

Electrolux Professional has already enrolled a Ph.D. module in DIA and extends their engagement in DIA+.

## 5.2 Fortnox – Document classification and entity extraction

Fortnox provides a cloud-based corporate platform containing products and solutions for businesses such as accounting, invoicing, salaries, payment solutions, etc. Fortnox helps companies start, grow, and develop. With smart technical solutions and services, and the opportunity to connect them with hundreds of external partners, Fortnox is a hub for entrepreneurship in Sweden.

**Vision and goal:** Fortnox customer data contains a lot of unstructured documents, such as invoices and receipts. These documents contain important information such as customer number, organization number, invoice date, due date, total amount to pay, vat etc. To be able to automate accounting for customers, necessary information must be extracted from invoices and receipts. Document classification is also needed to, for example, suggest which accounts an invoice or receipt should be book-kept at or the type of document (invoice, receipt, etc.).

**Research needs and benefits:** Fortnox has solutions for extracting information mainly for invoices, but the solutions scale badly with increased size of data and require lots of maintenance. A possibility is to use third party solutions provided by for example Google, but they have some severe limitations; they are very costly, have limited support for Swedish, and don't provide control of where data is physically stored. Therefore, an AI-based in-house solution would be very beneficial for Fortnox. The Ph.D. project will develop: (1) a flexible and scalable machine learning based solution for extracting necessary information from unstructured documents based on state-of-the-art research. (2) an innovative GUI for correcting errors on misclassified documents without needing programming knowledge. (3) document classification based on state-of-the-art research.

## 5.3 Micropower Group – Data intensive support for battery management

Micropower is one of the world's leading industrial battery and charger companies. With our own R&D and production, we take battery and charger innovation all the way from the drawing table to the customer.

**Vision and goal:** We are always a part of something bigger – our system solutions and products power innovation and advancements worldwide. We are constantly looking for new ways to solve our customers' challenges. Our R&D department develops new systems and products, both unique customer specific solutions, and new products for our standard range. Micropower strongly believes that turning data into insights and solutions will strengthen our offer and be a strategic success factor for the future.

**Research needs and benefits:** Software and Solutions is a very important business area for us. With smart offerings, we can add value to hardware, help our customers make the most of their operation, optimize costs, usage, and much more. Micropower's participation in DIA will strengthen the Software and Solutions team with competence in data intensive technologies. The Ph.D. module will revolve around the following main areas: (1) Processing Big Data, turning them into insights and solutions helping our customers improve efficiency and reduce their environmental

footprint. (2) Utilizing and combining data from multiple sources, adding value to our offer outside our Micropower's traditional core area. (3) Optimizing data management and logging by leveraging data warehouse technology. (4) Exploring capabilities of moving exhaustive computation, big data storage, and AI from the cloud to the edge.

#### **5.4 Sigma Technology – Proactive monitoring and predictive maintenance as a service**

Sigma Technology Informatics Solutions AB focuses on digitalization of customers' products and business processes and gathers the expert team specializing in software design, information management, and business analysis. The company's Digital Services offer covers the areas of Big Data Analytics and Visualization, both consulting services and a high-end analytics product for clients.

**Vision and goal:** Create new business models and better customer experience by offering proactive monitoring and predictive maintenance as a service. This shall lead to offering new services to our customers.

**Research needs and benefits:** Leveraging on Big Data, Data Analytics, Machine Learning, Data Visualization, and Content Management, we have a strong belief that we can improve support and maintenance of technical advanced products, especially, (1) prevent costly equipment failures: avoid unscheduled downtime by analyzing streaming data to assess conditions, recognize warning signs and trigger preventive actions, (2) reduce resource consumption: less maintenance and maintenance at the right time will reduce waste, energy consumption, travels and lead-time, (3) maximize up-time: increase the efficiency of your product by strategically scheduled maintenance, and (4) learn to improve products: capture and analyze data and use it to fine-tune processes, maintenance actions and make modifications that improve the product.

Sigma Technology is already active in the steering committee of DIA and wants to extend their involvement in DIA+ with a Ph.D. module in DIA+.

#### **5.5 Softwerk – Anomaly detection with computer vision and unsupervised learning**

Softwerk AB is a software development company based in Växjö founded by employees of the Department of Computer Science at Linnaeus University, and has grown to employ over 30 people who all live and breathe coding. Since we've got one leg in the academic world and the other in the commercial, our software solutions are always in the scientific and technological vanguard. That's how we're able to provide the most valuable services to our customers.

**Vision and goal:** Through machine learning, artificially intelligent computer systems train themselves to perform tasks that normally require human intelligence, such as decision-making, translation, or visual perception. Machines can work together with or replace humans in doing highly complicated, repetitive, or even dangerous tasks. AI, machine learning, and automation make businesses more efficient, precise, and sustainable, by for example lowering the operating costs, improving data insights, or extending equipment upkeep. Softwerk has the proven expertise to custom develop and deploy an AI strategy that transforms and scales to entire businesses and has the ambition to further excel in this field.

**Research needs and benefits:** Softwerk always aims at bringing the latest AI research findings to work in industrial practice. One of our customers is world leading in complete paper, board, and tissue production lines. The automated process includes mechanical pulping, stock preparation, paper, board, and tissue machines etc. Visual inspection of intermediate stages in process improves the quality of the final products and detects wear and tear in the production lines. Softwerk will introduce computer vision-based quality inspections and, to avoid cumbersome data collection with manual labelling, leverage on leading edge unsupervised deep learning technologies. The DIA Ph.D. student will adopt this technology in the production lines of our customer(s).

Softwerk has already enrolled a Ph.D. module in DIA and extends their engagement in DIA+.

#### **5.6 Volvo CE – Function development for Data Intensive Applications**

Volvo Construction Equipment (CE) is a leading international manufacturer of premium construction equipment.

**Vision and goal:** Volvo Construction Equipment has a clear ambition to doubling revenue from services until 2030. This will drive service growth over the coming 10 years, with new on-board as well as off-board services. Gathering, analysis and processing of data will be a key element in the development of new services.

**Research needs and benefits:** Software Systems AAH is responsible for the software development for Volvo CE's articulated and autonomous haulers (AAH). This includes implementation of on-board services, development and implementation of data logs, but also a responsibility to develop and implement a software architecture that is sustainable over time, enables future technology and enables efficiency in the development process.

The Ph.D. student will have a crucial role assessing how the development of data intensive applications, their provisioning as services, and the machine functionality sets new requirements on our architecture, our development environment, our processes, and the onboard resources. The student will contribute to ways to handle these requirements. Results will secure efficient function development in the coming years. Areas that shall be in the focus for the research are: (1) Data collection and logging, (2) Software architecture, (3) Function development process with focus on service development, (4) Interface to and responsibilities for different stakeholders in the development process, (5) Tools and development environment, (6) Limitations and best utilization of on-board resources, and (7) Validation and verification of ML-based services.

Volvo CE has already enrolled two Ph.D. modules in DIA and extends the engagement in DIA+.

## 5.7 Vultus – Analysis and decision support for the forest industry

Vultus is a company that provides analysis and decision support for growers regardless of crop. The analyses are produced in the company's platform by processing satellite data. Species identification, crop health, irrigation needs, soil content, and fertilization requirements are examples of analyses that growers find very useful in making decisions regarding measures before, during and after the growing season.

**Vision and goal:** Vultus' ambition is to make use of and commercialize academic research with the aim of creating services that can contribute to solving the world's food supply. With a growing population combined with a climate crisis, innovative solutions are required to make better use of the agricultural area and, at the same time, maintain natural values.

**Research needs and benefits:** The Ph.D. student will set the focus on: (1) Combining data from various sources and time intervals to build and improve Vultus' models and services for forest owners and the agricultural and forest industry, (2) Developing models that generate reproducible, validated, and trusted results, and (3) Using models to make automatic recommendations based on the data and best practices in agriculture and the forest industry.

## 6 Timetable

Year	Planned activities
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Year 4 of DIA	<b>4 Licentiate Thesis defenses (first intake)</b> <i>Formal admin:</i> Sign DIA+ contracts with KKS and the companies. Recruit and enroll 11 Ph.D. students. Supervisor matchmaking. Define new ISPs. Approve syllabi of new courses.
Year 1 of DIA+	<i>Organization:</i> Define and refine contract templates and policy documents. Finalize the acquisition process for 4 new DIA+ partner companies and Ph.D. modules. Sync and merge activities with the first intake. Onboarding of new supervisors from Lnu and partner companies.
(2023)	<i>Events:</i> Run all (bi-) annual events: Ph.D. seminars, annual kick-off for the research school in September, annual workshop in December, board meetings, doctoral seminars etc. <i>Curriculum development:</i> Separate compulsory, optional, and individual courses and define a general study plan (ASP). Plan courses for 2024: determine the courses that should be dropped because of lacking interest; define courses to be developed according to needs. <i>Course development:</i> Develop the identified courses for 2024 including the course on paper and proposal reading and peer-reviewing.

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Year 2 (2024)	<p><b>5 Licentiate Thesis defenses (first intake)</b></p> <p><i>Formal admin:</i> Update ISPs. Approve syllabi. Budget and progress follow-up and report to KKS.</p> <p><i>Organization:</i> Continuation efforts (planning): set intake routines, refine the processes of partner company acquisition and student recruitment, the contract templates, the policy documents etc.</p> <p><i>Events:</i> Run all (bi-) annual events. Organize and offer joint trips.</p> <p><i>Curriculum development:</i> Get approval for the general study plan (ASP). Plan for 2025, determine the courses that should be dropped and define courses to be developed.</p> <p><i>Course development:</i> Develop the courses according to needs.</p>
Year 3 (2025)	<p><b>4 Ph.D. Thesis defenses (first intake)</b></p> <p><i>Formal admin:</i> Update ISPs. Approve syllabi. Budget and progress follow-up and report to KKS.</p> <p><i>Organization:</i> Continuation efforts (improving): Test run and adjust the acquisition/recruitment processes, Regular board meetings, Conduct internal half-time evaluation to track progress and to identify needed changes and potential improvements in organization, processes, activities etc.</p> <p><i>Events:</i> Run all (bi-) annual events, Potential joint trips.</p> <p><i>Curriculum development:</i> Define and follow a general process for revision of curriculum and courses.</p> <p><i>Course development:</i> Develop the courses according to needs.</p>
Year 4 (2026)	<p><b>5 Ph.D. Thesis defenses (first intake) + 11 Licentiate Thesis defenses (second intake)</b></p> <p><i>Formal admin:</i> Update ISPs. Approve syllabi. Budget and progress follow-up and report to KKS.</p> <p><i>Organization:</i> Continuation efforts (test intake of Ph.D. modules): Run the acquisition/recruitment processes with the goal of max 2 intakes in 2027, Regular board meetings.</p> <p><i>Events:</i> Run all (bi-) annual events and joint trips.</p> <p><i>Curriculum development:</i> Follow curriculum and course revision process.</p> <p><i>Course development:</i> Develop the courses according to needs.</p>
Year 5 (2027)	<p><i>Formal admin:</i> Handle test intakes (enrollment, appoint supervisors, ISPs, contracts) and test intake routines. Update ISPs. Approve syllabi. Budget and progress follow-up and report to KKS.</p> <p><i>Organization:</i> Continuation efforts (sharp intake of 2-5 Ph.D. modules): Acquire up to 5 new partner companies and recruit the corresponding Ph.D. students for intake 2028, Regular board meetings.</p> <p><i>Events:</i> Run all (bi-) annual events and joint trips.</p> <p><i>Curriculum development:</i> Follow curriculum and course revision process.</p> <p><i>Course development:</i> Develop the courses according to needs.</p>
Year 6 (2028)	<p><b>11 Ph.D. Thesis defenses (second intake)</b></p> <p><i>Formal admin:</i> Routinely handle new intakes. Enroll 2-5 new Ph.D. students. Update ISPs. Approve syllabi. Budget and progress follow-up. Final report to KKS.</p> <p><i>Organization:</i> Continuation efforts (continuous learning and improvement): retrospective to extract knowledge from the execution of the graduate school, continuously adapt focus, processes and organization.</p> <p><i>Events:</i> Run all (bi-) annual events and joint trips.</p> <p><i>Curriculum development:</i> Follow curriculum and course revision process.</p> <p><i>Course development:</i> Develop the courses according to needs.</p>

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## 7 Planned doctoral student projects

All Ph.D. students (NN) will be employed by the respective partner company. The planned study pace is 80% for all Ph.D. students. All Ph.D. students will be enrolled at the Department of Computer Science and Media Technology at Lnu. Their official third cycle subject area will be Computer and Information Science.<sup>8</sup> Already defined projects are:

<sup>8</sup>[lnu.se/en/education/Ph.D.-studies/computer-and-information-science](https://lnu.se/en/education/Ph.D.-studies/computer-and-information-science)

Project	Company/Employer	Progress at start
Enhance and prolong machine lifetimes by using AI	Electrolux Professional	0%
Document classification and entity extraction	Fortnox	0%
Data intensive support for battery management	Micropower Group	0%
Proactive monitoring and predictive maintenance as a service	Sigma Technology	0%
Anomaly detection with CV and unsupervised ML	Softwerk	0%
Function development for Data Intensive Applications	Volvo CE	0%
Analysis and decision support for the forest industry	Vultus	0%

## 8 Project staffing

Key personnel include the director Welf Löwe and the coordinator Diana Unander (both 30% of full time), the executive board members Morgan Ericsson and Mauro Caporuscio (both 15%), and the steering committee members (each 3%). To align the administration of DIA+ with DIA and the general Ph.D. education at FTK, we dedicate staff from the faculty administration of 3rd cycle studies to support DIA+ administration (25%, not in the DIA+ budget).

There are ca. 30 potential Ph.D. supervisors with backgrounds in Computer Science and Media Technology (CS), Mathematics (MA), Forest and Wood Technology (FWT), Building Technology (BT), Mechanical Engineering (ME), and the Computational Social Sciences (CSS), cf. the appendix of CVs. The CS/MA researchers contribute with competences in the data intensive sciences and technologies, the ME researchers with competences in proactive maintenance and application knowledge in the heavy vehicle industry, the FWT/CSS researchers with application knowledge in the forest industry and its sustainability, and the BT researchers with competences around wood as a building material. The two main supervisors of each Ph.D. module, from Lnu and the respective industry partner, will each dedicate 10% of full time to the project. In order to strengthen our junior researchers, we will include a number of senior lecturers as co-supervisors in each PhD-module; each co-supervisor will get 3% of full time for supervision. We will strengthen the supervisor teams with researchers from other universities and/or RISE.

## 9 Project budget

**Funds** We apply for 21,5 MSEK from KKS of which 29,9% are operational expenses, which matches the KKS spending constraint. The minimum in-kind co-funding of industry is 450 KSEK per company and year (in total 24,8 MSEK) matching the co-funding constraint. DIA+ overlaps with the first intake in the years 2023-2026. As we build a common graduate school, costs for management, curriculum development, and HPC infrastructure are common too. Hence, Lnu funding for DIA+ includes 4,9 MSEK for these years from the first intake's budget, and additional 4,2 MSEK in the DIA+ budget. The total Lnu funding of DIA (first and second intake) amounts to 20,8 MSEK.

**Costs** We budget for an initial annual salary of 566 KSEK per Ph.D. student and an annual raise of 2% (total 32,5 MSEK). For supervision, we budget 100 KSEK per year from companies—we learned that a substantial commitment from industry is important for the students' daily work—and 58 KSEK from Lnu (total 8,6 MSEK).

In the DIA+ budget, we only include the extra management costs of the second intake used mainly during the last two years and accounting only for the actual costs of the Lnu staff involved and the premises (total 1,8 MSEK).

We budget for the DIA+ related Ph.D. education costs of curriculum/course development and co-supervision by junior researchers (altogether 3,2 MSEK). It amounts to ca 58 KSEK per Ph.D. student and year, of which ca 2/3 are dedicated to support them with individual courses connected to their research. This fosters a close collaboration with the junior researcher involved in these courses and in supervision, boosts the researchers' academic careers, and leads to input to the general course development. The latter is still needed, but only 1/3 of the Ph.D. education costs are allocated to curriculum/course development because of the available funds from the first intake.

We account for 30 KSEK annual travel costs per Ph.D. student and main supervisors and for another 100 KSEK annual travel costs for the co-supervisors and the DIA+ management (total 1,7 MSEK + 500 KSEK). We account for annual costs of 200 KSEK for the workshops, seminars, and other communication costs (altogether 1 MSEK).