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Subject: TRV 2016/15206 ANSÖKAN CSA
Projektstitel: INFRA-the aviation infra system

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Industrial management, INDEK

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PhD student at Industrial management/Sustainability and industrial dynamics, INDEK (TBD)
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Abstract
The air transportation system strives to increase capacity and at the same time reduce environmental impact and increase safety. Commonly the environmental impact is referred to as CO2, but another environmental aspect is noise. Noise is a negative bi-product. KTH Centre for Sustainable Aviation (CSA) has been established with the aim and purpose to reduce noise from aviation in collaboration with all the main stakeholders of the ATS. And partners all agree that something will have to change in aviation.

The purpose is to investigate factors in the INFRA system, analyzed as a socio-technical system, that can contribute towards system change to reduce noise from aviation and to identify which system stakeholders that can contribute in this process. The aim of the research project is to contribute in the understanding of how system externalities, such as noise, can be internalized and become an integrated system component.

Research question: How does the INFRA system reduce noise?

INFRA is a unique opportunity to do a participatory research project in system change. It will be performed by a complementary team of researcher from Industrial management and Sustainability and industrial dynamics domains. In addition to the senior research group this will be a full time PhD project.

Thus, the proposed research project INFRA is not investigating what will reduce noise. Instead INFRA will complement the other studies by investigating how noise can be reduced within the system, how noise reduction initiatives will affect other system components and actors and how different actor groups react and manage the system changes needed. Earlier research show evidence that this type of system change is to be taken very seriously since there is evidence of failure rates as high as 60%. The expected impact of this proposed research is to increase the chances for a successful system change.
Appendix A: Research description

1 Introduction
With an anticipation of doubling of air traffic by 2035 (IATA, 2015) there is a positive growth in the aviation industry. The air transportation system (ATS) has goals set to increase capacity and at the same time reduce environmental impact and increase safety. Commonly the environmental impact is referred to as CO2, but another environmental aspect is noise. Noise is a negative bi-product that primarily affects neighbors to an airport. Recently a legal complaint was raised from a group of citizens in Upplands Väsby, to the owner of Arlanda airport. The group suffers from noise and argued that the system owners had not shown sufficient initiatives to reduce noise from aircrafts in their municipal. There are limited possibilities to move an airport. A more realistic alternative is to move the aircrafts away from Upplands Väsby. The service provider that control air traffic around Arlanda argues that such solution is near impossible too, since air traffic control is so complex it may not be safe.

Despite current challenges, the court concluded that something needs to be done about the noise, but, it was decided that a research program was required to resolve the issues. As a result KTH Centre for Sustainable Aviation (CSA) was launched with the aim and purpose to reduce noise from aviation in collaboration with all the main stakeholders of the ATS.

Earlier research shows clear evidence that this type of system change is to be taken very seriously to be successful. Much knowledge has been developed about “how to manage change” and there exist many theories on change. Yet, current reports show evidence of failure rates as high as 60% (Dent and Powley, 2001; Kotter, 1995). Great resources are expected to be invested and since change is a risky business there is chance that these investments are lost. In addition, a failure to reduce noise will possibly lead to other complaints and continued loss of quality of lives for those affected by the noise. The expected impact of this proposed research is to increase the chances for a successful system change.

A pre-study has been conducted on studying approach alternatives from a flight operations perspective and the system changes required to realize this (Moberg, Rignér and Ulfvengren, 2014). Pre-study projects like Brantare and SAFT are on-going and are investigating and planning research to identify what initiatives would have an effect on noise and under what conditions these are satisfactory from both operational and noise reduction effect perspective.

Thus, the proposed research project INFRA is not investigating what will reduce noise. Instead INFRA will complement the other studies by investigating how noise can be reduced within the system, how noise reduction initiatives will affect other system components and actors and how different actor groups react and manage the system changes needed. INFRA is based on the assumption that in order to realize any innovation to reduce noise substantially, the air transportation system also has to change accordingly: In the words of Thomas P. Hughes (1983) “…If only the technical components of a system changes, they can fall back to its original location such as charged particles in an electric field. Also the field requires attention; values may need to be changed or reformed institutions and laws to be revised”.

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The approach taken in INFRA is that a thorough anamnesis and analysis of the functionality of a current system is key to understand how it is possible to change. The complete system that will be studied is not yet defined. In this proposal it will be called the INFRA system.

1.1 Purpose
The purpose is to investigate factors in the INFRA system, analyzed as a socio-technical system, that can contribute towards system change to reduce noise from aviation and to identify which system stakeholders that can contribute in this process. The aim of the research project is to contribute in the understanding of how system externalities, such as noise, can be internalized and become an integrated system component.

Research question: How does the INFRA system reduce noise?

Issues that need to be understood in order to answer the research question are:

- How is the INFRA system internalizing the externality of noise?
- What is the functionality of INFRA in relation to noise?
- Who has the “privilege of problem formulation”. Which actors gains the privilege to formulate the problem and the strategy to solve it?
- Which are the various salients and reverse salients in the INFRA system?
- How do the different actors construct their particular ideal system?

1.1.1 Expected contribution
The INFRA project is comprehensive and contributes directly to ALL the goals of the KTH CSA: research for reducing noise from aviation, conducting research education within relevant complementary areas to the core research areas, producing scientific products as well as reports to industry and public, involving all system stakeholders identified and do all this in an applied research approach with intention to implement results in practice. The research fits the description of research on Aviation system change and implementation but will also contribute to Sustainability for environment and safety.

The INFRA project is a unique opportunity for this research field. First of all it is made possible through the wider scope of this call than traditional aviation research. Secondly the researchers have access to all stakeholders willing to collaborate. There is already an established “sense of urgency” that something needs to change (Kotter, 1995) as well as a need for short term changes with implementation as feasibility within the project life time. The case has a near-history that can and need to be studied to understand the present.

This research will contribute to both the development of knowledge as well as developing and deploying tools and methods for implementation and evaluating system change. Since noise is not the only systemic aspect in aviation the need for this type of research will contribute other areas in aviation and to others that deal with challenges of systemic issues, like sustainability.

The project will aim to involve the stakeholders in development that is of value to them. INFRA is applied research and contributes directly to practice in an action research like setting in supporting: current system analysis, future system development, implementing developed noise reduction initiatives and continuously evaluating this transformation.
2 State of the art

The research group has in the pre-study discussed the air transportation system and socio-technical theory. Here is a selection of ideas that are identified useful for this research project.

2.1 System theory

Systems thinking has been influential in almost every research field and became especially widespread after the Second World War, originating from success of efforts in “operational” research that promised control of large and complex technological systems. To understand the research connected to the ambition to control systems it can be fruitful to start with a simple system that is characterised by few components with few interactions. These are systems that are easy to understand like temperature regulating thermostats, a simple self-regulating system (Fel! Hittar inte referenskälla.) The transformation process of inputs to outputs regulated by a feedback loop and with a permeable boundary towards the environment.

A complex system is characterized by a high number of components and subsystems and high level of interactions between these parts. The complex system has equifinality, which means the ability to achieve its goal in different ways. Sometimes complex systems are described as being on the edge of chaos because the interactions of simple sub-systems can result in unpredictable and seemingly random outputs. A complex system may be emergent.

The borders of a system are not given by nature, but it is the task of the analyst to define the delimitations of the system that the analyst sets out to investigate. Churchman (1968) provided a way of defining system borders, or rather to define what was a part of the system and what was not. His approach was to ask two questions: (1) Does "it" matter concerning the systems possibility to fulfil its goals? (2) Can the system do anything about "it"? (Churchman 1968).

In the middle of the 1960:s systems thinking had spread to many fields with ambition to control systems. One prominent example is the General systems theory (GST) (Von Bertalanffy, 1968). In the work on GST the interactions between components and the nonlinearity of these interactions in a system was highlighted. He also argued that no system that is open to interactions with the surrounding environment, i.e. an open system, should be viewed in isolation. This work was a response to the reductionist approach that suggested that all parts of a system could be divided into its individual components and optimised separately.

Another important systems concept that developed in parallel with GST was Cybernetics. The mathematician Norbert Wiener published the seminal book Cybernetics: Or Control and Communication in the Animal and the Machine in 1948. Wiener used the term cybernetics to describe self-regulating mechanisms. Cybernetics is foremost applicable for systems that are strongly characterised by a (semi-) closed feedback signalling loop and is often connected to designed systems, i.e. man-made physical systems designed to fill a specific purpose, figure 1.

Influenced by Cybernetics-research the pioneering computer engineer Jay Forrester developed the System dynamics at MIT Sloan School of Management in the 1950's. In 1970 Forrester created a system model to simulate the world as a socio-economic system (called World1).
The agent-based modelling (ABM) approach represents a more recent advancement in modelling social systems. It is not equation based and as structured as the above mentioned system dynamics approach but instead focus on the behaviour of actors and rules for this.

After WWII systems thinking began spreading to management. But even though system researchers in social sciences highlighted the need to include both social and technical aspects in optimising systems, they did not acknowledge the importance of actor agency on systems.

2.1.1 Changing Large Socio-Technical Systems
Hughes (1983) stressed that a large technical system must be analysed as a *seamless web* of socio-political, economic, cultural, institutional and technical components and thus not only *technical* but *socio-technical* in its nature. The basic idea of the LTS perspective is that technological development can’t be analysed properly by only investigating the individual component or the different sub-systems (Hughes 1983; Kaijser 2003).

A *mature* system is deeply embedded in society and not easily changed or transformed. It is often noted that it was not the stage coach owners that invested in the railroad. The system culture in mature socio-technical system is often very conservative, its actors, *system builders* are unwilling to change since they are living of the system.

In Hughes’s (1992) terminology, change is caused by a “salient” or a “reverse salient”. These are metaphors borrowed from the military, denoting a bulge that is ahead or behind of a front moving forward. The concepts are used to describe a system component or a sub-system being ahead or lagging, compared to other components and given the desired direction of the advance. Salients and reverse salients disturb the system and slows down growth. They give impulses to innovate, but only if they are recognized by key actors.

The fact, that system actors must recognize a reverse salient, is crucial when managing a system in periods of transformation pressure. But identifying a salient or a reverse salient can be difficult for actors deeply embedded in the system. A reverse salient is, to a certain extent, a social construction as its definition depends on the point of view of different actors – a reverse salient is a fact in the eye of the beholder.

In the management of infra systems it is evident that history matters. History and heritage is evident within the existing system and influences the way its actors are able to meet the need for transformation. The physical system components are standardized and aligned with each other and system actors are used to deal with system operations and business models in a certain way. Thus, every established system has its own systems logic. When change is approaching it is not even certain that the incumbent system actors are able to identify the way to handle the upcoming challenges. It is hard to think outside the systems logic with its established architecture of standardized components, stable hierarchies and successful business models and when trapped in a conservative “systems culture”.

Of course, the incumbent system actors can use another strategy to deal with a reverse salient, and that is to view it as an “externality”. That is, to draw the border of the system in such a

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1 A concept used by Swedish historian of technology, Professor Arne Kaijser.
way that the issues related to more serious transformation pressure is placed outside their responsibilities. But what happens when an externality, as previously defined by system actors, is transformed into a reverse salient? What happens when system actors must handle issues that they earlier saw as problems outside the realm of the system? Like CO2 or noise?

Tom Hughes stresses the importance of identifying reverse salient and trying to formulate a solution within the system logic. Defining a reverse salient as one or more critical problems is in itself a major step toward a solution. But who has the right to define a reverse salient and point to a solution? In our interpretation of this process we want to point to the “privilege of problem formulation”. Which actors gain this privilege as well as the strategy to solve it?

2.2 Socio-technical process and system analysis

Understanding the functionality of a socio-technical system is key to managing it more effectively, changing it for better outcomes, or designing a well-functioning future system. This a starting point for a research program on system and process analysis in socio-technical systems that have been led by Nick McDonald at the Centre for innovative human systems at Trinity College, Dublin (Corrigan and McDonald, 2015; McDonald, 2015). A series of EU-funded projects over a period of 20 years has produced more than 20 case studies, performed with participative design with industrial partners, mainly in aviation. This research is still on-going and has resulted in a number of socio-technical frameworks: SCOPE (System Change and Operations Evaluation) a concept and software tool and Structured Enquiry which is a systematic method for iteratively analyse and evaluate change.

2.2.1 SCOPE

In order to deliver value at an operational level it requires knowing how to reduce the uncertainty that can compromise the outcome of the process. In any functional process, these elements have been identified as core source of uncertainty (figure 1):

- Availability of resources (people, material, information) according to demand.
- Performance of tasks, including influence of contextual factors
- Coordination between tasks and processes
- Clarity of process goals

If one is to represent a system, then it is not enough to represent different points of views. It needs to be systemic and establish a consistent pattern of activity that relates to some underlying boundary conditions of the production system, such as: the technology that makes possible the transformation of resources, the organization of technologies that enables delivery of product or service and the organization of people to make the system work.

However, the real social system of production is nearly always partially hidden. The normal way of doing is not written down. The actual functional social groupings are not recognizable as a team. The knowledge of how things happen is tacit. Information does not flow freely. Management processes often do not have clear outcomes and their functional role in the system as a whole is not understood even by the people performing them. Therefore, the underlying reality of the production system needs to be uncovered in a deliberate and purposeful way. In order to do this some basic principles are proposed to direct an enquiry
producing an analysis of a socio-technical system. A theory of the mechanisms of socio-technical systems is proposed based on the relation between the functional requirements of its processes and the social relations that are necessary to support them. Cycles of knowledge and information mediate between these and provide opportunities for intervention. Each subsystem is organized according to a particular logic (figure 2). Each if the logics have a basic organising principle, a mode of creating value, a timescale and a role (table 1).

- Process logic: The functional integrity and the technological support of either operational or management processes (similar mechanisms applies).
- Social logic: The structure and quality of social relations (team structure and trust).
- Knowledge logic and information logic: The way in which knowledge can be deployed in functional processes and in adaptation and change.

If the goal is to deliver value for the customer then goals relate to interests which may vary with various stakeholders within and externally to the system with conflicting or counter balanced goals as result. Within an organization this is commonly referred to balancing between individuals potential conflicts of interests with the organization. The analysis of value interests and strategy should identify where there are conflicts of interest. People will have different points of view of the socio-technical system they share. “Fundamental conflicts of interest cannot be resolved simply through analysis and recommendation, as if there were a technocratic solution to everything.” (McDonald, 2015).

However, even when there are fundamental conflicts of interest, there can still be a need to cooperate and work to achieve an objective. A specially tailored analysis of socio-technical systems could support a way to do this. With a participative approach it can help create mutual understanding of each other's perspective on the system, as a shared precursor to a shared understanding of how the system can be improved.

2.2.2 Structured Enquiry - Evaluation of change

The structured enquiry is supported by the SCOPE model representing the functionality of the system. However, here it is used for relevant enquiries to support and evaluate a process of change. Understanding how the system performs in relation to the three sub-systems recommendations per system logic may be given and evaluated, depending on the progress of change which may alter which logic needs mitigation in order to increase chances for successful change.

The predictive element is initiated with predictive risk assessments, based on expert judgement. With a thorough system analysis prior to change an objective reference point is available, against which to extrapolate what could happen in the future. A series of extrapolation needs to be conducted iteratively throughout the process of system change. It is comparable to a “moving bow-tie”. Questions are listed in table 2.

The data comes from a dossier that is built through the structured enquiry with representatives of the actor, the company or organization and need to be a thick description to give reasonable degree of confidence in answering the questions. In consolidation of each enquiry the experts answers questions like: Assuming a successful implementation, how likely is the current
situation? Assuming an unsuccessful implementation, how likely is the current situation? As barriers are identified from analysis of system requirements, recommendations are given to change the prospect for success of the initiative. The effectiveness of these is then measured by comparing the outcome to a current reference point, the system model.

2.3 Backcasting for the future
Backcasting is used in studies of industrial transformations (Quist and Vergragt, 2006) and provides various types of scenario analysis in developing strategies and pathways during major changes of society. The method starts by constructing scenarios by looking backwards from the desired future. Possible uses of scenarios may include, risk and crisis management, project development, clarifying conflicts to understand their causes, and to antecedents when consensus regarding what you disagree on (figure 4 and 5).

Idealized system is an ideal picture of how a system could look like, free from historically conditioned restrictions that no longer serve a purpose. It attempts to answer the question of what a logically coherent system could look like starting from the current knowledge.

3 Project description
The first task will be to initiate the development of a theoretical framework. This will support a more detailed research design. Theories for system analysis and change are closely linked to methods and tools for producing analysis. The research group has experience with methods presented in this proposal. SCOPE and Structured Enquiry has been applied to operations, management processes (risk and change), multi-organisational collaborative change in aviation, but never an INFRA system with externalities and actors outside aviation influencing change. Backcasting has been used in INFRA systems but not in aviation. So, the project will include a methodological development based on these methods and theories.

For the latter part of the project, support will be given to implementation of any noise reduction initiative taken. The initiative developed by the system builders will most likely be influenced by the results from projects like SAFT, Brantare, ULLA. Close collaboration and communication with those projects will be input to stakeholders in the system development process of INFRA (i.e in backcasting and designing a well-functioning future system).

System analysis tasks will progress in parallel with various stakeholders. Consolidation of overall system analysis and idealized system will be evaluated with “re-analysis” and re-design of both future system as well as the change process. This project is planned to have a participative approach that builds on knowledge and information sharing since “it can help create mutual understanding of each other’s perspective on the system”. Main methods will be interviews of stakeholders and multifunctional workshops using SCOPE and Structured enquiry to “uncovered underlying reality of the system in a deliberate and purposeful way”.

The project is organized with a set of work packages: System analysis (WP2), Future system development (WP3), Implementation - noise reduction initiatives (WP4) and Evaluation of change (WP5). In addition the project has two coordinating work packages with Project management (WP1) and Knowledge management (WP6).
INFRA will be a five year project with a mix of both PhD student work and senior researchers and a Post Doc about two years into the project replacing senior resources.

3.1 Work plan — Work packages, deliverables (see table 3).

WP1 Project management M1-M60
Objective: To manage the INFRA project accordingly to plan (goals, time and budget).
Tasks: This includes performing administrate and financial tasks, plan and coordinate project, recruiting a PhD and a Post Doc. Supporting dissemination events.

- Produce the Project Management Plan (M1)
- Hold monthly project meetings.
- Planning and coordinating the field work to ensure that effective communication (including confidentiality) exists between researchers and collaborating partners.

WP2 INFRA system analysis M1-M24
Objective: Develop a thorough understanding of the system as a whole (AS-IS). Define the INFRA system boundaries, actors and components, based on past and present description. WP2 will develop a theoretical framework for INFRA, a methods- and toolkit for INFRA participative studies, perform process and system functionality analysis of each actor and develop an INFRA system definition and description.

- A Systematic Literature Review (SLR) and comparative studies will be made to allow for generalizable systemic research to be included in INFRA theoretical framework.
- Review and develop methods for system analysis to define the INFRA system using methods and models identified in state of art and currently in use by the researchers.
- Performa a near history analysis (anamnesis) of past event leading up to the current situation using interviews and studying historical document and communications.
- Applying developed methods to map the system components, main functionalities and roles applying participative research for identifying and producing analysis of the stakeholders and potential actors. Conduct interviews and run multifunctional knowledge transformational workshops.
- Perform an INFRA system analysis consolidating earlier tasks. Here central concepts will be identified in the INFRA system and the system discussed in terms of the theoretical framework. Multi-actor workshops may be used to validate the prototypes of the INFRA system definition and description.

WP3 Future system development M18-M30
Objective: Develop a prototype future system (TO-BE) with reduced noise. Understanding the different actors systems thinking, problem formulation perspective, sharing information to develop knowledge among actors their respective perspectives. Identifying different problem formulations with various salients and reverse salients for system development and building and how externalities are internalised.

- Perform scenarios and backcasting workshops including elements of the Structured enquiry or as recommended from methods in WP2.
- Consolidate and collect input from projects like SAFT, ULLA and BRANTARE to diagnose the future impact of various suggested desired system
Iterative process of prototyping between needs, idealised systems and noise reduction research.

**WP4 Implementation - Noise reduction initiative**  M30-M54

**Objective:** Plan and prepare strategy for changing to the future system based on WP3.

**Tasks:** This activity foresees major participation from INFRA system actors that needs to participate in the system change. INFRA project will support the noise reduction initiatives taken, producing value for the different actors in activities aligned with their strategy.

- Developed a plan together with each actor
- Develop a common collaborative system change process.
- Support change initiatives by knowledge sharing and hand-over (from WP2 and WP3) to potentially new operative actors in the change team.

**WP5 Evaluation of change**  M1-M56

**Objective:** Evaluation of change using structured enquiry and the moving bow-tie mainly on Throughout work in WP3 and WP4.

- Produce dossiers in an iterative prototype manner. Allow for learning and progress of change (both from experts in research team and in change team and also the society interest group) to be reflected in new reference points and new strategies and new targets for the future system.
- Perform the moving “bow-tie” to assess risk and guide recommendations.

**WP6 Knowledge management**  M1-M60

**Objective:** Support knowledge transformation processes for shared understanding in research, in practice, in society on the challenges and issues related to changing the INFRA system in order to reduce noise in aviation.

- Shared supervision of the shared PhD student.
- Monthly open INFRA-seminars at INDEK
- Dissemination at conferences and in journals

### 3.2 CONSORTIUM

The project leader Pernilla Ulfvengren has been collaborating with the Centre for Innovative human systems at Trinity College, Dublin since 2005. In three EU-projects HILAS (Human integration into the life-cycle of aviation systems), MASCA (Managing system change in aviation) and PROSPERO ((PROactive Safety PERformance for Operations), research on system and process analysis and developing systems for change in socio-technical systems have been carried out with airports, airlines and regulators. INFRA is the first common project between the two divisions SID and IM at INDEK. Pär Blomkvist and Niklas Arvidsson are both docents and with excellent merits in the field of industrial dynamics and sustainability research. Many common areas of interest and benefits with complementary knowledge from both large technical systems research and aviation research were identified in the pre-study to INFRA. Apart from these senior researchers at INDEK a PhD student will be recruited and supervised and co-supervised in collaboration between the divisions of SID and
IM. A Post Doc after two years will also be recruited in support for field work with the PhD in the implementation phase to cover larger grounds.

### 3.3 Dissemination

Dissemination is described also in WP6. Multi-functional workshops as well as multi-actor workshops will enhance stakeholder collaboration as well as increase transparency to other actor outside the aviation actors. INFRA may engage students in i.e. Master theses.

As this is also a PhD project regular dissemination required in research education at KTH will make available material like thesis proposals, mid-terms and finally a PhD thesis.

List of conferences: ICRAT (International Conference on Research in Air Transportation), ICN, (International Conference on Noise Pollution), USA/Europe ATM seminar, SID (SESAR innovation days). List of journals: Journal of air transport and management: Journal of transport History: Noise Control Engineering Journal

### 3.4 Risk management

Even if stakeholders’ close participation in INFRA is essential and desired, it is still possible to conduct with only minimum, expected access. Less participation will mostly affect the implementation research to become more of a common case study of the system change.

Mitigation strategies are to keep the stakeholders in the loop will be to deliver value to them. For project resilience, the ambition is to get at least two contact persons per stakeholder that is kept in the loop for redundancy.

### References:

Appendix B
Budget INFRA

<table>
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<tr>
<th>Staff</th>
<th>WP lead</th>
<th>PM</th>
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<td>Pernilla Ulfvengren</td>
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<td>WP1,5</td>
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<td>Pär Blomkvist</td>
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<td>Niklas Arvidsson</td>
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INFRA applies for a total of 6.5 M SEK.

The project is planned for a 5 year period.

The PhD student is enrolled in PhD program for 5 years. 80% per year in INFRA and 20% at INDEK. So the equivalent funds from CSA are 4 years with a cost of 900 000 SEK per year.

The Post Doc is planned for year 3 and 4 and will work 50% in the project and the rest at INDEK.

The final and fifth year is mostly dedicated for follow up studies and for the PhD to finish writing articles and the Doctoral thesis.

The costs are based on the level of salaries (2016) for the involved persons including social taxes and the university overheads.

The 300 000 SEK is for potential need to reimburse participants from industry and other groups for their time in interviews and workshops etc.
Appendix C CVs for INFRA

Curriculum Vitae – Pernilla Ulfvengren, 680514-0487

Positions/Degrees
2003 Ph.D. In Industrial work science, specialization in human factors
1995 M.Sc M.E.(mechanical engineering), KTH.

Employments
2015- Director of programme, Industrial Technology and Sustainability, ITM, KTH
2012- Associate professor in Industrial Work Science (Human-Machine Systems), INDEK, KTH
2005-2012 Assistant professor in Industrial Work Science (Human-Machine Systems), INDEK, KTH
2013-2015 Avdelningschef Industrial Management, INDEK, KTH
2011-2012 Visiting Scholar at University of California, Berkeley, NEXTOR, USA

Assignments
2015- Vice director of Centre for Sustainable Aviation, KTH
2015- AKUT project– (Akademi UT i industri), SCANIA position. VINNOVA
2015- Reaktorsäkerhetsnämnden, Strålsäkerhetsmyndigheten, SSM.
2015- School of Industrial Engineering and Management Recruiting council
2013- VINNOVA FFI kvalitetsgranskningråd

Personal
Born 1968. Live in Stockholm with Fredrik and our children Fabian (11) and Erika (9).

Research projects
2010-2014 Higher Automation Levels in ATM, HALA. Thematic network in SESAR.
2010-2013 MAnaging System Change in Aviation, MASCA- EU FP7.
Project manager (proposal and contract), personal basic research funding.
2012-2014 MESAUT Measuring high level automation related system performance in a future ATM environment – a pilot perspective. VINNOVA Transport / Aviation
2009-2013 Clinic-Centered Innovation, Technology and Organization, C2ITO - Research on KTH-KI-SLL Fellowship program. Funded by Vinnvärd/VINNOVA.
2005-2009 Human Integration into the Lifecycle of Aviation Systems, HILAS, EU 6th FP.
1996-2000 Warning systems in aircraft, NFFP/VINNOVA

Scholarships (1998-2011)
2011 KTH Transport Platform Fellow for Visiting Scholar at UC Berkeley
2011 Sweden-America foundation scholarship for Visiting Scholar at UC Berkeley
Invited presentations
2015 Norwegian (AS) Safety Review Committee, Safety management seminar
2014 Vattenfall, Safety Management Institute, Seminar: Safety management and operations
2013 HRO (High reliability organizations) third European conference, Aix en Provence, guest speaker and seminar leader
2012 Human factors, Safety and Change: Tutorial seminar at International Conference on Aviation Transport ICRAT, Berkeley, USA
2012 Safety performance, Institute of Transportation Studies, ITS, UC Berkeley
2012 HILAS and MASCA research – HRO, CCRM seminar, Haas School of Business, Berkeley, Centre for Catastrophic Risk Management.

Supervisory activities
Assistant supervisor for PhD:
2013- PhD student Matthew Stogsdill, Risk concepts, (Industrial Management, INDEK, KTH)
2013- PhD student Simon Okwir, Performance measures in multi-organisation settings, (European Doctorate in Industrial Management, EDIM, INDEK, KTH)
2007- Industrial PhD student, Johan Rignér Automation in aviation.

Review assignments for journals and conferences
2015- Transportation Research Part A: Policy and Practice, Elsevier
2014- Reliability Engineering and System Safety
2012 - ICRAT, International conference on research in air transportation, Session chair
2011- ATACCS (1st Int. Conf. on Application and Theory in Automation Command and Control Systems) Scientific programme committee
2010- HCI-Aero (Human-Computer Interaction) International program committee
2010- International Journal: Cognition, Technology and Work, Springer
2011- International Journal of Applied Aviation Studies, FAA (Federal Aviation Authorities)

CV Pär Blomkvist

<table>
<thead>
<tr>
<th>Namn</th>
<th>Pär Blomkvist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ålder</td>
<td>1961</td>
</tr>
<tr>
<td>Kön</td>
<td>M</td>
</tr>
<tr>
<td>Organisation</td>
<td>Enheten för hållbarhet och industriell dynamik, INDEK, KTH</td>
</tr>
<tr>
<td>Titel</td>
<td>Docent, Fil. Dr.</td>
</tr>
<tr>
<td>Roll i projektet</td>
<td>Forskare</td>
</tr>
</tbody>
</table>

Kompetens, erfarenhet i förhållande till idén
Long research experience on Large Technical Systems and infrastructure planning

Motiv till varför person är en nyckelperson
Brings the historical and institutional perspective to the project concerning large infrastructural challenges

Övrigt
• Higher education qualification
  Bachelor of philosophy, 1995, History, Stockholm university
Doctoral degree
**PhD**: 21 March 2001, History – Dep. Of history, University of Stockholm, Title: *Den goda vägens vänner. Väg- och billobbyn och framväxten av det svenska bilsamhället 1914-1959* (Symposion 2001), Supervisors: Klas Åmark (SU) and Arne Kaijser (KTH)

Qualification required for appointments as a docent: 2013

Current position:
Lektor and Associate professor (docent, 2013) in Industrial Economics (especially Industrial Dynamics) at the Department of Industrial Economics and Management (INDEK), Royal Institute of Technology (Kungliga Tekniska Högskolan, KTH), Stockholm (januari 2005 --) – 20% research

Previous positions and periods of appointment
At KTH since 2001 in various positions

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**Curriculum Vitae – Niklas Arvidsson, 640424-1793**

**Current affiliation**
Department of Sustainability and Industrial Dynamics, Industrial Engineering and Management (INDEK) at the Royal Institute of Technology. Mail: niklas.arvidsson@indek.kth.se. Phone number: +46-8-790 7655.

**Current position**
Associate Professor (Lektor), Employed January 1st, 2012.

**Previous employments**
- Head of department of Sustainability and Industrial Dynamics, Industrial Engineering and Management (INDEK) at the Royal Institute of Technology (2014-2016).
- Associate Professor, Centre for Banking and Finance at the Royal Institute of Technology (2007-2011)
- Research assistant, National Institute of Working Life (2005 - 2007)

**Other work**
- Associated consultant, NormannPartners AB (2003 –)
- Invited guest researcher at the University of Warwick (1994)

**Education**
- Ph.D. in International Business, Stockholm School of Economics 1999
- Master of Business Administration, Stockholm School of Economics (Civ.Ek.) 1991
Other assignments

- I organized the seminar “Hur ser Riksbanken på de förändringar som sker på betalningsmarknaden?” (The view of the Swedish Riksbank on the developments in the retail payment industry) where Cecilia Skingsley, Deputy Governor, presented a report challenges and possible action in this area, November 24, 2014. The seminar was held at KTH.

- I was interviewed by the international newspaper the Guardian on the use of cash in Sweden, November 11, 2014. www.theguardian.com/world/2014/nov/11/welcome-sweden-electronic-money-not-so-funny

- I was interviewed by the US news agency Bloomberg on how the use of cash in Sweden is decreasing rapidly and that Sweden is moving towards a cashless society. http://www.bloomberg.com/video/future-of-money-welcome-to-cashless-sweden-W3q24OtBT0mXhs1z1PcQHW.html

- I was interviewed in Dagens Nyheter about the innovative potential of Apple Pay on September 17, 2014. http://www.dn.se/ekonomi/oprovat-system-bakom-apple-pay/

- I was invited as a panel discussant of the future of the mass payment system organized Sveriges Riksbank on June 11th, 2013. http://www.riksbank.se/en/Calender/2013/#m6

- I was invited as an expert to present my views on the future of the payment system at Round Table meetings organized by Sveriges Riksbank on November 26th, 2012, and March 8th, 2013.

- I was speaker and moderator during the conference called Nordic Payment Forum in Stockholm 2013 as well as 2012. The conference was organized by the Swedish business magazine Affärsvärlden and Talentum Events.

- I presented my study The Cashless Society in a seminar hosted by Handelns Utvecklingsråd and Sparbanksstiftelsen Nya for almost 80 persons at Nalen in Stockholm on February 22, 2013.
Appendix D - Publications lists INFRA

Pernilla Ulfvengren:

Peer reviewed international journal articles:
Okwir, S., & Correas, A. & Pernilla, U (2014), Collaborative Decision Making (CDM) in Airport Surface: Europe vs USA implementations, challenges and best practices, Under review in the Journal of Air Transport Management (JAM)

Peer reviewed international conference articles:
Corrigan, S., Baranzini, D., McDonald, N. and Ulfvengren, P. (2015) Managing the risk of change, ESREL, European Safety and Reliability conference ETH, Zurich, Schweiz, 7-10 September, 2015
Ulfvengren, P., Rignér, J. Moberg, B. (2012) Airline perspective on future automation performance - Increased need for new types of operational data. 5th International Conference on Research in Air Transportation – ICRAT 2012, May, University of

Pär Blomkvist

Peer-reviewed original articles

Blomkvist, Pär and Lars Uppvall: “A Chain is only as Strong as its Weakest Link: Managing Change in the Curriculum of Industrial Management Education” in International Journal of Industrial Engineering and Management (IJIEM), Vol. 3 No 2, 2012, pp. 53-65


Blomkvist, Pär and Lars Uppvall: “LEARNING TO LOVE AMBIGUITY: AUTHENTIC LIVE CASE METHODOLOGY IN INDUSTRIAL MANAGEMENT EDUCATION” in International Journal of Case Method Research & Application 2012, XXIV, 4

Peer-reviewed conference contributions


Monographs

Blomkvist, Pär och Anette Hallin: Metod för teknologer. Examensarbete enligt 4-fasmodellen, Studentlitteratur 2014 (Engelsk version 2015)

Blomkvist, Pär Om förvaltning av gemensamma resurser: Enskild väghållning och allmänningens dilemma i svensk historia 1200–2010 (Managing Common Pool Resources: Road Keeping and the Dilemma of the Commons in Swedish History 1200–2010), Division of Industrial Dynamics, Royal Institute of Technology, Stockholm (Stockholm 2010), TRITA-IEO 2010:06


Blomkvist, Pär “Fysisk infrastruktur som förutsättning och som arena för demokratutvecklingen i Sverige 1850-2000” i Horgby, Björn och Lars Ilshammar (red.) Demokratins infrastrukturer i Sverige (kommande antologi)

Blomkvist, Pär Den goda vägens vänner. Väg- och billobbyn och framväxten av det svenska bilsamhället 1914-1959, Symposion 2001 (diss.)

Popular science articles/presentations

Pär Blomkvist och Thomas Sandberg, “Vindkraft och samfällighetsförvaltning” i ASPECT nr. 7 -2011
Essay in Dagens Nyheter 2010-04-15 “Vägen från medeltiden” i Dagens nyheter(Kultur) 2010, s 8


Niklas Arvidsson

Selected publications


Appendix E: Tables and figures

Figure 1: A figure of a simple model.

Figure 2: Architecture of process analysis (source: McDonald, 2014).

Figure 3: Architecture of overall system analysis (source: McDonald, 2014).
Figure 4. Scenarios are wind Tunnels for testing a current and alternative strategies.

Figure 5. Method steps from idealized design to new system.

Table 1. Functional principles of subsystems 1, 2 and 3.

<table>
<thead>
<tr>
<th></th>
<th>1: Process logic</th>
<th>3: Knowledge logic</th>
<th>2: Social logic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value delivered</td>
<td>Transactional value</td>
<td>Possibility of change</td>
<td>Enduring relationships, sustain value</td>
</tr>
<tr>
<td>Mechanism</td>
<td>Transformation of resources to output</td>
<td>Transformation of meaning</td>
<td>Team integration and trust</td>
</tr>
<tr>
<td>Relationships</td>
<td>Sequential</td>
<td>Circular – validation</td>
<td>Reciprocal</td>
</tr>
<tr>
<td>Timeline</td>
<td>Real time</td>
<td>Relates past, present and future</td>
<td>Slow build up over time</td>
</tr>
<tr>
<td>Key functional</td>
<td>Propagation and/or control of uncertainty</td>
<td>Common understanding of system and values</td>
<td>Co-ordination of activity</td>
</tr>
<tr>
<td>parameter</td>
<td></td>
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</tbody>
</table>
### Table 2. Synthesis of Structured Enquiry (McDonald, 2014)

| **Initial state** | Do deficiencies of the existing state threaten the sustainability of the system?  
Are the risks of not changing understood?  
Can divergent interests block change? |
| **Goals** | Do goals represent credible targets that improve system sustainability?  
Are goals clear, well defined & attainable?  
Are goals shared amongst stakeholders? |
| **Operational process** | Can the (to-be) operational process deliver the performance to satisfy the goals? |
| **Management process** | Can (to-be) management processes enable operational processes in achieving the goals? |
| **Social structure** | Does the quality of the social relationships match the demands of the change?  
Are all relevant stakeholders involved in a team structure that enables effective decision & action? |
| **Trust** | Does the level of mutual trust support collaboration to achieve the goals? |
| **Knowledge cycle** | Is system knowledge actively developed, shared & validated to  
- Support operational action?  
- Support system design and change? |
| **Information cycle** | Will the flow of data provide knowledge about the activity of the system and its situation, to  
- Support operational action?  
- Support system review & evaluation? |

### Table 3. Deliverables

<table>
<thead>
<tr>
<th>WP NUMBER</th>
<th>WP1</th>
<th>WP number</th>
<th>WP leader SEN1/PL</th>
<th>M1-M60</th>
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<tbody>
<tr>
<td><strong>WP TITLE</strong></td>
<td>Project Management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>Project leader will do the administration, all participate in meetings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliverables</td>
<td>D1.1</td>
<td>Project management Plan</td>
<td>M1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D1.2-1.5</td>
<td>Project reports</td>
<td>M12, M24, M36, M48</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D1.6</td>
<td>Final project report</td>
<td>M60</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WP NUMBER</td>
<td>WP2</td>
<td>WP number</td>
<td>WP leader SEN2</td>
<td>M1-M24</td>
</tr>
<tr>
<td><strong>WP TITLE</strong></td>
<td>INFRA system analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Resources | PhD: perform systematic literature, participate in interviews and workshops write PhD thesis proposal and write a PhD mid-term report.  
SEN1: conduct interviews and facilitate workshops, INFRA system analysis  
SEN2: Near history investigation, conduct actor interviews and participate in workshops, INFRA system analysis  
SEN3: INFRA system analysis |
| Deliverables | D2.1 | Theoretical framework | M18 |
| | D2.2 | PhD Thesis proposal | M12 |
| | D2.3 | System’s actors analysis dossiers no.1 | M24 |
| | D2.4 | The INFRA System—description. | M24 |
| | D2.5 | PhD Mid-term report | M24 |
| | | | |
| WP NUMBER | WP3 | WP number | WP leader SEN3 | M18-M30 |
| **WP TITLE** | Future system development |
| Resources | All will perform scenario and follow-up analysis with actors.  
SEN1 will coordinate between other Noise projects i.e. SAFT, ULLA, Brantare |
| Deliverables | D3.1 | Idealised future systems and One future INFRA system | M30 |
| | | | |
| WP NUMBER | WP4 | WP number | WP leader PhD | M30-M54 |
| **WP TITLE** | Implementation-Noise reduction initiative |
| Resources | PhD and PD will do most field work with participants. SEN1 and SEN2 will |
contribute to analysis and coordinate between WP3 and WP4.

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>WP NUMBER</th>
<th>WP TITLE</th>
<th>WP leader</th>
<th>WP leader</th>
<th>WP leader</th>
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<tbody>
<tr>
<td>D4.1</td>
<td>WP5</td>
<td>WP5</td>
<td>SEN1</td>
<td>SEN1</td>
<td>SEN1</td>
</tr>
<tr>
<td>Strategy for change and feasibility study report</td>
<td>M54</td>
<td></td>
<td>M1-M56</td>
<td></td>
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<tr>
<td>WP PACKAGE TITLE</td>
<td>WORK PACKAGE TITLE</td>
<td>Evaluation of change of change</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>SEN1 will lead the overall process of Structured Enquiry and analysis to produce recommendations and risk assessments. Workshops and interviews will coincide or even be the same as in WP2–WP4 but with focus on the change process. All others will participate and support according to their time in project.</td>
<td></td>
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<tr>
<td>Deliverables</td>
<td>D5.1</td>
<td>Evaluation of change in the INFRA system</td>
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<td>M56</td>
<td></td>
</tr>
<tr>
<td>WP NUMBER</td>
<td>WP6</td>
<td>WP6</td>
<td>SEN2</td>
<td>SEN2</td>
<td>SEN2</td>
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<tr>
<td>WP TITLE</td>
<td>Knowledge management</td>
<td>Knowledge management</td>
<td></td>
<td></td>
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<tr>
<td>Resources</td>
<td>SEN2 will arrange the INFRA seminars and facilitate tasks for dissemination. ALL will contribute into dissemination and knowledge sharing events.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Deliverables</td>
<td>D6.1</td>
<td>INFRA seminars summary report</td>
<td></td>
<td>M60</td>
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Table 4. Gantt schema

Table: Gantt schema

<table>
<thead>
<tr>
<th>WP 1 - Project Management</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
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<tbody>
<tr>
<td>WP 2 - INFRA System Analysis</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td>WP 3 - Future system development</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td>WP 4 - Implementation - Noise reduction Initiative</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td>WP 5 - Evaluation of Change</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td>WP 6 - Knowledge Management</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
</tr>
</tbody>
</table>
Komplettering till ansökan CSA
INFRA: TRV 2016/15206
Pernilla Ulfvengren, INDEK, KTH, Stockholm 2016-08-28


INFRA - Luftfartssystemet som bland annat producerar buller

The Blind Men and the Matter of the Elephant
Beyond Ghor, there was a city. All its inhabitants were blind. A king with his entourage arrived nearby; he brought his army and camped in the desert. He had a mighty elephant, which he used to increase the people’s awe.

The populace became anxious to see the elephant, and some sightless from among his blind community ran like fools to find it. As they did not even know the form or shape of the elephant, they groped sightlessly, gathering information by touching some part of it.

Each thought that he knew something, because he could feel a part... The man whose hand had reached an ear...said: “It is a large, rough thing, wide and broad, like a rug.” And the one who had felt the trunk said: “I have the real facts about it. It is like a straight and hollow pipe, awful and destructive.” The one who had felt its feet and legs said: “It is mighty and firm, like a pillar.”

Each had felt one part out of many. Each had perceived it “wrongly”... This ancient Sufi story was told to teach a simple lesson but one that we often ignore: The behavior of a system cannot be known just by knowing the elements of which the system is made.

Introduktion


Detta system står nu inför utmaningen att significat minska det buller som det producerar. Ingen enskild aktör kan på egen hand nå ner till önskad bullernivå. Oavsett vilken form denna förändring kommer att ha, oavsett vilken typ av bullerbekämpande initiativ som tas, så kommer en implementering och realisering av detta att påverka och omfatta alla som ingår i systemet.


Om dessa faktorer ligger utanför vad man betraktar som ”sitt system” så hanteras de normalt som ”externaliteter”. Fram till nu har buller varit en externalitet. Systemgränserna måste nu ändras att inkludera buller. Det innebär att buller går från att betraktas som en externalitet till att ”internaliseras” i systemet. Detta, komplikerar systemet och ökar behovet av att hantera buller systemiskt, tillsammans, i samverkan med alla systemaktörer, alla de som berörs och de som kan påverka, både de som producerar buller och de som utsätts för det.


Det finns flera exempel att hämta från luftfarten. Om LFV säger att det helt enkelt inte går att flyga kurvat över Upplands Väsby så kan man utföra från en flygoperatörs perspektiv havda att det inte finns något hinder alls att göra det. Ett annat exempel skulle vara om Transportstyrelsen säger att det inte är lika säkert att flyga kurvat som att flyga rakt, medan man som pilot inte ser större risk att svänga ett flygplan än att svänga en bil i en vägkurva.


INFRA som projekt kan tillföra nödvändiga resurser för att kartlägga och utveckla ett sådant helhetsperspektiv. Vår forskning utvecklar kunskap, metoder och verktyst för systemanalys och systemdiagnos. Tillämpningar av detta i möten med systemaktörer bidrar till att man förbättrar förståelse för systemet och de olika systemperspektiven i förhållande till sitt egna. Forskning visar att det är grunden för att på allvar förändra systemet. I vår forskning ingår också att förstå systemdynamik och implementering av systemförändringar.
Flyget är inte det första stora (socio-) tekniska systemet som studeras eller som måste hitta samverkansformer för att genomföra komplexa förändringar i en ny önskvärd riktning. Att se till hur andra har gjort och vilka lärdomar som finns kan ge en bild av ”best practice” på området. För att säkerställa att det är tillämpligt på vårt system så bör man också analysera skillnader och likheter mellan systemen. Inom KTHs avdelning INDEK forskas bland annat på industriell dynamik. Vi har bland annat tidigare studerat biltransportsystem och forskning pågår just nu på att analysera betalsystemet som står inför utmaningar kring kontanter och gemensamma betallösningar mellan enskilda affärsaktörer som banker och telefonbolag.

På INDEK, KTH, har vi också forskat på förändring och implementering av nya sätt att bedriva verksamheter inom flyget (MASCA – MAnaging System Change in Aviation). Inom flygbolag har utveckling och implementering av nya internationella krav på säkerhetsledningssystem (SMS) gjorts och på Arlanda har implementering av en ny flygplatsstandard, A-CDM (Airport Collaborative Decision Making), studerats och stöttats under aktionsforskningsliknande former. INDEK på KTH har även lång erfarenhet av forskning inom säkerhetskritiska system, där säkerhet är ett systemiskt element. Flyget, kärnkraft samt sjukvård har studerats.

Mål och syfte

Det är ett känt faktum i förändringslitteratur och forskning att systemförändringar är något av de svåraste en organisation eller system där flera organisationer ingår, kan företa sig. Det är en högriskaktivitet som bör tas på största allvar. Det är inte ovanligt att forskare kommer fram till att upp till 60% av alla systemförändringar misslyckas! En av riskerna är att man förbiser oönskade effekter och suboptimerar för att man inte tillräckligt förstår systemets funktionalitet.

Det övergripande målet med INFRA är att bidra till att öka chanserna för att genomföra en hållbar och lyckad systemförändring för att minska buller. Ett delmål är att förbereda systemet på implementering av de nya bullerreducerande initiativ och lösningar som parallell forskning utvecklar (t.ex. andra finansierade projekt inom KTH centrum för hållbar luftfart). INFRA:s resultat kan tillämpas också i utvärdering och prioritering av olika lösningsförslag.

Syftet med INFRA är att studera flyget som ett sammanhållet infrastrukturellt (transport-)system – ett ”infraresystem” – samt att studera hur man på allvar kan beakta buller som en internaliserad systemkomponent. Detta i sin tur leder till att utveckla kunskap nödvändig för att utforma och anpassa metoder och verktyg för implementering och realisering av framtida lösningar.

Genomförande och forskningsaktiviteter

Då den ursprungliga ansökan diskuterades med Swedavia och LFV vid ett förmöte innan sommaren var vi överens om att projektet i huvudsak består av tre delar:

1. Studera flyget som ett transport- och infrasystem.
2. Studera hur man på allvar kan beakta buller som en fullvårdig systemkomponent inom flyget.
3. Implementering av systemförändring.

För att minska omfånget så föreslogs att implementeringsfasen (nr 3) studeras i ett framtida projekt. Detta beskrivs kortfattat nedan under rubriken Framtida forskning. Kvarstår gör del 1 och 2.

1. Studera flyget som ett infrasystem.

2. Buller som en fullvårdig systemkomponent inom luftfarten.

Literaturstudier och metodstudier (M1-M12)
- Kartläggning av litteratur och kunskap på området.
- Utveckling av ett teoretiskt ramverk.
- Utveckling av intervju mallar.
- Utformning av detaljerad projektplan.
- Utformning av material och planering av workshops.

Kartläggning av INFRA-systemet (M1-M12)
- Intervjuer av samtliga systemaktörer, ca 10 intervjuer per systemaktör.
- Dokumentstudier.
- Beskrivning av systemets historia och systemdiagnos, ”anamnes”.
- Framtagande av en systemmodell och beskrivning av delarnas relationer.

Backcasting (M12-M24)
- Deltagande av 2-5 personer av de som intervjuats i workshops enligt ”Backcasting” metoden (beskriven i ursprungliga ansökan).
- Backcasting kommer att ske dels utifrån olika systemperspektiv och dels konsoliderande workshops i samverkan tillsammans med olika systemaktörer (se tidigare ansökan).
- Framtagning av en idealiserad systemmodell, ett önskeläge.
- Utveckling av scenarios som beskriver hur vägen dit skulle behöva se ut (backcasting).
- Detta ger också rimliga förväntningar och fingervisning om hur lång process det är frågan om. Detta kan kommuniseras till de i och utanför systemet.

Validering (M24-M36)
- Systemaktörerna kommer också att behöva medverka i valideringsövningar. Detta kan vara att:
  - ge feedback på sammanfattande beskrivningar från intervjuer och workshops,
o läsa rapport och ge muntlig eller skriftlig feedback,
o delta vid seminarier där resultat presenteras och diskuteras.

- Uppföljningsintervjuer vid behov.

**Framtida forskning - Implementering av bullerreducerande initiativ (utlyft del)**
Projektet INFRA ses som en början på vidare implementeringsforskning. En fortsättning på INFRA är viktig för validering och vidareutveckling av resultaten i INFRA. Forskning och utvecklingsarbete som pågår parallellet med INFRA, utvecklar tekniska lösningar och bullerreducerande initiativ. Då detta ska implementeras så antas det krävas en systemförändring. I kommande forskningsprojekt planeras resultat från INFRA att tillämpas och valideras genom att medverka och följa implementering av bullerreducerande åtgärder.

Resultaten från INFRA anses högrelevanta även för andra systemaspekter med målet att uppnå ökad hållbarhet. Vi hävdar att internalisering av externaliteter är en väsentlig process för fler hållbarhetsaspekter än buller. INFRA kan utveckla kunskap som långsiktigt är relevant för andra projekt inom KTH centrum för hållbar luftfart som andra miljöeffekter och säkerhet.

**Projektledning**
Pernilla Ulfvengren är projektledare och senior forskare i projektet under de två första åren. Pernilla är även biträdsande handledare till doktoranden under hela projektet.

En referensgrupp till projektet med representanter från centrumets parter samt sakkunniga inom forskningsområdet föreslås:
- Som sakkunniga på KTH föreslås Pär Blomkvist och Niklas Arvidsson som också kommer bistå med handledning av doktoranden.
- Referensgrupp från de olika parterna tas fram i samråd med KTHs centrumets styrelse.

**Reviderad budget (antal år reducerat samt post-doc utgår)**

<table>
<thead>
<tr>
<th>Staff</th>
<th>PM</th>
<th>Cost (SEK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>Student</td>
<td>M1-M48</td>
</tr>
<tr>
<td>Pernilla Ulfvengren</td>
<td>Forskare</td>
<td>M1-M24</td>
</tr>
<tr>
<td>Pernilla Ulfvengren</td>
<td>Bi-handl.</td>
<td>M1-M48</td>
</tr>
<tr>
<td>Pär Blomkvist</td>
<td>H-handl.</td>
<td>M1-M48</td>
</tr>
<tr>
<td>Deltagande systemaktörer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PM/SEK</th>
<th>PM 1-12 SEK</th>
<th>PM 13-24 SEK</th>
<th>PM 25-36 SEK</th>
<th>PM 37-48 SEK</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>12 (100%)</td>
<td>900</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>SEN1</td>
<td>5 (40%)</td>
<td>725</td>
<td>725</td>
<td>0</td>
</tr>
<tr>
<td>COT</td>
<td>1625</td>
<td>1625</td>
<td>900</td>
<td>900</td>
</tr>
</tbody>
</table>

**INFRA ansöker om totalt 5.35 M SEK**, för 48 månader för perioden 2016-2020
- Doktoranden finansieras under 4 år med 900 000 SEK per år.
- 300 000 SEK avsätts för ersättning till deltagande industripartners.
- En senior forskare arbetar 40% under projektets två första år för att “kickstarta” projektet och stötta doktoranden initialt.
- Sakkunniga och senior forskare ingår indirekt genom handledning av doktoranden.
- Kostnaderna är baserade på 2016 års lönenivå, inklusive sociala avgifter och KTH overhead.