INTERNATIONAL KNOWLEDGE AND INNOVATION NETWORKS

FOR EUROPEAN INTEGRATION, COHESION AND ENLARGEMENT

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Innovation and Knowledge Creation Processes in the Cluster of Aeronautics in the region of Hamburg

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1. Introduction

1.1 Aims of Research

The EU Lisbon Agenda aims to build up Europe as the most competitive region in the world in 2010 (Sapir et al., 2003). A major part of this strategy to improve competitiveness against North America and Asia is the improvement of the knowledge base. Most instruments and programs, however, still follow a linear, sector-based concept of innovation with a special focus on high technology sectors. Innovation research shows that successful innovation strategies are based on recursive interactive processes of knowledge generation, examination and commercialisation – focusing on input factors as R&D investments cause risks not to have the capability for successful market introduction. Furthermore, innovation research stresses the increasing relevance of integrating technologies, which combine knowledge from different scientific disciplines and technological paradigms and link high and medium technology sectors. A closer look to the competitive advantages of European firms and regions reveals the dominant role of medium technology sectors for employment and trade volume. These sectors are characterised by specific forms of cooperation, knowledge acquisition and exploitation and a high share of SME. These SME now face specific challenges of adjustment to global market processes, as global, modular sourcing strategies by dominant OEM, shortening of innovation cycles, combination of traditional and high-technology sectors, changes of financial markets in the context of Basle II and increasing relevance of outsourcing and offshoring strategies. EU programs so far hardly reach these SME. As a consequence, an increasing knowledge gap between leading and lagging regions and between multinational companies having access to all R&D facilities worldwide and spatially bounded SME threatens to endanger Europe's dominant role in medium technology sectors.

IKINET intends to overcome these deficits in research and policy practise so far following three main research steps. Firstly, a better understanding of knowledge creation and exploitation strategies by interactive intra- and inter-organisational learning processes shall be achieved for medium technology sectors. In particular, the characteristics of the knowledge exchanged, the channels and codes of exchange as well as necessary formal and informal rules within and between organisations are investigated. Secondly, the interplay between the spatially bounded organisation of regional knowledge clusters and international knowledge flows is analysed. Here, existing gaps between regional and national level for SME and ways to overcome these deficits by specific organisations, informal and formal institutional arrangements are investigated. Finally, the role of European policies in this context will be discussed. Causes for the low impact of the existing instruments in the EU R&D framework program on SME in medium technology sectors are analysed, options to improve the knowledge transfer between R&D intensive firms and research institutes and other firms in medium technology sectors are discussed, and the role of standardisation and regulation is investigated. A special focus will be laid on economically lagging regions. These regions are particularly endangered of losing access to world market developments, as their traditional competitive advantage – cheaper factor costs – is easily replaced by competitors in Asia and other low-cost countries. If the improvement of the knowledge base is the only chance for Europe to stay competitive – which seems to be the common opinion of researchers and politicians –, then it is inevitable to look for new ways to integrate the lagging regions into European knowledge flows and look for institutional solutions to overcome barriers for SME in lagging regions to leading edge knowledge.

Within the German project, a case study on Hamburg as a metropolitan region shall serve to identify strategies of economically strong regions within the EU to be integrated within international knowledge flows and possible lessons to learn for economically lagging regions in

the Middle and Eastern European countries. Furthermore, the relationships between such a metropolitan area and Eastern European regions is analysed based on a case study of a single sector (aeronautics). Results of this investigation shall lead to insights on prerequisites for further collaboration between strong and lagging regions within the European Union.

1.2 State of research on regional clusters and innovation in medium-technology sectors

- *Regional Clusters*

In many OECD countries, the support and organisation of clusters has become a major field of regional and industrial policies (UNIDO, 2001; OECD, 2001), for example the "poles of competitiveness" in France, "networks of competences" in Germany, "Inno-Regios" in Eastern Germany, "regional innovation systems" in Finland or "technological districts" in Italy (inter alia Janson et al., 2004; Harmaakorpi, Melkas, 2005; Benzler; Wink, 2005). The basic idea behind these political efforts refers to the expectation of positive effects of geographical proximity of firms belonging to the same sector on their innovative behaviour and performance (Feldman, 1999) closely linked to the theoretical approaches of regional innovation systems, innovative milieux or territorial knowledge management (Amara et al., 2005; Cappellin, 2003; Cooke, 2004). The emergence and support of clusters is recognised as a prerequisite to defend and increase technological superiority against competitors from North America and Asia and as an opportunity to reduce the pressure by off shoring and outsourcing processes.

Scientific literature, however, still reveals uncertainties on the actual economic impact of geographical proximity and the causes for positive effects on productivity and innovation. Empirical research for German manufacturing companies shows that the availability of natural resources, supply chain linkages and human capital are the most important determinants of spatial concentration, while technological spillovers seem to be only less relevant (Alecke et al., 2005). Investigations for the US confirmed the hypothesis of weak spatial concentration in the high technology segments (Rosenthal; Strange, 2004), while studies for European regions at least observe a reduction of spatial concentration in innovative behaviour (Paci; Usai, 2000). Other studies, however, confirm the assumption that geographical proximity to knowledge actually matters to achieve knowledge spillovers (Cantwell; Piscitello, 2005; Funke; Niebuhr, 2005; Oerlemans; Meeus, 2005 particularly stressing the importance of supply chains for these effects). An empirical investigation of the relevance of clustering on innovative activities in German manufacturing industries reveals differences between product and process innovation with firms introducing process innovation more often to be found in clusters (Brenner, 2005). These contradicting results underline the necessity to come to a better understanding of actual processes of knowledge generation, transfer and absorption in and between firms and other organisations. IKINET with its research objectives and design contributes to fill this gap.

The idea of clusters has been influenced by different theoretical sources starting from different levels of aggregation, for example more micro-oriented approaches based on Marshallian ideas of industrial districts, industrial location theory or social network theories and more macro-based models based on new economics of geography or theories of regional competitiveness (see for attempts to categorise McCann; Shepard, 2003; Sorenson, 2003; Maskell; Kebir, 2005; Christensen; Drejer, 2005). The meso-level of clusters creates specific challenges on theoretical and empirical models (Tunzelmann, 2004). Open questions refer to the involved organisations and individuals, their necessary capabilities and skills, content and channels of interaction and necessary prerequisites. In the context of IKINET, we are concen-

trating on the analysis of knowledge clusters (Malmberg; Maskell, 2002 for a differentiation of cluster concepts).

Many critics on cluster literature stress the need for a firm-based or even individual approach to analyse changes of the knowledge base (Sternberg; Arndt, 2001; Martin; Sunley, 2003; Duranton; Puga, 2004; Giuliani; Bell, 2005). Firms might profit differently and via different channels from regional knowledge spillovers dependent on their organisational skills, existing absorptive capacities and embeddedness within the region (Vinding, 2002; Gann; Salter, 2002; Giuliani, 2005, based on social network analysis models from Wassermann; Faust, 1994). The integration into clusters shall help organisations to get access to tacit elements of knowledge otherwise not available via communication and becomes more important with increasing quality and exclusiveness of knowledge (Hymer, 1979, based on strategies by multinational companies, Grotz; Braun, 1997). Even codified knowledge, however, can be spatially bounded, if "sticky" elements as skills, experiences and institutional embeddedness are bounded to a region and can only be transferred fragmentally (Harmaakorpi, Melkas, 2005, based on works by Asheim, 1999, and Scharmer, 2001; Grabher, 2004). Due to restrictions of their spatial mobility, SME might face specific challenges approaching the knowledge from other regions (Asheim, Isaksen, 2002).

Scientific debates still cover the topic how these spatially bounded knowledge elements can be accessed. Many papers find only weak evidence for knowledge spillovers via formal contacts and institutions (inter alia Breschi; Lissoni, 2001; Fritsch, 2000). Other authors, however, stress that the use of relational capital and formal agreements is sector-specific (Capello; Faggian, 2005). Even those sectors with weak formal agreements might still be organised in knowledge clusters. For these clusters, "thick" labour markets with specific talents and characteristics might play an important role (Sørensen, 2004; Stuart; Sorenson, 2003; Florida, 2002; Gertler et al., 2000). Additionally, informal social contacts based on common professional background, cultural sources or joint private interests have also been identified as important channels of knowledge (Fornahl et al., 2005; Dahl, Pedersen, 2003). IKINET investigates formal as well as informal channels for knowledge transfer and learning and will offer new insights particularly for the European medium-technology industry, where professional traditions and analytical knowledge are more important than in science-based high-technology sectors, which are subject to most studies so far.

The ambiguous results of cluster policies in Europe so far are closely related to critical issues of cluster design as institutional settings, emergence and evolution with time and openness. The analysis of institutional issues includes formal and informal norms of knowledge interaction as well as the integration of specific intermediaries acting as boundary spanning organisations (Tura; Harmaakorpi, 2005; Cooke, 2004; Gertler; Wolfe, 2004 with examples from different countries). These services do not necessarily be provided by specific (private, public, public-private) organisations. Standardisation in value chains or transfers of experiences from consultancy services can also be important sources for regional knowledge interaction (Muller; Zenker, 2001; Benneworth; Dawley, 2004). The latter processes might create further barriers for SME by defining specific technological skills or investments (Chiarvesio et al., 2004; Gerst, 2005). In most cases, regions still lack necessary systemic linkages to generate, examine and commercialise new knowledge within actual regional innovation systems, which is a deficit restricting their innovative potential. For the research objectives of IKINET, this means further causes to take a closer look on institutional solutions to get access to international knowledge within the case studies and to derive more general conclusions on suitable institutional models for European regions.

Most studies on clusters refer to the benefits of clustering and geographical proximity – compared to other forms of proximity (Boschma, 2005, based on the concept of Torre; Gilly, 2000) – without considering the dimension of time – emergence, adjustment, change, decline – to explain why clusters exist at a certain place on a certain time. Cluster benefits like social control and common cognitive patterns by frequent face-to-face (F2F) contacts inevitably require common norms, routines and experiences (Nooteboom, 2002; Storper; Venables, 2002), which might be rooted in the history of the region, the profession or the sector (Lambooy; Boschma, 2001; Iammarino, 2005). Simultaneously, such long-term processes restrict the adjustment capabilities of regions to structural changes (capabilities to "unlearn"), as new policies and formal institutions cannot provide the same boundary spanning services like common identities (senses of belonging) and informal norms derived from history (Hassink, 2005, on old-industrial regions). Furthermore, the increasing need for "horizontal integration" to integrative technologies – interdisciplinary and combinative use of new findings – makes it harder to stick to common routines and professional norms (Benzler; Wink, 2005). Brenner (2004) offers a theoretical model of cluster emergence and evolution based on critical masses of firms deciding whether another stage within the evolutionary cluster process can be achieved. Open questions, however, still refer to the determinants to reach the critical masses and the role of long-term historical processes. By looking at medium-technology sectors based on long-term development processes, IKINET will be able to integrate this evolutionary perspective and discuss the relevance of different factors on cluster processes in different kinds of regions.

Close to the issue of institutional and cognitive deadlocks in clusters due to historical processes is the aspect of openness in clusters to knowledge outside the cluster. Firms search in clusters for complementary knowledge assets and try to avoid sharing of knowledge with direct competitors (Brenner, 2005). On the contrary, close cognitive patterns cause lacks of diversity in knowledge and risks of losing access to global knowledge pipelines with cutting-edge findings (Rantisi, 2002; Bathelt et al., 2004). Thus, many authors call for differentiation of proximity needs according to innovation cycles and sectoral specificities (Gallaud; Torre, 2004; Malerba, 2002). As medium-technology sectors are typically driven by analytical skills based on single-case problem solutions, interregional transfer of new knowledge might cause more problems than in more science-based high-technology sectors, because in these sectors more abstract knowledge is important (Fontes, 2005; Cooke, 2005). IKINET will be able to analyse prerequisites for a virtuous combination between the use of geographical proximity to include SME into knowledge chains and other forms of proximity by networks to extend the spatial scope of knowledge interaction, improvement, examination and exploitation.

- *Innovation, interaction and learning*

Most innovation indicator systems in Europe like the Community Innovation System (CIS) and the European Innovation Scoreboard are still focusing on input factors as R&D investments, qualification of staff and R&D cooperation projects or output like new products and processes or patents (European Commission, 2004; Council of the European Union, 2004). These indicator systems might underestimate specific strengths of medium-technology sectors to continuously improve capabilities along existing technological experiences without formal results as intellectual property rights (Laursen; Salter, 2005, on appropriability strategies). Many European SMEs in medium-technology sectors are successfully specialised in small niches, which can only hardly represented in formalised score systems. IKINET shall contribute to a better understanding of innovation processes in medium-technology SME and their specific prerequisites. Furthermore, challenges to these existing systems by international competition and acceleration of innovation processes shall be revealed.

In contrast to this input-output approach within indicator systems, theoretical models are more interested in the process of generating and commercialising new knowledge (Dasgupta; David, 1994; Cooke et al., 2003). These views are more focused on three basic prerequisites for innovation processes:

- individual skills and capabilities,
- organisational rules and structures, and
- linkages between organisations.

Innovation is understood as a process linking together conscious or subconscious processing of experiential knowledge ("learning") and creative adjustments of the experiential knowledge base with successful commercial exploitation of this new knowledge (Metcalfe; Ramlogan, 2005; Cooke, 2004). Consequentially, innovation is dependent on ongoing feedback-processes between knowledge generation and exploitation (de Solla Price, 1984). On the individual level, specific skills and talents as creativity, leadership and capabilities of coping with complexity are stressed as necessary prerequisites (Florida, 2002; Amara et al., 2005). The investigation of connections between technological and entrepreneurial skills was already introduced by J.A. Schumpeter (Schumpeter, 1911). For affected markets, these creative changes cause uncertainties, as incumbent products might face intensified competition or might be assessed as obsolete by customers (Aghion, Tirole, 1994). Additionally, cognitive skills to absorb and transfer knowledge from experiences of others are seen as prerequisite for successful learning and knowledge exploitation (Rizzello, 2000; Stillings, 1995). For IKI-NET, individual skills serve only as a starting point for innovation, as the complex development and commercialisation of new knowledge requires intensive interactions between individuals. Therefore, the empirical study will consider the availability of social and technological skills within the clusters. The main focus, however, will be on the connections between skilled individuals.

On an organisational level, the main challenge of innovation process is caused by the necessities to create cognitive prerequisites and incentives for the individuals to share knowledge (Teece et al., 1997; Argyris; Schön, 1996). Cognitive prerequisites refer to communication codes securing that interacting partners actually understand the intended meaning of the content communicated ("turning data into information"; Wink, 2003; Cappellin, 2003). The uncertainties on the effectiveness of codes are particularly high for non-formalised knowledge. Infrastructures, repeated routines of communication and organisational cultures shall contribute to emerge shared mental frames (Brown; Duguid; 1991; Cohen; Levinthal, 1990; Denzau; North, 1994). The actual impact of these instruments, however, is still mainly based on single case studies, mostly in multinational and high-technology firms (Orlikowski, 2002). Many scientific and management papers deal with the challenge of "tacit" knowledge for communication processes, as it might not be possible to explicitly communicate this non-formalised knowledge (Cowan et al., 2000; Nonaka et al., 2000; Minkler, 1993). Tacit knowledge, however, actually consists of very different parts of knowledge, as e.g. absorptive capabilities to understand meanings from others, organisational and production routines, original thoughts without precedents, or information on the reputation of others, leaving different possibilities for explicit expressions. Without incentives to use these communication means, however, no valuable knowledge will be exchanged (Nooteboom, 2002; von Krogh et al., 2000). The creation of a motivation structure is hindered by information asymmetries, i.e. communication partners are uncertain whether the other partner actually reveals his best knowledge available or attempts to exploit by taking the free rider option (Blum; Müller, 2004 with a review to the theoretical literature). Organisational incentives refer to information and risk sharing based on reputation, and social integration (Tirole, 1998, on general solutions in cases of contractual uncertainty). These new challenges for the firms changed also the measurement systems of

the knowledge base. New indicator systems include relations between the individuals and the linkages between human capital, relations and knowledge (Grasenick; Ploder, 2002; Chen et al., 2004). IKINET will investigate, which organisational incentives are used in medium-technology SME. These firms are characterised by a high relevance of loyalty of the employees and a high level of embeddedness of specialised knowledge on the individual level. A sustainable diffusion and exploitation of this knowledge would require special tools to communicate and incentives to reveal it.

The inter-organisational level of innovation has been increasingly investigated during the last decade, as new technologies are only rarely developed by single organisations and therefore require more cooperation between organisations (Kogut et al., 1993; Miotti; Sachwald, 2003; Amesse; Cohendet, 2001; Belderbos et al., 2004). New technological paradigms as a basis for innovations are not only characterised by the integration of new hitherto unknown knowledge and tools but by new forms of knowledge generation and exploitation. The debate on "Mode 2" of knowledge production stresses the increasing relevance of integrative technologies, where knowledge from different scientific disciplines and sectors have to be merged, and the elimination of boundaries between abstract basic science and applied product development, as many scientific insights are closely linked to new services and products (Gibbons et al., 1994; Benzler; Wink, 2005). Consequentially, interaction between scientists and researchers of different disciplines and between researchers and firms gains importance with the emergence of specialised knowledge-based firms as knowledge brokers (Harada, 2003; Gann; Salter, 2000; Grabher, 2004). The emergence of these firms is supported by outsourcing and off-shoring strategies for these services by big multinational companies (Sanchez; Mahoney, 1996; UNCTAD, 2004; Mol, 2005). Additional input to these inter-organisational linkages comes from science and government (Etzkowitz; Leydesdorff, 2000 on the triple-helix-approach). Academic entrepreneurs and joint research projects between firms, universities and public research institutes shall support the exchange of knowledge along the vanishing boundaries of science and product development (Lockett et al., 2005; Markman et al., 2005). Government shall support these activities with liaison offices, technology transfer services and funding to create regional or national innovation systems (Lundvall et al., 2000; Furman et al., 2002). Success stories, however, are restricted to single cases. The need for interaction, however, causes new challenges for innovation processes, as cognitive distances and lack of trust might hinder knowledge transfers and mutual development (Nooteboom, 1999; Olk; Young, 1997). "Knowledge clusters" consisting of individuals from organisations with different types and bases of knowledge shall help to build up necessary geographical or organisational proximity (Keeble; Wilkinson, 2005 with several papers). Again, proximity plays a prominent role to explain the emergence of these types of clusters with geographical proximity being one possible driving force to closer cooperation (Simmie, 2005; Davenport, 2005). IKINET shall contribute to the identification of characteristics, prerequisites, and instruments of such knowledge clusters. A special focus will be laid on the relationships with organisations and clusters outside the investigated clusters. Experiences with openness to European knowledge interaction and political strategies to support such processes on the EU, national or regional level shall help to develop recommendations for changes in the existing EU programs.

1.3 The focus on aeronautics sector

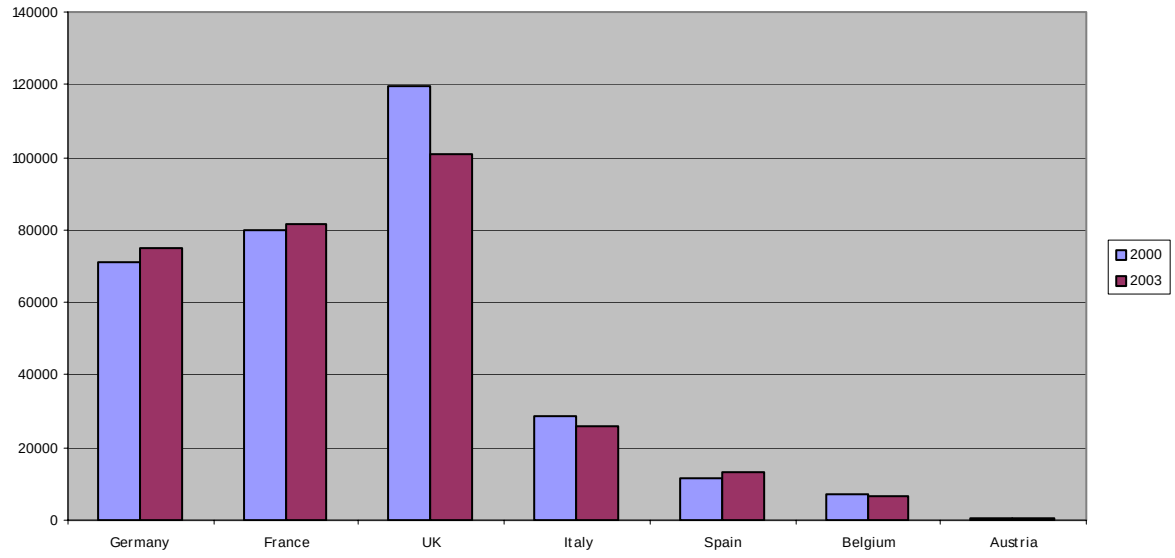
The sector of aeronautics covers the civil and military aircraft. For almost all statistical definitions, the sector of aircraft and spacecraft belongs to the segment of high technology manufacturing. A closer look to actual activities in the aeronautical sector, however, reveals a wide range of manufacturing from low technology manufacturing, e.g. in standardised textile production for the cabin interior, to advanced and sophisticated electronic manufacturing or new

advanced materials like e.g. carbon fibres. Products and services in civil aircraft cover structural systems (empennage, undercarriage, fuselage, wings, cockpit etc.), mechanical and hydraulic equipments, electric and electronic equipments, equipment systems (e.g. water, kitchen, toilets, light, entertainment, safety) and related services (e.g. logistics, consulting, design, finance, recruitment, prototyping) (Pfähler; Lublinski, 2003). Traditionally, these products and services have been supplied by a high number of specialised SME. For most of these firms, aircraft was only one, however a very specific, part of their sales markets, as production in this sector was restricted to small scales with an increasing degree of individualisation of products.

The market for civil aircraft is dominated by few firms. While in the market for smaller (regional) aeroplanes an oligopolistic market emerged with the Canadian firm BOMBARDIER and the Brazilian firm EMBRAER as main competitors, the market for large aircrafts is characterised by a dyopolistic competition between the US company BOEING and its European counterpart Airbus. These markets have been heavily influenced by public interventions following strategic objectives on industrial development as well as military sovereignty. As a consequence, decisions on supply structure and locations for production and R&D have always been dependent on political influences. Particularly for Europe, the result was a mainly national market for aircraft suppliers with clear definitions of specialised work shares within the Airbus value chain. This protection for regional locations against foreign competitors provided a secure basis for the development of value chain cooperation at least between Airbus and its suppliers. The lack of competition, however, caused deficits of incentives for closer cooperation within cluster structures, as suppliers of single components still could expect steady turnovers. Furthermore, aircraft markets have grown steadily through the last three decades with only short crises caused by singular events like the terror attacks on September, 11, 2001. Chart 1 illustrates the development of employment in the aerospace sector according to Eurostat, including aircraft as well as space technology segments. At least in Germany, France and Spain, employment still grew despite despite decreasing overall industrial employment in France and Germany.

For the next two decades, further growth is expected in the segment for large civil aeroplanes with an additional need of 16,601 new aeroplanes for passengers with more than 100 seats (Airbus, 2004). Additionally, market growth and fleet renewal in freight markets shall create a demand for 3,139 freighter deliveries, of which 727 shall be factory-built freighters. According to Airbus forecasts, 41% of future demand on passenger aircraft will come from the United States, the United Kingdom and the People’s Republic of China. Most aeroplanes to be built until 2023 (63% of total demand) will be single-aisle and small jet freighters. Similarly the US Federal Aviation Agency expects strong growth in air traffic within the next decade with a relative increase of the market share of smaller aeroplanes (FAA, 2005).

Chart 1: Number of Employees in Aerospace (Eurostat, 2006)



Within the aircraft markets, however, several structural changes challenge the existing relatively "peaceful" atmosphere:

- *the increasing relevance of markets outside EU and North America*

The markets in Asia become increasingly important, as future growth of demand for aircrafts is mainly expected in these areas. Countries like China and Japan use this importance as sales markets to put formal or informal pressure on location decisions via local content requirements. Large parts of the new aeroplane 7E7 by BOEING are coming from Japan. Recently, Airbus announced to decide on building up an assembly line in China until June 2006, as China ordered 150 single aisle passenger planes. Furthermore, a joint venture between Airbus and the Chinese state company Aviation Industry Corporation II shall develop, produce and market a new civil helicopter to be introduced into markets in 2011. Simultaneously, Aviation Industry Corporation I, another state-owned Chinese company announced to start delivery of a new small regional aircraft with 80-100 seats at the end of 2006. With the experiences of other industries in mind, competition in large civil aircraft markets is expected to become more expensive with one or two additional competitors to Airbus and BOEING.

- *changes in sourcing strategies of aircraft producers*

So far, the value chain management by Airbus was determined by political agreements on the allocation of work shares between the four countries of origin for this consortium (France, Germany, Spain, United Kingdom). In particular in Germany, many small suppliers of single components were still able to act as direct suppliers to Airbus. In the last years, however, Airbus changed its sourcing strategies aiming to increase the share of outsourced components and services to large system suppliers and concentrate its sourcing to larger system modules to be supplied by few big firms worldwide (global dual modular sourcing). This strategy imitates experiences from the strategies by Original Equipment Manufacturers (OEM) in the automotive industry, where, however, larger scales are possible. For example, Airbus announced to reduce the number of suppliers of engineering systems from 700 to 7 within one year. This reduction is accompanied by requests for cost savings, which can be met in the near future only by relocating parts of the production to low cost countries in Middle and Eastern Europe and Asia. So far, however, relocation has been hindered by quality standards within public safety approval procedures, which could not be met in low-cost countries without necessary

expertise. These new requirements by Airbus do not only cause challenges for the management of SME, which have to look for cooperation partners and mergers and acquisition to achieve necessary scale for system supply and internationalisation. By forcing suppliers to integrate production from low-cost countries, Airbus shifts quality risks, which are crucial in the aircraft sector, to the suppliers. Additionally, financial risks have been shifted from Airbus to its suppliers. Payments to suppliers have been made dependent on sales of aircrafts by Airbus. As aircrafts are sold typically along time horizons up to three decades, suppliers have to cope with long-term risks on refinancing their investments in new production for new aircrafts. As a result, SME face increasing difficulties in proving capabilities to cope with these risks to banks and capital markets as well as to Airbus. In the short term, BOEING tried to counteract to the sourcing strategy by Airbus in Europe to achieve access to European specialised knowledge. In the next years, however, only firm growth and diversification will help SME in the long term to stay independently within the value chain of civil aircraft production. According to estimations by European Association of Aerospace Industry (AECMA), the number of firms within the value chain for aircraft and spacecraft production will be reduced from 80,000 to 1,000 firms within the next decade.

- *increased diversity and accelerated speed of innovation*

Radical innovation in aircraft industry has always been connected to the introduction of new types of aeroplanes. The main objectives have always been to increase the capacity and/or to increase maximum speed of the aircraft. Innovation within aircraft industry has to integrate basic scientific research (e.g. including physics, electronics, material sciences) with engineering and construction services and production technologies. In 2001, European Commission invited to establish an expert group to facilitate strategic development processes on a European level (Advisory Council for Aeronautics Research in Europe - ACARE). In October 2004, Strategic Research Agenda II (SRA II) has been published defining research activities and objectives until 2020 on different fields. Parts of the vision for innovative aircrafts are the following elements:

- blended wing body-configurations without sharp separations between body and wings
- morphing aircrafts adjusting the form of the external aircraft skin to different flight situations
- fibre reinforced materials to reduce weight of the aircraft
- adaptive systems for all mechanical elements to reduce noise and risks of wear and tear of materials
- optimisation of existing power plants and testing of electronic fuel cells
- fly by wire systems for purely electronic steering systems
- optimisation of cabin interior systems.

For the organisation of innovation processes, these strategic objectives cause new challenges to link more abstract, scientific knowledge with applied processes of direct problem solutions and to link insights from other – more or less related – sectors as automotive, optronics or energy with needs in aeronautics. These challenges led to the emergence of more knowledge-based service firms specialised in transferring knowledge from basic research to direct applications. Academic entrepreneurship and close connections between research centres and service firms are typical characteristics of this type of firm. Further specific challenges in the aeronautics sector are caused by linkages between military and civil aircraft production and scientific research, as military production is often connected with severe barriers to knowledge transfers and regulation on secrecy, while basic scientists are used to cooperate regardless of national borders and civil aeronautics markets are characterised by transnational (trade-driven) linkages.

As a result, existing models of regionalised value chain systems and their organisation of knowledge flows are challenged and particularly SME face the request to grow, to build up expertise for whole systems and to integrate international knowledge. At the different European production locations of Airbus, specific regional conditions lead to specific reactions to these challenges. The case of Hamburg offers insights into institutional specificities and its consequences on the internationalisation of knowledge pipelines.

2. The regional background

2.1 Hamburg: A metropolitan region

The German case study focuses on the Aeronautics Cluster in Northern Germany. The affected area covers large parts of different NUTS I regions (Länder): Lower Saxony, Schleswig-Holstein, Mecklenburg-Pommerania, Bremen and Hamburg. Within the study, we will particularly focus on Hamburg and its regional characteristics, as most of the firms in the cluster are located in Hamburg and its suburban surroundings, two main clients in the aeronautics market are located in Hamburg (Airbus with two sites and Lufthansa Technik) and the final assembly and centre of excellence for cabin systems is located within the City of Hamburg. Furthermore, the City of Hamburg serves within the IKINET project as a typical metropolitan region.

Several characteristics underline the status of Hamburg as a metropolitan region:

- population density and spatial labour market concentration

Within the German federal system, the City of Hamburg is a NUTS I region. It is the second largest city in Germany (after Berlin) with more than 2 million inhabitants. The population density is 426,5 inhabitants per square kilometre. Due to the high population density, agglomeration effects set in with a high share of services. The regional labour market is dominated by the core city with more than 200,000 commuters coming into town from the surrounding areas.

- economic power and attractiveness for foreign direct investors

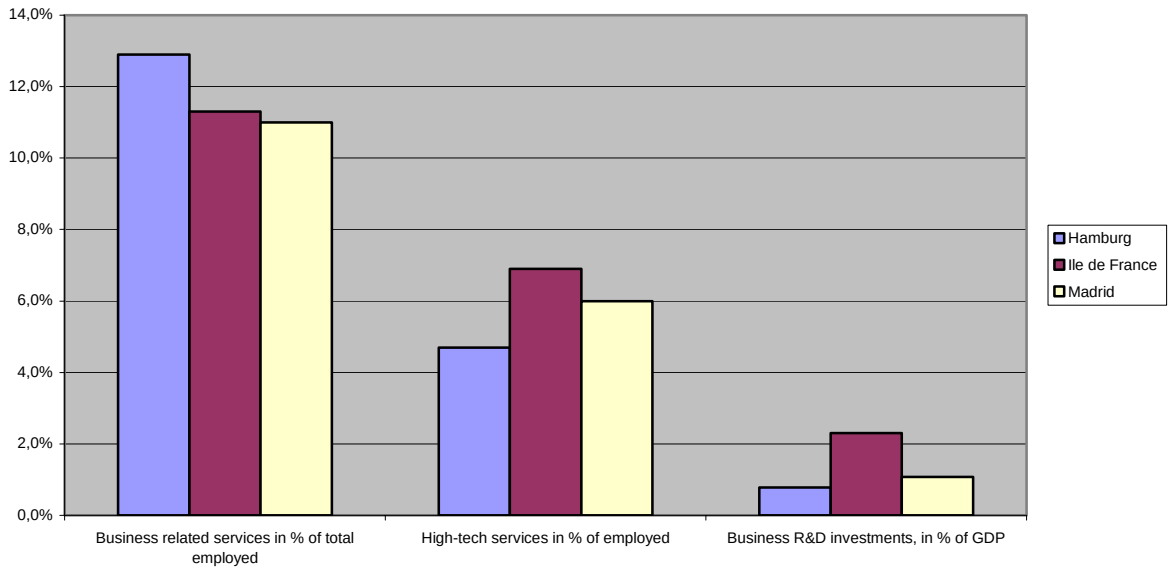
Hamburg is the region with the highest per capita GDP in PPP within the European Union with 87.8 % above the EU-25 average. The labour productivity is higher than in the other city-states of Germany. Furthermore, Hamburg was one of the major winners of increasing openness of the Middle and Eastern European countries. Due to its central location between East and West, its huge seaport and its proximity to the major sea-routes, foreign direct investments increased sharply since 1990. In 2002, more than 48 billion Euros have been invested in Hamburg. A comparison of all German NUTS I regions revealed that companies in Hamburg showed between 2002 and 2004 the strongest growth in private equity ratios (4.3%) and profitability after sales (1.9%; Foundation Social Market Economy, 2005).

- dominance of service sectors

Due to its location and its seaport, Hamburg has a long history as an international trade centre within the Hanseatic Community. Services stand for more than 85% of employment. Within the service sector, business related and high technology services gain importance. Hamburg has the highest share of business services employment in Germany and is one of the most important regions in Germany for high-tech services. Besides business-related services, cultural services are one further growth segment leading to a relatively high share of foreign visitors staying overnight. For employment in high- and medium-tech manufacturing, however, other regions in Germany are more important. Chart 2 illustrates the specificity of the service sector in Hamburg by comparing to the other two metropolitan regions within IKINET (Ile de

France and Madrid). Hamburg has the largest share in business related service employment but the lowest in high technology services.

Chart 2: Comparison between metropolitan regions (Applica, 2005)



Hamburg has a long tradition in industrial development. Many of the dominating industries like maritime industries, steel and processing industries of metal and other natural resources went to other regions due to the relatively high production and energy costs. The aeronautics sector is the only industrial sector to grow in Hamburg, and many activities in this sector serve to compensate for the loss in other industrial segments.

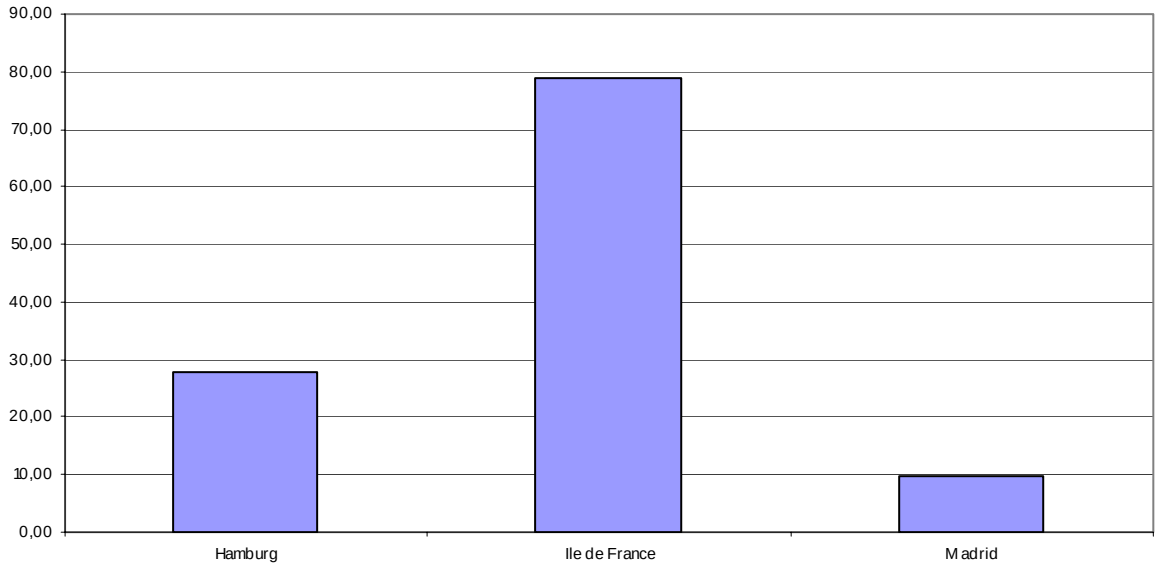
- high share of academic qualification

Hamburg has a great variety of public and private universities, universities of applied sciences, research institutes and private schools. The share of people with tertiary education is slightly above the average and particularly the registration in tertiary education is higher than the German average. On the other side, the share of young persons without upper secondary education is above the German average stressing the large disparities within the regional population. A specific problem refers to the output of the school and academic system in terms of innovation. The patent intensity is below the German average with relative strengths in medicine, food, metal processing and vehicle technology, including aeronautics. The comparison with Madrid and Ile de France, which is shown in Chart 3, stresses the weaknesses in the segment of high technology patents. The academic employment is only slightly higher than the German average despite the high density of educational institutes.

- social disparities and risks of segmentation

Metropolitan regions are often characterised by two different social worlds: a high share of high-qualified and high-technology oriented services employees and the availability of headquarters for multinational firms, while simultaneously structural unemployment and a high share of persons dependent on social welfare cause problems of educational divides and increasing rates of criminality. Consequentially, Hamburg was still involved into programs of Objective 2 in the European Fund for Regional Development despite its overall high level of welfare.

Chart 3: EPA high tech patents, per million inhabitants (Applica, 2005)

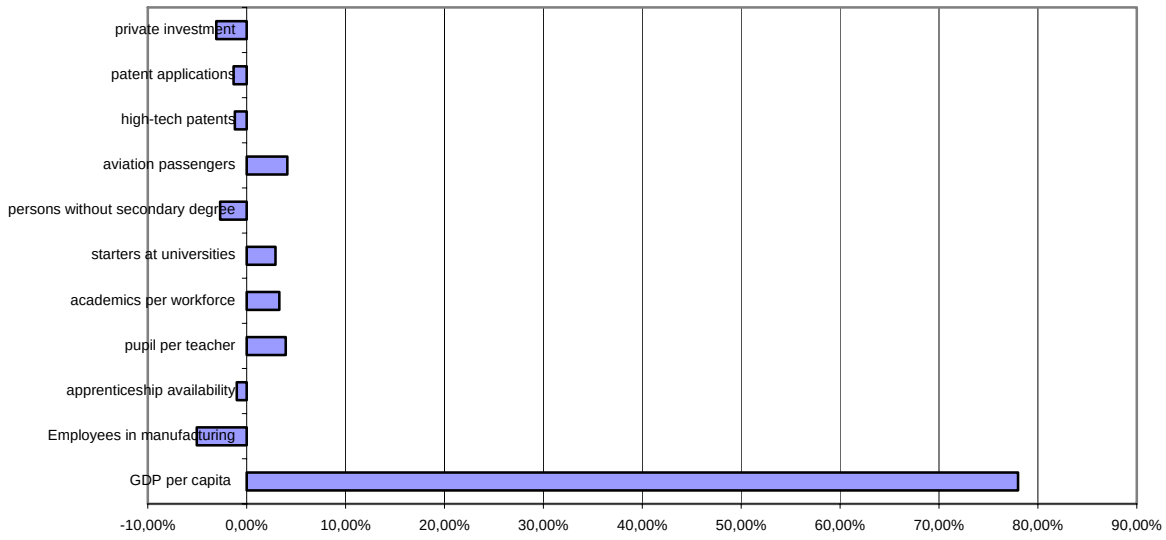


- high dependence of surrounding regions

The areas around Hamburg belong to the areas with highest GDP per capita in their NUTS I regions due to their attractiveness for persons working in the Centre of Hamburg. Only few of the surrounding areas are regions eligible for European Regional Development Funds with the more rural area of Lüneburg in the south as former Objective 1 area as a remarkable exemption. For the neighbouring Länder, coordination with the urban centre of Hamburg is necessary to maximise positive inputs on investment and employment.

As a kind of summary of the regional strengths and weaknesses, Chart 4 provides a comparison between Hamburg and the other German Länder. Hamburg has a very high economic performance a good academic endowment. Weaknesses refer to R&D investments, patents, industrial performance and the social inclusion by schools and apprentices.

Chart 4: Hamburg in relation to German Länder average, 2002-2004 (Bertelsmann Foundation, 2005)



2.2 Hamburg Aeronautics Cluster

Germany has two main regional centres for aerospace activities with Southern Germany (mainly Bavaria) as centre for motor technologies and electronics with several power engine producers and Northern Germany as centre for cabin interiors and materials. Besides these two centres, a regional cluster in Eastern Germany has been promoted by public programs and single private investments. A critical mass of firms and inter-firm linkages in Eastern Germany, however, is missing so far. The aeronautics activities in Northern Germany are relatively differentiated due to different single sites from Airbus and different research priorities. Cluster strategies and attempts to improve cooperation between firms, universities and research institutes emerged relatively recent during the last decade despite a long history of aeronautic activity in Hamburg and Bremen. Aviation in Hamburg began already in 1911, when the first commercial company was founded to build and operate an airport (Deutsche Luftschiffhallen GmbH) at the location, which is still the place for Hamburg Airport, the fifth largest civil German airport. Aircraft manufacturing in Hamburg started in 1933, when the shipyard company Blohm & Voss founded an aircraft company (Hamburger Flugzeugbau) to build long-range passenger seaplanes. These activities were suspended after World War II, but were taken up again from 1956. The company was not successful as OEM, but succeeded to position itself as a subcontractor for German and later on for European projects. These experiences have been used in the 1970s to become a subcontractor within the Airbus project. In 1969, this firm was merged with two others to MBB, which became a part of Deutsche Aerospace AG (DASA, now Daimler Chrysler Aerospace AG), the firm bundling all aeronautic and space activities of Daimler Chrysler, in 1989. Political agreements between France and Germany made it possible that Hamburg became in the 1980s the second final assembly wharf after Toulouse. Only this decision joined by the positive economic development of the Airbus project caused the sharp increase of employment and sales in the aeronautic sector in Hamburg.

A similar development can be observed in Bremen. Initial nucleus of aeronautic activity was here the company Focke-Wulf Flugzeugbau, founded in 1923 based on works already started in 1910. Two main lines of development followed from that: One part bundling all aerospace activities merged with Hamburger Flugzeugwerke and Weserflug in 1961 to become as ERNO (Entwicklungsring Nord) a part of the European aerospace program. This project is now as ASTRIUM a part of EADS. The aeronautic activity have been merged with Weserflug and then in 1969 with the Dutch company FOKKER to VFW-Fokker. In 1981, MBB took over the aeronautic site of this firm in Bremen, and from this merger onwards a division of labour in aeronautics between Hamburg and Bremen has started, which became a part of the Airbus structure of activities in Germany.

In the North-Western parts, around Bremen, basic research with a relatively high share of electronics and space technologies can be observed due to linkages to ERNO. The Airbus location in Bremen has more than 3,000 employees. They are responsible for the whole process chain of wing high lift. As a part of the Airbus Centre of Excellence forward and aft fuselage, sheet metal plants like clips and thrust crests for all Airbus aircrafts are manufactured in Bremen. A regional investigation in 2001 revealed that the Airbus site in Bremen has a large share of regional suppliers directly from Bremen with a relatively high share of R&D services. The Airbus location in Nordenham – also in the North-West – is also part of the Centre of Excellence forward and aft fuselage. More than 2,100 employees are responsible for all fuselage shells for Airbus aircrafts. The Airbus location at Varel, which is also in the North-Western part in Lower Saxony, is responsible for the production of machined structural components and tooling manufacture for all German Airbus sites. Aluminium, titanium and steel

are basic materials for most of the components. Furthermore, this site with 1,100 employees specialises in wind tunnel models. Here, more suppliers are industrial SMEs coming from Lower Saxony.

In Hamburg, cabin interiors are a main focus for economic and research activities due to the locations of Airbus and Lufthansa Technik. The Airbus location in Hamburg Finkenwerder with more than 10,000 employees is part of the Centre of Excellence for cabin interior and cargo customisation. Here, the interior of the A 300/310, the whole A 320 family and the A 380 are fitted and furnished, and these machines are painted for final delivery. Hamburg is also part of the Centre for Excellence forward and aft fuselage and responsible for complete fuselage sections, e.g. for the A 380. Furthermore, maintenance and procurement for the whole A 320 family is done in Hamburg. In Buxtehude, close to Hamburg, more than 300 employees work in a subsidiary specialised in electronic communication and cabin interior for crew and passengers.

Airbus Stade, nearly 40 kilometres from Hamburg, has nearly 1,500 employees. This site is responsible for the vertical tail planes, for which carbon fibre reinstructured plastic particularly has been incorporated. Furthermore, landing flaps, pressure bulkheads and spoilers are produced in Stade, which is one of the world's leading centres for carbon fibre reinstructured plastics.

In Brunswick and Hannover, south-eastern parts of the Northern Cluster, research activities focus on technologies, which are closer to more abstract and theoretical aeronautics (e.g. structural systems, aero-dynamics) or relevant for applications in different sectors (e.g. adaptronics, composites). Brunswick and Bremen are linked together by research topics and researchers from both locations are involved to the Airbus location at Stade for the development of new applications for composites.

A second major player in Hamburg besides Airbus is Lufthansa Technik, one of the global leaders in maintenance, repair and overhaul (MRO). After World War II in 1956, the leading German airline Deutsche Lufthansa started its operations from Hamburg. Since then, Hamburg has always been the technical centre. In 1995, Lufthansa Technik became an independent firm with now more than 24,000 employees worldwide. In Hamburg, Lufthansa Technik has its headquarter and competence centre with more than 7,000 employees. Here, for example, the biggest maintenance centre for civil aircraft engines outside the USA can be found. A special expertise has been developed in the field of customising VIP machines. More than 400 specialists are working in Hamburg making Lufthansa Technik to an important competitor for Airbus in this field.

The relevance of aeronautics for the Hamburg metropolitan area increased sharply after the decision within the Airbus consortium to have a second final assembly wharf for the smaller models A 310 and A 320 in Hamburg. Consequentially, 40% of the suppliers in Hamburg have been established in Hamburg after 1990, 20% after 1995. Most of these companies are relatively small: a study in 2000 showed that 62% of the suppliers of Airbus Germany had less than 50 employees and only 4% more than 500 employees (Zuliani et al., 2003). Only four system suppliers have been identified (Albert Mühlenberg Apparatebau on kitchens, ESW-Extel Systems on electricity and de-icing systems, Draeger Aerosystems on oxygen systems and KID Systeme on toilets and cabin interior systems) with one (KID) being a 100% subsidiary of Airbus. Other firms with more than 100 employees are subsidiaries of Lufthansa Technik (LHT Logistik) or joint ventures of DASA (Dassell on interior systems). Most of the

orders by Airbus Germany are going to German firms with an increasing interest of foreign firms in looking for geographical proximity to the Airbus sites.

The development of the A 380 caused further growth of employment in Hamburg. Between 2000 and 2004, industrial employment was reduced from 98.126 to 91.853, while simultaneously employment in aerospace grew from 14.209 to 19.436. Only at the Airbus site in Hamburg Finkenwerder, the number of employees went up from 7.439 to 10.249 between 2000 and 2004 with 1.739 additional employees for the A 380. For 2006, Airbus announced the recruitment of additional 1,250 employees with 850 only at Hamburg Finkenwerder. The suppliers of Airbus in Hamburg reported nearly 2,000 additional employees between 2001 and 2004. These developments underline the relative recent development of aeronautics in Hamburg and the increasing relevance of the Airbus value chain for Hamburg. Positive perspectives in the near future are particularly expected for the cabin interior segment, as intensified competition between aircraft manufacturers and airlines in the VIP and business segment cause shorter innovation cycles and higher willingness to pay for innovations than in other fields of aeronautics.

Cooperation and strategic positioning within the value chain, however, are still weak, as an investigation revealed in 2002 (Pfähler; Lubinski). Comparisons between firms located in Northern Germany and firms located outside the cluster showed only weak advantages for cluster firms. The dominant advantage of geographical proximity in Hamburg was the impact of demanding customers. Other factors as the proximity to public information sources and research institutes also affects positively the innovation potential of firms in North Germany but did not seem to be cluster specific. As a consequence, the study recommended activities to enhance cooperation and integration to develop system capabilities in the cabin interior segment and initiatives for more diversification of cabin interior products.

Several initiatives to organise the SMEs within the value chain attempted to overcome the strategic weaknesses. Private associations of SMEs have been founded for the segment of engineering companies (HECAS, founded in 2001) and suppliers (Hanse Aerospace, founded in 1996). A private-public location initiative for the aeronautics sector in Hamburg has been launched by the major companies (Airbus, Lufthansa Technik, Hamburg Airport), associations, public administration and other relevant groups in 2001 to cooperate in specific fields like qualification, public relation and transnationalisation. Hanse Aerospace supported the emergence of a system supplier in cabin interior systems in 2004 (Cabin Systems Holding), which was formed as a holding of SMEs. These developments and activities form the background of the empirical research in Hamburg and neighbouring areas.

3. Empirical study on the Hamburg Aeronautics Sector

3.1 Structure of the empirical research for SMEs in the aeronautics sector

The empirical research on the aeronautics sector in Hamburg was based on a series of interviews with representatives of firms and related organisations. The core of the empirical research was based on interviews in fourteen manufacturing SMEs within the aeronautics sector, which are actively engaged on innovations. Indicators for innovations are new products, patents and recommendations from other firms. The indication of SMEs is oriented to the EU definition. These firms can be differentiated into three classes based on the share of academic employees:

(1) knowledge-intensive firms with a share of more than 20% academic employees in total employment

Firms belonging to this segment are

- m.u.t. Aviation Technology, provider of electronic equipment, with less than 10 employees and less than 10 millions Euro sales
- Saertex Stade GmbH, specialised in non crimp fabrics, which make it possible to introduce existing strengths of fibres to its end product, and belonging to the Saertex GmbH & Co. KG with several international sites in France, USA, South Africa and India

(2) knowledge-intensified firms with a share of 10-20% academic employees in total employment

Firms within the sample belonging to this segment are

- Innovint Aircraft Interior, providing specified seats and other components for cabin interior, founded in 1977, with less than 100 employees and a share of exports in sales of more than 50%
- M + B Lasertechnik, specialised in laser characterisation, founded in 1985, with less than 100 employees and less than 10 million Euros sales, but an export rate above 50%
- E.I.S. Electronics GmbH Aviation and Space Technology, a company specialised in manufacturing wire harness, founded in 1980, with less than 100 employees and less than 10 mio. Euro sales
- Cabin Systems Holding, which strives to become a system supplier for cabin interiors by integrating several SMEs
- Albert Mühlenberg Apparatebau, a systems provider for galleys, stowages and similar light weight components, with a high export rate and 150 employees

(3) conventional firms with a share of less than 20% academic employees in total employment

Firms within the sample belonging to this segment are

- SaFa Fassondreherei, specialised in turning and milling activities, founded in 1968, with less than 100 employees and less than 10 million Euros sales
- Eickworth Modellbau, specialised in milling activities, founded in 1920, with less than 100 employees and no exports
- Hein & Oetting Feinwerktechnik, specialised in hydraulic and mechanical equipment systems, with less than 100 employees and less than 10 millions Euro sales
- Aljo Aluminium Bau Jonuscheit, specialised in manufacturing aluminium components, inter alia for wings at A 330-340 and different interior components up to wastewater systems, founded in 1970, with more than 100 employees and more than 10 millions Euro sales
- Arthur Krüger Technik in Kunststoff, provider of certified plastics mirror and components bending plastics and filing, founded in 1938, with more than 100 employees and more than 10 millions Euro sales
- Behrens Feinwerktechnik, supplier for precision components up to complete compact vacuum toilets, founded in 1988, with less than 100 employees and less than 10 million Euros sales
- Paustian Airtex, supplier of textile equipment, founded in 1973, with less than 100 employees and less than 10 million Euros sales

This investigation was accompanied by an analysis of the two main players in the regional aeronautics sector: Airbus SAS (Airbus Germany GmbH) with five production sites within the region (more than 10,000 employees in Hamburg only) and Lufthansa Technik as one of the world market leaders in aeronautics services, specialised in MRO services and having its headquarter in Hamburg with more than 7,000 employees.

Additionally, representatives of twenty service organisations relevant to the aeronautics sector from different sectors have been interviewed: four organisations from engineering and design services, three organisations from personal services markets, three organisations from financial services markets, five organisations from research services and five organisations from public or private-public services segments.

The set of interviews was focused on six main topics: an assessment on strengths and weaknesses of the organisations, a report on the history of innovation events, a description of the internal organisational structure, information on the organisation of the regional cluster, and reports on relationships between the regional organisations and between the regional actors and actors outside the region. All interviews have been made in 2005.

3.2 Results of the empirical research

3.2.1 Strengths and weaknesses of the firms and market environment

The firms interviewed differ in the assessment of own innovation capabilities and strategic positioning in the market. Seven of the sixteen companies are conventional firms and act as technological followers adjusting existing technologies to their production. Their main strength is based on experiential knowledge and existing linkages to Airbus as the dominant client. Following Porter's five forces to define their strategic positioning (rivalry by existing competitors, buyer and supplier power, barriers to entry and threat of substitutes; Porter, 2004), these firms are confronted with a high level of buyer power by Airbus and with increasing threats by rivals, as their products can be substituted and their possibilities to upgrade as system suppliers are limited. Five of the companies are knowledge-intensified firms developing their own original products and having selective R&D contacts to universities and research institutes. A high level of specialisation and experiential knowledge define their strategic advantage. Again, the buyer power by Airbus and the changes in the sourcing strategy threatens their market position, but the original and specified knowledge opens the opportunity to become systems suppliers. The other two companies are knowledge-intensive firms with a systematic development of innovation projects and close linkages to R&D specialists. Their strengths are based on superior knowledge bases and originality of research and development. According to these strengths, threats to be substituted by rivals are limited, while at least in the case of Saertex diversification of technological application reduces the dependence on Airbus.

Two main strategic forces have been identified in the market by all firms:

(1) growing pressure within the value chain, particularly by Airbus

This process causes increasing challenges of risk participation, internationalisation of production to countries with lower factor costs and local content requirements and system integration. For the affected SMEs, these challenges refer to the availability of financial resources to be able to cope with the request by Airbus to participate in the risk of selling the final aircrafts for the next two or three decades, organisational resources to cope with the need for production in foreign countries or outsourcing while securing the same level of quality, technological resources to manage complex systems within the aircraft, i.e. integrative capabilities by skilled personnel as well as organisational incentives and opportunities to integrate knowledge from different single components into one system to be delivered to the OEM, and management resources to organise external firm growth.

(2) the integration of new technologies into aeronautics value chain and similar markets as opportunities for further diversification

The most prominent example for this process is the attraction of additional work shares in the Airbus value chain by providers of fibre-reinforced composites in Stade and Bremen. Saertex is a case study within this composites cluster. Strategic aims of the firms refer more or less to growth within the value chain, while keeping diversification and fostering internationalisation as necessary conditions. The actual relevance of these general objectives, however, differs. For the firms in the segment of cabin systems, growth within the value chain means horizontal or vertical integration to become a system supplier. As the firms in Hamburg are a lot smaller than aeronautic firms at other locations and system suppliers in other markets, there are only weak hopes that one of the cluster firms is actually able to become a system supplier by external growth. Diversification in cabin system refers to the exploitation of similar transport markets, like trains or cruise ships. For the firms integrating fibre-reinforced structures into aircraft production, growth in the value chain includes first of all access to the value chain and growth at the costs of existing competitors with more traditional technologies, as they are newcomers in the aeronautics market and some of the parts have so far been produced on the basis of other materials at other locations, e.g. metal wings in Wales. The aeronautics sector serves in this context as a market, where new materials can be developed for products in relatively small numbers with a relatively high willingness-to-pay for high-quality components. Positive experiences and reference cases shall then be used to diversify in mass markets like automotive production.

Main weaknesses refer to lack of financial and organizational resources within the firms and a lack of suitable qualifications within the regions. Most of the firms interviewed are family-based SMEs with a relatively small number of employees. Airbus required from their suppliers that they participate with the risks of the aircraft markets for several decades, which means that the suppliers need private or foreign equity to cope with these risks. Most of the SMEs, however, have only limited private equity rates, and banks are not willing to offer long-term loans and credits without additional securities. New financial instruments, like mezzanine capital or loans based on securities by the OEM, are still not known well by the SMEs. Missing experiences with new instruments make it even less probable that SMEs demand them. These financial bottlenecks lead at least in one case – Albert Mühlenberg Apparatebau as a systems supplier of galleys for the cabin interior – to an agreement on cooperation with a French company to proof the necessary financial capabilities for the execution of an Airbus order.

Organizational deficits refer in particular to the need for strategies by the SME management to generate external growth to be upgraded within value chains (becoming a systems supplier), to look for new (diversified) markets and to relocate production to Eastern European or Asian regions. Most firms still have a relatively high level of integration with only few organisational capacities to use outsourcing, e.g. to Eastern Europe. The regional SME managers are used to their domestic markets and more focused on products and production processes than on organisational and growth issues. There is a growing awareness in the firms on their weaknesses. Consequences, however, are so far missing in most cases. Thus, all firms expect a consolidation within the market causing negative effects on performance and sovereignty of regional firms – loss of market shares and/or financial independence to foreign competitors or private equity funds – and reduced relevance of political influence. These challenges motivated the local association of aeronautics SME (Hanse Aerospace) to launch and support an initiative for an integrating holding company shared by different SMEs, which will be explained later in this report.

Bottlenecks in qualification are mainly caused by the cyclical development of the labour market for aviation engineers. In the second half of the 1990s, Airbus introduced in Germany a

tough rationalisation program to cut costs ("DOLORES") leading to a sharp reduction in the number of employed engineers. The observed problems of engineers to find jobs at Airbus discouraged many potential students and increased the mobility of engineers. The increased production at Airbus and the introduction of new models causing additional orders to the suppliers, however, led to additional demand for engineers as well as other qualified employees. Several initiatives to attract engineers from other countries (e.g. Sweden), to launch new modules at local universities, to improve vocational training schemes and to introduce training schemes for qualified personnel from other sectors shall help overcome the current bottleneck. For many SMEs, however, limited capabilities to pay high salaries similar to big multinational companies still limit their possibilities to attract necessary qualified staff. This does not only affect internal production and innovation capacities, but also limit the access to cooperation with public R&D institutions and R&D staff of the OEM.

3.2.2 Innovation events history

Innovation in the aeronautics sector is primarily driven by the demand of the dominant OEM. Visible radical innovations are always connected with new models, e.g. in history the regulation of cabin pressure, the introduction of jet propulsion, fly-by-wire-technologies or composites. The background of these innovations has been experiences in other technological segments – space technology, military aeronautics, or race cars – and incremental adjustments to existing technologies in aircraft production. As the product cycle for each model refers to more than three decades, speed of innovative changes and adjustments is limited. In the context of cabin interior, the time scale differs, as the interior is changed several times within a life cycle of a model according to technological changes, preferences of the passengers or extension of sales markets to other cultures.

Within the innovation process, Airbus plays a dominant role due to several reasons. First, the oligopolistic market structure restricts the number of possible demanders for innovative products, as long as diversification is poor. In the context of cabin interior, airlines play also a vital role, as they look for innovative products in the VIP business interior segment to separate themselves from competitors. Secondly, Airbus has the economic power for large investments in R&D staff. For many suppliers, cooperation with R&D departments by Airbus is the only possibility to do necessary research and tests. In particular, the small scale of production and the specificity of products and services make it inevitable for suppliers to concentrate on this way of cooperation. Thirdly, any innovation means a change of the aircraft causing safety or environmental risks, which have to be investigated and approved by public authorities. Only big firms as Airbus or the international airlines can cover the necessary costs for certification, including documentation and testing. This constellation means that only innovations, which fit into the strategic plans of the OEM or airlines, e.g. reduction of costs, visible achievement of higher quality levels or compliance with public standards, have a chance.[1]

The possibilities of the firms interviewed differ according to their knowledge base. For knowledge intensive firms having a high share of academically qualified staff and own R&D investments, close cooperation with Airbus and public research institutions in R&D projects builds the typical source for innovation. Some of these firms even have been created as spin-offs from universities and public research organisations. Public research organisations provide necessary interdisciplinary knowledge, e.g. in the case of new types of composites on adap-

[1] One typical example for this challenge to the suppliers is the story of a firm within the cabin interior market, which developed a new seat to enhance the safety level for children. Their only chance for successful market introduction might be a new public safety standard, which depend on the public awareness of safety risks for children.

tronics as a combination of physics, information sciences and material sciences, while the cooperation with Airbus makes it possible to integrate engineering experiences and examination of theoretical knowledge by challenges in production processes. These firms are used to be integrated into public R&D programs and have international contacts. As a result of this cooperation with customers from different markets, a diversified set of applications can be developed.

For knowledge intensified firms with a relatively high share of academically qualified personnel and restricted access to R&D, internal knowledge with specified experiences plays a crucial role for innovations. They need contacts to the dominant OEM in particular to receive necessary support for certification processes and a critical mass of demand for funding. For these firms, access to public R&D is often difficult, as the cognitive patterns differ between more theory-led research and experience-driven problem solutions. Furthermore, they are often confronted with a lack of contacts to a necessary variety of research institutions outside the region and the country. As cooperation within the value chain to other suppliers is relatively weak, these firms have to restrict their knowledge creation, examination and exploitation to their internal capabilities.

Conventional firms with a relatively low share of academically qualified staff and no own R&D investments concentrate their innovations on adjustments to requests by the OEM. For them, standards set by the OEM as an entry barrier to the value chain play the decisive role to extend the knowledge base. With increasing formalisation of private certification, these firms face problems to cope with technological requirements and necessary investments in their equipment and qualifications. Engineering and other service companies serve as providers of necessary training and information.

Again, qualification and the development of specialised research facilities are seen as major bottlenecks in particular within the segment of cabin interior. The creation of new university modules and research excellence centres on cabin interior shall help overcome deficits in knowledge creation. Additional efforts refer to transnational cooperation between vocational schools in Hamburg and Toulouse. Furthermore, strategic initiatives to improve cooperation between suppliers with a specific knowledge base shall help develop necessary integrative capabilities within this segment.

With the increased importance of the Asian market, protection of IPR becomes a bigger issue within the region. Knowledge intensive and intensified firms use patents to protect their innovations. Their basic competitive advantage, however, lies in the internal experiential knowledge. With Airbus deciding to build a new production site in China, Chinese competitors will have better opportunities to close the gap to the knowledge base in Europe. Furthermore, their production according to internal Airbus standards and European and North American safety standards will make it easier for them to reach formally the quality level for sales to foreign markets, thus building a more severe competition for the European suppliers.

3.2.3 Internal organisation and knowledge creation

Most of the interviewed firms are traditional family or founder based SME. Hence, entrepreneurs from the founding family still have a major influence. In many companies, however, generational change also causes adjustments of management styles improving the openness of the firm for internal discourses and external contacts. CSH – the firm constructed as a holding of SMEs – attempts to change completely the typical management styles within the SMEs. The basic strategic plan of CSH is to create a systems supplier on cabin interior not only in

the aeronautics, but also in neighbouring markets like trains and cruise ships, as the market potential for such a diversification has been assessed as promising (Pfähler, Lublinski, 2003). So far, twenty suppliers, including several specialists in personnel and IT management and one company from the Netherlands, have been integrated into the holding. In 2005, CSH founded a joint venture with T-Systems, a subsidiary of German Telecom, to offer IT services in cabin interior (Cabin Systems Information Technologies, CSI). These close connections to large companies as well as the structure of the CSH management – both top managers came from large multinational firms – influence the structure and the strategies of this organisation. In contrast to the other interviewed firms, fast external growth and internationalisation are explicit objectives, and formal knowledge management tools shall help improve knowledge creation and diffusion. They planned a learning organisation with boot camps at the beginning for new members and project and process management within network structures. Practical experiences, however, were not available at the time of interviews. For many traditional managers in SMEs, such tools are still assessed controversially, and direct benefits for the efficiency of production have been missing by them.

Employment is still characterised by a high degree of mutual loyalty with long-term contracts. Again, differences can be observed according to the share of academically qualified employees. In conventional firms, fluctuation of employees is below 10 per cent. Only very few of the employed participated in further education courses, and the share of foreign employees is below 10 per cent. The top managers in these firms have only very few experiences in large firms or in other countries. Location decisions are affected by personal origins of the entrepreneurs. Knowledge and project management tools do not play a major role in these organisations. The recruitment of staff is concentrated on the region with regional universities of applied sciences and technical college as important sources. Labour flows with competitors in the region are more important than labour mobility from clients or suppliers.

In knowledge intensified firms, loyalty of employees still is important. The share of foreign employees within qualified staff, however, is higher than in conventional firms, and more than ¾ of the staff took part in formalised further education. These firms have regular contacts to regional universities for practises or diploma thesis. Recruitment, however, is not restricted to the region.

In knowledge intensive firms, labour mobility is higher than in other firms. The share of foreign employees in qualified staff is not significant higher than in other firms, in some firms even no foreign qualified employees can be found. Further education is an important issue for these firms, which use team organisation and communities-of-practice for a better knowledge interaction between employees. These communities do not only refer to internal organisation but also to cooperation with clients like Airbus.

As a consequence of only slow changes in the organisational structure of conventional and knowledge-intensified firms, tacit knowledge remains often on an individual basis. Only few – knowledge-intensive – firms use documentation of experiences for the transfer of knowledge and greater independence from individual expertise. These management tools are typical for firms belonging to larger firms (like Saertex or many engineering companies, see 3.3) or forming holding structures like CSH. Tacit knowledge refers in most cases to absorptive capacities, i.e. capabilities to understand and transfer own and foreign experiences. Common professional background – e.g. joint experiences at a university or at Airbus or its predecessor – plays also an important role for knowledge interaction on an inter-individual level.

3.2.4 The regional cluster

From a traditional perspective based on material interrelationships, the aeronautics sector in Hamburg cannot be seen as a cluster. Relationships between firms are restricted to the hierarchical organisation within a value chain with Lufthansa Technik and Airbus as dominant organisations and common denominator. Figure xxx illustrates the weak and hierarchical ties within the cluster in Hamburg. Short-term contracts via spot-markets are the most relevant form of formal cooperation. Small conventional SMEs have fewer formal cooperation contracts and are more dependent on single clients within the value chain. Complementary expertise is given, but for most companies the expertise in Hamburg is too diversified and unfocused to be attractive for intensive cooperation. A more detailed empirical study with a larger number of firms (110 aeronautical firms) compared the innovative performance of these firms with a geographically dispersed control group of 68 firms. The only cluster-specific positive impact was caused by geographical proximity to demanding clients. All other factors, including labour market pooling and proximity to research institutes and competitors, were not identified as cluster-specific (Bönte, 2004).

During the last five years, several initiatives have been launched to improve cooperation within the regional cluster. The main driving forces behind these activities are the big customers (Airbus, Lufthansa) initiating pressure on organisational changes and launching new topics on the agenda. A formal umbrella for many activities is the initiative "Aeronautics location Hamburg (*Luftfahrtinitiative Hamburg*)". Members of this initiative are Airbus, Lufthansa Technik and Hamburg Airport, the municipality, the association of regional aeronautical SMEs (Hanse Aerospace) and regional engineering companies (HECAS), the chamber of commerce, the labour administration, the professional association of engineers, the employers' association and trade union. The initiative is registered as a network of competence by the Federal German government (www.kompetenznetze.de) and is coordinated by the local agency for business development. The main functions of this initiative are marketing and public relations for the location, organisation of social events, internal regional information on firms and competences and the umbrella for several working groups on specific topics, e.g. qualification.

Most of the small SME are too small to influence the agenda within the cluster. Single individuals, however, are able to use organisations like the regional association of aeronautical SMEs Hanse Aerospace or the aerospace location initiative as a forum for new topics. All these activities, however, depend on individual engagement and capabilities. One major issue for cooperation within the cluster refers to the achievement of necessary size for internationalisation. These activities include

- common presentations on international fairs organised by Hanse Aerospace
- support of establishing "*Aircraft Interior*" as an international fair in Hamburg
- information on certification
- support of new qualification programs (still with Airbus and Lufthansa Technik as main partners)
- integration into public R&D programs (EU 6th framework and the regional aeronautics research program)
- launching of CSH as system supplier
- organisation of contacts to firms from other aeronautical clusters (Toulouse)

The cooperation style within this cluster is based on informal structures. Geographical proximity helps develop joint social norms and mutual trust, and repeated informal events serve as framing processes. The overall cooperation is sub-divided into sub-networks according to specific topics (qualification, R&D, or finance). Joint communication codes are developed

through common sectoral (disciplinary) and regional background. All members of this formalised cluster, however, accept the relevance of openness to international actors and clusters.

Besides the cooperation between industrial firms, engineering companies become more important as consultants and specialised service providers. One of these specialised services includes the certification of suppliers to be accepted within the Airbus or Lufthansa Technik value chain. With increasing relevance of global modular sourcing and relocation of systems competencies to suppliers, engineering firms serve as knowledge brokers managing interfaces between single systems and securing overall systems competence, as the dominant customers reduce their investments in systems competence.

The most important partner for industrial SMEs in the segment of associations is the regional association of aeronautical SMEs Hanse Aerospace. More than 100 SME are organised within this association, which was founded in 1996. Joint presentations on fairs are the most popular product of Hanse Aerospace. In the segment of public authorities and agencies, regional development agencies are the most important partners for industrial firms. The city of Hamburg increasingly tries to promote cluster processes despite not being a region eligible to EU or national funding for regional development. Local political support refers to R&D funding, organisation of informal meetings (via the location initiative), formal cooperation with other aerospace regions (Midi-Pyrenees and Aquitaine on qualification and entrepreneurial exchange) and qualification initiatives. The role of the Business Promotion Agency as administration for the joint location initiative makes them a perfect knowledge broker on all organisational and social issues. In Lower Saxony, Bremen and Schleswig Holstein, aeronautics is also seen as an important future sector. Strategic objectives and organisational power, however, differs between Hamburg and its neighbouring regions. Schleswig Holstein even plans to become a member of the location initiative Hamburg.

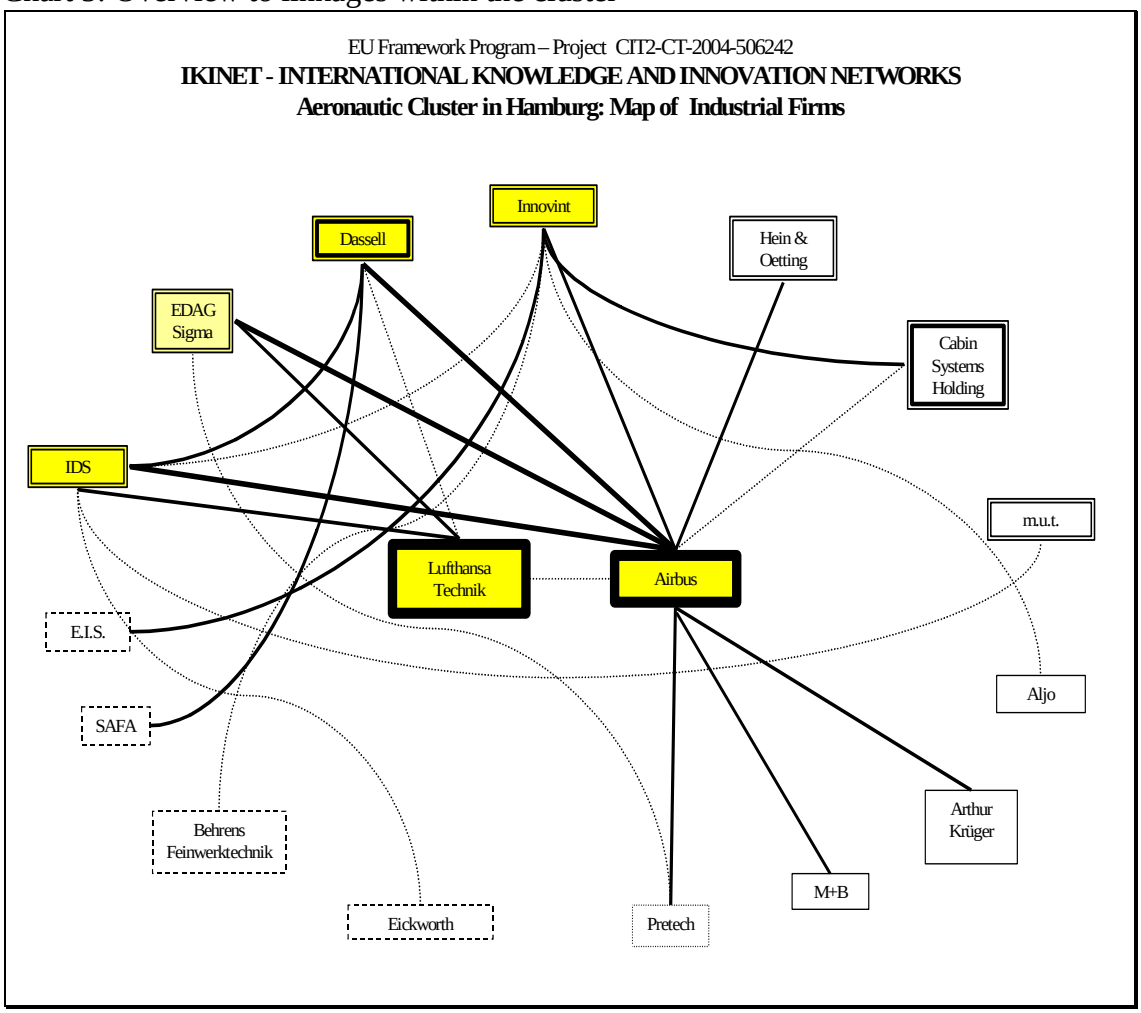
The availability of suitable qualifications has been identified as a major challenge in Hamburg. New university master courses, new qualification schemes for technical colleges and new schemes for further education are examples to overcome these barriers to regional development. The regional universities for applied sciences and technical universities are seen as most important partners for industrial SMEs. In the context of public R&D infrastructure, the DLR (Deutsches Zentrum für Luft- und Raumfahrt) as a federal organisation plays a major role with Brunswick as a centre for adaptronics and other aerospace related competencies. Their linkages to the companies providing composites, which are mainly located in geographical proximity to the Airbus site in Stade, are deep due to staff mobility. Other close linkages to this composite cluster refer to the University of Bremen.

Lack of financial resources has been recognised as a major weakness for all companies. Their relationship to banks has changed due to increased pressure by standardised rating systems. CSH is seen as one step towards better cooperation with banks, while particularly public development banks try to offer new programs to overcome the challenges of modular, global and single sourcing and the Basle process for SME. Most companies nominate local banks as most important market partner. The local savings bank of Hamburg – Hamburger Sparkasse – and the regional development bank of Lower Saxony – N-Bank – play a vital role to provide new financial instruments.

All in all, the regional cluster structures have to be seen more differentiated. One important distinction refers to the products. In the composites context, close cooperation structures have been developed due to the specific role of public research (University of Bremen and Technical University/DLR Brunswick) and the limited number of suppliers in geographical prox-

imity to Stade. In the context of cabin interiors, the high number of suppliers and the diversity of competencies reduce the benefits of cooperation. Formal initiatives along specific topics help interested firms to develop new forms of cooperation with a strong impact of the big regional clients. Again, conventional firms face the biggest problems, as they often miss necessary capabilities and resources to find suitable interface segments to other firms and develop necessary systems expertise. For knowledge-intensified firms, the initiatives offer new ways to overcome gaps to formal R&D staff in multinational firms and public research institutes, while knowledge-intensive firms are less dependent on regional linkages and develop their own transnational cooperation patterns.

Chart 5: Overview to linkages within the cluster



3.2.5 Relationship to international markets

Most of the conventional SME have only small or no shares of exports in sales and relationships to foreign markets. Their shares of exports as well as imports in sales are below 20 per cent with the exception of one firm (Paustian Airtex) having larger shares. The dominant clients for them are still within Northern Germany with shares of regional sales in total sales of more than 50%. These firms do not have production sites or formal cooperation in other countries. All of these companies expect increasing international business, in particular in Western Europe. They identify sales markets as major driving force for internationalisation, which means that they expect to sell more to firms within the Airbus value chain at other European locations. Two of the companies expect further business in Eastern Europe, which will be

driven by production. Dominant barriers for the internationalisation of these firms are information deficits and lacks of experiences and contacts. Most of the managers do not have experiences in foreign companies, and there are lacks of resources in language skills and uncertainties on the organisation of foreign markets. As a result, these firms are aware of their needs to increase internationalisation but realise internal deficits.

Knowledge intensified firms have more experiences in exports and international business. Their shares of exports in sales are above 50%. They are not only focused on Western European markets but expect growing shares of business in Northern America and Asia. These business relations are not only driven by sales, but also by cooperation in production and R&D. For these firms, access to financial markets plays a major role as barrier to investment in foreign markets. Similar observations have been made in knowledge intensive firms. Two of these companies (PRETECH as an engineering firm, m.u.t.), however, do not expect changes in their international business. In contrast to most engineering firms in the cluster, which have been integrated in large diversified and/or multinational companies, the industrial firms still act independently with only few formal contracts with foreign partners. Saertex formed an international group, CSH has at least one Dutch firm as a shareholder within the holding and Albert Mühlenberg Apparatebau is present at the two other major global locations in Seattle and Toulouse.

On the level of R&D international contacts between public R&D institutions play a major role. German researchers have several contacts to Asian and North American institutions, organise joint research projects and stays and are members of the Advisory Council for Aeronautical Research in Europe (ACARE). Hence, many spin-offs and knowledge-intensive firms in close cooperation with the public research institutes use these international linkages.

As Airbus forces internationalisation, integration and growth of suppliers by global modular sourcing, most firms in the cluster are aware of necessary changes in international business. The most important forum for international contacts so far is the participation at international fairs. An important step in this development has been achieved with the establishment of the world's biggest annual fair on aircraft interior in Hamburg.[2] A major international fair in the composites market is the JET Composites Show in Paris. The association of aeronautical SMEs Hanse Aerospace organises joint presentations for cabin interior firms at several international fairs, e.g. in Le Bourget or Singapore, and the interviewed firms recognise these activities as a central part of their internationalisation. Other activities of this association to overcome barriers to internationalisation, however, have so far not been demanded in the same intensity. Hanse Aerospace is part of the ECARE project aiming to cluster regional clusters at the European level and particularly to increase the participation of SMEs within EU FP 6 and 7. So far, only few SMEs from Hamburg have been part of EU-funded R&D projects and are integrated into the three databases for transnational cooperation run by ECARE, AeroSME and SCRATCH.[3]

The regional location initiative has been particularly focused on cooperation with the French Airbus clusters. The main part of the cooperation with Midi-Pyrenees and Aquitaine deals with coordination of joint qualification schemes with the City of Hamburg as main driver of the process. They have been able to define a joint qualification module for vocational training based on certified requests for aeronautical employees. Within this module, French and Ger-

[2] The fair "Aircraft Interiors" – organised by a British publishing house – has been removed from Cannes due to larger numbers of exhibitors and visitors in Hamburg.

[3] An information workshop on FP 7 has only been visited by 10-12 local SMEs and a joint visit to Brussels has been cancelled due to lack of participants.

man students can be exchanged and work for a period up to six months in firms of the other cluster. In Germany, the big firms Lufthansa Technik and Airbus are the main driver on the firm level with only few SMEs offering part-time apprenticeship places for the French exchange students. Additional contacts in the context of qualification exist between the universities in Toulouse and Hamburg. Besides qualification, closer cooperation shall be enhanced by joint social events like mutual visits of entrepreneurs in France and Hamburg. These visits shall help build up social and cultural proximity between firms of the two clusters. Concrete impact on inter-firm cooperation, however, has been rare.

3.3 Empirical research on service organisations in the Hamburg Aeronautics Cluster

3.3.1 Private engineering and design firms

The design and engineering segment in the Hamburg cluster changed its structure within a very short time span. Many international engineering companies relocated offices to Hamburg or integrated existing service providers in Hamburg. Airbus with its strategy to reduce the number of suppliers and increase the relevance of system suppliers acts as a major driving force for this development. The evolution of membership within the association of engineering companies HECAS illustrates the changes: Currently, 13 firms are organised within this association. Four of these firms are now part of French engineering groups, one firm is part of a Swedish group, four firms are now part of German groups with headquarters outside North Germany, three firms have grown to other locations based on their experience in North Germany and one firm is located outside North Germany. All these organisational changes and new investments in Hamburg took place during the last decade. Hence, the engineering and design firms are increasingly important as (transnational) knowledge brokers for OEM and SMEs within the cluster. Furthermore, most of the engineering firms diversify their products along different sectors with most linkages between aeronautics and automotive, but also in single firms to maritime shipbuilding, machinery and wind energy equipment.

Within our interview sample, we focused on four companies with different background:

- EDAG Sigma Concurrent Engineering, an engineering company, originally founded in 1992 and focused on aeronautics market in Hamburg and after several attempts to grow in Hamburg and in the sector since 2004 a 100% subsidiary of a multinational diversified engineering company
- IDS Industrial Design Studio, a small company with few employees specialised on design and construction in aeronautics and related sectors, organised as a spin-off from the local university of applied sciences and strengthened by lots of international contacts to automotive and aeronautics firms all over the world,
- ICARUS Consulting GmbH, a regional engineering firm with more than 30 employees focused on the automotive sector (subsidiaries in Wolfsburg and Munich) and specialised in production process management
- PRETECH Predictive Design Technologies GmbH, specialised in virtual prototyping within several industrial sectors and one of the founding shareholders of CSH.

- *Strengths and weaknesses of the firms and market environment*

Two main characteristics explain differences of the empirical results between the industrial firms and the engineering and design service providers:

(1) the higher formal knowledge base

All of the firms interviewed have shares of academic employees in total employment above 70%. All of the firms have international experiences and contacts. Consequentially, their mar-

ket vision is more diversified and open for internationalisation. EDAG Sigma is already part of a multinational engineering company. Strategic expectations, however, differ between the firms. Two of the firms (IDS, EDAG Sigma) expect growing internationalisation in R&D, while one firm expects growing sales markets and one firm (PRETECH) do not expect any further change in internationalisation.[4]

(2) the higher level of consolidation in the market

Airbus started to change its sourcing strategy in the engineering sector. Consequentially, less but bigger engineering firms grew within the value chain. These big integrated and diversified firms use experiences and contacts in other markets and are less dependent on the OEM in the aeronautics sector. EDAG Sigma is a typical example for that. Growth and specified knowledge base also lead to different destinations for internationalisation. IDS and EDAG Sigma not only expect R&D as major driving force for internationalisation but also see Asia (and North America) as more important for their growth strategies than Europe. Main barriers to Asia are so far lacks of reliable contacts and experiences with the culture. Growth to Asia is realised as inevitable by these two firms, because the knowledge base particularly in China is growing fast. Barriers to growth for Chinese firms are seen so far in deficits in creativity and compliance with formal certification standards, but at least the achievement of comparable standards for the smaller aircrafts is expected within the next five years after the decision by Airbus to produce in China. EDAG Sigma is a typical example for candidates to upgrading in the Airbus value chain, as they are able to internationalise in short term according to the needs of Airbus and transfer experiences from the automotive sector.

Weaknesses of the engineering markets became obvious during the process of consolidation. The lack of a big regional firm led to the integration of several regional firms within foreign companies. The attempt by three engineering firms, including EDAG, to organise an integrated bigger firm on their own was not successful, as sales of shares to foreign companies led to higher profits. For the remaining smaller firms – like ICARUS and PRETECH – limits to growth become obvious, as they have only few (or no) international contacts and have no possibilities to grow within the Airbus value chain. IDS as a specialised design service provider also face strategic barriers, as access to resources to finance internationalisation and investment in additional risks and capacities is limited for this small firm. Scarcity of qualification also affects the engineering firms. The share of foreign qualified employees is relatively high at PRETECH and EDAG Sigma, and EDAG Sigma even mentioned to look for engineers from Eastern Europe.

- *Innovation events history*

The firms interviewed within this segment increase incrementally their knowledge based on initial individual capabilities and dependent on single problems. Compared to the industrial SMEs, they have higher shares in formal R&D investments. With the increasing share of outsourced services by Airbus, the importance of the engineering firms to develop system competencies increases. Consequentially, market performance achievements are expressed by certification as supplier by major customers for specific system elements or services. Again, big integrated firms have strategic advantages, as they can use experiences in other sectors or countries to transfer to Airbus, Lufthansa Technik and the aeronautics market. Furthermore, they are less dependent on single projects than smaller suppliers. The relatively long life cycles of aircrafts and the limited number of aircraft models, however, intensify competition and dependence in the aeronautics engineering market. Regulation and certification are critical issues for any innovation process, as only certified companies gain access to the OEM and

[4] This underlines a remarkable inconsistency within CSH, as the top management of the holding believes particularly in growing internationalisation.

quality standards set by public safety authorities act as market barriers for foreign competitors. Patents play also an important role, and three of the companies (ICARUS as exception) interviewed made recently use of patents.

IDS and EDAG Sigma have experiences with EU and national research programs. Main barriers for the participation of these firms are the requirements for co-funding and the technological priorities within the calls. Here, an important difference to the research institutes become obvious, as these researchers have already been integrated in the ACARE process and familiar with the technological priorities in public research programs. Contacts to universities have been particularly important for IDS as a firm run by a university professor. Practises and diploma theses have been used as steady sources for future human capital and projects.

- *internal management and knowledge creation*

Engineering companies are usually organised in teams with decentralised responsibilities for single projects. Consequentially, hierarchical leadership with strict formal regulations is less relevant. The high formal qualification also encourages higher levels of sovereignty for the individual employees. Even within EDAG Sigma as part of an international company decentralised power with responsibilities for the single offices is given. EDAG Sigma and ICARUS have a relatively high level of fluctuation (more than 10% within the last three years), while in the other two firms fluctuation is (close to) zero. The interaction with Airbus and the other engineering suppliers within the concurrent engineering program by Airbus is only relevant for EDAG Sigma, as the two other engineering companies do not have the same status within the supply chain. The required technological skills and equipments have not been a problem for EDAG Sigma, as they are used to it within the firm group. IDS also has an intensified interaction with staff by Airbus, as they are developing design studies in close connection to the OEM in Hamburg as well as other locations. As a result, these close interactions with the customers (in aeronautics as well as other sectors) are the main source for knowledge creation. Therefore, the case studies on engineering and design firms follow the expected pattern of knowledge creation by problem solving, however, based on formal and theoretical qualifications (de Vries, 2003). It will be interesting to compare whether different "engineering Cultures" (Wengenroth, 2000) might influence this way of organising knowledge creation.

- *integration into the regional cluster*

As in the case of industrial firms, direct cooperation between the firms is relatively weak. Few firms merged to grow, and the Internet presentation of the association HECAS serves to present a joint overview to main skills and references. The main driving force for the location in Hamburg is the access to Airbus as a major client. Besides these direct effects of procurement by Airbus to enhance service linkages within the cluster, indirect effects have been created by the certification requirements of Airbus. Several engineering firms (as PRETECH and ICARUS) use their certified services and skills for the supply of training courses (e.g. on different levels of CAE) organised by the OEM or other organisations. With the increasing relocation of system competencies from Airbus to the engineering system suppliers, these firms will gain additional importance for the regional suppliers to get necessary access to certification and interface requirements between different components or services. In this context, engineering companies act as knowledge brokers between the OEM, research institutes, system suppliers and other suppliers within the value chain. A further dimension of knowledge brokerage refers to transnationalisation of knowledge, as they use their integration in international firm groups and the concurrent engineering program to transfer necessary interface knowledge between the different Airbus locations.

- *internationalisation of knowledge flows*

As already mentioned, the consolidation of engineering firms within the Hamburg cluster led to an increasing influence of foreign companies. EDAG Sigma is a typical example of an engineering firm in Hamburg now being integrated into a firm group with several subsidiaries in all major markets. Weaknesses in contacts mainly refer to the Middle and Eastern European countries, while they expect that these countries will not be competitive against Asian engineers. IDS is a typical firm with international contacts and cooperation based on knowledge and individual experiences. Students have been placed into practises even in Detroit or California and repeated stays by the entrepreneur helps encourage social relationships to researchers and designers in North America, New Zealand or Asia. For the other two companies, these regular contacts are missed. They face similar problems as the industrial SMEs with lacks of contacts and experiences as main barriers to international business. International fairs and information provided by the regional associations have been seen as major tools to improve international contacts. But it becomes obvious that these instruments cannot compensate for lacks in formal international contacts (within a firm group) or informal and research-based contacts (as in the case of IDS).

3.3.2 Private personnel service firms

Originally, personnel service firms have not been in the focus of innovation research. For the study of the Hamburg cluster, however, they play an important role, as the lack of qualified personnel is recognised as a major barrier for future growth and innovation within the cluster. Consequentially, these service firms are part of all formal cluster activities and plan to improve cooperation with local and international schools. Furthermore, they look for qualified personnel from other countries to overcome the existing bottlenecks in qualification. Within our interview sample we integrated three service companies with different market positions

- 7 (S), an international personnel services firm group with more than 4,000 employees specialised inter alia in the aeronautics sector with headquarter in Hamburg and founded in its current structure only in 1997
- Hanseteam as national personnel service firm with specialisation inter alia in aviation and headquarter in Hamburg and subsidiaries in Frankfurt and Flensburg, founded in Hamburg in 1989
- RKM Zeitarbeit as national personnel service firm with headquarter in Munich, where the organisation was founded in 1978, and specialised in aviation and automotive segments

- *strengths and weaknesses of the firms and market environment*

All the firms interviewed observe a fast growth of the regional personnel services market in aeronautics. In particular the fast growth of employment at Airbus with the increasing bottlenecks in qualified engineers drives the demand. Furthermore, the experience of employment cycles – strong rationalisation and reduction of workforce in the late 1990s at Airbus and increasing demand after 2002 – cause a higher attractiveness of the more flexible use of temporary contracts in lower qualification segments. Further growth is expected by increasing shares of outsourcing by Airbus to personnel service providers and increasing markets for qualification.

All the firms expect steady growth in internationalisation of the business driven by increasing supply and demand. These increases, however, are concentrated to the European labour markets with a special focus on Eastern European labour markets. The possibilities to grow international, however, differ between the companies. Export shares have so far been relatively low ranging from 0% at Hanseteam to nearly 20% at 7 (S) and RKM. Hanseteam is organised as a national service provider with a share of regional sales, which is higher than 50%, and

expects to stay in the national market. 7 (S) has already subsidiaries in other – European – countries (UK, Netherlands, France, Czech Republic and Poland) and expects to grow in these markets as well as in other Western and Eastern European countries. Transnational recruitment of personnel is a major source for their business. RKM Zeitarbeit has focused so far on transnational recruitment of staff and temporary contracts. They also expect growth within the European markets. Regulatory standards are seen as major barriers to transnationalisation. Transnational staff in engineering has to show certified professional skills, which makes it more difficult to hire and place Eastern European engineers in the aeronautics sector. The increasing pressure on the suppliers by Airbus to outsource parts of the value chain to Eastern Europe has been assessed critically, as they fear that these outsourcing partners, e.g. in countries like Ukraine, do not cope with the professional certification standards currently given within the EU.

- *innovation events history*

For personnel service firms, innovation mainly refers to the diversification of products and services. They do not invest in formal R&D but they offer training courses and have to develop customer-driven services. Consequentially, all providers stress the relevance of long-term cooperation with major demanders like Airbus. For Hanseteam as a small regionally focused firm, temporary placement of experienced staff with problem solving capabilities and absorptive capacities as specific tacit knowledge is pronounced as a major asset. Contacts to universities and research institutions do not play any role. Similarly, public research programs are not compatible with their business model. There are options to integrate training modules of personnel services into European programs like LEONARDO or ERASMUS, but exchange of human resources in EU R&D policies are more related to researchers than staff.

- *Internal organisation and knowledge creation*

All of the interviewed firms are companies with headquarters and subsidiaries in other regions and countries. Hanseteam as the smallest firm within the sample with ten employees in management at the headquarter works with close linkages between headquarter and subsidiaries. 7 (S) with more than 70 locations nationally and internationally has a more decentralised structure of decision-making and responsibility. 50 % of management staff at 7 (S) has experiences in large firms, while the whole management team at Hanseteam has only experiences in SMEs. Foreign experiences are also not given at Hanseteam, while 10% of the management at 7 (S) worked in foreign countries. All the firms interviewed have shares of qualified staff between 15 and 20%. Shares of formal further education are relatively high (70-80%), as the firms themselves offer training courses. The fluctuation of staff depends on the product structure with higher rates of mobility in case of placement services. All the firms hope to profit from organisational changes in the industrial and engineering firms with increasing relevance of outsourcing personnel services and – specifically in the case of 7 (S) – consulting for process reorganisation and organisations of communities-of-practice.

- *Integration in the cluster and internationalisation*

All the firms interviewed are organised within Hanse Aerospace and belong to the most active members within this association. These activities serve as acquisition strategies within the regional market and shall help reduce dependence on Airbus. The main node of interaction within the cluster for the personnel service firms is still Airbus. Internationalisation is for these firms a relatively urgent topic, as the joint agreements on professional certifications open up new options for transnational recruitment of aeronautical engineers and specialists. As a result, the personnel service firms use intensively platforms like the international fair on aircraft interiors in Hamburg and joint presentations of Hanse Aerospace. Differences of the strategies between the single firms were already mentioned at the beginning of this chapter.

3.3.3 Private and public research organisations

Within this segment, we included six service organisations to cover the variety of research skills within the cluster:

- the DLR Centre of Excellence Composite Structures and Adaptronics in Brunswick, one of the leading research centres on this topic in the world
- the Institute of Aerodynamics and Flow Technology in Brunswick and Göttingen
- the Institute for Aircraft Design and Lightweight Structures at the Technical University Brunswick
- the Institute for Aircraft Systems Engineering, led by Professor Udo Carl at the Technical University Hamburg Harburg (TUHH)
- the Chair on aviation design of Professor Werner Granzeier at the Hamburg University of Applied Sciences (HAW)
- Composite Technology Centre Stade (CTC) focused on developing new technologies and market applications based on polymer fibre reinforced plastics

This sample shall at least partly represent the geographical, organisational and disciplinary range of research service within the cluster. The first three organisations are located in the Eastern parts of the cluster and two of them are integrated within the organisational infrastructure of DLR. The universities in Hamburg represent activities on research, academic qualification and knowledge transfer within the City of Hamburg with so far only weak linkages to the cabin interior segment. CTC represent a subsidiary of Airbus with close connections to the carbon fibre reinforced composites cluster in Stade and research activities at the university of Bremen. Additionally, the Fraunhofer Institute for Production Technology and Applied Material Research (IFAM) in Bremen is an important actor in the development of composites, but will not be included due to our restricted resources. The description in this chapter will follow the geographical range.

- DLR in Brunswick

Germany has a well-designed structure of public associations for different objectives in research and development. In the context of aeronautics the Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Centre; DLR) is the most important umbrella organisation for public basic and applied research. This centre is part of the Helmholtz Association, a public association with a special focus on capital-intensive basic research. The Helmholtz Association with more than 24,000 employees and a total annual budget of more than 2 billion Euros covers topics ranging from structure of the matter to space and traffic. 90% of the budget is financed by the Federal government and 10% by the host Länder (Karl et al., 2003 for more details). DLR has approximately 5,100 employees working on four main topics: aeronautics, space, transportation, and energy. 31 institutes at eight German locations belong to the centre, which has also offices in Brussels, Paris and Washington, DC, as the centre represents the German interests in all international negotiations on public space programs. The annual budget of DLR is 450 million Euros with one third covered by own earnings. Most of the research in aeronautics is oriented along the objectives of the Strategic Research Agenda, as many German researchers participated in the Advisory Council for Aeronautical Research. DLR has specific close relationships to its French and Dutch counterparts. The activities on aeronautics and traffic shall be concentrated at Brunswick and Göttingen. Both locations are in Lower Saxony at the Eastern part of the North German aeronautics cluster. Brunswick has a long tradition as aeronautics centre due to its airport and research capacities by DLR and Technical University. In 1955, the Federal Office of Civil Aviation was established in Brunswick. After German unification, Brunswick Airport, which is close to the border to Eastern

Germany, became a regional commercial airport, but also a test site for the DLR and institutes of the Technical University of Brunswick. Consequentially, the airport is now called "Research Airport" with special capabilities in traffic management based on positioning technologies and satellite navigation. Future growth is particularly expected due to the development of the Galileo project. In Göttingen, the Aerodynamic Testing Authority was founded already in 1907, and currently more than 350 researchers are working on aeronautical topics.

Within our sample, we included two institutes from the DLR, the DLR Centre of Excellence Composite Structures and Adaptronics in Brunswick, one of the leading research centres on this topic in the world, and the Institute of Aerodynamics and Flow Technology in Brunswick and Göttingen. The first institute covers two topics, which enjoy a high research priority within the Strategic Research Agenda. Adaptronics is a combination of different scientific disciplines. It is based on multi-functional materials, which integrate sensors and actuators. Possible applications include all technological systems, which require mechanical moves. For aeronautics, potential are seen in reduced noise and abrasion as well as more flexible structures. Cost savings are expected by substituting incumbent control circuits. First applications are planned for the military transport aircraft A 400 M, where an adaptive engine hoisting shall reduce the transfer of swings between engine and body or wing. The centre of excellence is the coordinator of a competence network on adaptronics with 33 members, which aims to integrate the new technology into all segments of the machinery sector. Members of this competence network are inter alia Volkswagen, EADS, Siemens Corporate Technology Microsystems and Medicine Technology, Carl Zeiss Optics Research, Daimler Chrysler Research and Dornier together with several SMEs, which started as spin-offs from the research institutes. Members from the research segment include different Fraunhofer Institutes, DLR institutes and departments of technical universities. The Centre of Excellence on Adaptronics is the largest national research group in the world on this field.

Theoretical and applied research is connected with qualifications in Adaptronics at universities. The Centre of Excellence cooperates with the University of Magdeburg and plans to support the establishment of a Master for Adaptronics at the private university of applied sciences in Göttingen. Students from Magedeburg and Brunswick are continuously integrated into research activities.

In the context of composites, the centre of excellence offers basic research on materials as well as prototyping and process organisation up to the design of new products. The centre has been involved in the development of the carbon fibre wing for the A400M, the new composites body for the single aisle Airbus and components of the "Eurofighter". Other applications include space technology, the interior of train cabins, sail racing boats and racing cars, or protection clothes. All products are developed in close cooperation with big multinational companies. Specific fairs and international congresses shall help enhance international contacts and open up international markets.

The second institute provides new tools for simulations and measurement as well as tests on effects of different configurations on aerodynamics and aero-acoustics. Main customers are in the aeronautics segment. Research on ways to reduce noise is also provided to automotive and train industries.

Both institutes are integrated into international markets. Main customers are always multinational OEM or big multinational authorities like European Space Agency. In the aeronautics markets, Airbus is looking for exclusiveness and restricts explicitly contracts with BOEING. Most of the research contracts are concentrated to Western Europe and North America. China

has only recently begun to look for research services. In scientific contexts, cooperation structures are more international. Chinese experts have been sent to Brunswick, and the German researchers have regular research stays at NASA or the Air-Force Labs. Regional SMEs are only weakly linked to the institutes. The SMEs involved into the competence network Adaptronics had already close contacts to DLR and started as spin-offs. Similar linkages exist in the composites markets. Conventional SMEs do not have the necessary knowledge base and awareness of new technological options to look for cooperation.

One instrument to improve linkages between firms and DLR institutes is the so-called "partnership contract". Here, DLR and the private firm each pay 50% of the salary, and the researcher spends 2/3 of the contractual time at DLR to develop theoretical ideas, which will be applied in the remaining time in the firm. After the termination of the contract, the researcher has the perspective of a permanent contract at the firm. Airbus and Rolls Royce are typical partners for this instrument. Another way of cooperation is the temporary stay of researchers in the firms for specific projects. In general, these forms of cooperation are easy to organise due to geographical proximity (most of the partners are located in Bremen or Stade).

Public funding is still a major issue for the institutes. Both institutes have steady budgets by the DLR and complain on too few performance incentives within the association. EU funding has been assessed as very beneficial, as the long-term strategic plans developed by ACARE and integrated within the EU RTD FP as well as national and regional schemes provides a basis for long-term planning of resources and priorities. This is recognised as a competitive advantage against US counterparts, as public funding in the US is increasingly orientated to short-term calls. Problems have been caused by co-funding requirements, as they restrict growth of the institutes within the given DLR budget.

Despite the strong orientation on internationalisation, relationships to Middle and Eastern Europe are still relatively weak. There are several contacts on scientific cooperation and also recruitments of Eastern European researchers. It is expected to increase the number of cooperation projects with Eastern European partners in particular to cope with EU requirements on integration. Main barriers for Eastern European partners to join European consortia, however, are so far lacks of big aeronautics companies in these countries to serve as partners on application and product development.

The aviation research at the Technical University Brunswick is closely related to the DLR and the research airport. The institute for Aircraft Design and Lightweight Structures, led by Prof. Peter Horst, is integrated within the Faculty for Machinery. Again, this institute has a long research tradition, which started already in 1938 with a special focus on slow aircrafts. In the 1970s, research priorities were turned to composites. Currently, the IFL offers specific tests for new aircraft structures and components as well as basic research in the development of new optimised structures. The IFL has several testing facilities, which allow testing of standardised specimen up to complex structures, e.g. the spar of a composite wing. Customers for this service are mainly OEM like Airbus. Experiences of cooperation with industrial partners have been similar to those already mentioned for the DLR. Regional SMEs do not have the necessary expertise to cooperate directly. They mainly profit from development initiated by joint research between public organisations like the IFL and Airbus. EU funding is seen as an important input for the research infrastructure. As a university institute, co-funding is not a problem. One example of EU-funded research is a project on the optimisation of supersonic wing structures based on the method of finite elements.

A second centre for research and qualification in the aeronautics cluster is the City of Hamburg with several universities, research institutes and schools. Within our interview sample, we concentrated on two institutes at universities in Hamburg with the Institute for Aircraft Systems Engineering, led by Professor Udo Carl at the Technical University Hamburg Harburg (TUHH) and the Chair on aviation design of Professor Werner Granzeier at the Hamburg University of Applied Sciences (HAW).

Both institute leaders have former experiences as employees at Airbus sites. The Institute for Aircraft Systems Engineering is located in a technology centre in the neighbourhood of Airbus in Hamburg-Finkenwerder. Airbus supported the foundation and research design of this institute. The research is focused on the development of new tools for computer-assisted simulation and the analysis of system technologies and architectures. The Institute for Aircraft Systems has several test rigs for different systems, e.g. cooling systems, energy systems, or actuation systems. The main industrial partner for the institute is Airbus. On the European level, the institute is integrated into different multinational consortia. The close relationships to Airbus helped to get access to these multinational structures. Linkages to research partners outside Western Europe, however, are relatively weak. Similar to the institutes in Brunswick, cooperation with SMEs is hindered by lacks of capacities and financial resources within the SMEs. Besides research, qualification is offered within diploma and bachelor courses in close cooperation with Airbus. The specialisation in specific modules of aircraft systems engineering is unique in Europe. Consequentially, TUHH and HAW are the most important partners for the interviewed engineering companies and investigated industrial firms located in the City of Hamburg. This assessment, however, is not necessarily a proof of quality. An investigation on the Cluster in 2001 came to the results that the OEM in Hamburg realise deficits in all segments of the research and teaching infrastructure. Reasons for this were seen in lacks of focus and staff within the universities as well as lack of coordination between the institutes. Compared to Hamburg, Toulouse had five times more graduates in fields of aerospace and 15 times more staff in teaching and research available, according to this investigation (Pfähler, Lublinski, 2003). SMEs also complained on deficits of qualified personnel. As most SMEs did not invest in formal R&D and research cooperation with public institutes, quality deficits in this segment have not been observed by interviewed SMEs.

The University of Applied Sciences Hamburg (HAW) introduced a degree in aircraft engineering already in 1970. Currently, they offer integrative courses in aircraft engineering and production technology in close partnership with Lufthansa Technik (6 students per year) and Airbus (8 students per year), besides a bachelor program on aeronautics engineering and a master of Engineering in Lightweight Aeronautical and Vehicles. Around 40 graduates in aircraft engineering leave this university annually.[5] Based on diploma theses and single private initiatives in cooperation between students and professors, several student initiatives have been launched. One prestigious project is the cooperation between students at the Technical University Munich and HAW on the configuration of a blended wing body aircraft, for which a model at 1:30 has already been designed and produced. Data for this configuration have been provided by EADS Airbus. Other student projects refer to racing cars or carts. Again, the relatively small scale of the faculty segment on aeronautics restricts the possible number of graduates and the intensity of research and cooperation with local firms. The design service firm IDS included in our sample is a spin-off by Professor Granzeier from HAW.

Both universities in Hamburg offer specific services for schools. At the TU Hamburg Harburg, pupils can do their own research tests within the DLR school lab, including acoustic

[5] For the TU Hamburg Harburg, the investigation in 2001 showed an average of 11 graduates in aircraft system engineering in the years 1999-2001 (Pfähler; Lublinski).

testing or aerodynamic testing. Engineering students are sent out to schools to show and develop robotic experiments together with young female pupils of more than twelve years. At the Hamburg University of applied sciences, lectures on topics of aerodynamics offer theoretical knowledge combined with tests on aerodynamic effects on aircrafts. The knowledge transfer infrastructure between universities in Hamburg and aeronautical firms is restricted to the technology transfer centre in Hamburg Finkenwerder and single initiatives on further education. The investigation from 2001 also revealed poor cooperation between universities and firms or associations for trade fairs, exceptions include cooperation between HAW and Hanse Aerospace for joint presentation at international aircraft trade fairs.

Composite Technology Centre Stade GmbH (CTC) is a subsidiary of Airbus Deutschland GmbH and located in Stade Technology Centre close to the Airbus site in Stade. The basic objective of CTC is to develop new technologies and market applications based on polymer composite fibre materials. Composite materials show basic advantages in all cases, when weight and mechanical loading capacity are important. For large-volume series production, however, still problems of manufacturing costs, integration into existing production processes and recycling have to be solved. For these reasons, a network has been formed in Stade to develop solutions for different markets. CTC is the development centre for this network. New process chains for composites shall be particularly developed in aircraft construction, automobile, shipbuilding, track vehicle and commercial vehicle construction. Consequentially, projects include the development of fuselages, tail planes and window frames for aircrafts based on composite fibre reinforced plastics. The centre is led by Prof. Axel Hermann, who also has a Chair on Fibre and Composite Technology at the University of Bremen and is the Head of the Fibre Institute in Bremen. This institute was founded in 1969 as a merger between a cotton and a wool laboratory. Composite technology became later one research focus and was stressed with the recruitment of Prof. Hermann. He represents the interface between basic research in Bremen, development of marketable technologies in Stade and application particularly by Airbus. Airbus is still the biggest customer of the centre. Several projects are funded by public authorities, e.g. the German Federal government or the EU. Technological cooperation on composites technologies within EU is shown by the TANGO project[6] with technology partners like ALENIA, INTA (Spain), SONACA (Belgium), INASCO (Greece) and NLR (Netherlands). So far, CTC develops and manufactures components based on composites within the technology centre at Stade in small scales. Strategically, vertical disintegration shall lead to outsourcing of manufacturing to SMEs in the textile industry. Only few of the existing suppliers to Airbus will be able to join this new market. From our sample of industrial firm, Saertex GmbH is one of the companies gaining from future outsourcing processes.

Summing up, the research and academic qualification infrastructure is relatively broad and diversified in North Germany. Several linkages can be observed in all cases to Airbus, who is the most important customer and cooperation partner. SMEs, however, are only poorly integrated. In particular conventional SMEs do not have necessary prerequisites in knowledge and funding to cooperate with the institutes. Strategic priorities in research have only slowly been developed during the last decade. Here, the increasing interest by Airbus to increase the share of composites within the new aircrafts caused several initiatives in Brunswick, Bremen and Stade. In the City of Hamburg, however, it still remains an open question how the Airbus Centre of Excellence Cabin Interior can be linked with similarly focused research. Problems in academic qualification refer primarily to lacks of resources. Again, the big OEM play an important role as partners for integrated courses, while SMEs and their representations are still relatively poorly linked to the universities. International cooperation and contacts are – as

[6] TANGO means Technology Application to the Near-Term Business Goals and aims at the development of monolithic aircraft fuselage and wing structures based on composites.

expected – rather common for all universities and research institutes and they include all major knowledge centres in Europe, North America and Asia. These activities open up the opportunity to integrate knowledge from other regions and countries into the cluster, either by cooperation with firms or by providing internationally oriented qualifications. This diffusion, however, is still mainly based on activities by Airbus, while the SMEs might profit from this at best indirectly within the market relationship to Airbus.

3.3.4 Private and public business promotion organisations

Within this section, private and public organisations in the two heart regions of the cluster will be described:

- the private association for aeronautics SME Hanse Aerospace
- the private-public business promotion agency in Hamburg
- the regional Department for Economics and Labour in Hamburg
- the public-private cluster organisation CFK Valley in Stade
- the public consultancy institute Innovation Centre in Hannover, Lower Saxony

Due to the long history as Hanseatic city, private – formal and informal – organisations of business have always played a major role in Hamburg. For the aeronautics sector, the German Aerospace Industries Association (BDLI) serves as a representation of the larger companies. Regional associations shall help organise SMEs in this sector. Hanse Aerospace was founded in 1996 as an initiative of individual entrepreneurs. It is still an association without full-time paid management. All the managers of this association have full-time jobs in their firms. The main strategic objectives are the provision of information, platforms for cooperation and the mobilisation of SMEs as contractual partners of the big OEM as well as a better representation of SMEs within political discourses. More than 100 organisations are organised within this association, including industrial firms within the aeronautics supply chain as well as universities, engineering companies and personnel service providers. Main products of Hanse Aerospace are the organisation of joint representations on international fairs, the organisation of conferences and social events and the publication of a newsletter. The interviews with the SMEs showed that they highly appreciated the support for international fairs as the most visible output. Hanse Aerospace supported the emergence of CSH as a way to develop a system supplier without foreign investor. Members of the association, however, assessed this approach relatively controversially. Hanse Aerospace is also member of the regional location initiative ("Initiative Luftfahrtstandort Hamburg").

In the European context, Hanse Aerospace is member of the project ECARE with several regional aeronautics associations all over Europe.[7] The strategic objective of ECARE is a better representation of SMEs in this sector on the European level and better access to the EU RTD FP. They developed an Internet platform for SMEs to look for suitable cooperation partners and organised SMEs conferences, presentations of clusters and discussion forums with European policy-makers to influence strategic processes for the new Framework Program. As a result of the first two years of this process, best practises have been published on networking between European clusters, organisation of training multipliers in clusters to ensure knowledge diffusion, sampling information of aeronautical SMEs as possible partners for Integrated Projects in the FP run by multinational companies, mapping this information and ensuring necessary quality of information before release. Further activities in this field are conferences

[7] Founded in 2003, ECARE had at the end of 2005 eight founding members from France, Belgium, Italy, Germany, UK and Spain, nine additional members from the same countries plus Ireland, Czech Republic, Greece and Romania and four associated members from Switzerland, Hungary, Poland and Portugal.

within the regions to raise the awareness on EU research projects and to inform SMEs on the prerequisites and support. ECARE is co-funded by the EU FTD FP 6 and 7. The demand for these services by regional SMEs in Hamburg, however, has been relatively weak with only few companies publishing their data on the Internet platform and only relatively weak participation in conferences and trips on European issues.

The public business promotion agency in Hamburg (Hamburger Wirtschaftsförderung, HFW) acts as a broker within the cluster. Shareholders of HFW are the City of Hamburg, Hamburg Chamber of Commerce, Hamburg Chamber of Skilled Trade and a consortium of leading commercial banks. Their main task is the attraction of foreign investors and the support of local firms with consultancy services, cluster management and location marketing. The organisation of the agency includes specialists for local and international services and special contact persons exclusively for aviation industry and logistics. As already mentioned in the second chapter, Hamburg has enjoyed a boom in FDI during the last fifteen years. A special focus in the attraction of foreign investors has been directed to the Baltic Sea and East Asia. In 2005, 58 from 120 new companies investing in Hamburg came from China and the Far East.[8] In 2006, the business promotion agency reorganises its priorities based on clusters in aeronautics, logistics, life sciences and media and information technologies.

With most of the traditional industries closing down in Hamburg, aeronautics became a strategic priority for Hamburg, particularly after the decision by Airbus to locate a second final assembly in this city and then recently to build up a Centre of Excellence Cabin Interior in Hamburg with additional capacities for the A 380. The traditional forms of regional business promotion – subsidisation of investments – are not available in Hamburg due to the high economic performance. Therefore, HFW concentrates on more unconventional promotion instruments. One of the most important impacts on the development of the sector in Hamburg is the coordination of the regional location initiative and the continuous supply of social contacts and events to help at least informally forming a cluster. This activity is mainly driven by the individual networking skill of the coordinator at HFW, which is assessed as the only person in Hamburg to know everybody and everything on the aeronautics sector in Hamburg. The impact of this initiative on strategic changes, however, is restricted by the capabilities and willingness of the individual representatives in the conventional firms. Further activities refer to public relations campaigns and contacts to foreign investors, not only as aeronautics companies, but also as in the case of Aircraft Interior as the organisers of international fairs. The strategic objective of HFW is to attract suppliers to cover the whole value chain at least in the cabin interior segment. So far, however, only few big multinational suppliers came to Hamburg (e.g. Goodrich, Liebherr) and every investment by a big supplier of cabin interior is always accompanied by fears of regional firms to be purchased or driven out of the market.

The regional Department for Economic Development and Labour in Hamburg (Behörde für Wirtschaft und Arbeit) follows similar strategic objectives to HFW. Three main instruments have been used to improve the attractiveness as location for aeronautics:

(1) the improvement of infrastructure for Airbus by asserting and funding an extension of the runway for Airbus to become final assembly location for the A 380

This project has a total budget of 693 million Euros. Besides financial efforts, the location of the new runway in a former natural habitat caused severe conflicts in the City. Huge activities had to be planned for compensation of the environmental damages as well as for flood protec-

[8] More than 400 Chinese firms are located in Hamburg as the most important German centre for trade with China.

tion. For the regional SMEs, this major infrastructure projects symbolises the expectation of future growth within the cluster.

(2) a specific funding scheme for aeronautics research, which shall primarily support research and development by SMEs (Luftfahrtforschungsprogramm)

In 2000, the City of Hamburg established a regional funding scheme for aeronautics research based on the Federal program for aviation research. 18.3 million Euros have been allocated to 30 projects by firms, universities and research institutes in Hamburg. The basic idea of this amendment to the Federal program was to improve the involvement of regional SMEs and to strengthen specific research priorities for the cluster in Hamburg. Industrial firms had to be integrated in all projects with SMEs receiving subsidies up to 50% and larger firms 40% of their R&D investments. As most of the traditional SMEs do not invest formally in R&D, most projects were led by Airbus, Lufthansa Technik or one of the universities and research institutes in Hamburg with at least some SMEs as possible partners. Only engineering companies and knowledge intensive firms were able to develop suitable projects. The new program from 2006-2010 focuses particularly on the development of systems capabilities in aeronautics, which can be diversified to neighboured sectors. This shall help improving research capacities in cabin interior, as the overview to research and qualification services reveals deficits in this segment. Several interviewed representatives in the SMEs, however, were not aware on any specific superiority of the regional contributions compared to the Federal level.

(3) support for new qualification schemes particularly in schools and cooperation with Midi Pyrenées and Aquitaine in the field of vocational training.

As availability of qualified staff was identified as a major bottleneck for future development in the aviation sector in Hamburg, the initiative for the aeronautics location Hamburg was used to initiate a qualification programs with several instruments. This initiative included a great variety of activities in schools, apprenticeships, vocational training and academic education, including additional apprenticeship places, concentration of dual apprenticeship for aeronautics in one school, integration of European standards into apprenticeship training, new courses for further education at universities, new modules for aeronautics, particularly cabin systems, with additional studentship places at the regional universities, joint international recruitment of qualified personnel and practises in other German regions, Sweden, France or Spain, joint public relation activities at fairs, in schools, nursery schools or crèches. The regional department for Economics and Labour coordinated the whole program with special emphasis of the one individual coordinator. The whole program (Qualifizierungsoffensive Luftfahrtindustrie) was identified as a best practise by the European Commission for its Star 21 report.

Special focus within this program has been laid on cooperation with the French regions Midi Pyrénées and Aquitaine. Formal declarations of cooperation between the regions have been established in 2004. This cooperation includes joint information events and visits of representatives of the regional aeronautical firms. In the context of qualification, the cooperation has been even more intensified. Special problems always occur due to different education standards and curricular. On the university level, the Bologna Process helped to develop exchange programs between Hamburg, Bordeaux and Toulouse. The emergence of double degrees with French universities is the explicit objective of TUHH as well as HAW. On the level of dual apprenticeship, barriers of different education have at least partly been overcome by defining joint elements of curricular based on European professional standards (JAR, EASA). This made it possible that young apprentices from Hamburg, Midi Pyrénées and Aquitaine could spend some months at firms and schools in the other regions. Again, Airbus and Lufthansa Technik act as forerunner for these exchange programs, but there is hope to integrate also

SMEs. According to all participants, these exchange programs and further activities were only possible due to the personal efforts by the coordinator from the regional department for Economics and Labour. As the big firms are particularly engaged in these programs, awareness on these activities by the SMEs has been ambiguous: some people stress the positive role of activities by the location initiative in the segments of qualification, others did not realise anything at all.

In Stade, a different model of supporting cluster processes has been chosen. While in Hamburg the informal public-private initiative started with social events, public relations campaigns and working groups on specific topics like qualification, the cluster initiative in Stade CFK Valley was launched as a formal cooperation with professional management and a steering board, clear responsibilities and rights. The basic objective of this organisation is the development and growth of a network for the research, development, production and marketing of products and processes based on composites. All parts of the value chain for composites shall be included within the network to develop new production processes suitable for large scale series as well as applications in new markets (mainly related to aircraft, track systems, automotive and shipbuilding) and recycling. Like the initiative for the aeronautic location Hamburg, CFK Valley is member of the German program on network of competences. More than 50 national and international organisations (firms and research institutes) are integrated within CFK valley with Airbus, Volkswagen and Hottinger Baldwin Measurement Technology as big OEM and 29 SMEs from different sectors. The basic prerequisite for membership is the acceptance by the other network members due to excellence in the market or research (being one of the "market leaders") and non-rivalry to incumbent members. The organisation of CFK valley follows a "classical" cluster management approach with a professional management from an experienced firm specialised in technology consultancy: all members shall contribute to a network effect, i.e. additional benefits for all due to interaction on specific topics, with a guarantee on exclusiveness of the benefits to the network members by protection against competitors. Interaction is primarily supported on three ways: firstly R&D cooperation projects funded by public programs or private firms are launched, moderated and administered by the cluster management organisation, secondly concrete problems of one network member are communicated by the cluster management organisation to the other members to look for common solutions, and thirdly joint presentations on international fairs and recruitment initiatives are coordinated by the cluster management to overcome bottlenecks in sales or qualification. For the relatively small municipality of Stade, close to the City of Hamburg belonging to Lower Saxony, with a severe loss of industrial workplaces in the Chemical Industry, the CFK valley is a chance to attract new investors: within the last three years, more than 350 new workplaces have been created in Stade by cluster members. Although the cluster is not based on geographical proximity but on cognitive proximity due to similar technological challenges, many composite firms and customers decided to go to Stade. As already described in the context of CTC, Airbus is an important player in the network. Concrete projects on wings and fuselages help to develop new solutions and proof the potential of the new technologies. So far, bottlenecks in academic qualification were caused, because no university was located in Stade. An agreement with the private University for Applied Sciences Göttingen led to a new location of this organisation in Stade, where new bachelor and master programs on engineering with special focus on composites will be offered from October 2006 onwards. Access to international knowledge flows within the network shall be guaranteed by the members. Many research institutes, including e.g. TUHH, CTC, Fibre Institute Bremen or Fraunhofer Institute for Applied Material Science Bremen, have international contacts to Asia, North America and Western Europe. Deficits are identified in Eastern Europe, because necessary experiences with composite technologies on this high level are missing in these

countries. The big OEM and some SMEs with international subsidiaries (like Saertex) bring in further international experiences and knowledge from other composites locations.

The Innovation Centre Lower Saxony (Innovationszentrum Niedersachsen) is the consultancy service organisation for the regional government of Lower Saxony. They provide recommendations for innovation policies on the regional level and the coordination of regional centres of competences. Basic ideas of innovation policies in Lower Saxony are the orientation on technological fields and networking within and between (sub-)regions on the NUTS II and III level. For the aeronautical sector, the orientation on technology fields means that the support should not be directed to the specific industry (aeronautics) but on leading technologies like carbon fibre reinforced plastics or navigation technologies for mobility. This shall reduce dependence on single sectors and help exploiting synergetic effects. Within aeronautics, the innovation centre sees a great potential for Lower Saxony due the great diversity of technological competencies within the region covering all elements of the value chain. In contrast to Hamburg, no final assembly line is located in the region and the growth of employment at the sites in Varel, Stade, Buxtehude and Nordenham is slower than at Hamburg Finkenwerder. The close relationships of new SMEs in the composites segments to research centres in Brunswick (DLR) and Bremen (Fraunhofer, University with Fibre Institute), however, are seen as a decisive difference to the situation of conventional firms in cabin interiors, which are not able to rely on specific knowledge excellence. The (sub-)regional approach in Lower Saxony means that interregional competition shall lead to new (sub-)regional cluster approaches like CFK valley, which will be supported by the regional government, if they proof to be at the national or European top.[9] Interregional cooperation with the Hanseatic Cities of Bremen and Hamburg is described as relatively good, as long as complementary objectives and effects can be observed. [10] More conflicts are mentioned with the north-eastern region of Mecklenburg Pommerania, as the high level of subsidies there animated one aeronautical firm to leave Lower Saxony for the North East.

Summing up, the private and regional business promotion services are spread along different regions and products. Our sample of five organisations should show the diversity of approaches: more informal approaches in Hamburg with its specific development in cabin interior, two big OEM and several conventional firms based on intensive individual efforts by the coordinators for the location initiative and qualification, the private more informal approach by the association Hanse Aerospace developing along specific topics and challenges, a classical cluster management approach in Stade with a relatively high degree of formalisation and strategic focus, accompanied by a philosophy of technological development and interregional competition on a NUTS III level in Lower Saxony. The different solutions have to be seen against the background of different challenges – specific technological capabilities and research infrastructures in Lower Saxony, and few strategic infrastructures in Hamburg – and will be confronted with different future challenges caused by the new sourcing strategies of Airbus. For all organisations, however, common problems are given in the context of strategic mobilisation of SMEs. Most initiatives and activities are driven by the OEM, and the SMEs are at best able to cooperate with the OEM within these fields or at worst not aware or not able to exploit cooperation potentials.

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9 Possible restrictions of this competitive philosophy, however, are given for rural areas with only few chances to develop successful clusters.

10 The regional department for Labour and Economics in Hamburg mentioned in this context possible conflicts with Lower Saxony on two fields: the cooperation of TUHH with the CFK valley, where some researchers from TUHH complain on restricted access, and the high European regional subsidies for the region of Lüneburg as an objective 1 phasing out region.

3.3.5 Private and public financial service organisations

In this section, only three organisations are described, as the coordination deficits between the regional SMEs and the financial organisations are similar for all kinds of financial organisations. Almost all industrial firms complain on bottlenecks in financial resources. Due to the adjustment of banks to Basle II, firms report on more restrictive requirements for credits and loans. Old informal linkages based on mutual experiences have been substituted by more formalised relationships. Banks look for private equity ratios of the SMEs, formal securities and balance ratios. This change affects particularly SMEs in aeronautics, as the new sourcing strategy of Airbus leads to a shift of risks to the SMEs, which are not able to cover these risks without additional financial resources. Special problems are caused by the long life cycles of aircrafts and the volatility of sales markets. Firms within international groups – like the big engineering companies – report fewer problems with financial service organisations. No bank is formally integrated in the different formal and informal cluster initiatives. Contacts are restricted to business relationships and visits of bank representatives at official events of associations, chambers or public authorities. Within the location initiative, banks presented their instruments and strategies. Most of the industrial SMEs, however, do not understand the causes for new instruments and requirements in the financial markets and fear to loose sovereignty.

Within our sample, we included three organisations with different corporate objectives and regional focus considering the local linkages of the interviewed SMEs:

- the local Beteiligungsgesellschaft für den Mittelstand (BGM), a private equity fund organisation of the local savings bank in Hamburg
- Deutsche Industriebank AG (IKB), focused on financial services for SMEs and young firms, with its subsidiary in Hamburg
- the regional development bank for Lower Saxony N-Bank in Hannover

BGM is a 100% subsidiary of the local savings bank (Hamburger Sparkasse, HASPA), one of the biggest savings bank in Germany. BGM was founded to provide silent partnerships between 0.5 and 5 million Euros. Causes for these investments could be growth strategies of the firm – mergers, new international locations, new market segments, fast internal growth – adjustment strategies of the balance structure (private equity ratios) to obtain creditworthiness or the organisation of succession. Additionally, BGM offers consultancy services and access to network resources (lawyers, interim managers, accountants etc.). So far, the priority of BGM partnerships was in the service sector, but several negotiations with aeronautical SMEs have been started in the last years to finance necessary investments to get access to the Airbus value chain for A 400 M and A 380. From the perspective of BGM, many SMEs manager are still not aware on the actual situation. Particularly for the older generation of managers, sovereignty of the management can only be secured by exclusive family ownership. Bottlenecks for internal and external growth are underestimated, according to the BGM representatives. The succession by younger owners might reduce these coordination barriers, as the first negotiations showed. The foundation of a common holding by cabin interior suppliers CSH was assessed negatively, as this organisational design seems not to be sufficiently attractive for SMEs with a relatively high – and exclusive – knowledge base. Without these firms, however, CSH will not develop necessary systems supplier competencies. Consequentially, the BGM representatives expect the investments of bigger French and British suppliers in the next years to form systems suppliers for cabin interior, and some of the firms in the Hamburg cluster would then have a future as parts of an international holding, similar to the example of the engineering companies. For the BGM, such a scenario would cause problems, as they can

only act on the regional level and would not be able to offer their partnerships to firms outside the region.

The Industriekreditbank IKB AG was founded in 1974 as a merger of two private banks focused on corporate financial services. The organisation has 1,500 employees at seven locations in Germany and five foreign locations. 38% of the shares are held by the Kreditanstalt für Wiederaufbau, the federal development particularly focused on SMEs, 11% by a private foundation and the rest by private institutional investors. Five product segments are offered: corporate finance, private equity, structured assets, real estate finance and treasury. Within the segment of corporate finance, they developed a new product – a model of investment outsourcing – designed for suppliers within industrial value chains. The basis of this product is a long-term credit by IKB to a project firm founded by the supplier with limited liability. The supplier sells the whole contract with the OEM, including all claims for payments to the project firm, which uses these claims as securities for the credit. This model can be used for R&D projects as well as long-term production supply. Advantages for the suppliers are the separation from internal balances securing the availability of financial liquidity. For the OEM, the creditworthiness of the supplier and consequentially the economic existence for the long-term contract might be secured as well as the access to the specific know-how of the supplier or R&D service provider. For the bank, a higher level of security is achieved by the integration of the OEM. IKB has already positive experiences in the automotive sector. Within aeronautics, however, Airbus was so far not willing to accept additional risks caused by the suppliers. As in the case of BGM, basic problems in the business with industrial SMEs in the aeronautical sector are seen in a lack of awareness on necessary growth and internationalisation. In contrast to BGM, the representatives of IKB assessed CSH positively, as they expect at least an international vision for growth within the cluster, which might lead to the necessary scale for international financial products. Central problem for most innovative instruments by the private banks is the necessary scale of financial resources provided. The industrial SMEs in the aeronautics sector are too small to be potential customers for these services.

The N-Bank started business at the beginning of 2004. Before that, public financial services for regional development in Lower Saxony and Saxony Anhalt have been offered by the Nord LB as a holding with public savings bank and the Land Lower Saxony as shareholders. Shareholders of the N-Bank are the Land Lower Saxony (50%) and Nord-LB. The objectives of the N-Bank are derived from the strategies of the regional government in Lower Saxony. The bank offers financial instruments and consultancy services to follow the regional objectives of technology, SME and regional development policies. The bank is present at four locations in Lower Saxony. There are no explicit instruments exclusively for the aeronautics sector, as Lower Saxony has no sector-oriented policy. Besides instruments also offered by the Federal development bank KfW, the N-Bank offers low-interest specific credits for long-term investments in Lower Saxony up to 300,000 Euros, repayable low-interest loans for R&D and subsidies for presentations of SMEs at national and international fairs. For credits, applications have to be directed to the private bank of the firm, which makes a contract on repayment with the development bank. Additionally, the Nord-LB as shareholder of the N-Bank offers secondary loans and profit participation right capital as “mezzanine capital”. Mezzanine capital serves as private equity within the balance of the SMEs, because the bank receives less securities and repayment rights than foreign equity providers. But from the perspective of sovereignty of the firm-owner and obligations to repay, including interests, mezzanine capital has characteristics of foreign equity. For the SMEs, advantages are that they receive a better access to financial resources due to higher private equity ratios, but without direct participation of the bank in management or board. In practice, however, aeronautical SMEs do not have necessary information on the instruments available and fear the complexity of innovative

instruments in the context of mezzanine capital. Consequentially, coordination and communication deficits between banks and firms remain.

4. Outlook

The objective of this first report was to give an overview to the empirical study in the cluster investigated and to describe the results. The aeronautical cluster in Hamburg is at a decisive point of development. So far, the sourcing policy by Airbus with a high number of small suppliers and weak coordination between the suppliers made it possible for conventional SMEs to develop without decisive changes and adjustments of knowledge management and focus. The transition to global modular sourcing, however, will require changes towards higher levels of integration within the value chain, combinative capabilities to master complex interfaces and openness for international knowledge and capabilities to extend international business. So far, most of the clustering activities in the cabin interior segment was initiated and driven by the two big OEM Airbus and Lufthansa Technik and individual efforts in the public coordinating authorities and private associations. Mobilisation to industrial SMEs is still relatively weak, but inevitable to cope with changes as the interviewed representatives stressed. In the composites cluster in Stade, different conditions are given, as the roots for clustering are based on common technological and marketing objectives and growth requires coordination and internationalisation right from the beginning. The next steps will be to compare the experiences within this cluster with observations in other European clusters to find some more general conclusions on prerequisites and instruments to enhance knowledge flows within medium-technology sectors between European regions.

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