A NOVEL APPROACH TOWARDS DESIGN INFORMATION MANAGEMENT WITHIN AIRBUS

A. Lowe, C. A. McMahon, S. J. Culley, P. Coleman and M. Dotter

Abstract

The creation, use and exchange of informal information are daily concerns in the aeronautical design world. This paper describes the combined application of two novel information management systems that provide a very promising answer to these concerns. The IDEA system provides automatic classification and the novel Adaptive Concept Match (ACM) approach for accessing documents from electronic repositories. The Engineering Book of Knowledge (EBoK) application provides user-friendly document management and workflow capabilities to assist in the transfer of engineering knowledge, represented as lessons learned and company best practice. The integration of IDEA within EBoK is one part of the wider set of solutions being developed to answer knowledge management concerns at Airbus.

Keywords: knowledge management, design information management, communities of practice, industrial case study, aerospace engineering

1. Introduction

The nature of engineering product development within modern aerospace companies has altered dramatically over the last few decades. Products are increasingly the result of collaborative projects carried out by design teams and companies that are geographically distributed and temporally unstable [1]. This is not only due to increased product complexity but is also a consequence of the need to mitigate the risks associated with their development. The requirement of organisations to reduce their operating costs and to increase the ease in which they can respond to customer requirements has also led to them becoming more reliant on external organisations, in addition to short term contractors and suppliers, for design activities that might once have been carried out within the parent company. Additionally, Concurrent Engineering methodologies have profoundly changed the way in which engineers are required to continually interact and communicate throughout the design process [2].

An inevitable side-effect of these factors is that valuable engineering knowledge and experience is increasingly difficult to retain and manage [3]. Engineers have traditionally been reliant on personal contacts and their (or their colleagues') familiarity and memory of what happened in the past to inform the decisions that they make [4]. However, the aforementioned changes in working trends will inevitably result in these *personal* and *individual* means of connecting to information and knowledge becoming *less reliable* in the future [5].

1.1 Computer-based support systems in engineering design

Computer-based systems are very widely used in aspects of the engineering design process. However, as noted by Toye *et al*, "…(computer-based) systems do not support the tasks on which engineers spend the most time: gathering and organising information, communicating with clients, suppliers and colleagues, negotiating trade-offs and using each others' services" [6].

More specifically within aerospace organisations, whilst the formal product representation resulting from the design process is strictly captured and configuration managed, much of the information used by engineers is not available in such a structured form. Importantly, many of the most influential design activities that are undertaken by engineers tend to be informed by access to softer, less formal types of textual information (e.g. minutes of meetings, memos, notes, technical documents, etc.). However, at present, computer-based engineering information support systems offer little practical help to designers performing more creative aspects of design, or those that involve complex reasoning and collaboration [7].

In such tasks (characteristic of key product design activities) it is usually not possible to predict in advance the specific knowledge or information that engineers will need to call upon. Computer-based support systems therefore need to aim to perform the following functions:

- Codify and preserve bodies of knowledge (represented as documented information entities) and facilitate their access / retrieval and transfer.
- Connect people to information and expertise that they require, when they require it.

1.2 Knowledge Management at Airbus

Airbus recognises knowledge as one of the most valuable assets in the company. Traditional ways of sharing knowledge have shown their limitations within the changing industrial and demographic context, described earlier. The Airbus Knowledge Management team has the mission to support engineers and improve the performance of the company, by deploying methodologies and solutions necessary to preserve, share and transfer knowledge.

The Airbus approach is to consider the knowledge concerns emerging from the operational units, to evaluate their extent, and to provide solutions from a people, process and tools point of view - in that hierarchical order. Airbus already has some considerable experience and achievements in creating knowledge books, capturing lessons learned and supporting Communities of Practice for a variety of aircraft programmes.

A range of co-ordinated activities are building towards the vision of an integrated platform or knowledge portal, for each employee to benefit from and contribute to the corporate knowledge store. Research is evaluating and developing the technologies necessary to support these activities, for example to identify appropriate advances in information management that are the subject of this paper.

2. Objectives

This paper shows how the results of an academic research project are being combined with a user-friendly knowledge sharing support tool under deployment in Airbus. This will provide a very effective answer to improving the capture, organisation and subsequent access to information relating to experience gained from product design.

The **IDEA software system** (see section 3) provides (i) a means of automatically organising textual documents into pre-defined categories and (ii) a novel hybrid search / browse end-user interface for accessing and retrieving the pre-classified documents.

The **Advanced Engineering Book of Knowledge (EBoK)** (see section 4) facilitates the capture, distribution and connection of engineers to informal documents that represent lessons learned and company best practice.

The above capabilities complement the wider range of knowledge management activities within Airbus (see section 1.2). Finally, the paper presents conclusions arising from the two projects and a brief overview of work that is looking to integrate the two applications.

3. The IDEA information management system

The two main ways to search for information in electronic document collections are by using: (i) free-text retrieval search engines or (ii) browsing information that has been organised into pre-defined (hierarchical) categories. However, each of these approaches has limitations. Using word or phrase searches, users are faced with a compromise between overly broad searches returning an excessive amount of information, or overly narrow searches that may fail to return relevant information. Alternatively, browsing is dependent on the user's knowledge of the classification structure. Users may experience difficulties in refining searches or become frustrated from having to continually 'drill-in-and-out' of a hierarchy to locate documents. In practice it has become apparent that computer tools need to be developed that combine the benefits of free-text directed searching and category browsing.

3.1 The IDEA information management approach

The IDEA (Information for Design Engineering in Aerospace) research project resulted in a software system (developed by the Universities of Bristol and Bath) to provide **hybrid** search / browse functionality for accessing information from *multiple user perspectives*. This is achieved by combining: (i) faceted, automatic classification principles and (ii) a novel approach called Adaptive Concept Match (ACM) browsing.

Faceted, automatic classification – Unlike their paper-based counterparts, electronic documents are not tied to a physical location. Rather than trying to 'pigeonhole' documents in a single location in a monolithic hierarchical structure, faceted classification permits the association of documents with categories in *multiple Concept Hierarchies* (each of these represents a different facet).

Adaptive Concept Match (ACM) browsing – Users can simultaneously explore multiple hierarchical arrangements of categories against which documents have been associated (analogous to the process of browsing folders containing files using a Windows File Manger). Users interact with the ACM browser by selecting concepts of interest from hierarchical tree-like structures (against which documents have been automatically classified). As concepts of interest are selected, the hierarchical display is dynamically pruned to reflect the user's concept selections in order to indicate which concepts may be used to further refine the selection [8]. Note that ACM browsing was formerly called No-Zero-Match (NZM) browsing.

3.2 Overview of the IDEA software system

Figure 1 provides a high-level overview of the IDEA software system. The system comprises a number of separate components and has been designed using scalable Web-based standards and technologies with a distributed, modular architecture. The functions provided by these components fall into one of two categories:

- **'Back-end' components** – Used by system administrators to: (i) define the Concept Hierarchies (ii) identify the document collections to classify and (iii) configure the automatic classifier. These components include a relational database server and the system's application logic.

- **'Front-end' user interface** – This comprises the ACM browsing application that is finally used by system end-users to access documents. Multiple end-users are able to access the ACM browser using a standard Web-browser. The ACM application is a thin client and uses Java Server Page (JSP) and servlet technology.

The ACM browser lets users interactively browse for documents that have been pre-classified from disparate data sources 'into' multiple Concept Hierarchies. The ACM browser permits the retrieval of documents irrespective of their actual storage locations – thereby concealing the complexity of the underlying document collections. Users only interact with a virtual set of 'viewpoints' and need not be concerned with the details of the actual location of the relevant electronic files (which could be stored on a diverse range of company networks or database systems).

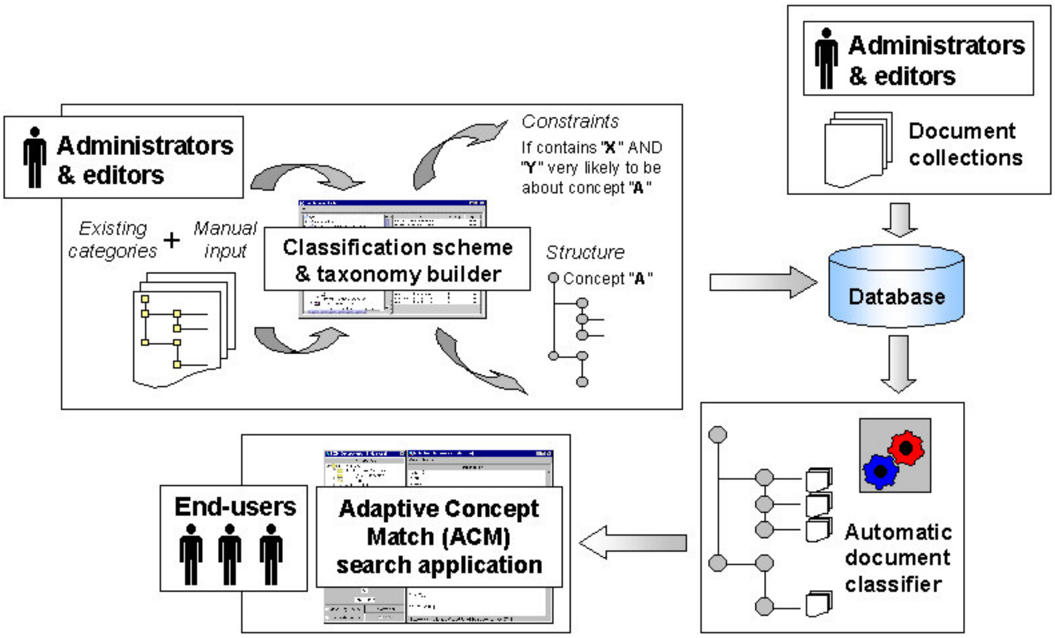

Figure 1 – High-level overview of the IDEA software system

3.3 Application of the IDEA software system within Airbus

The IDEA system has been applied to provide a means of organising and facilitating access to the electronic documents stored on one specific area of a shared network drive, used by over 100 members of the Knowledge Engineering team at the Airbus UK site in Filton. This document repository comprises a mixture of document types and formats, mostly unstructured and mainly in the form of HTML and 'office' type files. This was identified as a suitable application since it was immediately apparent from a cursory inspection that of the 38,500 documents (located in 4,200 folders) stored on the drive, many were duplicated elsewhere and / or located in illogically named folders.

The users of this shared document repository often find it difficult to retrieve all relevant information by browsing the existing folder structures. It was apparent that, in effect, there were many individual collections of information rather than a collectively managed and shared repository. This lack of consistent document organisation obviously affects the ease with which information can be effectively shared and accessed.

3.3.1 Concept Hierarchies to support multiple user perspectives

The development of Concept Hierarchies for the Airbus UK demonstrator was largely based on classifications, taxonomies and directories that already existed within the organisation. This offered a dual advantage: (i) using concepts with which engineers were already familiar and (ii) speeding up the process of identifying and structuring the Concept Hierarchies.

The following distinct Concept Hierarchies were used in the demonstrator to provide different search perspectives on the documents contained on the shared network drive (i.e. a document could conceivably be associated with concepts from any of these Concept Hierarchies):

(a) Aircraft Types (b) Document Formats (c) Document Types (e) KE People (f) KE Procedures (g) Statement of Work Task Breakdown (h) Business Exposure (i) Computing Tools (j) External Partners (k) Projects.

3.3.2 Example screenshot of the ACM browser

Figure 2 shows a screenshot from the ACM browser application in use. This has been edited to make specific names anonymous, but illustrates a notable feature of the system. In the example, the user has selected the concepts *'Engineer C'*, *'PC App'* and *'Software Incident Reports'* from different Concept Hierarchies (see under *"Selected concepts:"* in Figure 2). From the original display of concepts, only those documents (and concepts) associated with the user selected concepts are displayed.

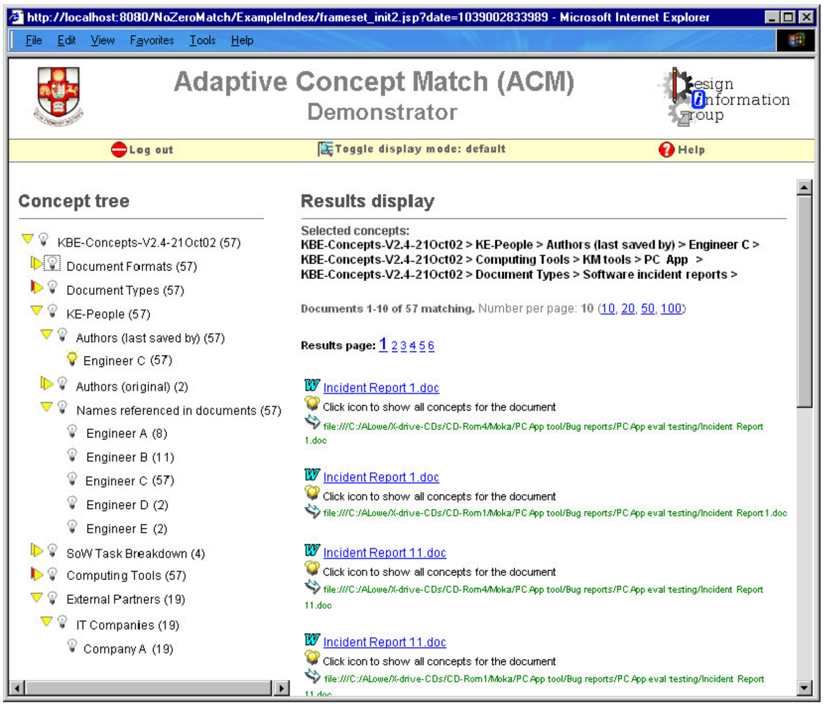

Figure 2 – Example screenshot of the ACM browser

In this example, the adapted display shows that the user would be able to *associate* the *selected concepts* with the following sets of *unselected concepts*:

- *'Company A'* from the *'External Partners'* hierarchy ('Company A' is the supplier of the 'PC-App' software application and 'Engineer C' is involved in the deployment of this application within the KE Team).
- *'Engineer A'*, *'Engineer B'*, *'Engineer D'* and *'Engineer E'* from the *'Names referenced in documents'* hierarchy (the names listed are members of the KE team

involved in 'PC App' testing and deployment).

These inferences can be made despite there being no 'hard-coded' association between any of these concepts.

3.3.3 The benefits of ACM browsing

Observations of the use of the ACM browser within Airbus indicated that, in many instances, engineers were able to more easily retrieve relevant documents using the novel hybrid browsing approach, when compared with directed keyword searching or conventional browsing of existing folder structures. The effect of combining faceted classification principles with ACM browsing is to reduce the size and complexity of the hierarchical display of concepts with which users need to interact. The ACM interface can help users avoid having to continually 'drill-in-and-out' of hierarchical structures to locate documents (a time consuming and frustrating process), since the size and complexity of the concept hierarchies that users browse are continually reduced as concepts are selected.

4. The Advanced Engineering Book of Knowledge (EBoK)

Informal networks of people carrying out similar tasks within organisations are an important means of promoting engineering knowledge transfer and in supporting group learning. Such networks are often described as Communities of Practice (CoPs) [9]. CoPs perform the following functions:

- Support people carrying out tasks, but are *not central to the tasks themselves.*
- Provide workers with 'lateral' ties to those performing similar tasks.

Table 1 summarises some of the particular characteristics of CoPs (in comparison with various other means of organising workgroups).

Due to the richness of face-to-face communication, physical co-location provides the best way to develop CoPs. However, in large aerospace organisations – performing complex, distributed design activities – the physical co-location of all those carrying out similar tasks is not practical. Computer systems and communication technology therefore have an important role in promoting the building of *virtual CoPs*.

Table 1: Various characteristics of Communities of Practice

	Functional 'silos'	**Project teams**	**Informal networks**	**Communities of Practice**
Purpose	Produce an output	Accomplish a specific task	Disseminate information	Develop capability
Boundary	Market, product or function	Particular project aim	Scope of relationships	Knowledge domain
Connection	Reporting relationships	Commitment to project aims	Interpersonal acquaintances	Identity
Timescale	Enduring	Temporary	Variable	Enduring

4.1 Overview of the EBoK Approach

The Advanced Engineering Book of Knowledge (EBoK) is a process supported by an interactive, easy to use information system which helps promote the building and supporting of virtual CoPs. The concept was initially developed by the former Chrysler Corporation [10]. Airbus Deutschland adopted this concept and is adapting it to meet its own needs by developing an EBoK computer system in conjunction with Daimler Chrysler Research India. The system provides a means to facilitate the capture, distribution and connection of engineers to *informal documents*, representing *lessons learned* and company *best practice.*

The documents in the system have a simple structure containing the following elements: (i) meta information (i.e. author, date of creation, date of last modification, status, version etc.) (ii) the title (iii) keywords (iv) a brief abstract and (v) the core lessons learned / best practice content. The core content of the documents can be typed in with the help of an HTML editor (see section 4.3), or simply copied-and-pasted from other text editing applications. In addition, attachments and hypertext links to other documents can be included (such as pictures, office documents, etc.).

The EBoK system aims to provide the following business benefits:

- **Increase the efficiency of engineers** – The need to reduce the time to develop product development time drives the demand for key information at people's fingertips (i.e. providing engineers with the right information at the right time).
- **Improve the quality of the product development process** – Achieved by identifying standard corporate best practice and making this easily available to engineers who can benefit.
- **Minimise recurring errors** – Achieved by capturing and making available critical lessons learned from projects or activities that went either well or badly (i.e. both *positive* and *negative* lessons learned).

The underlying EBoK process strives to ensure that only high quality information is maintained in the system [11]. In part, this is achieved by defining particular roles and responsibilities for administrators, contributors and end-users. This helps ensure the provenance of the lessons learned and best practice advice in the system, especially when compared with alternative, less structured approaches towards the management of such information (e.g. static network drives). In addition, confidentiality issues are addressed, since 'knowledge holders' determine which members of particular CoPs can access and re-use particular information. The EBoK system provides the flexibility to allow each CoP to adapt and modify their information management processes according to its users' needs.

The main roles for EBoK system users are noted below:

- **The whole of the CoP** – Decide on members, structure the knowledge areas (similar to books with chapters and sub-chapters) and agree on the responsibilities within the community.
- **Administrators and co-ordinators** – Manage users and their access privileges within the system.
- **Book owners** – Take care of their respective knowledge area (e.g. Is the content correct? Are the documents up do date? Is there content missing? Etc.).
- **Authors and reviewers of documents** – Authors create lessons learned and best practice documents from their personal working experience. Reviewers proof-read and validate these documents (this validation process is carried out by peer-to-peer review). Note that whoever qualifies as an author in a knowledge area also qualifies as a reviewer. Importantly, every document included in the systems has to be approved by the review process (thereby ensuring the quality of the information in the system).
- **General end-users / readers** – Access and read the documents, thereby benefiting from the knowledge contained in the system. In addition, users can annotate the

lessons learned / best practice documents and also start discussions within the CoP.

4.2 The implementation of the EBoK system

The main requirements which have influenced the development of the EBoK system are as follows: (i) platform independence, (ii) a strong security model and (iii) easy adaptability / integration with other applications. It was considered that these requirements could be best met by providing a Web-based tool (accessible via the Airbus corporate Intranet) with a 3-tier-architecture based on the Java 2 Enterprise Edition (J2EE) standard [11]:

- Web-tier with the presentation logic, using servlets and Java Server Pages (JSPs).
- Middle-tier with the business logic, using Enterprise Java Beans (EJBs).
- Data base server.

The functionality provided by the system comprises document management capabilities on one hand, and a workflow to enforce the review process and support the roles (see Figure 3).

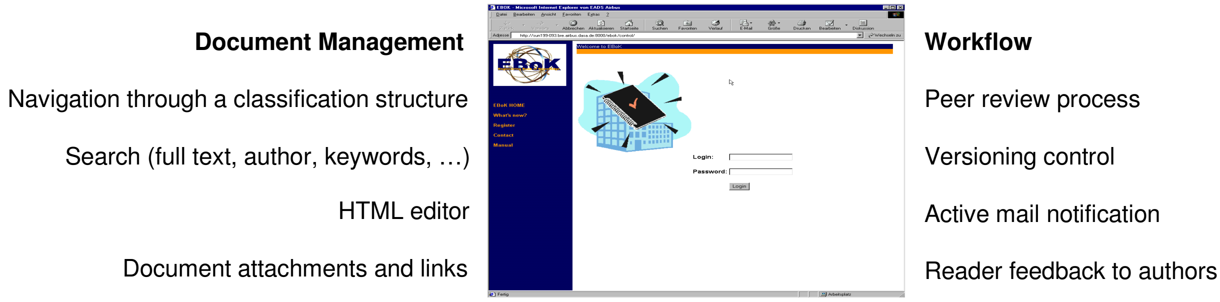

Figure 3 – Overview of the features of the EBoK software system

The use of the J2EE standard ensures accessibility from both PCs and UNIX workstations. In addition, the modular concept of EJBs allows for the easy adaptation of the system to new users needs. To date, two 'spin-off' applications of the EBoK have been developed and deployed. Furthermore, the standard technologies used in the implementation of the EBoK application ensures that it can be easily integrated into other Web-based portals (as shown in the WISE research project [12]).

4.3 Application of the EBoK within Airbus

The EBoK process and the associated computer system have been in use within Airbus Deutschland since early 2001. The roll-out has adopted an organic bottom-up deployment, starting with small user groups working in restricted domains and spreading to more generic domains. Currently, the system is being more extensively deployed, primarily to those in various departments performing Engineering and Manufacturing roles [13].

To date, valuable feedback has been gathered from the users, which is being used to improve the quality of information and the functionality provided by EBoK application. In particular the feedback addressed two issues:

Workflow and the document approval process – Users found that the workflow and the document approval processes (see Figure 3) helped to ensure (and even improve) the quality of documents managed by the system. This is a vital factor to consider in organisations where engineers have heavy workloads and may therefore be disinclined to contribute towards a virtual CoP, unless they can immediately perceive a benefit. Since users of the EBoK knew that their peers would review documents – and also that their visibility within the CoP depended on their contributions – they were found to compose documents with more care (helping to improve the quality of the overall content of the system).

Structuring and organising documents – When a CoP starts using the EBoK, a book owner / administrator devises an initial structure of their knowledge area which end-users have to use to navigate to locate documents. This structure essentially comprises a strict hierarchy of topics and sub-topics (i.e. a book with chapters and sub-chapters) into which documents are manually classified. Note that each document is classified with only a *single* topic in the hierarchy (in the same way that computer files are manually located in a particular folders in a file manager). However, depending on the scope of the knowledge area, the number of CoP participants and the time the system has been used, the knowledge structure can become large and complex. Thus, at present the EBoK knowledge structure only provides a *single viewpoint* (i.e. the hierarchy editor's) on the collection of documents in the CoP (resulting in the problems previously discussed in section 3).

5. Conclusions and further work

Computer-based storage and developments in communication and networking technologies permit, in principle, easier access to a wide range of relevant information which has the potential to allow engineers to more effectively carry out the necessary design tasks. This paper discusses how two novel information management systems are being combined within Airbus as one part of the broader knowledge management activity.

The IDEA system provides faceted, automatic document classification and hybrid search / browse functionality for accessing documents from electronic repositories (e.g. shared network drives, content management systems, etc.). Adaptive Concept Match (ACM) browsing dynamically prunes browsable classification schemes, according to concept selections made by users (thereby overcoming some of the limitations with conventional browsing approaches).

The Engineering Book of Knowledge (EBoK) application provides user-friendly document management and workflow capabilities and assists in the transfer of engineering knowledge, company best practice and in supporting group learning.

Within Airbus, EBoK is now envisaged as being the support for a comprehensive lessons learned solution, as well as the supporting solution for virtual Communities of Practice (CoPs) in engineering and manufacturing. Integrating the IDEA automatic classifier and ACM browsing with the EBoK application will improve the flexibility of the search capabilities. Users will be able to search for documents from *multiple perspectives*, in addition to simplifying the knowledge structure that they need to 'drill-in-and-out' of in order to locate documents. However, there remains an issue, since to date the IDEA system has been developed using relatively low-cost, non-proprietary technologies. In order to successfully integrate the two systems the IDEA software will need to be migrated to use Airbus standards and technologies (e.g. an Oracle database, J2EE application server and search engine).

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Chris McMahon*, Alistair Lowe & Steve Culley
Innovative Manufacturing Research Centre
Department of Mechanical Engineering
University of Bath
Bath BA2 7AY
UK
Tel: Int +44 1225 384026
Fax: Int +44 1225 826928
Email: c.a.mcmahon@bath.ac.uk
URL: http://staff.bath.ac.uk/enscam/

Peter Coleman
Airbus UK
New Filton House
Bristol BS99 7AR
UK
Email: peter.coleman@airbus.com

Martin Dotter
Airbus Deutschland
Huenefeldstrasse 1-5
28199 Bremen
Germany
Email: martin.dotter@airbus.com
URL: http://www.airbus.com