Business Plan
Institute for Aerospace Maintenance
Maastricht

8 February 2014
### Content

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>2</td>
</tr>
<tr>
<td>Market analysis MRO aerospace</td>
<td>3</td>
</tr>
<tr>
<td><strong>Future trends in MRO and demand for innovation</strong></td>
<td>4</td>
</tr>
<tr>
<td>Future trends in MRO</td>
<td>7</td>
</tr>
<tr>
<td>Demand for innovation</td>
<td>9</td>
</tr>
<tr>
<td><strong>Knowledge providers and opportunities for networking</strong></td>
<td>10</td>
</tr>
<tr>
<td>Limburg</td>
<td>10</td>
</tr>
<tr>
<td>Netherlands</td>
<td>11</td>
</tr>
<tr>
<td>EUregion</td>
<td>12</td>
</tr>
<tr>
<td><strong>Business plan</strong></td>
<td>14</td>
</tr>
</tbody>
</table>
1. Introduction

Maastricht Maintenance Boulevard (MMB) is a cluster of aerospace companies specialized in Maintenance, Repair and Overhaul (MRO). The core of the cluster is on Maastricht Aachen Airport (MAA) and includes companies like Samco Aircraft Maintenance, United Technologies Aerospace Systems, KVE Composites Repair, Allied International Support, MAAS Aircraft Painting TiaT Europe as well as the Aviation Competence Centre (ACC) Part 147 training school for licensed engineers. The cluster has grown in the last 5 years with 20% both in revenues (2013: EUR 70 mln.) and employment (2013: 300 FTE).

The MMB cluster strategy is based on the combination of various skills and MRO services.

Figure 1, Strategy Maastricht Maintenance Boulevard

The strategy has been translated into the MMB Masterplan 2013-2016, which describes the objectives and related activities of MMB for the near future. The MMB Masterplan provides the conditions for business development and attraction of new companies to Maastricht. Important ingredients for a good business climate are a good infrastructure (airport, hangars), enough supply on the labour market and a sustainable innovation programme.

In today’s economy knowledge and innovation are key factors for growth. Maastricht Maintenance Boulevard recognizes the importance of these factors and has initiated two projects to strengthen the knowledge and innovation infrastructure for aerospace MRO in Limburg. One (EUregion Life Cycle Costing – EULC2) has the objective to support the MRO companies in MMB to develop innovative concepts that will strengthen their position in the aerospace supply chain, the second one is to develop a research & development (R&D) network that will ensure a long term exchange of data and information with research institutes, universities and other knowledge providers.

This document describes the business plan for an Institute for Aerospace Maintenance Maastricht (IAMM). The business plan is the conclusion of phase 1 of a project sponsored by Limburg Economic Development (LED) and the start for phase 2, the pilot phase in which three R&D projects will be defined and started.

Research & Development (R&D) in MRO is important to attract the interest of larger aerospace companies worldwide. Aerospace is a complex, high technology, international market in which R&D determines industry leadership. The objective of the LED IAMM project is to create an organisation within Maastricht Maintenance Boulevard, that is able to provide the required services to the various companies on a long term, sustainable basis.

The business plan starts with a short description of the aerospace market (chapter 2), followed by an analysis of the most important future technological trends and the demand for R&D from MMB companies (chapter 3). Chapter 4 gives an overview of various knowledge sources around MMB, not only in the area of aerospace but also in other high tech sectors such as chemicals, automotive, health and life sciences. The final chapter is the actual business plan for phase 2 of IAMM including a description of activities, planning, financial resources and results.
2. Market analysis MRO aerospace

The companies in Maastricht Maintenance Boulevard are active in a broad range of market segments. The focus is on regional jets and turboprop aircraft, but there are also activities on aircraft, systems and components of narrow and wide body aircraft of Airbus and Boeing. Some companies also repair components on military aircraft. Despite this wide variety in markets, the focus of the MMB cluster is on the MRO market for civil aircraft.

The global turbine-powered civil aviation fleet is about 80,000 aircraft (Figure 2). There are over 53,000 business and general (BGA) aircraft, which represent over two-thirds of the world civil fleet. There are over 26,000 aircraft in the air transport fleet. Nearly half of the global civil aviation fleet, 37,000 aircraft, is located in North America. Europe is the next largest market with 16,000 aircraft, followed by Asia Pacific with nearly 11,000 aircraft.

Aircraft flight hours or utilization is a key driver of MRO services. The civil aviation fleet flies approximately 85 million hours per year. Air transport aircraft, only 33% of the fleet, fly 65 million hours per year or nearly 80% of the total. On average, air transport aircraft fly 2,500 hours per year versus 370 hours per year for BGA aircraft.

The civil MRO market consists of four distinct markets: heavy airframe, engine overhaul, component and line maintenance.

**Heavy Airframe Maintenance** - A regularly scheduled work scope with detailed inspection, maintenance, preventive maintenance and alteration of the entire aircraft and its installed components that will place the aircraft out of service for a pre-determined period of time.

**Engine Overhaul** - Off-wing maintenance, preventive maintenance and alteration that restores the engine to designed operational condition; by regulation the engine must be disassembled, inspected, parts are repaired or replaced as necessary, re-assembled and tested.

**Component** - Maintenance, preventive maintenance and alteration of components that will be installed on an aircraft, airframe, engine or propeller.

**Line Maintenance** - Maintenance checks that are carried out to ensure that the aircraft is fit for flight but that do not remove the aircraft from service.

The world civil aviation MRO market is estimated to be over $65B (Figure 3). Engine overhaul is the largest segment at $26.1B, followed by component MRO at $16.8B. The North American MRO market is the largest geographic market – estimated to be $23.5B. Europe and Asia Pacific are the next largest markets at $16.3B and $15.5B, respectively.
A final segmentation is the split up in aircraft size (Figure 4).

The focus of Maastricht Maintenance Boulevard is on regional aircraft and the regions Europe, Middle East and Africa as far as base maintenance is concerned. This market is estimated at $10 bln. in 2012.

Another important characteristics is that the supply of MRO services is very fragmented. The largest supplier has 6% market share. In the European market MMB has less than 1% market share, not uncommon.
One of the reasons for this fragmentation is the complicated supply chain. In order to provide a full service package to aircraft operators various specialist companies are cooperating.

Figure 6, Heavy maintenance supply chain

In this challenging aerospace MRO market the companies of Maastricht Maintenance Boulevard have done relatively well in the last 5 years. But it is a dynamic market with various new developments that need to be addressed and integrated into companies strategies.
3. Future trends in MRO and demand for innovation

Future trends in MRO

The economics of MRO are customer driven. Thus, the prime driver for MRO companies is to offer services and products that will help aircraft operators and owners. On the revenue side this means that downtime for aircraft, whether caused by scheduled or unscheduled maintenance, should be minimized. Minimal downtime ensures operators and owners with maximum revenue potential. On the cost side maintenance on aircraft is a combination of labour and materials. However, innovation and cost reduction have to fit in the strict regulations on safety that the aviation sector has installed. This means that cross sector transfer of technology is not that easy.

The future of the MRO market is strongly dependent on developments in the air transport market and the way airlines are acting in that market.

Figure 7, MRO and customer support to airlines dependent on air transport market and external factors

Most experts agree that the aircraft fleet will grow further in the next 10 years. MRO spending will, in close correlation with the number of aircraft and flight hours, also grow. According to Boeing with 3,8% annually.

Figure 8, Forecast of MRO market development, source Boeing

At the same time, the supply side of the market is shifting. Outsourcing of MRO has proven to be a major factor in cost reduction. Also this trend is expected to continue.
Cost is the name of the game and with each new generation of aircraft, new maintenance concepts have been developed, leading to cost reductions in the range of 25-40%.

Another important factor in reducing cost was the shift of MRO towards low wage countries in Asia and Central/Eastern Europe. The expectation is that the wage gap will shrink and disappear in the next decade, even faster if one takes into account labour productivity.
Demand for innovation

In this global and complex MRO market the companies of Maastricht Maintenance Boulevard have to prepare for future challenges. Innovation strategies are dependent on the pace of technological development in the market and requirements such as sustainability. In recent years maintenance concepts have changed from just a cost factor towards cost-benefit, investment and corporate strategy.

Within this framework the key challenges for the aircraft MRO industry can be placed:

1. Cost-benefit: logistics, supply chain management, downtime
2. Investment: parts management and production
3. Strategy: Vertical and horizontal integration, cross-overs with other sectors

After consultation with the stakeholders within Maastricht Maintenance Boulevard the challenges have been translated into three pilot R&D projects for IAMM:

1. Virtual technology
   In this project the potential role of ICT and virtual reality will be explored. The objective is to reduce man hours and labour cost. Important subjects are virtual training, paperless documentation and robot technology. Apart from the technological aspects of these innovations, the research will focus on safety and certification.

2. Additive manufacturing (3D printing)
   This R&D project will focus on applicability of 3D printing technology on parts and component supply in the MRO chain. It will be clear that this technology will affect parts inventories and related cost.

3. Cross sector learning (process industry, health)
   This project will identify opportunities for cross sector applications in MRO. Focus will be on process industry (chemicals) and life sciences (health), but also on cross-over in the aerospace industry between civil and military aircraft.
4. Knowledge providers and opportunities for networking

Now that the demand for innovation and knowledge is clear, the business plan will identify potential suppliers of knowledge. These include the private sector (MRO companies, engineering experts) and public sector (research institutes and universities). In the public sector there are few specialist departments that focus on MRO. Most faculties are offering aerospace engineering in a broad scope, but primarily focusing on aircraft development and production. Only in education and training there are specialist courses for maintenance, but then only on vocational level.

This means that on the knowledge supply side there is no established player able to address the demand of MMB companies and a new approach is needed. The IAMM approach is to develop a network where fragmented pieces of information and knowledge can be gathered.

As part of this business plan the following institutions have been identified.

<table>
<thead>
<tr>
<th>Aerospace</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limburg region</td>
<td>Chemelot Campus - CHILL</td>
</tr>
<tr>
<td></td>
<td>Health Campus Maastricht</td>
</tr>
<tr>
<td>Netherlands</td>
<td>TU Delft</td>
</tr>
<tr>
<td></td>
<td>TU Twente</td>
</tr>
<tr>
<td>Euregion</td>
<td>University Luik</td>
</tr>
<tr>
<td></td>
<td>RWTH Aachen</td>
</tr>
<tr>
<td></td>
<td>DLR</td>
</tr>
<tr>
<td></td>
<td>NLR</td>
</tr>
<tr>
<td></td>
<td>World Class Maintenance</td>
</tr>
</tbody>
</table>

Figure 13, MRO knowledge supply in the public domain

Limburg

‘Kennis-As Limburg’ is an initiative of Maastricht University, Maastricht UMC+ and Zuyd Hogeschool. With the financial support of the Province of Limburg, the European Union, the Dutch Government and the business sector about half a billion euros will be available to strengthen the provincial knowledge economy in the next ten years. This massive financial impulse will lead to multiple investments.

Playing a crucial role in this strategy are the ‘triple helix’ of educational institutions, business and government, as well as the various Limburg campuses: the Maastricht Health Campus; the Chemelot Campus in Sittard-Geleen, which focuses on materials; the Greenport Campus in Venlo, specialising in agriculture, logistics, food and health.

The Chemelot Campus is one of six open innovation campuses of national importance. Open innovation means that students, researchers and entrepreneurs work together in a community, forming the optimal climate for knowledge exchange and valorisation. The Chemelot Campus in Sittard-Geleen is becoming the Euregional hub for businesses as well as education and research institutes in the field of new materials. This includes technologically advanced, high-performance materials for the automobile industry and telephony, but also new products from biobased materials, sustainable energy, clean technologies and the life sciences.

CHILL helps organisations increase their innovation power. CHILL: Chemelot Learning and Innovation Labs. The connection between people, knowledge and facilities at the Chemelot Campus in Geleen, the
centre of chemistry in Limburg. Our focus is clear: to connect learning and innovation. CHILL is a unique collaboration between the business world and education. The educational partners are Arcus College, Leeuwenborgh Opleidingen, ZUYD University of Applied Sciences and Maastricht University. From the business world, DSM and SABIC have committed themselves as partners with CHILL. In addition, CHILL works together with and for other enterprises within and outside the field. The entrepreneur determines the role of, and the form of partnership with, CHILL. Often small and medium-sized businesses originate the best ideas, but lack the specific knowledge or research facilities. Investing in apparatus or people would be too costly or unjustified, so that there are no further research or feasibility tests on the idea.

With Chemelot Campus and CHILL IAMM will focus on the R&D for virtual reality.

The Maastricht Health Campus is a valorization campus where ideas and innovations from research and health care practice are developed and clinically tested “on site”. The objective is to use the acquired knowledge to carry out a proof of market or market introduction. The Maastricht Valorization Center (MVC) has the facilities to support every phase of the valorization chain. The valorization chain consists of initial idea, proof of principle, proof of concept to and including proof of market and, in some cases, introduction to the market. The MVC also assists researchers and entrepreneurs with patent applications, completing licensing agreements, starting businesses, networking, etc.

One of the companies on the Maastricht Health Campus is Maastricht Instruments. This is a potential partner in a cross-over project.

---

**Netherlands**

Within the Technical University of Delft aircraft maintenance has a role within the department of Air Transport and Operations (ATO). The section of ATO started back in 2004. Prof. Curran joined from Queens University Belfast in August 2008 and took over as Section Chair with a view to developing the strong air transport focus and our international research relevance. In 2009 the less technical pure management, business and entrepreneurship elements were removed from the core academic content in order to focus on the operations modelling, optimisation and validation of the applied technical challenges within air transport, renaming ourselves more precisely as Air Transport and Operations (ATO).

The permanent core ATO staff more than doubled in 2010 to deal with the continued student growth and 2 new ATO MSc Profiles were developed (out of the 13 Profiles offered by the Faculty to circa 230 new MSc students each year). The Profiles are entitled: ‘Air Transport and Aerospace Operations’ and ‘Air Traffic Management and Airports’, with the first being more focused on airlines and the latter being shared with the Control and Simulation Section.

Anyone familiar with the challenges expressed by SESAR and ACARE 2020 Vision in Europe and NextGen in the US will understand something of the motivation for the impact that ATO can make both in education and research. The aim of ATO is to be recognised as one of the top five centres of excellence in the world in air transport and to play a significant role in understanding, modelling and improving air transport performance in capacity, cost effectiveness, environmental impact and safety. For example the ATO section has worked on the development and application of a Value-Driven Aircraft Maintenance Operations Performance Assessment Model combined with Real Options Analysis.

The National Aerospace Laboratory (NLR) is the Dutch knowledge enterprise for identifying, developing and applying advanced technological knowledge in the area of aerospace. Our activities are relevant to society, market-oriented and carried out on a non-profit basis. We thus strengthen the innovativeness, competitiveness and effectiveness of government and business. The NLR has extensive technical knowledge of fixed-wing and rotary-wing aircraft which provides insight on maintenance activities that are necessary for each system to remain operational. Combined with extensive knowledge, tools and experience in training and aviation regulations, NLR can help develop maintenance training for various organisations. NLR has for example a Force Life Management System for military aircraft and equipment, that could be used in IAMM’s cross sector R&D project.
Outside aerospace Stichting Maastricht Maintenance Boulevard has strengthened the relationship with the Dutch Institute – World Class Maintenance (DI-WCM). WCM is a project driven innovation organisation for southern Netherlands. Maintenance is multi-disciplinary and pivotal to many industry sectors. Within the scope of WCM these are: Aerospace, Maritime, Energy, Infrastructure, Process industries. These industries are well established in South Netherlands supported by a strong logistics infrastructure, and many firms have already started collaboration with other participants via one or more of the running initiatives. World Class Maintenance has the objective to support the participants to realize their individual maintenance objectives. WCM has the legal structure of a non-profit Foundation. The WCM master plan embodies a unique and aligned collaboration of all relevant parties – asset owners, suppliers, service providers, knowledge centers, universities and regional governments – with respect to maintenance, in all parts of the value chain and across all relevant sectors.

WCM aims for international recognition for The Netherlands as the leading region with respect to MRO, with South Netherlands as the pounding heart. Collaboration projects to (i) develop knowledge, (ii) disseminate knowledge and (iii) commercialize knowledge are at the basis of WCM. The activities of WCM are primarily geared towards the initiation and facilitation of knowledge projects. These projects are the core of WCM and consume the lion share of the budgets. Project proposals are submitted by participants, in one of the three focus areas ‘knowledge’, ‘know how’ and ‘money’. The projects are approved based on criteria defined by the innovation agenda, which is governed by an independent Scientific Advisory Board. Finally projects are executed via multiple WCM members and facilitated by WCM via project management, project office and project administration services.

Important and relevant projects are:

- Performance Based Contracting
- Asset Management for remote installed base
- Condition based maintenance
- Design for reliability and availability
- Automated asset information and documentation

The Technical University of Twente is offering R&D in areas such as

- design of production, maintenance warehouse and materials handling systems,
- logistics optimization for service contract fulfillment of capital goods,
- impact of product design on operational system availability and system upkeep costs during the life cycle,
- inventory management in (service) supply chains

**EUregion**

Maastricht is part of the EUregion, in which relevant research institutions offer resources that could be of value to Maastricht Maintenance Boulevard. In Aachen, Germany, there is the Rheinisch-Westfaelische Technische Hochschule Aachen (RWTHA), in English University of Aachen, where there is a faculty of aeronautical engineering. Focus is mainly on education. DLR in Cologne is the German equivalent of NLR,
also active in aircraft maintenance research. However, most activities in maintenance are concentrated on other DLR locations (Braunschweig, Oberpfaffenhofen).

Through the cooperation with Skywin, the aerospace organisation of Walloon region, Maastricht Maintenance Boulevard has established contacts with Liege University, aerospace and mechanics department.

**Other international opportunities**

The network approach of IAMM will have a global scope. Therefore also other aerospace R&D institutions will be included in the network development phase, such as Singapore Institute of Technology (SIT) and Massachusetts Institute of Technology (MIT) or in the UK (University of Coventry).
5. Business plan

Based on the results of desk research and interviews that were part of Phase 1 of the LED IAMM Project, Stichting Maastricht Maintenance Boulevard has drawn the following conclusions:

- Aerospace MRO is a promising sector for the next 10 years;
- Adjustment to new technological developments will determine largely the competitive position of Maastricht Maintenance Boulevard companies;
- There is a need for (applied) R&D capabilities within Maastricht Maintenance Boulevard in order to achieve market driven innovation;
- There are no existing suppliers of knowledge that can offer the required services of MMB;
- For that reason MMB will start three pilot projects in order to investigate whether a network approach offers an alternative to collect and develop the required knowledge for innovation;

The business plan for Phase 2 of IAMM is unchanged. Budget spending in Phase 1 is in line with the approval. Budget for Phase 2 is still as was foreseen in the application. Total amount is EUR 135.000. Divided in three activities and executed by three parties: Aeroconsort/AIS, LIOF and Stichting Maastricht Maintenance Boulevard.

<table>
<thead>
<tr>
<th>LED - Phase 2 (feb-dec 2014)</th>
<th>Total</th>
<th>Aeroconsort/AIS</th>
<th>LIOF</th>
<th>Project coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Project definition and criteria</td>
<td>13000</td>
<td>5000</td>
<td>8000</td>
<td></td>
</tr>
<tr>
<td>- Development of R&amp;D projects</td>
<td>110000</td>
<td>46000</td>
<td>14000</td>
<td>50000</td>
</tr>
<tr>
<td>- Evaluation</td>
<td>12000</td>
<td>5000</td>
<td>7000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>135000</td>
<td>56000</td>
<td>14000</td>
<td>65000</td>
</tr>
</tbody>
</table>

Financing of the budget is still the same:

- Companies EUR 20.000 (man days)
- LIOF EUR 14.000 (man days)
- Gemeente Beek EUR 33.500
- LED EUR 67.500
- Total EUR 135.000

Stichting MMB will approach other municipalities in the LED program (Maastricht, Sittard-Geleen) to take part of the cofinancing amount of Gemeente Beek.

An important part of the IAMM Phase 2 project will be performed by Aeroconsort and Allied International Support, two companies in MMB that have the knowledge about part repair and logistic, but also have expertise in the cross-over sectors (Chemelot Campus and Health Campus Maastricht).

The result of Phase 2 IAMM is the execution of 3 R&D projects by using the existing network knowledge. Stichting MMB will collect the necessary information and put this in three research reports. At the end of the project an evaluation report will be delivered in order to describe whether a sustainable follow-on is possible. If positive, a plan for this network model within Stichting MMB will be developed.