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CompoWorld: an innovative approach to technology and economic development

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ABSTRACT

Seven years ago a Netherlands delegation visited Lockheed Martin to investigate business opportunities in connection with the Joint Fight Striker (JSF)/F35. Participants in the delegation were Fokker Landing Gear, NLR (Netherlands National Aerospace Laboratory) and representatives of the Flevoland region (Province, Investment Agency). During this visit a vital coalition was formed in a triple helix configuration (private, public, knowledge) focussing on composite technology. After this visit the Municipality of Noordoostpolder and the Windesheim University in Almere, both part of the Netherlands Province Flevoland, joined this vital coalition. The market potential of composites technology was confirmed by a market study in 2011. This study concluded that the vital coalition in Flevoland had "golden" opportunities for further development, especially in the combination of existing aerospace knowledge at NLR and business opportunities and local Small and Medium Sized Enterprises (SMEs) with a joint ambition in developing new composite technology, with the aim of developing new products and high-quality employment in northern Flevoland. All these ambitions were translated into an Operational Program Compoworld, which was managed by a foundation CompoWorld, supported by all parties of the vital coalition as well as local SMEs. The Masterplan CompoWorld contains three lines activities. The largest part is an innovation program both for larger projects as well as SMEs. The second part is the connection between (vocational) training and the demands of businesses on the labour market. The third line is business development, which consists of promotional activities (www.compoworld.nl), an annual congress and efforts to attract composite technology activities to (northern) Flevoland.

The CompoWorld Masterplan activities are financed by regional authorities , contributions of knowledge institutes, SMEs and larger companies and universities and colleges and sponsorship contributions. Total budget for the period 2012-2015 is ca. € 4,9 mln. The CompoWorld Master plan has initiated 17 innovation projects. Two of these project have contributed to the realization of a pilot plant for composite production at the NLR location in Marknesse, two other projects have resulted into a successful application of composite technology ina heavy machinery shovel for infrastructure digging machines, a project launched with a SME innovation package has resulted in a sustainable mobile cleaning machine for shopping carts and baskets.
In the area of education and training CompoWorld has delivered an education package for vocational technical training as well as a Masterclass Composites. The project is well underway to establish a lector ship (research facility for practical applied research) for higher education in Flevoland.
The business development activities have led to an annual composite technology congress in Flevoland, but also to increased employment with companies in Flevoland, both established and new, in the amount of 100 Full Time Equivalents (FTE) end of 2014. It is expected that this will increase to 200 FTE end of 2016.

1 INTRODUCTION

This paper describes the development of a regional economic cluster (CompoWorld) in the northern part of Flevoland – municipality Noordoostpolder, based on knowledge, research &development of composite technology in aerospace. Pivot point for the cluster development is the National Aerospace Laboratory (NLR), which started its Automated Composite Manufacturing initiative in 2008. A major challenge for NLR at that time was to find companies that would be willing to enter into an innovative cooperation model where NLR would provide a pilot plant environment, which would reduce development risks for companies. Although composite technology has its major benefits in aerospace, there are more sectors that can benefit from application of composite technology such as automotive, maritime, construction and infrastructure. NLR in its current charter is allowed to work on projects in other areas than aerospace, which offers new opportunities for its composites department, especially the development of new cooperation models with SMEs.

CompoWorld provided a structure for the cooperation between NLR and companies, both large and SME, as well as with regional authorities. This new way of applying the triple helix created new business opportunities, new employment, and a new business model for NLR in the Province Flevoland. As an organization CompoWorld is a non-for-profit foundation, contract partner for the regional authorities, businesses and research institutes for managing the execution of the CompoWorld Masterplan 2012-2015. The Masterplan provides the details for specific activities, such as innovation instruments, education and labour market projects and business development initiatives.

The structure of the paper is as follows. It analyses how CompoWorld fits in the economic and technology policy of The Netherlands (2), the development of the composites sector with of focus on high tech/high spec applications (3), the CompoWorld initiative as a triple helix cooperation (4), a description of the innovation projects (5), labour market and education projects (6), business development (7), results (8), and finally the long term perspective (9).

2 ECONOMY AND TECHNOLOGY POLICY IN THE NETHERLANDS

2.1 Top sectors

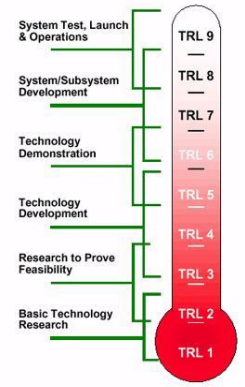
In the Netherlands the economic policy is closely linked with technology. This, of course, a consequence of the Lisbon Agenda set by the European Union. Currently, there are nine top sectors, one of them High Tech Systems and Materials (HTSM). High tech materials, aerospace and automotive activities are all included in this cluster. The HTSM cluster has produced an innovation contract with 17 road maps, each one describing the ambitions of the triple helix partners in the area of innovation and research. The CompoWorld masterplan fits in this national framework, but operates as an independent entity.

2.2 Technology Readiness Levels (TRL)

Innovation and R&D can be distinguished into various phases. Within CompoWorld the NASA methodology of Technology Readiness Levels (TRL) is used (figure 1). This TRL methodology is important for the role of the triple helix partners. TRL 1-3 can be characterized as basic or fundamental research and is mainly taking place at (technical) universities. As a consequence financing is largely provided by the public sector. TRL 4-6 is called applied research. The CompoWorld innovation projects fall within this range. Applied research is a cooperation between research institutes and companies where technology is further developed into products. It stops short of providing a prototype. Financing is a joint venture of the three parties involved with public sector contribution of maximum 60%. TRL 7-9 is industrial research

and are the last steps needed for commercial application of the product. Research institutes can play a role and will apply commercial rates. Most of the work is done by the companies themselves, as well as the financing of the R&D.

The TRL structure not only has consequences for financing, but also for intellectual property rights (IPR). TRL 1-3 qualifies as open, pre-competitive innovation; TRL 4-6 as semi-open innovation where IPR and non-disclosure play a role; TRL 7-9 is subject for IPR and patents.

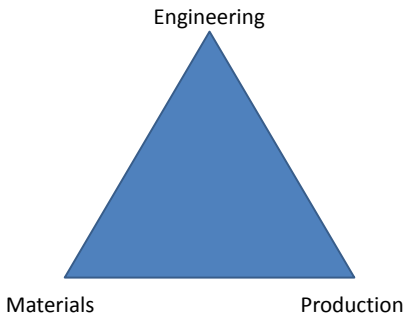


Technology Readiness Levels

3 COMPOSITES: HIGH TECH-HIGH SPEC

3.1 Composites Technology

Composites generally applies to composite materials, a combination of fibers and resins or any combination of a raster structure and hardening materials: reinforced or ferroconcrete are in principle also composite materials. For CompoWorld materials is not enough, the masterplan is focused on application of composite materials and for that also engineering and production technology are important elements. Therefore, within CompoWorld composite technology is the basis, consisting of the integrated and coherent use of the three elements: engineering, materials, production.



In its application and finally its economic value to the market, it is essential that this integrated approach is used. It provides a base for quality assessment and life cycle cost concepts. Composite technology is

often a substitute for materials and technologies that are used for a long time, such as metal, concrete or stone. These current technologies are the benchmark for composite technology in many aspects. For that reason it is important to compare apples with apples and not compare composite materials as if it is metal, but compare the results of the technology.

3.2 Composites in aerospace

This way of composite technology application has started in the aerospace sector. The unique characteristics of composite materials are its relative light weight in combination with its relative high strength. The characteristics of composite materials provide most economic benefits in aerospace applications where the reduction of the weight of the spacecraft or aircraft is of great importance in reducing the energy required to place a satellite into orbit or for the propulsion of an aircraft (reduction of the aerodynamic drag related to lift. First application of composite technology were in non-critical parts, but the most recent commercial passenger aircraft have 50% of the aircraft empty weight of composite parts and components, including large parts of the fuselage, wing and tail. CompoWorld is engaged in developing composite parts for landing gears, one of the most critical subsystems of aircraft.

The aerospace industry is highly regulated with respect to safety and thus quality. Its certification system requires extensive testing before new technology can be applied. The two main features are consistency in quality of production (reproducibility) and longevity (long term integrity/endurance). Hard proof of these characteristics are essential for OEMs before composite technology can make an entry in the aerospace supply chain. In recent years also the production cost are becoming more and more important. Therefore, the future of composite technology in aerospace but also in other sectors requires that these conditions are met.

3.3 Composites in other sectors

Composite materials are more and more also applied to non-aerospace products. Also in sports apparel, bikes, small boats and wind energy there is already many years of experience. These applications were largely based on thermoset materials used in manually tape laying moulds. Relatively new is the application of composite technology in more complex products, such as cars and trucks, larger boats, medical equipment, bridges, construction equipment and deep sea pipelines (offshore). In these areas the market demands are getting close to those of the aerospace sector, and thus the R&D requirements will follow a same pattern as in aerospace. The consequence for CompoWorld is that it will focus on the high tech/high spec application of composite technology in a hybrid environment.

3.4 High tech/high spec composites in hybrid structures

Few applications of composite technology are 100% composite. In most cases it is a combination of materials. An optimal product needs the optimal combination of composites and other materials as e.g. metals. This means that composite technology also needs to address adhesion processes or other technologies to fix different parts of different materials. As in aerospace the customers that will use products with composite technology are demanding the same kind of assurances as in aerospace. Consistency of quality of production, especially in mass production and an estimate of technological longevity (life cycle limitations) are essential for the further development of composite technology outside aerospace. Consistency of quality of production is something else than smart production. Consistency of quality of production is a necessary and essential condition for automation of production. Therefore smart production is another technology development, mainly ICT applications, than high tech/high spec composite application, although in that development automation and ICT also play a role. Within this

framework, CompoWorld has initiated in close cooperation with NLR, its CompoWorld Masterplan 2012-2015.

4 COMPOWORLD: REGIONAL TRIPLE HELIX INITIATIVE

4.1 Cluster development

Seven years ago a Netherlands delegation visited Lockheed Martin to investigate business opportunities in connection with the Joint Fight Striker (JSF)/F35. Participants in the delegation were Fokker Landing Gear, NLR (Netherlands Aerospace Laboratory) and representatives of the Flevoland region (Province, Investment Agency). During this visit a vital coalition was developed in a triple helix configuration (private, public, knowledge) focussing on composite technology. After this visit the Municipality of Noordoostpolder and the Windesheim University in Almere, both part of the Netherlands Province Flevoland, joined this vital coalition. The market potential of composites technology was confirmed by a market study in 2011. This study concluded that the vital coalition in Flevoland had "golden" opportunities for further development, especially in the combination of aerospace knowledge and business opportunities and local Small and Medium Sized Enterprises (SMEs) with a joint ambition in composite technology. The report also indicated that the development of a successful, sustainable cluster would require at least 10 years of efforts and a budget of € 15 mln. in total.

All these ambitions were translated into the CompoWorld Masterplan 2012-2015, which was managed by a not for profit foundation CompoWorld, supported by all parties of the vital coalition as well as local SMEs. The masterplan had as theme: "a regional initiative, of national interest, with international exposure". In the Flevoland region there is potential for composite applications in sectors as agriculture, maritime, construction/infrastructure, transport/machinery equipment, offshore and wind energy.

The objective of the CompoWorld Masterplan is to foster economic development in the region with specific attention on employment. From this main objective three more operational objectives were derived:

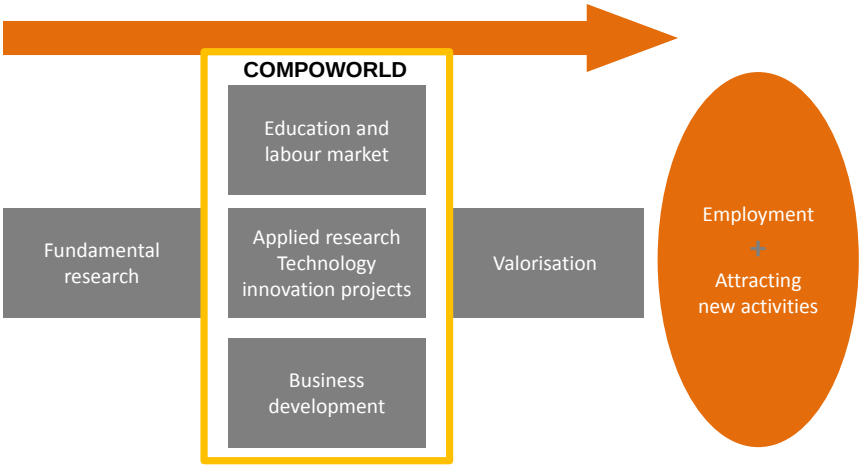
- Improvement of the innovation infrastructure (both hardware and software) by offering opportunities for businesses in cooperation with NLR;
- Increase the quantity and quality of skilled labour in the region;
- Attract more business activities to the region (business development)

Today the CompoWorld cluster has built a network of various local and regional authorities, R&D institutes and universities, larger companies (Fokker Aerospace, Ten Cate, Nedal) and SMEs (Vabo Composites/ICO, Dutch Thermoplastic Composites (DTC), Donkervoort Automotive) as well as many other parties in and outside the region Flevoland.

4.2 Innovation model

The CompoWorld Masterplan is a combination of three lines of activity in order to reach the objectives above. It builds on the results of fundamental research and delivers results that can be used in the valorization process of companies. CompoWorld thus provides the resources that will enable existing companies to grow and attract new activities.

This innovation model is new as it generates content and results, apart from building an innovation network and organizing meetings.



4.3 Funding

The CompoWorld masterplan has a budget of € 4,9 mln. for the period 2012-2015; 47% of the budget is publicly funded by the Province Flevoland and the Municipality of Noordoostpolder through a special economic development fund. The remaining 53% are financed by knowledge institutes (NLR, Windesheim University, Vocational Training School Friese Poort) and the participating companies. It is worthwhile to mention that program management cost are for 50% covered by sponsor contributions.

Innovation projects account for the majority of the budget (66%), business development for 14%, education and labour market for 10% and program management for 10%.

Most innovation projects are set up as previous strategic research programs for aerospace in The Netherlands. This means that the innovation project is executed by a research institute (NLR), which contributes 33% of the budget in time, another 33% (cash) is provided by the company and the last 33% is paid by CompoWorld. Maximum size of the innovation project is € 270.000 with a maximum duration of 24 months. Minimum size is € 90.000. A total of 13 innovation projects have been executed using this mechanism. Another 4 innovation projects were approved under a special SME innovation arrangement. In these projects NLR has a small role. Groups of 3 SME's are cooperating on a joint innovation project. Each SME contributes around 400 hours of labour and € 5000 cash, CompoWorld provides € 25.000 of cash for buying external knowledge, materials or components. Putting all resources together a SME innovation project has a value of almost € 300.000.

5 INNOVATION PROJECTS

In this paragraph an overview is provided of some major CompoWorld innovation projects

5.1 Landing Gear

There are two innovation projects for developing technology for composite parts for aircraft landing gears. Both projects have supported the development of the automated pilot plant by NLR in cooperation with industrial partners and the Province Flevoland.

The first technology development project concerned the automatic preform preparation of materials by pick and place technology. One of the major cost components in the production of thick composite components by means of Resin Transfer Moulding (RTM) is the developments of preforms. This is a manual process. This project focused on U shaped preforms and the control process afterwards for measurements and fiber directions. Once this proved to be a feasible technology, another problem came up. The number of preform moulds needed to produce for example a brace in a landing gear amounts to 50. The preform moulds differ only a little bit in size. So the second innovation project addresses the question whether a preform mould with adjustable settings can be a solution. This would reduce the number of moulds drastically and thus the cost. Simultaneously, the innovation project investigates whether other handling procedures, such as fast changing systems and the turning of the preforms 90 degrees, could speed up the cleaning process. Finally, the R&D focusses on the question whether shrinking of the composite material during the cure cycle can be compensated. Results of the project will be available later this year.

5.2 Heavy Machinery Shovel

This innovation project has won the JEC Innovation Prize 2015 in the category Heavy Machinery.

The project is the result of two CompoWorld innovation projects. The first project focused on the feasibility of composite technology to replace the metal technology currently used. The objective was to

develop a shovel of 30% less weight, with the current strengths and damage characteristics and with a price that is commercially viable. This first project has resulted in two demonstrators, that have been used for real time testing. The outcome of these tests were positive.

In a second CompoWorld innovation project research focused on a modular injection system for production of large components for series production. Also this project, similar to the landing gear innovation, focusses on the cost of moulding. But in this project the focus is on large components, such as the shovel. This would require modular moulds, that can be used for different products. In this project the consistency and robustness of the production with one mould will be investigated for various sizes of the shovels. Results of the project will be available later this year.

5.3 Off shore High pressure pipes

Two different innovation projects investigate the feasibility of high pressure pipes for the oil & gas industry. Drilling of oil shifts to larger depths in oceans and seas. In order to reach productivity targets injection of fluids is being used. The result is that a mix of highly corroding fluids is extracted and transported through pipelines. Corrosion is one of the major causes of leakages. Also pipelines need high performance in deep water, which means good performance under high pressure and a low weight. The two innovation projects differ in the kind of composite material: thermoset versus thermoplastic, but in essence NLR is providing both concepts with a test environment in which materials can be tested in different environments (temperature, pressure, fluids).

5.4 Automotive

There are 4 innovation projects that are linked with the automotive sector. One project investigated the feasibility of composite materials for a truck frame (chassis), which is possible. Another project looks at the aerodynamic advantages for cars when a bottom plate is attached underneath the car. This bottom plate is constructed with composite technology. Both innovations have direct effect on fuel consumption and thus operating cost of the vehicles, but also on the emission of CO2.

A third project investigates improvements in the connection between metal and carbon fiber components in multi-material parts, such as the frame/chassis of a car. Such a frame combines the material characteristics of carbon fibers with metal. The attachment between parts of different materials (connection technology) is subject of the research, including use of glues.

The last innovation project in this category is the development of a foldable rotor blade for the Personal Air and Land Vehicle (PAL-V).

5.5 Out of autoclave consolidating with automated fiber placement

Modelling heat transfer to control temperatures during out-of-autoclave consolidation of thermoplastics using automated fiber placement. In this project it is proposed to improve the control parameter settings by a physics-based support tool for control parameter selection, using a tailored heat balance model of the specimens and fiber placement machine. The short turn-around time predictive tool will model heat transfer including an appropriate control strategy, thereby facilitating a comparison of different control parameter settings and supporting the selection of the optimum choice prior to any test runs. The required scope, model complexity and performance of the control strategy analysis tool will be discussed during the initial phases of the proposed project. Tool prototype development and verification and validation using in-house generated experimental time-dependent temperature data will be conducted. The benefit of modelling heat transfer to control processing temperatures during out-of-autoclave consolidation of thermoplastics using automated fiber placement is reduced cost through a reduction of experimental testing hours to find appropriate control parameter settings for every new product, or new material system, or new fiber placement sequence.

5.6 Other projects

Apart from the above describe technology development projects CompoWorld has supported other innovation projects as:

- The development of a thermoplastic aircraft seat frame
- The testing of composites used under high temperature conditions
- The application of composite technology in a breaking device for a light post
- The technology development for a composite steering house on a fishing boat
- The technology development for a mobile shopping cart cleaning machine
- The technology redevelopment for a hybrid Airflow Plus spraying arm for agriculture

Most of these innovation projects have led to very promising concrete results

6 LABOUR MARKET AND EDUCATION

Innovation for companies and the accompanying business development efforts to attract new activities to Flevoland and the municipality of Noordoostpolder can be further stimulated when the regional labor market provides the right skilled workforce both in quantity and quality. Therefore, in the CompoWorld ecosystem innovation and education go hand in hand.

CompoWorld has been able to develop a specific minor course for vocational training. This minor was used in combination with practical assignments, outside the school, in business environments. An important part of this course development has been the train the trainers sessions. Next year the minor courses will be taught by teachers of local schools.

Also for higher professional education (HBO) a minor course is in development and taught in 2015. Education and research within the Windesheim school will be further integrated. An associate lector composite technology has started in 2015 for a period of at least four years.

7 BUSINESS DEVELOPMENT

7.1 Annual congress

When CompoWorld started in 2012, the Flevoland region was little known for its composite technology potential. Within the program management organization immediate efforts were taken to change this. Visits to small and large companies in the composite technology sector, as well as to companies that were considered future applicants, were made. In that way CompoWorld was able to develop a network of hundreds of contacts. Right from the beginning this network was offered the opportunity to meet during the annual CompoWorld congress in Noordoostpolder (Emmeloord). From a one day event with 100 participants this congress has developed into a two day event with 400 participants and can be considered a composite meeting event on a national level. The congress addresses new technological developments, but combines it with presenting the results of the CompoWorld composite technology innovation projects and offers businesses and schools to show products in a small trade exhibition. Each congress has its own theme, in 2013 "*composites in motion*", in 2014 "*composites in production*", in 2015 "*composites smart solutions*".

7.2 Incubators

CompoWorld has also attracted technostarters by offering incubator facilities. This has led to three interesting new concepts. The first is a hybrid light weight kiosk, the Minimono, which is on the brink of starting full scale production. A second one is the application of light and printing technology in composite materials, so these can be used for transmitting messages. The third one is the production of a composite chair for the high end design market, using the formability characteristics of composite technology.

8 RESULTS

Although the final results of the CompoWorld masterplan can only be assessed at the end of 2016, there is already a good estimate of output and results of the CompoWorld masterplan 2012-2015. There are 17 innovation projects implemented and by the end of 2016 completed. Minor courses in composite technology are developed for vocational and higher professional education. An associate lector composite technology has started for a period of 4 years.

In terms of business development new companies have come to Flevoland, composite technology is (for the first time) applied in new bridge development and replacement. Crossovers with the maritime and agricultural technology have been realized. A new pilot plant at NLR has been built and is in use. Existing companies in the composite sector in Flevoland have been growing, mostly thanks to their own efforts and strategy but supported by CompoWorld.

In terms of **regional impact** CompoWorld can be linked to the growth of around 100 new jobs in Flevoland, half of these in the northern part of the province. At the end of the masterplan (2016) this number is expected to double with 75% of the new jobs in the Noordoostpolder. On a **national level** NLR and CompoWorld are recognized are recognized as a centre of excellence for high tech/high spec composite technology, which will be important in the next phase of the cluster. **International exposure** is developing linking CompoWorld possibly with interregional cross border innovation (Interreg) and cooperation in the context of the EU Joint Undertaking Clean SKy 2.

9 LONG TERM PERSPECTIVE

Most objectives of the CompoWorld Masterplan 2012-2015 will be realized. The market study preceding the CompoWorld masterplan mentioned that the development of a successful, sustainable cluster would require at least 10 years of efforts and a budget of € 15 mln. in total. At this moment only 4 years of time and € 5 mln of budget have been spent.

The CompoWorld organisation is preparing for the next 4 years (2016-2019), continuing the successful features of the first masterplan, especially the innovation projects. These can be seen as the backbone of the CompoWorld innovation model and the basis for a successful combination of economic and technological regional development, using the available resources of businesses, research institutes and regional/local government.

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