K-4. *Keynote Address:* European Display Networks

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Abstract: There are a lot of European organizations focused on displays incl. subassemblies, materials and production (equipment). To join the forces, a networking activity called Advanced Displays Research Integrated Action (ADRIA) was granted by the EU. As examples, a display roadmap until 2020 and a competence database with 2,000 experts were made.

Key Words: ADRIA, network, roadmapping, competence mapping

1 ADRIA Consortium and Objectives

Europe has a long and strong tradition in R&D of displays, but display production is mainly in Far East. This situation, in combination with market studies pointing to strong future growth in display products, motivates some people to work closer together in Europe. The ADRIA project was designed to act as a catalyst in bringing the fragmented European Display community together.

The main facts & figures of the 'Advanced Displays Network' - project are:

- 6 Partners, see below
- Duration: 01.10.2004 - 31.12.2006
- Manpower: 67 person months
- The mission is to strengthen the advanced displays industries in Europe by creating a European platform on advanced displays research and technology.
- Vision is to appeal to the entire display and related community in Europe, to create a common knowledge base, to create a common vision for displays and large area electronics and to create appreciated services
- Funded by the European Commission under the Sixth Research framework programme

ADRIA is a joint Coordination Action with six project partners. The consortium already consists of strong European industry and academia networks by them-selves:

- DFF (Deutsches Flachdisplay Forum, Germany)
  is coordinating the ADRIA project. Its management expertise comes from the VDMA and technical input from various DFF platforms and activities.
  Info & contact via www.displayforum.de
- SEMI Europe (Belgium/International)
  has a strong background in international standards making, roadmapping, and FPD markets.
  Info & contact via www.semi.org
- The Scottish Optoelectronics Association (UK)
  contributes with its experience in road-mapping, standards, and education & training.
  Info & contact via www.optoelectronics.org.uk
- Le Club VISU (France)
  adds competence in education & training and conferences to ADRIA It also represents the European SID chapters.
  Info & contact via www.eurodisplay.org
- The Swedish LCD Center
  runs an LCD Master's Degree and additionally places its strong industry & university network at the disposal of the ADRIA platform.
  Info & contact via www.lcdcenter.com
- The University of Dundee (UK)
  has implemented a UK Display Master's Degree and adds its university network to ADRIA.
  Info & contact via www.dundee.ac.uk

The motivation of starting the ADRIA project was that displays R&D in Europe has been and still is a big source of innovation. The supply industries in Europe are an enabler for display production. Strong EU industries, e.g. automotive, telecommunication, mechanical engineering, aerospace, medical etc. have visions for future applications with displays. European Commission has been and still is funding displays activities and numerous projects funded by national sources.

What was missing was a "one-stop-shop" for flat panel displays (FPD) in Europe with the objectives of fostering interaction among all European players along the FPD value chain, common vision, i.e. common rules for future investment in the FPD sector, effective training / development of an EU FPD education curriculum, consolidation and enhancement of FPD standardisation knowledge, integration of dissemination activities and representation of the European FPD community globally.

2 ADRIA Workpackages

The following workpackages are setup by the consortium, working groups, European FPD community and partnering organisations worldwide:

1. **Competence mapping**
   Integration of advanced displays competence fields at European level. The objective of competence mapping was to gather together a database of the currently scattered FPD expertise in Europe, to identify strengths and weaknesses of the European display community and link together European firms and research institutes thereby enhancing cooperation and collaboration.
2. **Technology Roadmapping**
   Establishment of common rules for future investment and strategies on advanced displays at European level. A European Advanced Displays Roadmap (ADR) has been created to identify technology gaps and market opportunities and to inspire new display innovation and funding programs. Starting with the condensed information from the

Competence Mapping, over 300 experts in display and related technologies from all over Europe participated in ADRIA roadmapping workshops.

3. **Education and training**
   Reinforcement of the educational and training framework. Development of a coherent European approach to FPD Education and Training, and its implementation to facilitate access to the critical human resource of trained and well-educated scientists and engineers is essential for the sustainable future development of a European display industry.

4. **Standardization**
   Consolidation and enhancement of standardisation knowledge. ADRIA has created awareness of existing standards, identified gaps and industry needs in standards, and promoted the application of standards. There have been two standardization meetings one held in Manchester together with the roadmapping meeting and the second in Munich during SEMI 2006. In addition, an ADRIA Newsletter featured "Standards".

5. **Promotion and dissemination**
   Integration of activities at European level. To promote the ADRIA activities, to disseminate information about ADRIA results among the European display community and to inform about other interesting news and events, an internet-based information platform www.adria-network.org has been implemented. Moreover, 6 quarterly newsletters have been issued since the beginning of 2005. In addition the ADRIA partners have appeared at numerous conferences and exhibitions publicising ADRIA activities.

6. **Establishment of a permanent European platform**
   ADRIA strives to create a permanent European Platform that emerges from its activities to serve the European FPD community and that represents the European display community with a single and articulate voice, creating an interface to other national and international organizations, funding bodies, the European Commission, and the public. It is the goal that this association-type organization continues its activities even after the ADRIA project has finished.

These workpackages were worked out in many meetings ranging from small ones for special items up to 6 large events in Amsterdam, Manchester, Paris, Munich and Tampere for discussing and evaluating roadmaps.

The ADRIA project has successfully brought together the display community all over Europe. The most important results of the project – the outcome of more than 18 month of work and over 600 pages of reports are highlighted in the next three chapters.

3 ADRIA Competence Mapping

Over the duration of the ADRIA project almost 2000 display professionals have registered on the ADRIA website. In addition about 150 Research activities have been recorded and about 250 Company products or services entered. The input data provided by all organizations has been reviewed before dissemination. The database is accessible by those who have registered and given input. They also have access to the synthesis report issued during the ADRIA project. For the first two years of the project, registration and submission of a profile to the database was free of charge.

The focus on research is on LCD and OLED technology, followed by work in electrophoretic and electrochromic displays. OLED and the latter two display technologies are ideal for moving the industry from displays-only into system-integration with printed and / or organic electronics. A known strength of Europe – materials and equipment – is reflected by the registered research activity. Extensive financial and man-power resources are invested to improve properties of material and equipment for LCD and OLED. Polymer chemistry is a top issue – working both on coatings for displays and the availability of flexible and bendable substrates. First production lines are currently nearly finished in Germany and UK.

The dominant display technology in Europe is the well-established LCD technology, followed by OLED especially in the material and process technology. CRTs, diminishing in the global market, still play a role in Europe; this "old" display technology still finds its niche markets and acceptance. Material needed for the top seller display products LCD and OLED are produced in Europe. Although the European market size of e.g. the flat panel TV-sets is the world-wide strongest there is still no display production reflecting this fact. With the opening of assembly lines for LCD panels and TV sets in Eastern Europe a first step towards an improved production infrastructure in Europe is done.

Europe holds all possibilities to bring flat panel display manufacturing back into the region as well as gaining additional international reputation in the new field of printed electronics. Along with the existing and globally recognised expertise in material, process and equipment development and production can increase the importance of Europe in the global market.

4 ADRIA Education and Training

Specialized knowledge and trained workforce is the basis of technology driven development and production. ADRIA has therefore generated a raft of interesting ideas on how to take forward the idea of an advanced European Displays Masters degree and induced both a spirit of co-operation and a fruitful exchange of concepts, philosophies and practical information which has been welcomed by all the partners and associates. A dedicated taskforce has met several times to develop a basis for a "European Display Master's Degree". The starting point for this has been the Display's Masters Degree offered by a consortium of UK Universities and awarded by the University of Dundee. Links between universities, governmental bodies, membership organisations and the larger individual companies need to be strengthened so that the training required can be provided in the most efficient manner.

There is a plethora of workshops, seminars and training programmes available to those working in the industry, but these are often under-subscribed because different organisations operate broadly similar programmes and supply of courses sometimes outstrips the demand for them. ADRIA has implemented an "Advanced Displays Training Program", tailored to industry professionals. Two one-week courses were run, in Germany and France with basically the same course material. The presentations of the ADRIA training seminars have been recorded and are edited to DVD for distribution – the ADRIA approach to e-learning.

The findings of this workpackage have fed to a Report on Education and training on Advanced Displays in Europe, which represents a snapshot of the state of education and training in display technology within the EU. In addition it presents a model core curriculum together with some recommendations on how it could best be implemented with special regard to the imperative to drive towards a fully integrated European displays Masters degree. The training element of this report is looking at the ADRIA display training seminars organised in Pforzheim and Bordeaux, but also gives illustrative examples of other programmes.

The report is meant to act as a template on which to build the dream of a common advanced European Displays curriculum, one which satisfies both academic rigour and industrial needs, and which can act as a catalyst to crystallise a more integrated, efficient and demand-driven approach to education and training across the EU. A first result of this fruitful collaboration between the ADRIA partners is the introduction of a new module of the well established UK DisplayMasters on Industrial Display Applications at Pforzheim University, Germany starting in Feb. 2008.

5 ADRIA Roadmapping

The European advanced display community must continue to invest in its current position as a global player in advanced display technologies in order to stay competitive with Far East and US. To find common rules for future investment and strategies, the European Commission, national funding bodies, the industry, and academia have to focus on a limited set of research routes rather than redundantly funding the same research and underfunding or missing other important technologies. These common rules do not exist yet in the field of advanced displays. ADRIA Roadmapping attempts to form the basis for these rules.

In total 6 workshops were organized, roughly every quarter, between February 2005 and September 2006. The workshops were held in locations throughout Europe in order to attract easy access for as many participants as possible. Through the discussions and exchange of views during these workshops, the ADR has been developed. The ADRIA staff drafted working versions of the roadmap which are available on the ADRIA web site to workshop participants, helping them to align their business and research strategies with the most possible, and profitable, future scenarios.

Application field	Product features	Technology
Automotive, avionics	ruggedized, micro-display, high resolution, flexible (curved)	LCD, OLED, FED, AM
Mobile communications	flexible, bi-stable, high resolution, micro-displays, 3D	LCD, OLED, e-paper, AM
Industry & medical	ruggedized, high resolution, 3D, micro-display, flexible	LCD, OLED, FED, AM
Public display, advertising and retail	large area, ruggedized, 3D, bi-stable, flexible	LCD, AM, Plasma, OLED, FED, e-paper, others (LED)
Consumer and household	flexible (curved, conformable), bi-stable, standard type	LCD, OLED, e-paper, AM

Figure 1 ADRIA roadmapping areas

Five roadmapping areas (see Fig. 1 including product features and technologies) have been identified as being essential for Europe today and in the future.

ADRIA developed a vision of the future for each display application area. The roadmappers found it essential to adopt as a framework, major movements in social (for example aging population), environmental (e.g. sustainability) and economic (e.g. 3rd world development) trends first to create a vision. Once the vision was agreed the products necessary to produce the vision were identified. Then the difficult task of assessing alternative technologies which might be evolved to meet the product requirements was undertaken and the “red brick walls" identified which would need to be overcome if the technology was to meet the product specification. Thereafter a Strategic Research Agenda for the present can be suggested.

For dedicated applications the display technologies, their backplane and substrate is judged in order to identify “red brick walls”. This allows the identification of gaps in technology and production. Therefore in combination with the competence mapping, special groups and consortia can meet and combine to solve these issues.

Grand challenges – the summary of the most important “red brick walls” - have been identified. They are in eye-quality displays, electronic paper, low cost displays, smart displays, 3D displays, environmental-friendly displays and display integration. We give a short summary of some of the grand challenges here:

- Eye quality does not only mean resolution, which can be expressed in dpi or pixel count. Ambient light, where most of display applications are exposed to, degrades contrast ratio, grey level representation and colour gamut. This is e.g. relevant for automotive displays where certain figures statutorily must be readable under severe conditions. E-paper shall resemble printed paper as much as possible.
- Flexible and low power displays are the dream of many designers and engineers. However there are some obstacles around like production (roll-to-roll), need for AM backplanes for many technologies when using higher resolutions. The price of currently about 1$ per cm² for AM paper-like displays is foreseen to shrink by a factor of 20 in 2020. By this time paper price labels will be largely disappeared and electronic labels penetrate the markets also in developing countries.
- As an original representation of natural impressions is favourable, stereoscopic and holographic displays come in. However data rates and capturing of the scenes, especially volumetric, are far beyond today’s feasibilities.
- How can electronic displays become more environmental friendly products from production over use to disposal? An ultimate solution would be a biodegradable display. This challenge covers also high(er) efficiencies or the increasing request for reflective and/or bi-stable displays.

The Advanced Displays Roadmap will help decision makers in the industry to adjust their business strategies, policies and investment decisions to supposable future scenarios and boundary conditions. Academic institutions are able to prove their current work for future transfer and/or eventually adjust their focus. This will in total also eventually promote of advanced display (mass) production activities in Europe beside current niche market manufacturing or final assembling like TV-sets in Poland and Czech.

As one example of the Advanced Displays Roadmap areas, we will go more into details for avionic displays. They do not only cover systems in the cockpit but also in-seat info- and entertainment for passengers. Unique are some features/requirements:

- Ultrahigh illuminance (direct sunlight) of more than 100,000 lx at the pilots displays
- Supply chain with about 10 years each for development and production and 20 years or more of maintenance.
- 200 MPixels or more for a closed or remote panoramic cockpit, lower resolutions for 1:1 overlay (augmented reality) on windshield (head-up)
- 3D displays for mission critical operations like refuelling
- Niche market opportunities for specialized manufactures because of low volume for e.g. cockpit displays like about 3,000 per year for AIRBUS.
- Mixed mode display systems for passengers with e.g. wireless notebook interfaces
- Large screen foldable and curved displays will give impressive entertainment
- In the past automotive developments follows avionics like head-up displays.

The dialogue with the European Commission and national funding bodies will become easier with the Advanced Displays Roadmap. It will be a basis for better directing and focusing the content of their future research and development programmes, and for improving the participation in and the access to these programmes by companies, particularly small and medium sized enterprises.

6 Other European Display Networks

Besides ADRIA, there are other European networks active in the display sectors, of which we want to introduce just a few.

6.1 UK Displays & Lighting Knowledge Transfer Network

The mission of the UK Displaynet (www.ukdisplay.net) is to support the disparate needs of the Displays and Lighting communities in the UK, including SMEs, OEMs and Academics. The scope covers activities in displays, lighting and supporting technologies ranges from the Science Base through Manufacturing and into the strategic End User markets. This depth of activity ranges from the point of initial scientific invention to the point of product disassembly, recycling and safe disposal of materials at end of life.

UK Displaynet is committed to make its members more profitable by increasing their knowledge and skills base, and by introducing them to potential partners for collaborative research and to potential supply chain members. The activities cover tutorials, training courses and workshops.

6.2 German Flat Panel Forum (Deutsches Flachdisplay Forum, DFF)

The German Flat Panel Display Forum (DFF), the Flat Panel Display Association within the German Engineering Federation VDMA, is the industry-led association of European FPD material and component suppliers, equipment manufacturers, display manufacturers, system integrators, end users, and research institutes. Founded in February 2000 as a German initiative, nearly 70 members from all over Europe have joined DFF in the meantime, representing the whole FPD process chain.

The vision of DFF is to enable its members to attain and sustain a leading position in flat panel display (FPD) industries. DFF catalyses and expands a network of excellence across the entire value chain, leading to new business opportunities. To achieve this, DFF has launched a communication platform promoting information exchange between European companies and the international display community.

6.3 SID Activities in Europe

The Society for Information display is the world's largest organization dedicated to all topics of display technologies, its materials and production as well as systems. Organized in chapters, Europe divides in Mid-Europe, Club Visu (France), Belarus, Russia and Ukraine headed by an European Vice-President. One of the numerous activities is the organization of the EURODISPLAY.

6.4 Display Activities in Eastern Europe

In the last decade, display activities in Eastern Europe gained more and more attention as numerous achievements and inventions were made there basing on a long tradition of state-of-the-art research. Especially materials research and simulations are the performed at many academic institutions. Many companies have established research centers and subsidiaries.

6.5 SOA

The Scottish Optoelectronics Association (SOA) was launched in October 1994 with the objective of stimulating economic growth in Scotland. SOA members are engaged in four main areas of Photonics Displays, Lasers, Sensors and Optical Components. Major display interests are Microdisplays with recent interest in LED backlighting for LCD and aspects of flexible displays. SOA participate in the Master's degree awarded by University of Dundee in Display Technology.

7 Summary

Many significant display inventions were made in Europe since the early days of CRTs. Despite many approaches it was unfortunately not possible to establish FPD mass production sites. On the other hand, many examples of the success of specialized companies can be listed. As displays are one of the major parts of information systems, it is necessary for Europe to achieve a leading position.

The first step is joining the forces as it is done in the European display networks especially in ADRIA. Fundamental steps are education, competence- and roadmapping to recognize the challenges to come. The opening to Eastern Europe will result in mutual benefits. More detailed information about the European display community (competence mapping) and future trends (roadmapping) can be obtained via www.adria-network.org. You should also register there, if not already done, to become part of the story.