

Advanced Displays Research Integration Action

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**Automobile  
& Avionics  
Displays**

**4<sup>th</sup> roadmapping  
workshop**  
Munich, February 22, 2006  
Eric Maiser, VDMA-DFD



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Information Society  
Technology

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**Sandia Technical Roadmapping Process**

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- **Phase 1**
  - Satisfy essential conditions
  - Provide leadership/sponsorship
  - Define the scope and boundaries
- **Phase 2**
  - **Identify the key display products assisted by Scenario planning**
  - **Identify the critical system requirements and their targets**
  - **Specify the major technology areas**
  - **Specify the major technology drivers and their targets**
  - **Identify technology alternatives and their time lines (W/S 4)**
  - Recommend the technology alternatives that should be pursued (W/S 5)
  - Create the technology roadmap report and consult (W/S 6)
- **Phase 3** Follow Up Action (Implementation, ...)

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**Automotive Applications**  
**3 key display products**



- Safety relevant information for the driver (pilot, operator) (speed, engine and system status (e.g. brakes), etc.),
- Additional driver / co-driver information (utility: parking assistance, etc., e.g. navigation) and
- Passenger work & entertainment (computer operation and communication).

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**Example key display product I.: Configurable combi-instrument**




Source: DaimlerChrysler

- flexible use of display area,
- content depending on context and situation.

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### Example key display product I. Futuristic view



Source: DaimlerChrysler

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### Example key display product II. Navigation system with realistic rendering



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### Example key display product III. Entertainment Display



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### Example key display product III. Displays for Entertainment and Office



Source: DaimlerChrysler


- Entertainment**
  - TV, gideo, games
- Infotainment**
  - internet, news,
- Office Work**
  - telephone
  - online banking
  - email, etc.

- large area display for information
- small area displays for menu selection

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## Avionics Applications 2 addtl. key display products



- Head-mounted display (mainly for military)
- Panoramic Display / immersion

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## Example key display product I. Head-mounted display



Source: IBM Germany

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## Example key display product II. Panoramic display

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**SUPERPANORAMIC COCKPIT WITH CLOSABLE OPAQUE LAYER**

**CLOSABLE INNER LAYER (CIL):**  
SHAPED CURTAIN ON RAILS (near-term)  
FOLD UP FPDs OVER PANEL (mid-term)  
CANOPY DISPLAY SYSTEM (CDS) (far-term)

**HUD Screen Support:**  
Attenuates Bird Strike;  
Braces Inner Layer

**CANOPY**

**Inner Layer Stowage**

**OPEN DISPLAY SYSTEM:**  
Panoramic Center Screen  
+ Between Knees  
+ Left/Right Curved Screens  
+ Multifunction HUD

**CLOSED DISPLAY SYSTEM:**  
Open Display System + CDS  
(CIL is segmented w/FPDs or is continuous flexible display)  
+ Audio SA + Haptic AA

Figure 5. Concept for 2010: Super Panoramic Cockpit Plus

Source: Darrel G. Hopper, DoD

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## Automotive and avionics applications Critical system requirements

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Product	Safety Display	Co-driver Display	Passenger Display
<b>Critical Requirement</b>			
colour gamut			X
image quality			
thickness			
Image Sticking			X
Lifetime	X	X	X
Brightness			X
Viewing angle	X	X	
Cost			X
Safety	X	X	X
Environmental	X	X	X
Portability			
3D			X
Virtual Reality			X*
Usability			X
Flexibility	X	X	X
Weight			
Power consumption	X	X	X
Resolution			
Disposable			
Transparency			
Contrast	X	X	
Video rate			X
Outdoor readability	X	X	X
Large Area			
Colour Fidelity			
Reliability	X	X	X
Latency	X	X	

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## Automotive & Avionic Generic requirements

- high reliability, wide operating temperature range
- standard -40°C ... +85°C
- enhanced -40°C... +100°C
- high humidity (up to 93% r.h. @ 65°C)
- shock resistance
- seamless integration into / onto instrument board wanted
- 3D option wanted
- integration of e.g. touch-panel wanted
- loudspeaker function wanted
- sunlight readability required (e.g. by use of transfective mode)

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## Avionic Generic requirements

	HDD	HUD	HMD
<b>Overall size</b>	up to 1,3" more than the active area	Design dependant	Design dependant
<b>Active area</b>	>2,8" diag and <10" vertical	up to 4"	<1,5"
<b>Definition</b>	from QXGA to UXGA or TVHD	>SXGA	>SVGA up to UXGA TVHD or more
<b>Pitch</b>	80 to over 120ppi	from 10µ to 50 µ	up to 20 µ
<b>Luminance</b>	350 cd/m2 to 1000 cd/m2	>8000 to 10000 cd/m2	>10000 to 20000 cd/m2
<b>Contraste</b>	>100	>100	>100
<b>Angle of view (CR&gt;20)</b>	+/-55° H -5/+35° V (depends on installati	>45° (depending on HUD field of view)	> 25° (depending on HMD field of view)
<b>High ambient light</b>	CR>3 (100000lux)	CR>1,2	CR>1,2
<b>Specular Reflectivity</b>	typical <1%	<1%	<1%
<b>Diffused Reflectivity</b>	typical <0,2%	<0,2%	<0,2%
<b>Grey scale</b>	8bits	8bits	8bits
<b>Color</b>	<0,03		
<b>r</b>	U: 0,43 V: 0,53	x	x
<b>g</b>	0,13 0,56	0,13 0,56	0,13 0,56
<b>b</b>	0,14 0,31	x	x
<b>w</b>	0,17 0,50	x	x
<b>MTBF</b>	100000h	10000h	10000h
<b>Ground survival Temp</b>	between -55°C to +85°C	between -55°C to +85°C	between -55°C to +85°C
<b>Operating Temp</b>	between -40°C to +70°C	between -40°C to +70°C	between -40°C to +70°C
<b>other environmental req</b>	altitude, schock, solar radiation, humidity	Altitude, schock....	Altitude, schock....
<b>cosmetics</b>	a few pixel defects	a few pixel defects	a few pixel defects

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**Automotive Example**




- **Performance Requirements 2015**

Operating Temperature	"-20C to 60C
Start Up	"-40C to 85C
Storage	"-40C to 95C
Life to 80%	10000hrs
Colour Gamut	EBU
Colour resolution	3X6 bits
Size, maximum space available	18x13.5 inches
Ambient illumination	100000 lux
Minimum luminance day	500cd/m2
Minimum luminance, night	1cd/m2
Dimming range	1000:01:00
Obsolescence	20 to 30 years
Shape	Conformal
Flexible	Yes

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**Automotive and Avionics Applications Timelines**



- Time-scale for cars:  
Start of development 72 months (6 years) before start of sales, 10 years of production and 15 years of spare-parts availability = 31 years in total.
- Avionics:  
civil aircraft / military aircraft
- Time-scale for roadmapping:  
2005 – 2010 – 2015

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**Performance requirements Technology targets:  
Example: Automotive head-up displays (HUDs)**





Source: BMW Group

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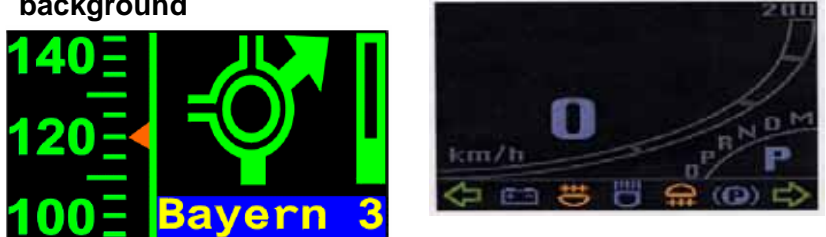
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**Automotive head-up displays (HUDs)  
Ergonomics**



- 1-5 information carrying items at a time are OK, size of information is critical:
  - 13-15mm status information
  - 25-30mm security related information
  - 35-60mm Navigation symbols
- Preferred colors: Green, Orange/Red, Yellow on a blue background



Source: Marcus Moell, VDO North America, SID Vehicular Displays Conference 2001

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## Automotive head-up displays (HUDs)

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Virtual Image at Bumper Distance  
Windshield  
Driver  
Aspheric Mirror  
Fold Mirror  
LC Display

**Day HUD Key Components**  
Source: General Motors

Source: SID Vehicle Displays 2002  
Kimberly Allen, iSuppli/Stanford Resources / FPDs for Autos: Are We There Yet ?

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## Automotive head-up displays (HUDs) Challenges

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- Optics
- Aspherical / fold mirror system: adjusted to direct beam into viewer's eyes
- Windshield vinyl film (combiner)
- Windshield shape
- Backlight (if LCD)
- Tungsten-Halogenic bulbs need cooling fans
- White LEDs ? (mercury-free !)
- User challenges: e.g. sunglasses polarize light!

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**Automotive head-up displays (HUDs)****Key display parameters:**

- Aspect ratio ~ 2:1, FOV several degrees vertical
- 20-60 pixels / degree minimum (3-1 arc-min / pixel)
- Luminance ~ 1.500 - 5.000 cd/m<sup>2</sup>, contrast 100:1
- Only need a few highly contrasting colors
- Display could be a small LCD or VFD, but true micro-displays are preferred for compact size (magnification would be ~ 5x)
- **Key concerns:**
  - Price < \$500 for entire HUD unit
  - Driver distraction (safety) ?  
(worse than with current head-down displays ?)

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**Automotive head-up displays (HUDs)  
Products**


- Delphi, Raytheon (small LCD)
- Siemens VDO Automotive announced 6-bit color product
- Microvision also has plans
- **General Motors**
  - First introduced in late 1980s:  
Pontiac Grand Prix, Olds Cutlass Supreme
  - Now: Buick Park Avenue, Pontiac Bonneville, Pontiac Grand Prix, Corvette, Cadillac LeSabre, Cadillac Deville NV, Pontiac, Aztek, Buick Rendezvous
- **Development at all major manufacturers**
- **More LCDs in future (smaller pixels / better color than VFD), possibly with LED backlight**
- **However, uptake still low today**

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## Automotive head-up displays (HUDs)




**Reflectivity / transmittance**

- windshield 20 %
- glare trap 92 %
- aspherical mirror r = 93 %
- flat fold mirror r = 93 %
- total transmission 15.9 %
- *image luminance (target) 4.000 cd/m<sup>2</sup>*
- *required source luminance 25.000 cd/m<sup>2</sup> !!!*
  
- *realized LED source luminance 420.000 cd/m<sup>2</sup>*

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## Automotive head-up displays (HUDs)

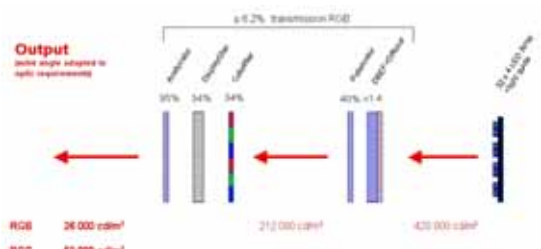


■ **Challenges to optical system**

Extreme windscreen curvatures in both x and y direction, limited packaging space, and high image quality expectations, require complicated optical systems (several aspherical folding mirrors or flat folding mirrors plus aspherical mirror).

■ **Solutions**


LED arrays with 32 "white dots" (= 2xG+R+B) mounted on aluminum carrier and connected to a heat sink. Local "white adjustment" is necessary because of high forward voltage tolerances (individually adjustable current sources).



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**Automotive head-up displays (HUDs)**



**Challenges to light-source**

- High reliability (no service required).
- Luminance > 5.000 cd/m<sup>2</sup> to assure visibility under all illumination conditions.
- Dimming ratio minimum 1000:1
- Operating temperature range -40°C to +85°C.
- No color shift with temperature.


**Challenges to LCD spatial modulator**

- am-LCDs for automotive use are complete modules with integrated backlight and driver IC's.
- Resolution and format does not match HUD requirements.
- Temperature range for storage and operation is limited.
  - **Security information must be displayed at -40°C.**
- Limited space for packaging of HUD system and direct exposure to sunlight increases temperatures to a maximum.
- Response times at low temperatures have to be considered (1-2ms) since important information has to be displayed.

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**Automotive head-up displays (HUDs)**



**Challenges to LCD spatial modulator**


- System magnification of ~ 5-6, virtual image distance of ~ 2.5m ⇒ LCD diagonal of < 2".
- Resolution of > 60 pixel per degree.
- LCD must have p-Si for backplane for sufficient aperture ratio (transmittance).
- Contrast > 100:1.
- Free design parameters: color filters and brightness enhancement measures. Color filters optimized for maximum transmittance. Not all colors are required.
- Display heating required at low temperatures.

Item	Specification	Unit	Remark
Dot count (H x V)	360xRGBx180	Dot	
Visible display size	40x20	mm	
Display size diagonal	5	cm	
Number of colors	18 (=3x6)	bit	
Color arrangement	RGB stripe		nothing else available
Dot pitch (H x V)	0.0335x0.1005	mm	
Aspect ratio	2:1		
Contrast	150:1		
Transmittance	6 %		
LC clearing temp.	105	°C	
Operation temperature	-40 ... +85	°C	
Storage temperature	-30 ... +95	°C	

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**Automotive Displays Temperature!**



**Challenges Temperature Dimension**


Passenger compartment	General	Direct sunlight	With exposure to thermal radiation
Operating range	-40°C to +85°C	-40°C to +105°C	-40°C to +90°C

Source: BMW Group


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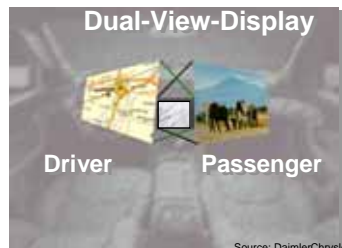
**Co-driver / navigation display Daimler-Chrysler**



- Displays on curved surfaces thin and flexible substrates (e.g. with OLEDs)
- "chameleon/mimikry displays" (merge with surround, become invisible when not used)
- Dual-View-Display: different visual information for driver and passenger on the same display



? is this a good idea ?

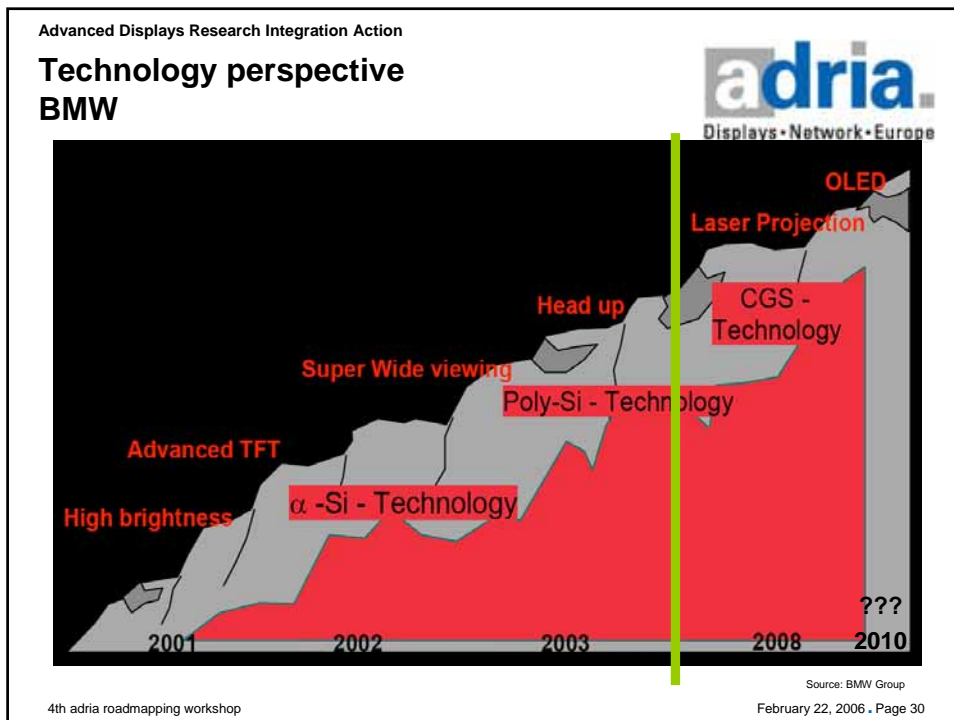
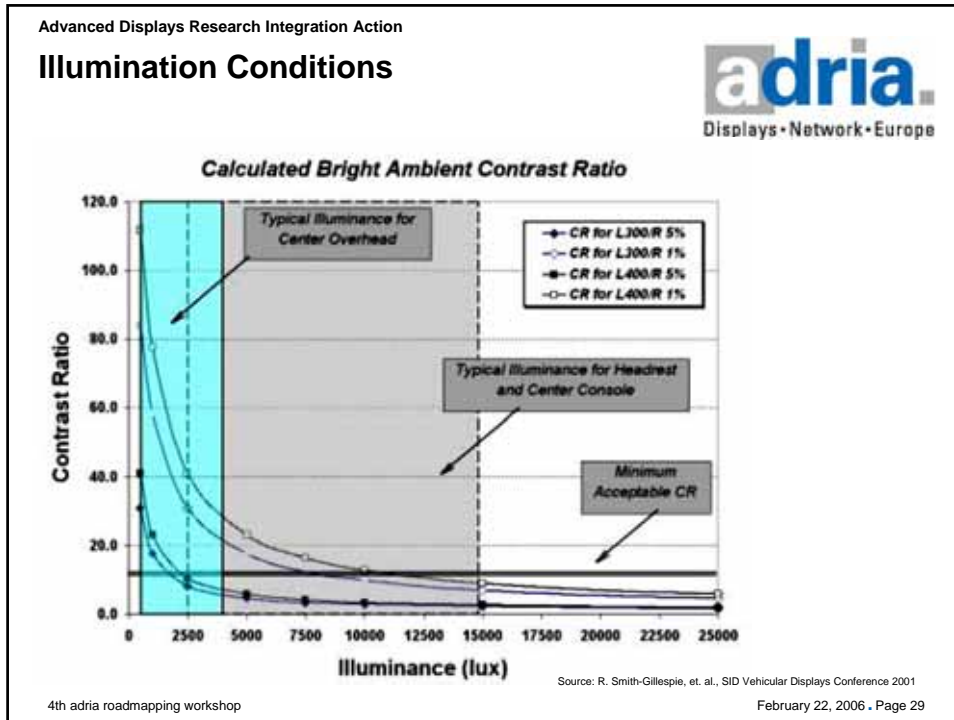


Dual-View-Display

Driver Passenger


Source: DaimlerChrysler

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## Technology perspective / scenario “Avionics moving into automotive”




	1960	1970	1980	1990	2000	2010	2020
<b>Head Down Display</b>							
Military aircraft	Clock dials	mono CRT	Colour CRT		Projection LCD		Closed Cockpit or remote control/simulator
Civil Aircraft per pilot	Dedicated instruments	50sq inch	100sq inch	Multi Function Display	1.35Mpixel	600sq inch Total Immersion	30 Mpixel
	Clock dials						
Automotive	Clock dials		Mono EL colour LCC	mouldable sectional			
	Dedicated instruments		15sq inch	50sq inch	100sq inch	200sq inch	
				Multi function displays	750K pixels	2 M pixels	
							Pixels 1.35M 30M Luminance 1-750 cd/m2 1-750cd/m2 Contrast 4.66:1 50to1 Colour 18 bits 24 to 48 bits
<b>Head Up Display</b>							
Military aircraft	mono CRT	20° FOV	20° FOV	30° X 20° FOV	30° X 25°		
	4inch	5inch					
Civil aircraft per pilot	Symbology		DHL 737	Video Airbus	30° X 25°		
Automotive			GM Prometheus	BMW 5/6 option	standard		Safety & vision enhancement
<b>Head Mounted Display</b>							
Military aircraft			Apache Monocular		Eurofighter Binocular		
Automobiles				F1			

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## Technology perspective / scenario “Avionics moving into automotive”

Source: Darrel G. Hopper, DoD

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**Technology perspective / scenario**  
**“Avionics moving into automotive”**



**High-Gear Grandma**

Source: Siemens, Pictures of the Future, Fall 2005

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