Fusion Helmet: Electronic Analysis

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Abstract

This document aims to analyze the Lyrtech's electronic boards developed for the "Système d'imagerie fusionnée" project. First of all, this document describes the main features of each circuit to understand their possibilities and flexibility. After that, in the spirit of reusing the current circuit, various design options will be presented. Finally, pictures of interesting display will be presented in annex.

Résumé

Ce document fait l'analyse de l'électronique développé par Lyrtech dans le cadre du projet Système d'imagerie fusionnée. Dans un premier temps ce document décrit les principales fonctionnalités de chacun des circuits développés pour en faire ressortir les possibilités. Par la suite, dans l'esprit de réutilisation des circuits existants, une série d'option de designs seront présentées. Finalement, en annexe, une série d'images présentant différents affichages pouvant être utilisés dans ce projet.

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1 Electronic

1.1 Board analysis

Lyrtech has designed 4 circuits to make images fusion as well as camera interface to satisfy the requirements of “Système d’image fusionnée” project. These boards are: LYR203-101B, LDA117-101A, LDA118-101A and LDA119-101A. This section aims to describe the main features of these boards.

1.1.1 LYR203-101B (DSP)

This board is the kernel of this project and it contains the DSP (Digital Signal Processor) used to process the fusion. Table 1 expose the main features of this processing board. Figure 1 is a block scheme of LYR203-101B board.

Feature	Value	Comments
Digital Signal Processor(DSP)	TI-TMS320DM648ZUT9	- High performance digital media processor. - 900MHz - 7200 MIPS (Mega instructions per sec.) - Fixed point 32bits - 5 video ports (4 used on LYR203 board) - **Not recommended for new designs** - Pin Compatible with 529 pins TMS320DM648CUT9 or CUTD9
DDR2 Memory	256 Mbytes	2x MT47H16HR 533MHz (500MHz on LYR203)
External Flash	16 Mbytes	This is an SPI memory
Video Ports	4 ports available: - Video 0 and video 1 on J1 - Video 2 and video 3 on P1	Can be configured as: - 2 X 16bits inputs and 2 X 16 bits output (current configuration) (PCLK , HCLK, VCLK, DATA[0:15]) - 2 X 16bits input and 1 32bits output (PCLK , HCLK, VCLK, DATA[0:15])
Serial Communication Ports	- 1 x UART - 1 x SPI - 1 x I2C	These communication ports are available on P2 connector of the LYR203 board.
SGMII (Serial Gigabit Media Independent Interface)	1 x SGMII	Available on P2 connector (Connect on LDA119 board for Ethernet communication)
JTAG	Available on P1	- Daisy chain facility for a LYR203 board stack. - Only one JP1 must be there on the LYR203 board stack for proper daisy chain (last one).
McASP (Multichannel Audio Serial Port)	2 digital serial audio available on J1 and P1	This module support most popular digital audio protocols like TDM, I2S and DIT.
Programmable Clock Generator	CDCE949PW	Can be programmed using TI-ClockPro software via I2C connection available on P2 connector. This Clock generator is used for DDR2 memory, DSP and video clock.

Input Voltage	12V and 3.3V	- Connector J1 and P1 - 12V is the main power - 3.3V comes from another voltage regulator (from LDA117 board). - A 3.3V power good pin in also needed for a proper power sequencing (pin 44 of P2).

Table 1: LYR203-101B Board Feature

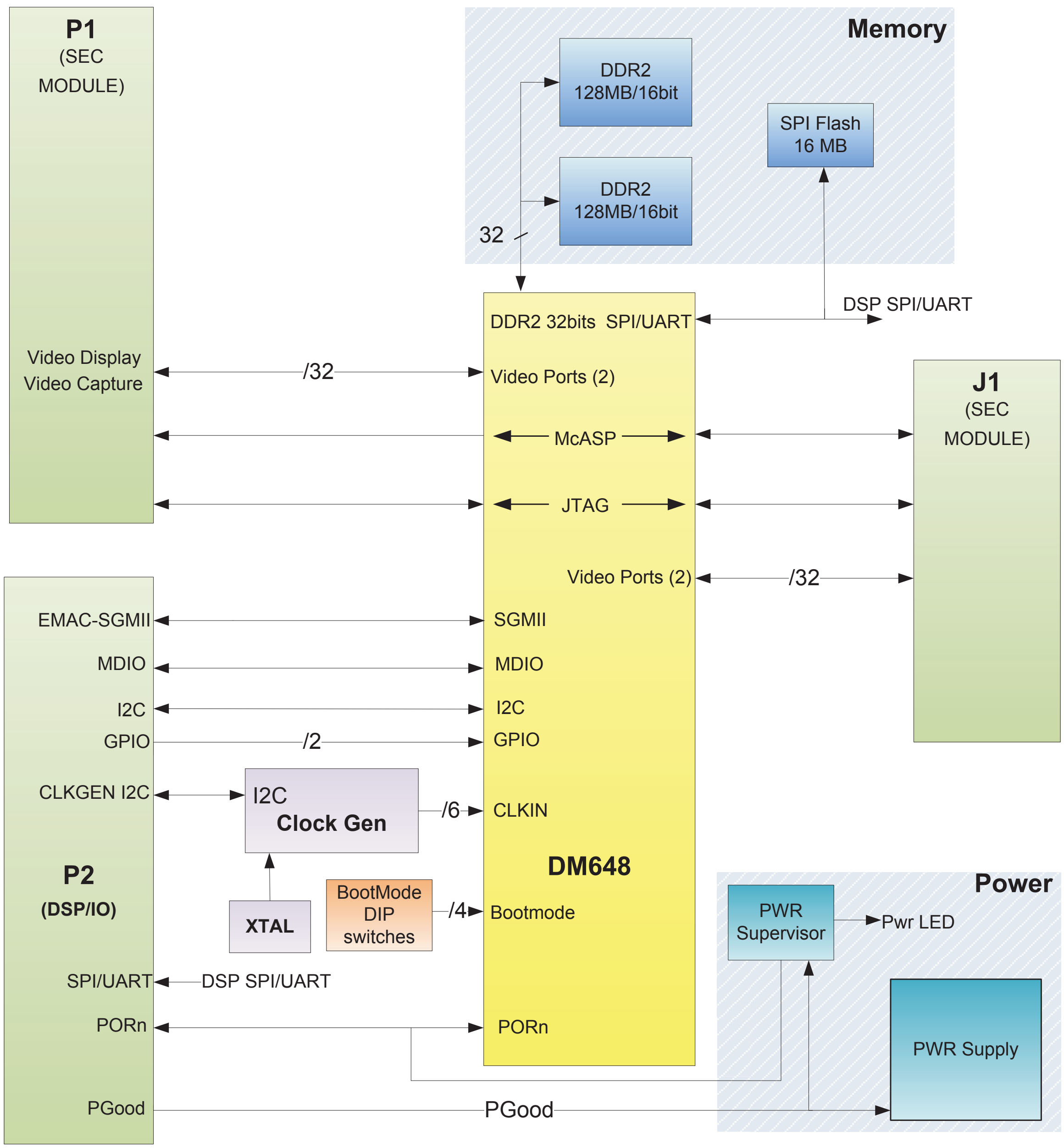

Figure 1: LYR203-101B Block diagram

1.1.2 LDA117-101A

This board is called Capture Board and was built to interface multiple video inputs and outputs. This board is based on an FPGA used to convert standard video input to a raw video format (PLCK, HCLK, VCLK, DATA [0:16]) and send to the processing board. This board also provides the 3.3V power for the LYR203 DSP board. Table 2 exposes the main features of the LDA117-101A board.

Feature	Value	Comments
NTSC/PAL/SECAM input	MiniCoax connector (J4)	The decoder chip is a TVP5150 from TI.
Miricle Bolometer Interface	Flat cable connector (J6)	- 16 bits data output (4-bit nibble form on a rising clock edge). - Power - RS232
Raw Video Port	J1	- Available on J1 connector. - Mate with P1 of LYR203-101B board for DSP video 2 and 3 ports.
FPGA	XC3S400AN	- Xilinx Spartan-3AN family - On chip flash memory for program - 195 user I/O / 90 Differential I/O - 640 Mbps deserialization
USB to UART interface	J5	- This interface is used to communicate with Miricle camera, FPGA, and DSP. - CP2103
I2C Bus	P4	- DSP through J2 - Video Decoder - FPGA
FPGA JTAG	P5	
DSP JTAG	P6	If LDA117-101A is connected to LYR203-101B
LYR203 Clock Gen. I2C	JP1	I2C for LYR203-101B Clock Generator.
12V power input	P3	Power supply for LDA117-101A, LDA118-101A, LDA119-101A and LYR203-101B.
Debug I/O	19 available on P1	Most are configurable in differential I/O
SGMII bridge connector	P2	This connector is used to transfer SGMII connections from LYR203 board to LDA119-101A.
Board Extension Connector	P1 and P2	These connectors are used to connect LDA119-101A Ethernet board.

Table 2: LDA117-101A Board Feature

1.1.3 LDA118-101A

This board is called display board. It can be connected directly to LYR203-101B board to output 2 video signals. Table 3 expose the main features of the LDA118-101A board.

Feature	Value	Comments
2 Raw video input	On connector P2	Mates with LYR203-101B – J1
NTSC/PAL output	RCA connector (J1)	- ADV7171 from Analog Device - Composite(CVBS) ,components S-Video (Y/C), YUV, RGB, component YUV + CHROMA available with board modification
1 Digital Output	Flex cable connector (J2).	- 30 pins 0.5mm pitch FPC, ZIF, Right angle, bottom contact. - Video port 1 from LYR203-101B – J1 - 3.3V and I2C bus also available on this connector.
Photonis camera power supply	Mini USB J3	This is a USB connector but only 5V and GND are connected. This power supply can source 2A max.
I2C Bus	P1	- Video encoder control - DSP I2C bus if P1 connected to P4 from LDA117-101A. A cable is needed to link these connectors.
Programmable video clock generator	I2C connector P3	CDCE913 from TI and can be reprogrammed using TI-ClockPro software via I2C connection. This I2C connection is not shared with the I2C bus.
12V and 3.3V power input	P2	Power supply from LDA117-101A.
1.8V 100mA output power	TP6	This LDO is actually not used by the circuit.

Table 3: LDA118-101A Board Feature

1.1.4 LDA119-101A

This board is called Ethernet board. Initially, Ethernet communication could be in LDA117 board but there was not sufficient space to do that. LDA119-101A is then an extension of LDA117 and provides Gigabit Ethernet communication and easy interface to FPGA debug I/Os. Table 4 expose the main features of the LDA119-101A board. As it can see in Table 5, at this point, no functional Ethernet boards are available, but empty PCBs of this board are available.

Feature	Value	Comments
LDA119-101A Extension connector	J2 and J1	- J1 mates with LDA117-101A – P1 - J2 mates with LDA117-101A – P2
SGMII Input	J2	- Mates with LDA117-101A - P2
Gigabit Ethernet Port	RJ-45 J6	
Debug FPGA I/O	19 available on P1, P2, P3 and P4	- Debug I/O from LDA117-101A via J1 extension connector. - Standard 2.54mm header connector. - Not possible to use in differential since impedance requirement is not meet.
3 DSP GPIO	TP4, TP5, TP6	- Available from J2 extension connector - DSP GPIO from LDA117-101A – P2 if LYR203-101B is connected to LDA117-101A.
12V and 3.3V power input	J1 and J2	Power supply from LDA117-101A.

Table 4:LDA119-101A Board Feature

1.1.5 Stack up

Figure 2 shows the stackup currently provided by Lyrtech. As it can be seen, there is no Ethernet communication board. On the other hand, Figure 3 shows the optional boards stackup with the LDA119-101A Ethernet board.

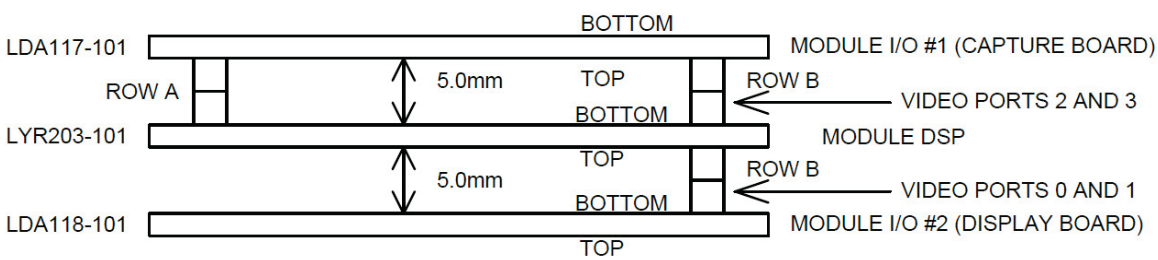

Figure 2 : Current Stackup

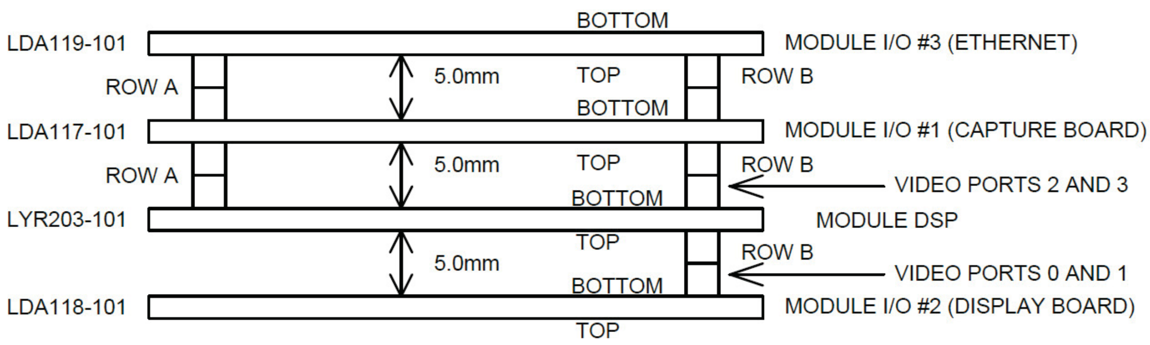

Figure 3: Optional Stackup

1.2 Board Manufacturing

Now the functionalities of each board designed by Lyrtech are well known. Nevertheless it is important to know the availability of the required documentation and/or hardware to manufacture at least another board set since only one sample of each board is available except for the Ethernet one (LDA119-101A) for which there is no sample. It is also important to take note that empty PCB and good documentation to manufacture the processing board (LYR203-101A) are not available. This situation is critical since the design options discussed in this document are based on the LYR203-101A board. Table 5 shows the availability of the critical parts of each board.

Board Name	Up and running	Blank PCB	Available Components	Schematic (P-CAD)	Routing (P-CAD)
LYR203-101B	1	0	0	PDF only	Y*
LDA117-101A	1	>10	0	Y	Y
LDA118-101A	1	>10	0	Y	Y
LDA119-101A	0	>10	0	Y	Y

Table 5: Board Status

∗ PCB routing comes from an unsafe source and validity cannot be verified easily.

1.3 Embedded Software

This document doesn't aim to describe in details the content of the available software. The DSP source code is available (including fusion algorithms), but the VHDL source code for the FPGA isn't. If needed, it would be possible to modify the behavior of the DSP board (LYR203-101B) without the need to rebuild the entire hardware. On the other hand, if modifications need to be done in the FPGA, the entire VHDL code will need to be rewritten from scratch.

Source Code	Availability	Complexity
DSP	Y	High
FPGA	N	Medium

Table 6: Embedded Software Status

Other images fusion and processing algorithms have been developed in the past by Aerex, but DRDC owns the Intellectual Property (IP). Should any new algorithm be implemented in the actual Lyretec system, chances are that an already existing piece of code could be adapted from their former environment (PC) to work on a DSP or a FPGA.

Nevertheless, at least some software will need to be written, no matter which option is chosen. For example, the images from both video sources are not registered and the result of the fusion algorithm flickers too much for a comfortable operation. The registration of the images could be done either in the FPGA or in the DSP, but the flickering would absolutely need to be addressed in the DSP. To make a precise analysis of the required amount of resources needed for the software upgrade, a hardware option would first, need to be selected.

1.4 Development Tools

This section describe contains a list of development tools needed to manufacture, understand, program and change board's behavior of the electronic part of this project.

Tools	Availability	Pricing	Reference
Altium Designer	Y	-	
Code Composer V5	N	795$ for 1 Floating license	http://www.ti.com/tool/ccstudio
Programmer/Debugger for DSP	N	1495	http://www.ti.com/tool/xds560
ISE-WebPack (FPGA)	N	Free	http://www.xilinx.com/products/design-tools/ise-design-suite/ise-webpack.htm
Platform Cable USB II (FPGA)	N	225$	http://www.xilinx.com/products/boards-and-kits/HW-USB-II-G.htm

Table 7: Development Tools

1.5 Design Option

The actual DSP board (LRY203-101B) is a generic and flexible design, so it is easily reusable. So each option presented below is based on the LYR203-101A DSP board. Nevertheless as presented in Table 5, there is only one functional sample on this circuit an no empty available PCB Assuming the fact that it's possible to order LYR203-101B board or at least get manufacturing data like electronic plan, CAD and BOM, this section describes 3 design options using the actual LYR203-101B DSP board. If the Lyrtech DSP board is not available, none of these options is possible since it is not recommended to develop a prototype if the main part of this design comes from an obsolete source. Table 8 compares the 3 options explained below.

1.5.1 Option 1

The actual Display board, the LDA118-101B is designed to output a PAL video signal. Unfortunately, there is no interesting HMD (head mounted display) who take PAL as video input. Because of this issue, a new display board replacing the actual LDA118-101A should be developed. This new board should receive 2 video signals from LRY203-101B board and should provide an HDMI/DVI and/or an analog VGA display output. This board should interface LYR203-101B DSP board with display device like LUMUS display or MRAdigital OLED driver (for eMagin SXGA OLED). This option gives the possibility to interface standard display for the HMD evaluation phase of this project. Nevertheless, this option is not recommended since there is no possibility to capture video from a camera-link camera which is expected to be used in the next generation design.

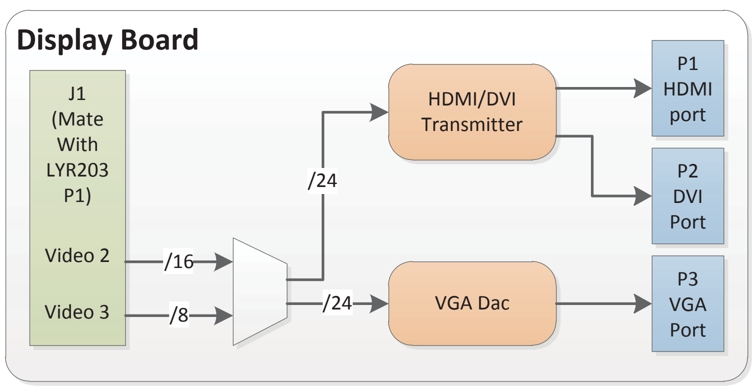

Figure 4: Option 1

1.5.2 Option 2

Develop a new display board as describe in option 1 and develop a new capture board replacing the actual LDA117-101A. This new capture board should have 4 video inputs: 2 Camera-Link Base, 1 analog input and 1 Miricle-LVDS. This board should capture video signal from a combination of 2 video inputs and should provide the captured video signals to the LYR203-101B DSP board. This option is more expensive and more complicated than option 1, since the capture board has a section that requires VHDL programing.

An additional benefit of this option is to program the FPGA to do some basic pre-processing on the input images to remove these functions from the DSP to let more process power for the fusion algorithms. The most obvious function would be to do the images registration and bit alignment on the images to provide the DSP with two registered images of the same format (width, height, bit depth).

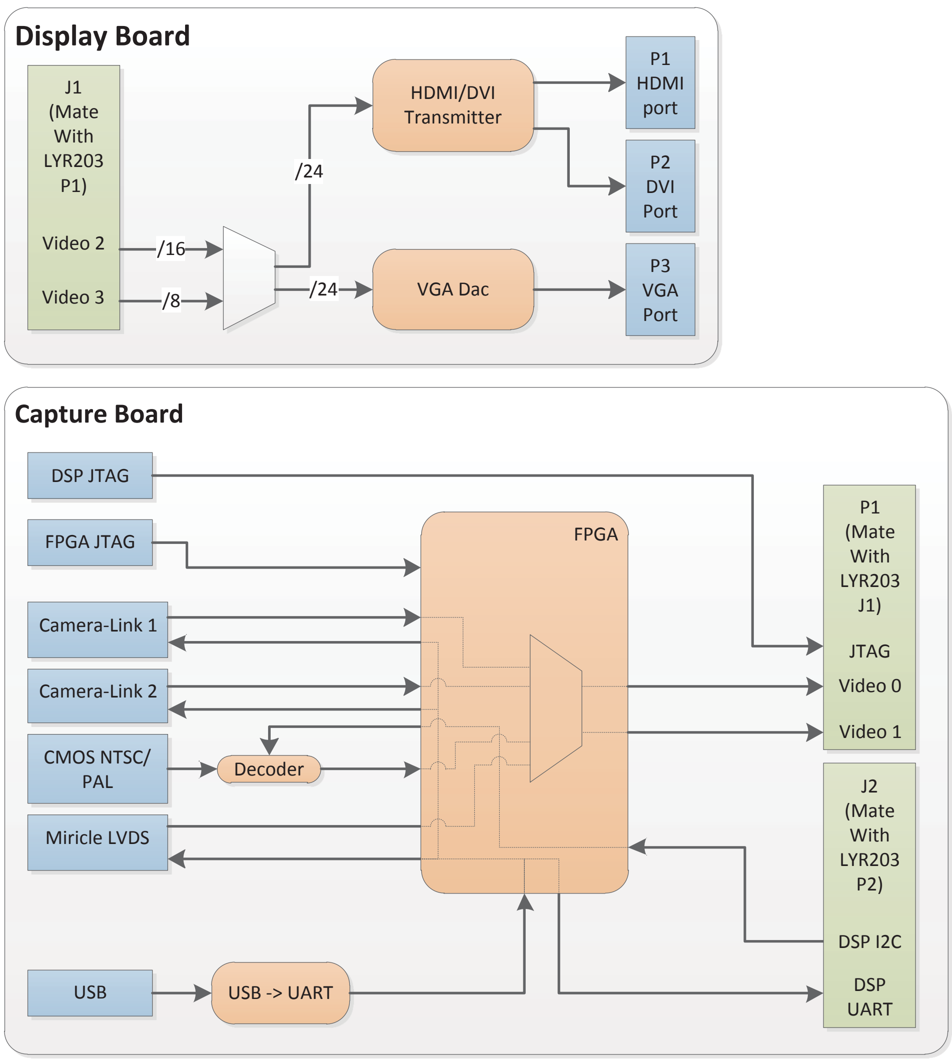

Figure 5: Option 2

1.5.3 Option 3

Develop a new capture board as describe in option 2 anddevelop a new display board as describe in option 1 plus another video output like NTSC/PAL, S-Video and composite. This new display board should also interface directly the eMagin XVGA OLED display without the MRAdigital driver. This option is more complicated than option 2 since eMagin display require complex digital and analog interface where timing is very important.

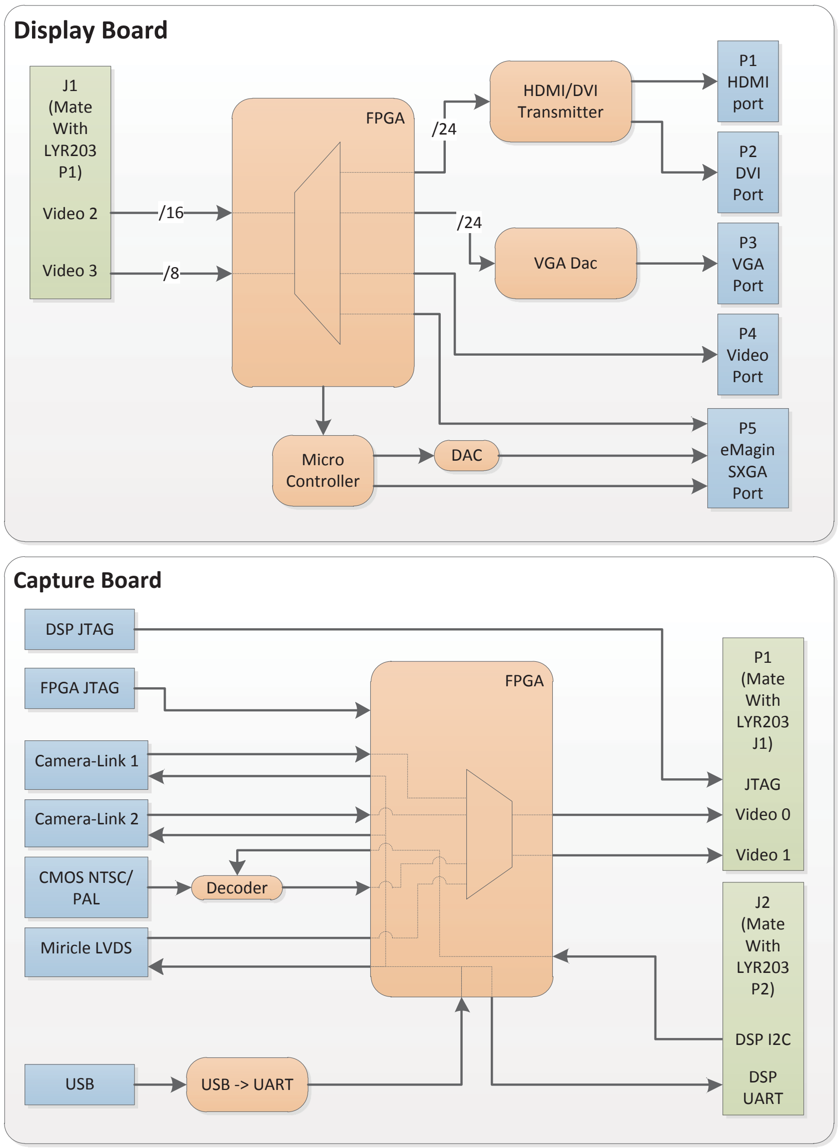

Figure 6: Option 3

Feature	Current Version	Option 1	Option 2	Option 3
Input				
Camera Link1 (Base)	N	N	Y	Y
Camera Link2 (Base)	N	N	Y	Y
NTSC/PAL	Y	Y	Y	Y
Miricle LVDS 4x4Bits	Y	Y	Y	Y
Output				
HDMI	N	Y	Y	Y
DVI	N	Y	Y	Y
Digital RGB 8bits (3 x pclk)	Y	Y	Y	Y
Digital RGB 16bits (3 x pclk)	Y	Y	Y	Y
Digital 8bits YCrCb (ITU-R Bt.656)	Y	Y	Y	Y
Digital 8bits Y/C	Y	Y	Y	Y
Digital 24bits (RGB parallel)	N	Y	Y	Y
SVGA (800x600)	N	Y	Y	Y
XVGA (1280x1024)	N	Y	Y	Y
PAL	Y	N	N	Y
NTSC	N	N	N	Y
S-Video	N	N	N	Y
Component YCrCb	N	N	N	Y
Component RGB	N	N	N	Y
eMagin XVGA Interface	N	N	N	Y
MRA OLED Driver board (Analog VGA/HDMI)	N	Y	Y	Y
Impact Assessment				
Cost	Null	Low	Medium	High
Time	Null	Low	Moderate	High
Complexity	Null	Low	High	High

Table 8: Design Option comparison

1.6 Cost Analysis

In this section the cost of each board will be presented[1]. There is the basic version of the display board used in option 1 and 2 describe before, the complex version of the display board used by option 3 and the capture board used in 3 options described before.

1.6.1 Display Board (Basic Version)

This version of the display is used by the option 1 and 2 and able to output video format (VGA, DVI and HDMI) for standard HMD device. Table 9 shows development cost estimation for this board. The total cost for this board is approximately $58K and based on the **pessimistic** assessment of the effort required. It **excludes** the cost of material, software development, system integration and validation.

	Time (month)	Effort (person-month)
Design	2	2
PCB Fabrication	1	
PCB Assembly	0.5	
Design (final version)	1	1
PCB Fabrication (final version)	1	
PCB Assembly (final version)	0.5	
Total	6 (3 - 9)	3 (1.5 – 4.5)

Table 9: Display Board (Basic Version)

1.6.2 Display Board (Complex Version)

This version of the display is used by the option 3 and able to output video format (VGA, DVI and HDMI) for standard HMD device and able to interface a micro display (eMagin and Microoled) without extra driver board. Table 10 shows development cost estimation for this board. The total cost for this board is approximately $211K and based on the **pessimistic** assessment of the effort required. It **excludes** the cost of material, software development, system integration and validation.

	Time (month)	Effort (person-month)
Design	3	3
PCB Fabrication	1	

[1] The costs presented here are an approximation of the effort required to design and build each board, and should not be considered as a formal offer of service.

PCB Assembly	0.5	
Design (final version)	1	1
PCB Fabrication (final version)	1	
PCB Assembly (final version)	0.5	
VHDL Programming	3 (begin before HW avail)	6
uController Programming	1	1
Total	8 (4 - 12)	11 (5.5 – 16.5)

Table 10: Display Board (Complex Version)

1.6.3 Capture Board

This board is used by option 2 and 3 and has 4 video inputs (Miricle-LVDS, Analog video (NTSC/PAL) and Camera Link (Base) x2). Table 11 shows development cost estimation for this board. The total cost for this board is approximately $154K and based on the **pessimistic** assessment of the effort required. It **excludes** the cost of material, software development, system integration and validation.

	Time (month)	Effort (person-month)
Design	3	3
PCB Fabrication	1	
PCB Assembly	0.5	
Design (final version)	1	1
PCB Fabrication (final version)	1	
PCB Assembly (final version)	0.5	
VHDL Programming	1 (begin before HW avail)	4
Total	8 (4 - 12)	8 (4 - 12)

Table 11: Capture Board

The cost for the different options described in chapter 1.5 still not including the cost of material, software development, system integration and validation, would be as follow[2]:

Option 1	
Display board (basic version)	$57,595.05
	$57,595.05
Option 2	
Capture Board	$153,586.80
Display board (basic version)	$57,595.05
	$211,181.85
Option 3	
Capture board	$153,586.80
Display board (complex version)	$211,181.85
	$364,768.65

[2] See Annex C for detailed calculations.

1.7 Other possible optional upgrades

Other upgrades are possible to the system. Not all those upgrades are available with all options. The cost to include those options isn't included in section 1.6.

Among other possible options:

1. Using multiple DSP boards to increase performance;
2. Build a simple remote control, either wired or wireless;
3. Use a touch interface (smartphone, tablet) to make a remote control;
4. Add a RF emitter to display the fused image remotely.

1.8 Conclusion

In the framework of "Système d'imagerie fusionnée" project, Lyrtech has developed 4 different electronic boards: LYR203-101B, LDA119-101A, LDA118-101A and the LDA119-101A. In this document these boards have been analysed resulting 3 design options using the current LYR203-101B board without hardware modifications. It is important to note that these options are based on the fact that it will be possible to get new LYR203-101B board or at least the possibility to manufacture it.

Based on a new display board providing HDMI/DVI and analog VGA outputs, the first option is the inexpensive solution. The advantage of this option is essentially the low price. Nevertheless since this option keep the actual capture board; it will not be possible to interface a Camera-link sensor. Also, an extra driver board should be used to interface a micro-display like eMagin or Microoled display. The second one is based on the display board of the option 1 and a new capture board receiving 2 Camera-link, 1 video analog, and 1 Miricle LVDS. The biggest advantage of this option is to be able to interface 2 Camera-link sensor and output a standard video format for the HMD. As the option one, an extra driver board should be used to interface a micro-display like eMagin or Microoled display. The last option is based on option 2 with a new display board providing HDMI/DVI, analog VGA, video analog, and eMagin SXGA oled outputs. As option 2 this option is able to capture 2 camera-link sensors. The advantage of this option is to be able to interface ether standard HMD or our HMD based on an eMagin SXGA or Microoled SXGA oled display. Unfortunately, this option is more expensive that the other one. Depending of what will be the requirements of the final system, we suggest the option 2, because of the Camera-Link interface which offers greater camera choices. Also option 2 offers more flexibility to evaluate most displays on the market without developing an FPGA based display board.

Annex A Display devices

A.1 eMagin

http://www.emagin.com/

Figure 7: SVGA/SXGA micro Oled

Figure 8:Z800 3DVISOR from eMagin (SVGA)

Figure 9: WFO5 PRISM OPTIC & MODULE From emagin (SVGA)

A.2 MRAdigital

http://mradigital.com/

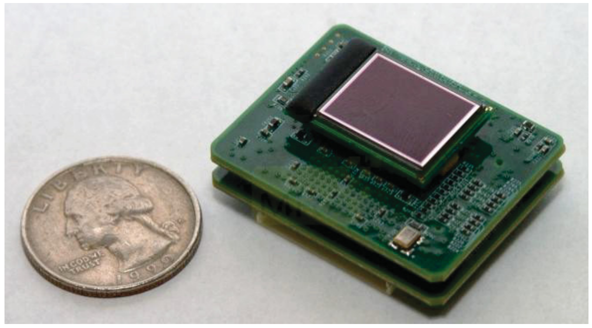

Figure 10: SXGA-1012SD Driver Boardfrom MRAdigita for eMagin SXGA OLED (VGA/HDMI)

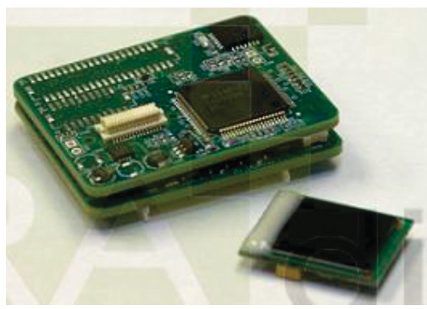

Figure 11: SVGA-800S Driver from MRAdigital for eMagin SVGA oled (analog VGA)

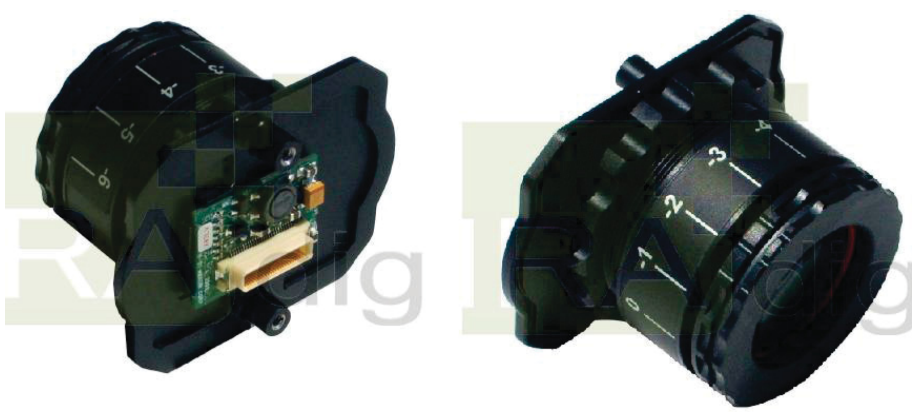

Figure 12: SXGA-eyeMod50 from MRAdigital

A.3 Rockwell Collin

http://www.rockwellcollins.com/Products_and_Systems/Displays/Soldier_Displays.aspx

Figure 13: Rockwell Collins MicroView 35 HMD MV35 (SVGA)

Figure 14: Rockwell Collins ProView PV35 (SVGA or NTSC)

A.4 Liteye

http://www.liteye.com/

Figure 15: LE 750A/700A from Liteye (VGA/SVGA or NTSC)

Figure 16:LE 720A form Liteye VGA/SVGA or NTSC)

A.5 LUMUS

http://www.lumus-optical.com/

OE-32
Specifications

Display format	720p 1280 x 720 pixels
Field of View	40°
Virtual screen size	Equivalent of 87" screen at 10 ft away; 870" at 100 ft away
Eye motion box	10 x 8 mm
Display color	Full color
Transparency	>78%
Brightness	>1,000 FtL
Contrast ratio	>250:1
Eye relief	22 mm
Weight	26g
LOE thickness	1.6 mm

Figure 17: LUMUS OE-32

OE-31
Specifications

Display format	nHD 640 x 360 pixels
Field of View	19°
Virtual screen size	Equivalent of 40" screen at 10 ft away; 400" at 100 ft away
Eye motion box	10 x 4 mm
Display color	Full color
Transparency	>78%
Brightness	>1,000 FtL
Contrast ratio	>250:1
Eye relief	18 mm
Weight	10g
LOE thickness	1.6 mm

Figure 18: LUMUS OE-31

Wearable Display Development Kit

To facilitate and expedite the design and experience-building process for customers manufacturing Lumus-enabled products, Lumus offers a development kit. In addition, Lumus offers its reference design material which includes industrial, mechanical and electrical designs. These elements aid in stimulating design ideas and enable OEM customers to benefit from Lumus' experience in solving critical challenges and reducing time-to-market.

DK-32
Currently, Lumus is offering its latest development kit the DK-32 to select OEM customers. The kit consists of a binocular set of the OE-32 Optical Engine modules embedded in a prototype frame with electronics, enabling the display of 720p resolution in 3D and receiving HDMI input.

Figure 19: LUMUS Development Kit

Annex B   Display Formats

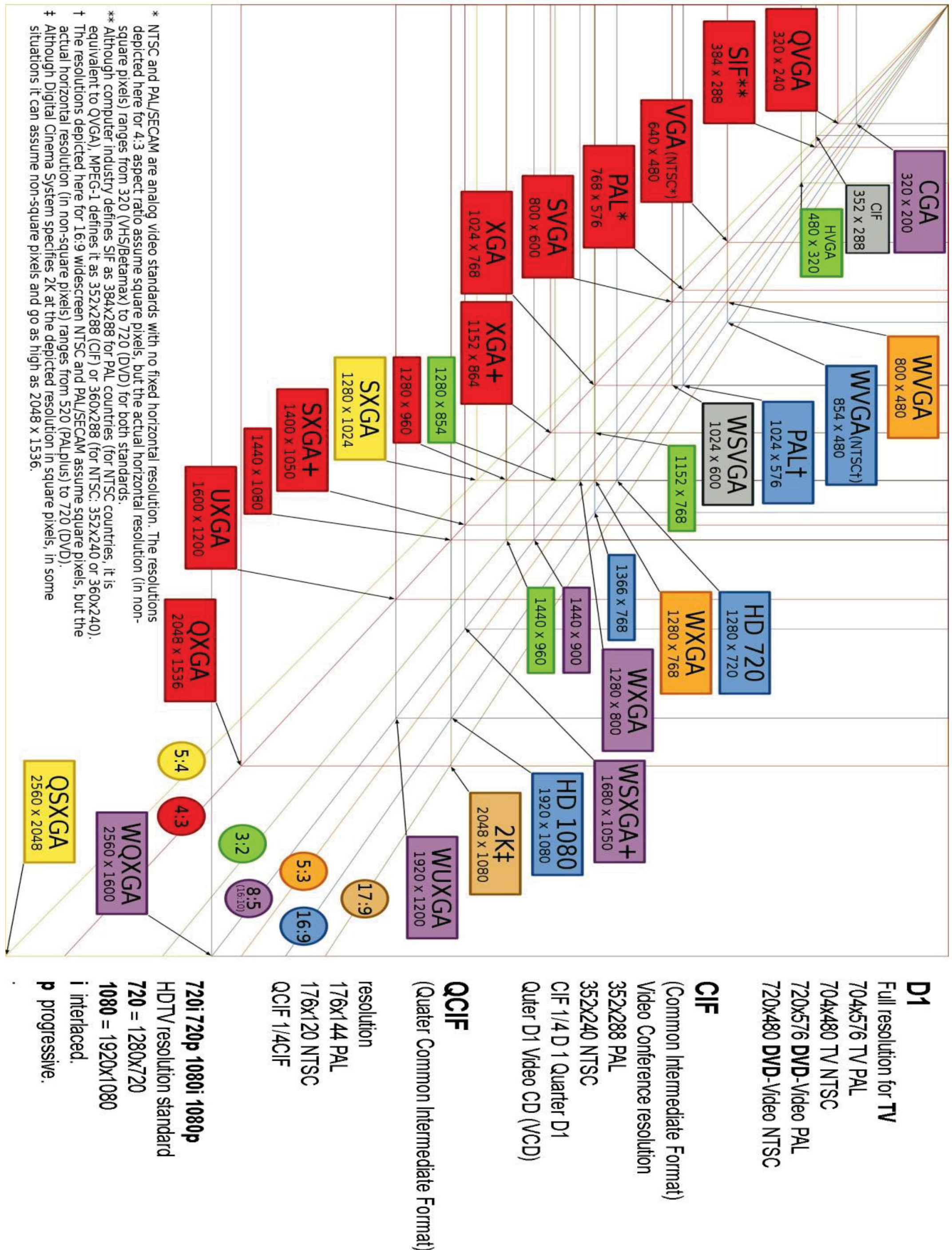

Figure 20:Resolution Chart

Annex C Cost analysis breakdown

Display Board (Basic Version)	Time (month)	Effort (person-month)	Day	Cost
Design	2	3.5	70	$44,796.15
PCB Fabrication	1		0	$0.00
PCB Assembly	0.5		0	$0.00
Design (final version)	1	1	20	$12,798.90
PCB Fabrication (final version)	1		0	$0.00
PCB Assembly (final version)	0.5		0	$0.00
			0	$0.00
Total	6 (3 - 9)	3 (1.5 – 4.5)		$57,595.05

Display Board (Complex Version)	Time (month)	Effort (person-month)	Day	Cost
Design	3	6.5	130	$83,192.85
PCB Fabrication	1		0	$0.00
PCB Assembly	0.5		0	$0.00
Design (final version)	1	2	40	$25,597.80
PCB Fabrication (final version)	1		0	$0.00
PCB Assembly (final version)	0.5		0	$0.00
			0	$0.00
VHDL Programming	3 (begin before HW avail)	6	120	$76,793.40
uController Programming	1	2	40	$25,597.80
			0	$0.00
Total	8 (4 - 12)	11 (5.5 - 16.5)		$211,181.85

Capture Board	Time (month)	Effort (person-month)	Day	Cost
Design	3	4	80	$51,195.60
PCB Fabrication	1		0	$0.00
PCB Assembly	0.5		0	$0.00
Design (final version)	1	2	40	$25,597.80
PCB Fabrication (final version)	1		0	$0.00
PCB Assembly (final version)	0.5		0	$0.00
			0	$0.00
VHDL Programming	1 (begin before HW avail)	6	120	$76,793.40
			0	$0.00
Total	8 (4 - 12)	8 (4 - 12)		$153,586.80

Option 1	
Display board (basic version)	$57,595.05
	$57,595.05
Option 2	
Capture Board	$153,586.80
Display board (basic version)	$57,595.05
	$211,181.85
Option 3	
Capture board	$153,586.80
Display board (complex version)	$211,181.85
	$364,768.65