

Buses, Boards & Embedded Design Considerations

**World Markets, User Perspectives and Significant
Trends**

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AGENDA



Market Research - HOWZITDONE


**A Look at Current & Forecast World Markets
for Merchant Computer Boards**

**Follow the Money - Opportunities in
Telecom**

Design Starts, Completions & Cancellations

Listening to Your Customers

Whatzitall Mean?



“In this new Internet society, customer expectations and what they pay for – where they view added value vs. what commoditizes – are going to change so rapidly, any company and any industry that doesn’t have its finger on the customer will be left behind.”

John Chambers, Cisco, Inc.

CEO

Qualifying Embedded Developers for User Survey



- Use *Embedded Systems Programming* Magazine Qualified Subscriber List
- 65,000 Embedded Developers Involved in the Purchase of Embedded Systems, Tools or Hardware
- 67% of Subscribers Have EE Degrees - 53% of Subscribers Call Themselves Software Engineers
- 79% are involved in hardware/software integration
- List is Filtered for Specific Embedded Developers who fit Survey Profile
- Nth Name Selection Process To Insure Randomness
- 95% Statistical Confidence Level

Questions Asked of Embedded Developers



- **Design Considerations**
 - **Source of design idea**
 - **Selection of microprocessor, OS and tools**
 - **Allocation of design and development time**
 - **Host & target platforms used**
 - **etc.**
- **Microprocessor considerations**
 - **Preference, intended replacement, etc.**
- **Design Starts**
 - **8-bit, 16-bit, 32-bit, 64-bit, etc.**

Counting the Beans



- **Counting Boards - not Systems**
- **TAM versus SAM - Why It's Important to Present Competitive Opportunities**
- **Excluding CEMs**
- **Exceptions for Custom cPCI**
- **End-to-End Solutions - Value Packaging, the New Embedded Opportunity**



**Worldwide Markets for
Embedded Technologies
Cannot be Determined by
Surveys of Embedded
Developers**

FOR WHAT BUS ARCHITECTURE IS YOUR EMBEDDED DESIGN INTENDED?

	AUTO	COMPTR	CONSMR	DATA-	ELCTRN	INDUST	MEI		
	TRANS-	AVION-	PERIPH	ELECT-	COM/	INSTRM	AUTOMN		
	TOTAL	PORTN	ICAL	ICAL	NETWKG	DEVICE	CONTLS		
	-----	-----	-----	-----	-----	-----	-----		
TOTAL ANSWERING	282	12	15	13	14	21	21	51	100
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
PCI	65	2	5	7	6	9	4	6	26
	23.0	16.7	33.3	53.8	42.9	42.9	19.0	11.8	26
VME	44	1	3	-	1	2	1	3	5
	15.6	8.3	20.0		7.1	9.5	4.8	5.9	5
ISA	24	-	-	1	1	1	2	9	10
	8.5			7.7	7.1	4.8	9.5	17.6	10
PC/104	24	1	2	1	-	1	4	7	10
	8.5	8.3	13.3	7.7		4.8	19.0	13.7	10
PC/AT	23	1	-	-	2	-	2	7	26
	8.2	8.3			14.3		9.5	13.7	26
COMPACPCI	18	-	-	-	2	4	-	2	
	6.4				14.3	19.0		3.9	
OTHER	84	7	5	4	2	4	8	17	21
	29.8	58.3	33.3	30.8	14.3	19.0	38.1	33.3	21

FOR WHAT BUS ARCHITECTURE IS YOUR EMBEDDED DESIGN INTENDED?

	TOTAL	AUTO TRANS- PORTN	AVION- ICS	COMPTR PERIPH ERAL	CONSMR ELECT- NICS	DATA- COM/ NETWKG	ELCTRN INSTRM DEVICE	INDUST AUTOMN CONTLS	MEI CAL
TOTAL ANSWERING	282 100.0	12 100.0	15 100.0	13 100.0	14 100.0	21 100.0	21 100.0	51 100.0	100
PCI	65 23.0	2 16.7	5 33.3	7 53.8	6 42.9	9 42.9	4 19.0	6 11.8	26
VME	44 15.6	1 8.3	3 20.0	-	1 7.1	2 9.5	1 4.8	3 5.9	5
ISA	24 8.5	-	-	1 7.7	1 7.1	1 4.8	2 9.5	9 17.6	10
PC/104	24 8.5	1 8.3	2 13.3	1 7.7	-	1 4.8	4 19.0	7 13.7	10
PC/AT	23 8.2	1 8.3	-	-	2 14.3	-	2 9.5	7 13.7	26
COMPACPCI	18 6.4	-	-	-	2 14.3	4 19.0	-	2 3.9	
OTHER	84 29.8	7 58.3	5 33.3	4 30.8	2 14.3	4 19.0	8 38.1	17 33.3	21

HOW IMPORTANT IS THE MICROPROCESSOR USED IN YOUR DECISION TO PURCHASE DEVELOPMENT TOOLS?

TYPE OF ENGINEER EMPLOYEES AT LOCAT'N SHIPPING STATUS OF PROJECT

	HARD- TOTAL WARE	SOFT- WARE	SYS- WARE	UNDER TEMS	100- 100	1000- 999	WITHIN PLUS	WITHIN 12 MOS	WITHIN 18 MOS	WITHIN 24 MOS	BEYOND 24 MOS
TOTAL ANSWERING	581	148	292	131	207	252	121	318	53	11	10
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
VERY IMPORT=7	187	49	95	42	70	70	47	104	19	6	4
	32.2	33.1	32.5	32.1	33.8	27.8	38.8	32.7	35.8	54.5	40.0
=6	173	48	79	44	52	83	38	91	14	3	4
	29.8	32.4	27.1	33.6	25.1	32.9	31.4	28.6	26.4	27.3	40.0
=5	115	30	61	21	47	48	19	63	13	1	-
	19.8	20.3	20.9	16.0	22.7	19.0	15.7	19.8	24.5	9.1	
=4	61	13	31	16	21	30	10	38	6	-	-
	10.5	8.8	10.6	12.2	10.1	11.9	8.3	11.9	11.3		
=3	23	4	13	4	6	12	5	12	1	-	2
	4.0	2.7	4.5	3.1	2.9	4.8	4.1	3.8	1.9		20.0
=2	11	2	7	2	4	6	1	4	-	1	-
	1.9	1.4	2.4	1.5	1.9	2.4	0.8	1.3		9.1	
NOT IMPORT =1	11	2	6	2	7	3	1	6	-	-	-
	1.9	1.4	2.1	1.5	3.4	1.2	0.8	1.9			
STATISTIC BASE	581	148	292	131	207	252	121	318	53	11	10
MEAN	5.62	5.75	5.57	5.69	5.57	5.55	5.87	5.63	5.83	6.09	5.80
MEDIAN	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	7.00	6.00



Worldwide Market for Embedded Merchant Computer Boards

Leading Board Vendors - 2000



VME

Motorola

Mercury

Cognex

Force

SBS

DY 4

cPCI

Force

Intel/Ziatech

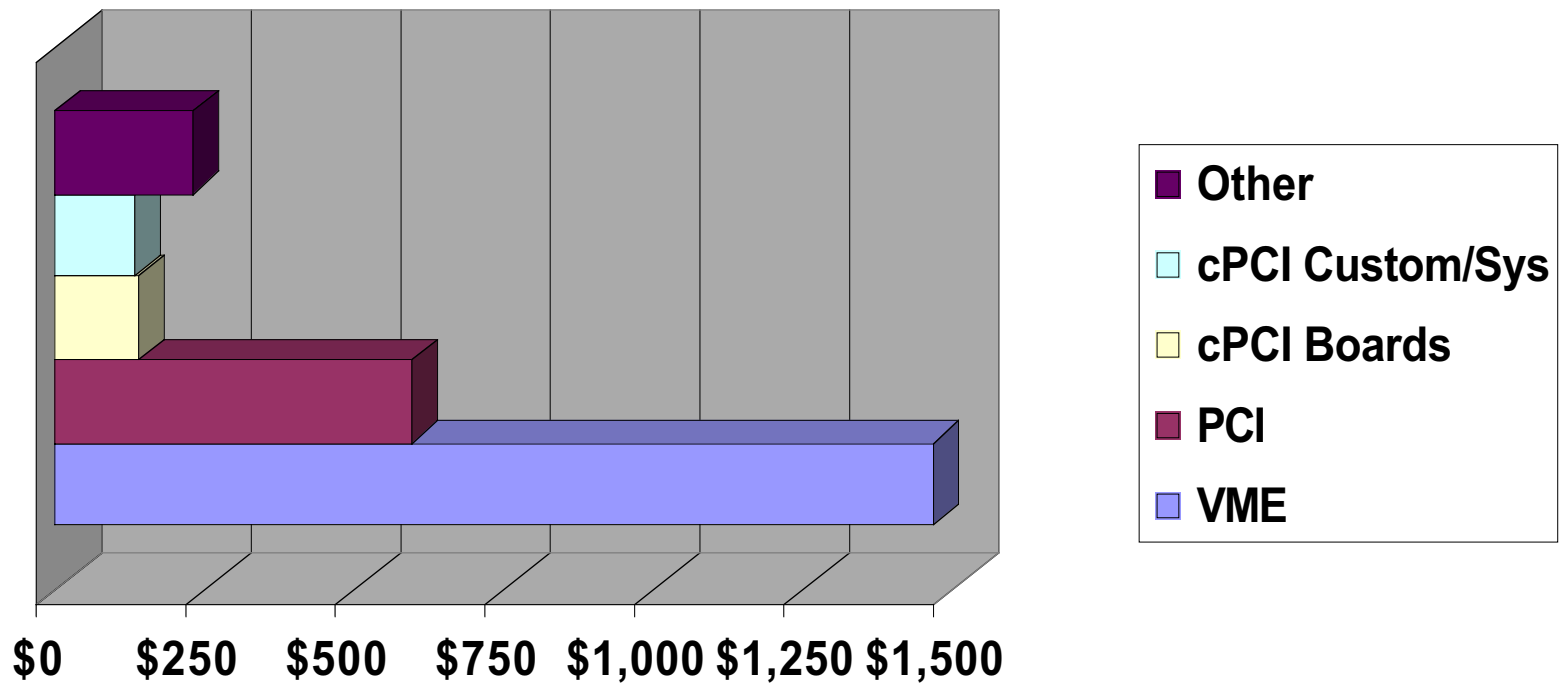
RadiSys

SBS

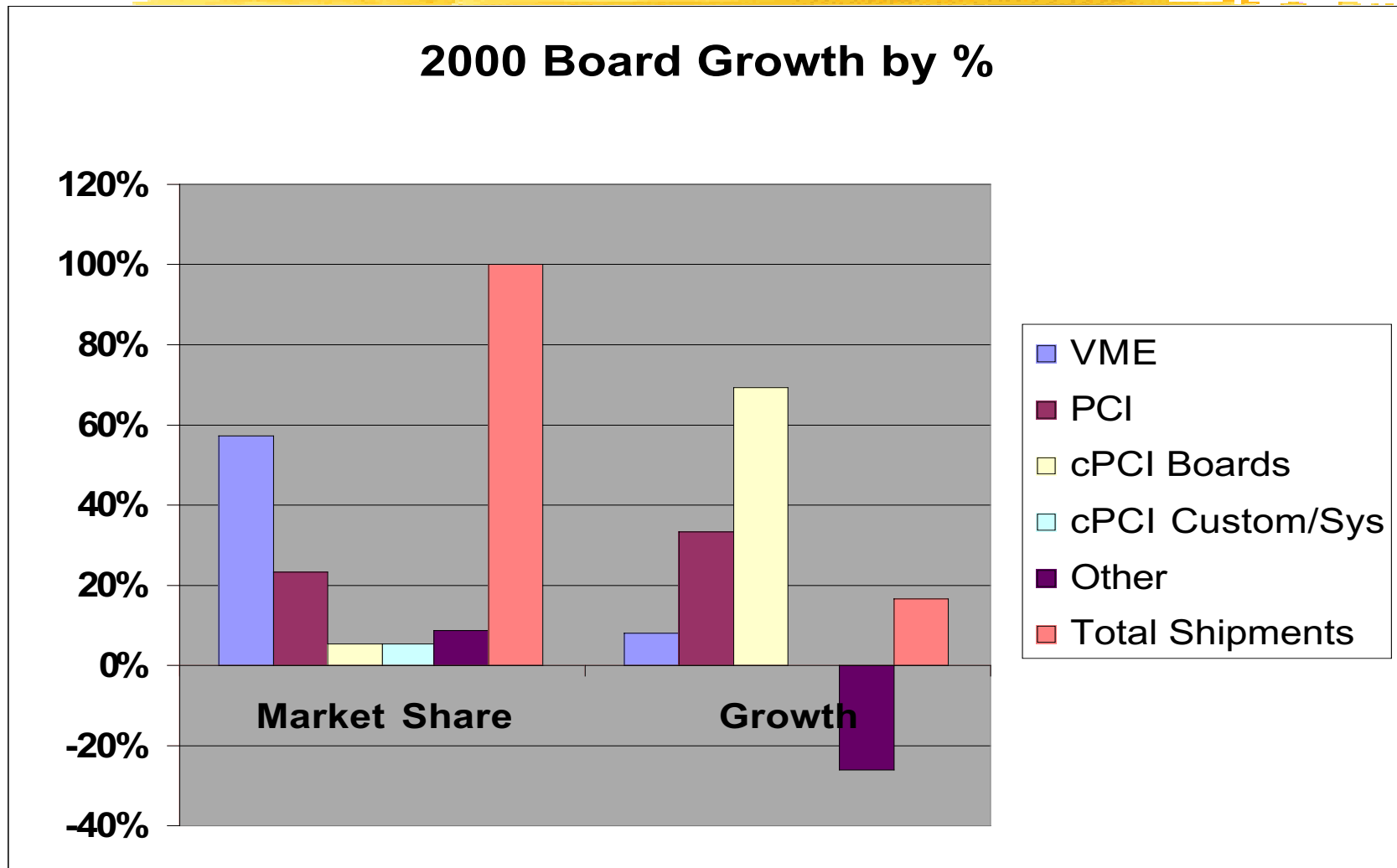
Natural Micro

2000 Embedded Board Shipments (\$millions)

2000 Board Shipments = \$2.55 Billion



Market Share and Growth by Bus



Forecast: Merchant Computer Boards

	2000	2001	2002	2003	CAGR
VME	\$1,462.9	\$1,695.0	\$1,859.4	\$2,039.8	11.7%
PCI	\$593.2	\$721.9	\$878.6	\$1,069.2	21.7%
cPCI Boards	\$136.1	\$167.3	\$205.6	\$252.6	22.9%
cPCI Custom/Sys	\$130.6	\$182.8	\$256.0	\$358.4	40.0%
Other	\$229.8	\$186.8	\$151.9	\$123.5	-18.7%
Total Shipments	\$2,552.6	\$2,953.9	\$3,351.4	\$3,843.5	14.6%

Microprocessor Preferences for Embedded Design



- **8-bit**
 - **Motorola (net) - 43.3%**
 - **Intel (net) - 38.7%**
 - **Microchip (net) - 33.6%**
- **16-bit**
 - **Intel (net) 34.6%**
 - **Motorola (net) - 22.4%**
 - **AMD 186/188 - 11.4%**
- **32-bit**
 - **Intel (net) - 43.4%**
 - **Motorola (net) - 42.8%**

Embedded Developers Speak out on:



*** Design**

Starts/Failures/Delays

- * How Design Completions
Compare with Expectations**
- * Problems with Hardware-
Software Integration**

Design Starts



- **On average, each embedded developer starts 2.5 projects per year**
- **On average, there are 6.8 developers per project**
 - **Assume 225,000 embedded developers worldwide (based upon Adams research - ESP)**
 - **These data would predict that there are some 82,720 embedded projects launched annually**
- **On average, 8% of these embedded designs are outsourced**

Looking at Design Starts

	Total			
Design Starts	Embedded	VME	PCI	cPCI
# design starts/developer/year	2.5	3.7	4.5	7.8
Ave # of developers/proj	6.8	8.6	8.1	10.3
Total # of emebdded developers	225000	26101	35146	9390
Number of Design Starts	82721	11230	19526	7111
% Outsourced	8.0%	9.8%	6.6%	7.0%

Design Delays and Cancellations



- **On average, 16.7% of embedded projects are completed ahead of schedule**
- **On average, 57.9% of embedded projects finish behind schedule**
 - **The average project delay is 3.8 Months**
- **On average, 18.4% of projects are cancelled**
- **On average, 5 months elapse between the onset of an embedded design and its cancellation**

Design Completions

	Total			
Delays/Cancellations	Embedded	VME	PCI	cPCI
# completed ahead of schedule	16.7%	18.5%	20.0%	26.1%
# completed behind schedule	57.9%	55.5%	51.0%	50.0%
Ave project delay (months)	3.8	4.7	4.1	3.1
# designs cancelled	18.4%	16.5%	21.2%	22.2%
Project length before cancelled	5.0	5.4	4.9	5.5

Leading Reasons for Embedded Design Cancellation



- **Emergence of Higher Priorities**
 - **Customer Changed Project Requirements**
- **“Change in Company Focus”**

**How Final Design
Compares with
Expectations in
Performance, System
Functionality, Features
& Scheduling**

Performance



- **17.4% of Completed Designs are within 10% of Expectation**
- **37.7% of Completed Designs are NOT within 30% of Expectation**
- **20.3% of Completed Designs are NOT within 50% of Expectation !**

Systems Functionality




- **25.9% of Completed Designs are within 10% of Expectation**
- **37.8% of Completed Designs are NOT within 30% of Expectation**
- **22.8% of Completed Designs are NOT within 50% of Expectation**

Features & Schedule



- **11.0% of Completed Designs are within 10% of Expectation**
- **45.0% of Completed Designs are NOT within 30% of Expectation**
- **21.0% of Completed Designs are NOT within 50% of Expectation !**



**Developers Options When
Expectations for
Performance,
Functionality, Features &
Scheduling are NOT
within Acceptable Ranges**

Embedded Developer Options



- **Slip Schedule - 72.8%**
- **Remove Features (HW & SW) - 56.0%**
 - **Rewrite Minor SW Modules - 47.7%**
- **Apply Additional Resources to Project - 37.3%**
- **Modify Minor HW Subcomponents - 29.1%**
 - **Rewrite Major SW Modules - 27.2%**

Greatest Challenges in Getting Software Project on track Prior to Hardware Availability



- **Constant changes in Hardware Specification**
- **Difficulty in Identifying Timing-Based Errors**
- **Difficulty Prioritizing SW Elements based on Uncertain Schedule**
- **Effort to Simulate HW/External Events at Cost of Implementation**
- **Difficulty Fixing Design w/o Prediction of Performance**
 - **Difficulty in Identifying Unlikely Occurrences**
 - **No Visibility into Hardware Specification**

Following the Telecom Food Chain



Examples of Embedded Opportunities

Show Me the Money



- **At the Source (PSTN Switches, Cellular, Wireless)**
- **Transport (SS7, ATM, FR, SONET, Optical Fiber, WAP, Bluetooth)**
- **Infinite Bandwidth Creates Significant Markets for Products that Waste Bandwidth**
- **Huge Bandwidth necessitates the need for and Creates Markets for STORAGE and Enhanced RETRIEVAL Systems (goodbye Client-Server)**
- **In the New Telecom Space OSes become Commoditized and New Opportunities are Created for API Developers**

stay with me ...



- **In order for a Hugely Expanding Marketplace to Grow Pervasively, Professional Associations MUST Grow to Enact and Protect Standards**
- **For Complex Telecom Systems, “Proof of Performance to the Standard” must be assured before Deployment - Hello to Simulation-Modeling Test Requirements**
- **Technologies and Systems Designed for Telecom will have application in Other Embedded Market Segments (e.g., Automotive-MBD, Medical, Avionics, etc.)**

bringing it home ...



- **Polyopoly Markets (in which no one company or select few companies can dominate) will thrive, providing the need for Niche Products (at desirable Gross Margins) to be developed by an expanding market presence**
- **Partnerships make the Best Business sense as Collaboration Increases Business Opportunities**
- **Commoditized Markets will Starve as Alternative Technologies and Solutions are Sought**

wrapping it up ...



**EMF anticipates that within the next
Three Years, Convergence Partnering
will become the Dominant Market
Strategy as the Internet Creates
Expanding Opportunities across
Parallel Market Segments**

What your Customers are Thinking and Saying

Issues That Affect Merchant
Board Utilization and
Purchasing

What are the Biggest Problems with Hardware-Software Integration?



- Limited Visibility into the Complete System (65%)
- Limited Ability to Trace (54%)
- Limited Ability to Control Execution (42%)
- Significant Intrusiveness Into the System (40%)

Who is PRIMARILY Responsible for the Purchasing Decision?



- Responsible Engineer (can be hardware, software or systems) -54%
- Project Mgr. -25%
- Group Mgr. -16%

Number of Units Shipped over the Life of the Product



- 23% of embedded designs shipped 100 or less units
- 42% of embedded designs resulted in shipments of 1000 units or less
- 16.7% of embedded designs shipped between 10,000 and 50,000 units
- 4.7% of embedded designs resulted in shipments of 1 million units or greater

Most Important Factors in Selecting MCU, MPU or DSP



- Software development tools available
- Price
- Available I/O
- Code compatibility
- Hardware development tools available
- Familiarity with architecture/instruction set

Most Important Factors in Selecting a Single Board Computer



- Software & development tools available (tied)
- Performance (tied)
- Available I/O
- Price
- Processor on board
- Documentation
- Company reputation

Wrapping it Up



Some Final Thoughts

Thoughts From the Embedded Cowboy



Always Drink Upstream from the Herd!

Thoughts From the Embedded Cowboy



Don't Squat with Your Spurs On

Thoughts From the Embedded Cowboy



**If at First you don't Succeed -
Check to see if the Loser gets
Anything**

Thoughts From the Embedded Cowboy



**Don't Let Your Reality Check
Bounce**

Thoughts From the Embedded Cowboy



**In Business You Can't Make Others Love You
All You Can Do Is Stalk Them and Hope
They Panic and Give in**

No Matter Who Says What



***Don't Believe it if it Doesn't
Make Sense!!***

ElectronicsMarket **forecasters**



Embedded Systems Programming
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... Hope that *Your Team Wins*