

FPGAs and the Quest for New Relevance of America's Space Program

FPGA Mission Assurance Center

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The FPGA Mission Assurance Center

• A consortium of:

- Air Force Research Lab
- University of New Mexico
- Sandia National Lab
- Los Alamos National Lab
- Xilinx, Inc.
- SES
- Funded by a combination of Air Force Research Lab, Congress and Sandia National Lab
- Intended to provide assistance to the military/aerospace community for successful use of FPGAs
- We are at your service













To Quote Tim Gallagher

"We shouldn't just **BILL GATES**!















Why Should We Care?

• Because FPGAs offer one of our best hopes to revitalize the space industry













Our Entire Society and Economy are Linked to Success in Space















What we do in Space?

- Weather
- Communications
- Intelligence
- Science about space
- Science about earth
- Navigation
- Limited missile defense













Key Government Findings

Many Studies

- 1999 Rumsfeld Commission
- 2003 Young Panel
- 2004 Young Panel
- 2006 NSPD 49
- 2006 China Space NIE
- 2007 Allard Panel
- 2007 POTUS Memo
- 2008 Congressional Direction on MFP
- 2008 PDM II Study
- 2008 Space NIE



Similar Results

- Space is <u>vulnerable</u> and <u>insecure</u>
- Ambiguous leadership
- Limited advocacy
- Insufficient space communications
- Too much duplication











Some Well Known Opinions/Factoids "Better, Faster, Cheaper" (?)

And industry must also deliver what they promise: Industry scane the federal hudget

BETTER, FASTER, CHEAPER

2001

C A NOT ALWAYS SUCCESSFUL...

Reasont N AND KEEPS GETTING SI SLOWER & COSTLIER!

ching in 2013!









http://en.wikipedia.org/wiki/NPOESS





Where do we stand?

- Relevant?
 Certainly
- Improving? Certainly
- Costly? Certainly

But are we:

- "New" enough to excite high interest?
- Cost effective enough relative to our rate of improvement?
- Finding new things to do that are also relevant?













One Way to be More Relevant

Talk like those slick guys from Marketing!

LeanValue-added

- Outside-thebox
- Focused
- Accelerated
- Empowered
- Customeroriented

- Machine-tomachine
 - Six-sigma
- ISO 9000 certified
- Networked
- B-to-B

- Leveraged
- Web-based





http://www.squidoo.com/valdes

- Value stream
- Core competency
- Architecture
- Portal
- Workflow
- Motion
- Center of Excellence







How Do We "Break the Mold" and Foster Growth?

- Find something ideally relevant
- Cut cost and improve the cost/benefit ratio
- Keep trying new things



http://karenrippleffect.blogspot.com/2007/10/mold-as-art.html

All are aided by reducing barriers

- Cost / Resource Access
- Decision inertia
- Regulation













Google's Approach To Fostering Innovation

- Teams not larger than 4-5
- Employees encouraged (required) to "steal" 20% of their time
 - Work on ideas of their own
 - Free from management decision-making
- Acceptance of high failure rates on new ideas

Source: Charles Beames NWC Thesis, 2008













Productivity, Individual Contribution and Living Outside the Box

• Soviet Days:

Approved Solution:

Collective Farms <u>95%</u> of arable land <u>< 50%</u> of gross agricultural output



http://dailylife.greenwood.com/teache r/lesson.asp?id=DLO_E_TE_L03

http://filebox.vt.edu/use rs/efalwell/sovietprop/st alin3.html







Out-of-theBox Solution:

Private Garden Plots <u>5%</u> of arable land <u>> 50%</u> of gross agricultural output









Out-of-the-box at Home

Approved Solution:

Newest/cheapest type-certified jet

Seats: 6 Cost: ~1.3 - 2.1M Speed: ~400 mph Efficiency: ~8 mpg



http://gulfstreamresale.com/p2index.php?id=77







Out-of-the-Box Solution:

Homebuilt (amateur) 4-place

Seats: 4 Cost: ~200-400K Speed: ~380 mph Efficiency: ~25 mpg



http://www.lancair.com/Main/secondary_page_images/ivp_lrg.jpg

Alam





Big contributions can come from seemingly laughable beginnings

Cheap airplanes Built in garages Led to ...





http://en.wikipedia.org/wiki/Pietenpol_Air_Camper





- Ballistic recovery systems
- Winglets
- Affordable aircraft
 composite manufacture
- Much lighter weight aircraft engines
- Aviation-safe electronic ignition
- Even private "spacecraft"! http://www.eaa.org/news/2008/2008-08-29_ab3.asp





http://www.youngeagles.org/photos/gallery.asp?action=viewimage&ca tegoryid=17&text=&imageid=1124&box=&shownew=



http://www.aeronews.net/news/genav.cfm?ComentBlockID=8ff5714f-6c12-4057-adbd-12e8e1ad4168&Dynamic=1

Improving Space Value



"Accelerated, **B-to-B** value stream!"

Cut Launch Cost

Make Better Use of Launch Capacity



http://www.space travel.com/reports/Air Force Approves SpaceX To O perate_On_Cape_Canaveral_Launch_Site_999.html

Standardize & Optimize



www.responsivespace.com/Papers/RS3%5CSESSION%2 0PAPERS%5CSESSION%205%5C5001-20&%20FRONTERHOUSE%5C5001P.pdf

Miniaturize



com/productss/productserv x?id=296&tv



http://www.broadreachengi neering.com/casi.html





63











Why FPGAs Are Highly Appealing

- Hardware easier (quicker, cheaper) to design/test for space qualification
- They are reconfigurable
 Reuse

- They are reconfigurable
 - Don't require repeated hardware qualification













We Are Not Alone In Recognizing This

2008 FPGA Survey



- EE Times
 - and -
- FPGA Mission Assurance Center
- Survey conducted by Wilson Research











FETIMES



Survey Specifics

- Follow-on to Prior Survey (2006)
- Sought input from the EDA community across application areas/industries
- Primarily U.S.
- So far, over 400 responses













Key Finding: Talent is Available but Not Easy to Find and Prepare

- Over 70% reported some difficulty recruiting
 We're not doing much to prepare new hires
 - B1. Does your organization have any <u>difficulty recruiting</u> professionals with an adequate skill set to work with FPGAs?



B5. How long does it typically take for a new designer to be fully productive in your environment?

| TOTAL No answer | 442 86 |
|--|----------------------------|
| Base: Total answering | Count Percent 356 100% |
| They are immediately fully capable | 9.0 |
| Less than 6 months | 36.5 |
| 6 - 11 months 12 - 17 months 18 - 23 months 24 months or more | 36.2 12.6 2.2 3.4 |
| Statistics Base: Mean: | 356 7.28 9% \$9% |





- EST. 1943

B3. How much of your time (or your designer's time) is spent in continuing education (learning how to use tools, etc.) - including seminars, courses, and self-study?



B4. What do you do the most to prepare your designers to produce in your environment?

| TOTAL No answer | 442 84 | | | | | | |
|--|-------------------|-----------------|----|-----|--------|------------|--------|
| Base: Total answering | Count 358 | Percent 100% | | | | | |
| Apprentice them under an existing designer or team of designers. | | 28.8 | | | | | |
| Provide organized design guidance from a company-defined best practices (design/coding stude test presented as a stude of the stude o | | 23.2 | | | | | |
| Nothing, they learn on the job. Nothing, we recruit them with sufficient on-the-job | 3 | 29.1 16.2 | _ | | | | |
| Nothing, they come properly prepared from wordergraduate (graduate education programs | | 1.1 | 1 | | | | |
| Other (please specify.) | | 1.7 | L | | | | |
| | | | 0% | 50% | | 100% | |
|) | • | | | 4 | | | |
| | Sandia Nationa | al | | #3 | SES Co | onsultants | , Inc. |

Write-in Awards!

• Wish Upon A Star Award

How do you get good designers? "By wishing rilly rilly hard!"



• Preparation H Award

What do you do to prepare your designers? "Nothing, they come ill prepared and stay that way"



http://www.flickr.com/photos/8341340@N05/2385545576/













Schedules

- Quick starts
- "Fair" schedule adherence ... but ...
- Serious impacts when schedules fail

B6. How long does it take your company to assemble a competent design team for a new project?



TOTAL 442 84 No answer Count Percent Base: Total answering 358 100% 100% 11.7 90% 10.3 80% 19.0 70% 14.5 60% 6.4 50% 15.9 40% 3.9 30% 5.3 20% 3.1 10% 3.1 67 None Statistics Base: 358 Mean: 62.29 50% 100%

B10. Over the past year, approximately what percent of your designs been completed on time?







Management Issues

- Very few managers with relevant background
- Challenges with complexity, skilled designers

B8. Are the managers in your organization also skilled FPGA designers?



B11. What have been your greatest impediments to creating designs on time?

| TOTAL No answer | 442 2 87 | | | | | |
|--|--------------|-----------------|----|---|-----|------|
| Note: Multiple response Base: Total answering | Count 355 | Percent 100% | | | | |
| Overall project complexity | | 57.5 | | | | |
| Availability of skilled designers | | 26.2 | | 1 | _ | |
| Maturity of design tools | | 23.7 | | | | |
| Interface design | | 21.7 | | | | |
| Building a proper board solution | | 14.9 | | | | |
| Finding an FPGA that suits our needs | | 9.9 | | | | |
| Finding a proper board solution | | 9.0 | | | | |
| Other (please specify) | | 11.0 | | | | |
| Don't have a problem completing projects on tim | iê. | 7.0 | | | | |
| | | | 0% | | 50% | 1005 |













Write-in Awards!

Wannabe Author Award

Why do your projects not finish on time?

"I could write a book, but I'd get in trouble for doing that."



http://www.flickr.com/photos/dnhoshor/129815468/





Impression of Industry is **Generally Favorable**

B22a. As you reflect on your total experience with FPGA vendors, what is your opinion or impression of the following? - Favorable

| TOTAL No answer | 442 93 | | | | |
|--|--------------|--|----|-----|------|
| Note: Multiple response Base: Total answering | Count 349 | Percent | | | |
| Technology Ease of use Sales reps Support Training Quality of software Pricing | | 94.0 86.8 77.4 70.5 69.1 63.9 60.7 | | | |
| Licensing Interoperability | | 59.6 58.7 | 0% | 50% | 100% |

B22b. As you reflect on your total experience with FPGA vendors, what is your opinion or impression of the following? - Unfavorable

| TOTAL No answer | 442 159 | | | | |
|-------------------------|------------|---------|----------|-----|------|
| Note: Multiple response | Count | Percent | | τ. | |
| Base: Total answering | 203 | 100% | | | |
| Licensing | | 49.8 | | | |
| Pricing | | 48.8 | | | |
| Interoperability | | 48.4 | | | |
| Quality of software | | 43.1 | | | |
| Support | | 35.0 | | | |
| Training | | 32.5 | <u> </u> | | |
| Sales reps | | 25.8 | 1 | | |
| Ease of use | | 17.7 | | | |
| Technology | | 7.4 | | | |
| | | | | | |
| | | | 0% | 50% | 100% |

B12a. If not, what percentage increase in performance is needed?

B12. Do FPGAs meet your performance needs in terms of speed?

Key Finding: Complex System-on-a-Chip Design is Now Very Common

"Most" use <u>soft cores</u>

B16. Do your projects require software written for embedded processors?

C10a. Which of the following embedded processor cores do <u>you currently</u> use and do you <u>plan to</u> <u>use</u> in your designs in the next 12 months? - Currently use

| TOTAL No answer | 442 210 | | | | | |
|--|--------------|---|----|-----|------|---|
| Note: Multiple response Base: Total answering | Count 232 | Percent 100% | | | | |
| PowerPC ARM Microblaze soft core Nios soft core Other MIPS Tensilica | k | 47.8 32.3 27.2 24.1 20.3 12.5 5.2 | | | | |
| | | | 0% | 50% | 100% | ļ |

Write-in Awards!

• Einstein Award

What best describes your organization's use of FPGAs? "Have no clue"

Or as Einstein said:

"If we knew what it was we were doing, it wouldn't be research."

Key Finding: Mil/Aero is a Large Portion of **FPGA** Community

General Trend: ~25% or more of Reconfigurable EDA engineers surveyed seek:

- Aerospace applications
- High-rel or rad-hard/tolerant components —
- SEU or other radiation effect mitigation

A1. What is your organization's primary business activity?

| TOTAL No answer | 424 7 | | | | |
|---|--------------|-----------------|------|----|----|
| Base: Total answering | Count 417 | Percent 100% | | | |
| Applications software development | | 2.2 | | | |
| Communications carrier (telecomm, datacomm, cable, internet/online service provider) | | 5.8 | | | |
| Computer manufacturer (hardware, software, | | 11.3 | | | |
| peripherals) Computer related retailer, distributor, wholesaler | | 0.2 | | | |
| Solutions provider/VAR/ e-business integrator | | 0.2 | | | |
| Other computer-related/communications | | 5.3 | | | |
| business (specify) Aerospace | | 15.1 | _ | | |
| Agriculture/mining/oil/gas | | 0.5 | | | |
| Banking | | 0.2 | | | |
| Business services | | 0.0 | | | |
| Construction/architecture | | 0.0 | | | |
| Consulting (non communications/computer) | | 1.7 | | | |
| Education/training | | 0.7 | | _ | |
| Engineering/science/research | | 20.4 | | | |
| Government: federal (including military) | | 3.4 | | | |
| Government: local | | 0.2 | | | |
| Government: state | | 0.5 | i i | | |
| Healthcare/pharmaceuticals/biotech/biomedical | | 5.0 | | | |
| Insurance | | 0.0 | Ē | | |
| Manufacturing and process (other than computer related) | | 10.1 | | | R |
| Media/marketing/advertising | | 0.0 | 1 | | |
| Non-profit/charity/trade association | | 0.0 | | | |
| Real estate/legal | | 0.0 | i | | |
| Transportation/logistics | | 0.7 | i | | |
| Travel/hospitality/recreation/entertainment | | 0.2 | | | |
| Utilities | | 0.7 | | | |
| Wholesale/trade/distribution/retail | | 1.0 | | | |
| Other general business (please specify) | | 8.6 | | | |
| | | Σ | 075X | ĽI | ٧X |

| Δ4. | What types of | applications | best | describe | vour | primary | develo | oment | project | ts? |
|-----|------------------|--------------|------|----------|------|---------|--------|---------|---------|------|
| | attinut types of | apprications | 0.00 | describe | your | primary | 104010 | puncing | projec | 40.1 |

| TOTAL No answer | 424 9 | | | | |
|---------------------------------|----------|---------|----|-----|------|
| Note: Multiple response | Count | Percent | | | |
| Base: Total answering | 415 | 100% | | | |
| Aerospace | | 22.7 | | | |
| Data communications, networking | | 21.2 | | | |
| Electronic instruments | | 21.0 | | | |
| Computers and peripherals | | 20.2 | | | |
| Industrial control & automation | | 19.3 | | | |
| Military | | 17.8 | | | |
| Telecommunications | | 15.2 | | | |
| Consumer electronics | | 14.5 | | | |
| Video & imaging | | 12.3 | | | |
| Medical | | 11.6 | | | |
| Automotive | | 8.0 | | | |
| Government & municipal | | 5.8 | | | |
| Audio | | 5.3 | | | |
| Security | | 5.1 | | | |
| Power generation and utilities | | 2.9 | | | |
| | | | L | | |
| | | | 0% | 50% | 100 |

E1. Which of the following best describes your organization's use of FPGAs?

| TOTAL | 424 | | | | |
|-------------------------------------|------------------------------------|---------|-----|-----------------------|------|
| No answer | 303 | | | | |
| | Count | Percent | | | |
| Base: Total answering | 121 | 100% | | | |
| Space-borne applications | | 18.2 | | | |
| Avionics applications | | 29.8 | | | |
| Signal processing | | 31.4 | | | |
| High performance computing | | 7.4 | | | |
| Design consultant or services | | 5.8 | | ₽. | |
| • Los Alamos National Laboratory | Sandia National Laboratories | 7.4 | τĘ3 | SES Consultants, Inc. | 1005 |

SEU Immunity / Scrubbing are Important to a Considerable Industry Segment

E2. Does your organization attempt to mitigate the effects of Single Event environments?

E10. If a scrubber were provided to your organization, how much NRE would this save?

E8. If a rad-hard universal scrubber (method for correcting configuration faults) could be bought off-the-shelf, would your organization be interested in using this?

E11. What would be the time savings impact if available?

Write-in Awards!

 "Customer-Oriented Six-Sigma Center of Excellence" Award

What Could FMAC do to best help you?

"Quit sending out 12-minute surveys that take 1-1/2 hours"

http://www.flickr.com/photos/pixxiestails/266397380/

FMAC's Highest Priority – Education To Ensure Qualified Designers!

- University-Level Programs
- Community College Outreach

Southwestern Indian Polytechnic Institute

Industrial Outreach

- Professor Workshops
- High School Outreach

Efforts to Merge FPGAs on Small Satellites

 Working to develop CubeSat constellation for space weather research utilizing Virtex-5 SIRF FPGA

 Collaboration between UNM, NM Tech, AFRL, Los Alamos

Test & Validation Processes for Aerospace and Defense Applications of FPGAs

- Los Alamos efforts in characterization of single event sensitivity, MBU, SEFI analyses.
- Sandia/UNM collaboration on the Materials on the International Space Station Experiment (MISSE) Project.

FMAC is At Your Service

Visit us at:

www.fpgamac.com

Or join us at:

FPGA Mission Assurance Center 2350 Alamo Ave., SE Albuquerque, NM 87106-3202 505-242-0339

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| | | 10- | FPGA Mission Assurance Center | |
| | Home About Us Research | Click here for a viewable presentation about the Center | FMAC Mission "Make Organizations Successful with Programmable Logic Every Time They Seek FMAC Help!" | |
| | Far Academia Education Resources | A New Mexico-based center and consortium to promote successful application of Field | If you want help, <u>contact up</u> f | |
| | Farindutby Spasson | defense, and commercial systems | System Generator by Dr. Meyer-Baese | |
| | FMAC Repository | Research and Development to include work on | 11 or 12 September. The servets of DSP design with Xitins System Ownerator will be explained. For more | |
| | Evente Evente Contact Us | reliability as well as tool and Brazy development with parkouler emphasis on space systems but with the capability of solving more general problems as set Exacution from the postgraduate level down to K-12 Customer sendor to work with outcide entities, monomember on care and design and monomember on care and design and monomember on care and design as to monomember on care and design as to monomem | | |
| | www.fmacpubs.org | FMAC Goals | | |
| | | Ensuring success of FPGA projects, particularly mose undertaken by the government. This includes exampling but poler handware and design from capabilities with the insure the use of FPGAs in space. Ratio examples consultan- and reterrate to prevent failed, delayed or problemacy design achieves. Substantial New Black business growth FMAC can also also an important portunity to | Free FPGA Topic Courses Write brow about PFOAT 1% offer a sale of topicing as gard to donking alree in the double designed is built a somewhat of the double and designed is built a somewhat of the double and the top double and the double and the Notification of the all socialization of the MONE built design for more details did on the MONE built part of double and the double and the design for more details did on the MONE built of the top double and the double and the double and the part of double and the double and the double and the design of the double and the design o | |
| | | through brokered collaboration and available skilled engineers Steady Flow of Competent Designers into the Workplace. FMAC will focus many of its efforts | PMAG begins Gubesat Program to perform Space Weather | |
| | | on education at the graduate and undergraduate levels to ensure highly sitiliad workers are available in this growth area. Furthermore, K-12 programs will focus on stimulating and raising the neessary takent on enter into high-quality unversity studies effecting a design flow for complete systems. FRAC will continuously investigate the best | Research. The Dottal popular is Querefly for a satisfit addising phase. If well involve putting phase the life involve putting particular popular is performing analysis INTER: INTER: IN | |
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