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PARAMETRIC WORLD

A Periodical of The International Society of Parametric Analysts

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Editor
Charles Hopkins
Email: charlesvhopkins9@aol.com
408-252-8690

Chair, Board of Directors
Andy Prince 256-682-6456
andy.prince@nasa.gov

Deputy Chair
Greg Kiviat..... 203-386-7274
gkiviat@sikorsky.com

Secretary
Lisa Yedo..... 303-939-5881
lyedo@ball.com

Treasurer
Bruce Minett 714-896-5080
freewayflier@earthlink.net

Executive Manager
Rich Harwin 562-797-3869
richard.a.harwin@boeing.com

Directors
Kurt Brunner..... 310-536-0011 x144
kbrunner@tecolote.com

Madeline Ellis 818-888-8216
madelineellis@socal.rr.com

Brian Glauser 602-993-8008
BGlauser@galorath.com

Hervé Joumier 31-71-565-3227
Hervé.Joumier@esa.int

Steve Sterk..... 661-276-2377
steve.a.sterk@nasa.gov

George Stratton 520-275-8299
glstratton@gmail.com

Parametric World Chair
Madeline Ellis 818-888-8216
madelineellis@socal.rr.com

ISPA/SCEA Joint International Office
527 Maple Avenue East, Suite 301
Vienna, VA 22180
Phone: (703) 938-5090
Fax: (703) 938-5091
Web: www.ispa-cost.org

LETTER FROM YOUR EDITOR

IN THIS ISSUE

This issue looks at where ISPA is going and also where it has been. Where ISPA is going is back overseas (about time!) and also to Orlando (cheers from the families!). Where ISPA has been is back to the Society's beginning with Hank Apgar's look at the years of our founding. Highlights of other features follow.

Our feature *State of Our Art* presents technical papers illustrating some important issues that parametric cost analysts face:

Arlene Minkiewicz explores costing of commercial programs. In particular she uses a technique that Frank Freiman used to build cost data bases, namely incorporating catalog prices. Frank famously said that he started his investigations with data from the Sears Roebuck catalog: i.e. price, weight and size for every product. Arlene's focus is a hardware product, i.e. fuel cells. This is a product that has been used for manned space applications but is increasingly used for commercial power applications. We have fuel cell costs from the Apollo era but space data clearly do not apply to commercial products. Commercial fuel-cell costs are closely held; however, their prices are shown in catalogs and so that was the starting point for Arlene's analysis.

Jon Wesick's paper uses the COCOMO software cost model to illustrate good practices for validating parametric costing tools. He explores how excursions in input variables can be mapped to predicted cost.

Our new *In Remembrance* section consolidates memories of colleagues who have recently passed on. These are not strictly obituaries. In the past we have published tributes to individuals, but always our tributes have emphasized their professional careers and, if possible, provided insight into how these individuals did what they did. I have tried to find people who were worked closely with our subjects. So Ron Larson writes about Meinholf Wenzel (they were co-workers at MBB when I met them). Bruce Fad remembers Kelly Chamberlain. And Karen McRitchey finishes our tribute to Peter Korda with memories of his time with Galorath Inc.

Charles Hopkins

Editor, *Parametric World*
charlesvhopkins9@aol.com

CHAIRMAN'S ADDRESS

By Andy Prince

Two things are on the top of my mind right now: the merger and the 2012 conference. First, a quick status on the merger. As per the plan discussed in the last *Parametric World*, ISPA and SCEA have formed an integration committee to work through the details. This committee stood-up several solution teams to address specific issues and make recommendations back to the committee. As of the writing of these remarks (mid-October), all the solution teams have submitted their reports except for the governance team. Because governance defines what the new society will be, we decided to elevate that discussion to the full integration committee level. As a result the process is taking longer than we originally planned. But the product that we will get from the process will provide a better, fuller picture of the new society. When we have those details, we will share them with you so you can see where we are going.

Plans for the 2012 Brussels Conference are rapidly coming together. The hotel provides excellent conference accommodations and the banquet location will be a treat. All we need to make this a great conference is to have top-notch papers and your presence. So if you are thinking about attending and writing a paper, get busy! Write that abstract and get it submitted (due date is January 9th). Then bug your boss to make sure the company will pay the conference fee and travel expenses (if you are your own boss, congratulations! You can skip this step). Finally, register and make your hotel reservations and other travel arrangements. It's that easy. By the way, be sure to stay at the Sheraton Brussels as we are getting a great deal.

While I have your attention, I want to give a big thanks to Kurt Brunner and all the members of the Southern California Chapter for allowing me to speak at the September Workshop. The workshop was well organized and executed, as usual. The folks at the University of Southern California were super hosts, very friendly and helpful. The facility was excellent and the speakers were first rate. Also, another big thank you to Kurt and the good folks at Tecolote, who graciously hosted our September board meeting.

Finally, a big wish for all of you to have a happy and healthy holiday season!

Andy Prince

ISPA CHAIRMAN OF THE BOARD
256-682-6456
andy.prince@nasa.gov

CALENDAR OF EVENTS

December 1, 2011
Joint ISPA/DACE Parametric Estimating Challenge
De Soester Duinen, Soest, Netherlands
Contact: info@dace.nl, www.dace.nl

December 14, 2011
Joint ISPA/SCEA So. Cal Workshop
Fort Mac Arthur, San Pedro, CA
Contact: Quentin Redman, 310-692-5926

February 7 – 8, 2012
Space Systems Cost Analysis Group (SSCAG)
Galorath Inc., El Segundo CA
Contact: David Pine: dpine2@cox.net

May 14 – 17, 2012
2012 ISPA/SCEA Joint International Conference & Training Workshop
Sheraton Brussels Hotel, Brussels, Belgium
Contact: Jason Dechoretz, jdechore@mcri.com

May 17 – 18, 2012
SSCAG (with European Aerospace Working Group for Cost Engineering)
Sheraton Brussels Hotel
Brussels, Belgium

June 11 – 14, 2012
Military Operations Research Society (MORS)
80th Symposium
US Air Force Academy
Colorado Springs CO
www.MORS.org

June 26 – 29, 2012
2012 SCEA/ISPA Joint Annual Conference & Training Workshop
Hilton Orlando Hotel, Orlando, FL

2012 ISPA/SCEA INTERNATIONAL CONFERENCE

By Jason Deschoretz, Conference Chair

We continue to make significant progress towards final plan for the Cost and Parametric Analysis event of 2012 in Brussels, Belgium. As you would expect, we are creating an event that showcases state-of-the-art analytical techniques and best practices. The objective is to achieve broader technical approaches, provide support to decision makers, and produce practical training that prepares the student for certificate examinations. Keynote speakers will present views from international government bodies and multi-national industry leaders. Networking opportunities will help you broaden your professional relationships.

As you can see from the conference flier (following pages), we have secured a very broad list of organizations to co-sponsor this unique event. We have the traditional partners of SCEA and SSCAG. For our leap year non-US conferences we are typically supported by the Society of Cost Analysis and Forecasting (SCAF) and the European Aerospace Working Group on Cost Engineering (EACE). However, for the 2012 conference we have broadened the support and interest base to include the Dutch Association for Cost Engineering (DACE) and ISPA Deutschland. We expect to have the largest and most diverse international representation in the history of our conference.

At PW press time we are putting the final touches on the Conference website which will provide the conference delegates with one-stop shopping for: conference registration, hotel room selection and registration, and selection of additional activities. For those of you who expect to submit abstracts followed by papers, the Conference website will take you to a customized portal where you can upload your products for evaluation and selection.

The venue for the awards banquet (which will be a shared event with the traditional SSCAG dinner) has been selected and will provide a memorable experience that is uniquely Belgian. It will be held at the nearby Comic Museum. Belgium has enjoyed a long history of being the home of widely appreciated comics for children and political satire. This museum was designed to house international events: 1) all the material is multiple languages (including English), 2) the facility has an open layout to accommodate socializing, seated meals and awards presentation, and 3) the museum has an on-premise kitchen and catering operation. We are fortunate to have secured this location since they host hundreds of events every year.

The training curriculum has been set and includes courses drawn from both ISPA and SCEA certification material. They have been focused into two parallel tracks that will enable attendees to maximize their exposure to this proven system of professional development. If you are interested in being a trainer, I encourage you reach out to Roy Smoker or Peter Braxton.

Sherry Stukes has reported yet another year of record interest from folks wanting to present their technical work at this conference. You will be receiving the URL link shortly so you can begin uploading your abstracts for consideration.

Brussels, Belgium is conveniently situated with easy access to many European cities. It has its own International Airport, and the city is served by frequent high-speed trains across Europe. The conference hotel, Sheraton Brussels, is also ideally situated in the heart of city next to public transportation and walking distance from several major tourist attractions. Take advantage of the special room discounts offered for early arrival to tour the city.

Your conference planning committee of Rene Berghuijs, Natalie Faucher, Henry Apgar and Hervé Joumier are working hard to bring you a fantastic conference. If you have any ideas or wish to volunteer please drop us an email!

Early Announcement

2012 ISPA/SCEA Joint International Conference & Training Workshop

Assuring Cost Efficiency: Global Solution

14-17 May 2012

Brussels, Belgium

Every four years, ISPA and SCEA present an annual conference in a non-US venue to accommodate our international membership and to provide a unique experience to meet with professionals and friends around the world. For 2012, we are pleased to announce our annual conference in **Brussels, Belgium.**

Consider the advantages to you:

- International networking opportunity with NATO mission and European Commission (EC) members
- Government and industry key-note speakers
- Subject matter experts on panels
- Nearly 100 workshop speakers—in several languages—offer hands-on opportunities in Parametrics, Risk Analysis, Earned Value Management, Whole Life Cost Analysis, and more
- Full training program to prepare for ISPA or SCEA certification
- Central European location; easy access via air and rail
- Traditional ISPA Receptions, Awards Banquet, and Guest Tour Program following the legacy of Brighton, Cannes, Munich, Frascati (as seen on right), and Noordwijk

Come to Brussels—heart of the Europe Union and home of NATO Headquarters. Enjoy the amenities of our international venue—the Sheraton Brussels. Enjoy the best international networking experience available — once every four years!

At an affordable, all inclusive, cost:

- €130 room rate (breakfast included)
- Cheaper room rates (€80) before and after conference
- Airline shoulder season assures lower air cost
- Discounted registration rate for sponsor members
- Adjoining SSCAG/EACE meeting (17-18 May 2012)

Additional Sponsors Include:

www.ispa-cost.org

Call for Papers

2012 ISPA/SCEA Joint International Conference & Training Workshop

Assuring Cost Efficiency: Global Solution

14-17 May 2012

Brussels, Belgium

Submit your abstract by 9 January 2012
Late submissions cannot be considered!

The Joint Conference Committee is seeking technical papers covering a wide variety of cost estimating and cost analysis topics including, but not limited to:

- Hardware/Software Estimating
- Cost Growth Analysis
- Whole Life Cost Analysis
- System of Systems Estimating
- Earned Value Management
- Risk Analysis
- Joint Confidence Levels
- Cost Estimating Models
- Cost Methodologies/Applications
- Decision Analysis
- Cost Benefit Analysis
- Benchmarking
- Cost As an Independent Variable
- Affordability Assessment

This is a great opportunity to demonstrate your expertise and contribute to the advancement of the profession. The schedule for this year's conference is as follows:

Abstract submission	**9 January 2012**	Instructions for uploading abstracts will be available at the ISPA web site, www.ispa-cost.org beginning in August 2011.
Author notification	**31 January 2012**	
Final submission	**2 April 2012**	

Note: For the two-day (17-18 May 2012) SSCAG/EACE meeting following the ISPA/SCEA conference, abstracts should be submitted directly to those sponsors.

If you have questions or need additional information about the workshops, please contact:

Sherry Stukes
sherry.a.stukes@jpl.nasa.gov
+1.818.393.7517

www.ispa-cost.org

2012 ISPA Board Elections

By Brian Glauser, Chair, 2012 ISPA Elections Committee

It is time to elicit nominations for the ISPA Board of Directors. There are five seats up for election. The term of office for Board of Directors is two years. This is an exciting time to be involved in our society with all of the activity surrounding the proposed ISPA/SCEA merger as well as all of our ongoing activities, including our publications, certification and both our international and domestic conferences in 2012. There are many of you who would be of tremendous service and we thank you in advance for your willingness to step forward at this time to offer your service to the society.

The requirements for being a Board of Directors member include:

- Being a member in good standing (meaning your membership dues must be current at all times).
- Attending four Board of Directors meetings each year, two at the Annual ISPA Conference and two other meetings at various locations across the country. ***Remember to confirm financial support from your employer for attending these meetings!***

Qualified candidates must submit a completed nomination form and return it to me by 13 January 2012. The Elections Committee has established the following schedule for conducting the 2012 elections:

Initial Nomination Period	**Opens: 3 October 2011, Closed: 13 January 2012**
Receive and Post Nominee Biographies and Photographs	**Due: 1 February 2012**
Additional Nominations	**Ends: 1 March 2012**
Ballot Distribution	**Starts: 20 March 2012**
Voting Period Closed (By Mail)	**27 April 2012**
Voting Period Closed (At Conference)	**15 May 2012 (at 12:00 noon)**
Newly Elected Board Members Announced	**16 May 2012 (at the Joint Conference in Brussels)**

The slate of candidates and their biographies will be posted on the ISPA web site at: **www.ispa-cost.org/elections.htm** initially on 1 Feb 2012; additional candidates and their biographies will be posted on 1 March 2012.

If you are interested in serving on the Elections Committee or running for the ISPA Board of Directors, please contact me **bglauser@galorath.com**, **310-414-3222 x631**.

2012 ISPA BOARD ELECTIONS

Petition for Nomination

Return Form to:
Galorath Incorporated
Attn: Brian Glauser
222 N. Sepulveda Blvd; 1700
El Segundo, CA 90245
Fax: (310) 414-3220 [Attn: Brian Glauser]
Email: bglauser@galorath.com

Dear Election Committee:

I would like to nominate _____to serve as **Director** of the International Society of Parametric Analysts (ISPA). A copy of his/her qualifications and photograph is attached. The Nominee is a member in good standing and is willing and able to contribute his/her time and talents to ISPA.

In accordance with ISPA bylaws, a total of (5) ISPA members must sign this petition, affirming the nomination.

1. _____, Member in Good Standing
   Signature Printed Name
2. _____, Member in Good Standing
   Signature Printed Name
3. _____, Member in Good Standing
   Signature Printed Name
4. _____, Member in Good Standing
   Signature Printed Name
5. _____, Member in Good Standing
   Signature Printed Name

Brian Glauser
Chair, 2012 ISPA Elections Committee
bglauser@galorath.com
310-414-3222 x631

Certified Parametric Practitioner News

The CPP Examinimation

By Roy Smoker, Chief Parametric Practitioner

As the Society of Cost Estimating and Analysis and the International Society of Parametric Analysis move toward integration, the Certification Integration Team has determined that it will keep the designations for the society's current formats for the Professional Cost Estimator/Analyst (PCEA) and Certified Cost Estimator/Analyst (CCEA) and change the format for the CPP Exam. The PCEA is for junior analysts with a bachelor's degree from an accredited college or university and more than two years but less than five years of experience. The CCEA is for more senior people with over five years' experience as a cost analyst along with a bachelor's degree in any field. The CPP designation will be re-designated as CCEA-P for Parametrics. Current CPP holders will be able to take the CCEA exam at a discount and earn a CCEA-P designation. Anyone holding both designations will automatically become a CCEA-P. In essence, the CPP exam becomes a specialty exam within the CCEA designation and other specialties may be added later as the community grows.

To get the PCEA designation, a junior cost analyst must have two years of experience in the discipline and take Part I of the CCEA exam. Part I consists of 60 multiple choice questions worth 1 point each. The applicant must pass Part I of the exam with an overall score of 70% or greater to receive credit for the examination and receive the designation of PCEA assuming that applicant meets the above eligibility criteria. To obtain a CCEA designation, an applicant must have five years of relevant experience and pass both Part I and Part II of the exam. Part I of the examination covers fundamental knowledge of budgets, investments, project planning, as well as business case analyses, statistical analyses (including regression), and some special analyses such as earned value management used by industry and the government. Part II of the CCEA exam consists of 48 multiple choice questions that cover advanced topics in economic analyses; work breakdown structures; program baselines; data collection and normalization; descriptive and inferential statistics; hypothesis testing; learning curve analysis and production rate effects; time series data analysis; modeling and simulation; cost as an independent variable; and activity based costing. In addition, the CCEA Part II contains two short answer questions that relate to case study type problems that a cost analyst might encounter during everyday problem solving for a business.

During 2012, the CPP exam will still be given at the annual conferences but new material will be developed to enhance modeling and simulation; statistical sampling and hypothesis testing; and interdependent and interactive parametric equations. It will also include advanced topics in econometrics to include limited information and full information maximum likelihood models, as well as the joining of marginal cost and schedule density functions.

Our ultimate goal is to expand the tools for the cost estimating community so as to improve the breadth and depth of the analytical capability to better answer program manager questions. With the integration of the two societies, we all can work together to enhance the state of the art and increase the relevance of these certifications.

REMEMBRANCES

MEINOLF WENZEL By Ron Larson

Meinolf Wenzel, named ISPA Parametrician of the Year in 1996, succumbed on September 14, 2011 after a long battle with cancer. Meinolf and his wife, Ingrid, lived in Prien am Chiemsee, Bavaria following his retirement from EADS in Munich-Ottobrunn several years ago. Meinolf first came to Prien as a young child after being evacuated from Berlin at the start of bombings there early in World War II. I feel fortunate to have had the opportunity to visit Ingrid and Meinolf at their home in the Fall of 2010. The memories of that last visit will remain very special to me. Meinolf and his team of cost estimators were involved in virtually every project that Messerschmitt-Bölkow-Blohm (MBB) undertook. MBB (later Deutsche Aerospace, then EADS and Astrium) estimated every project that had wings i.e. Tornado, Eurofighter, Airbus etc. Meinhoff's estimates usually exhibited uncanny accuracy thanks to his attention to detail and his large historical database accumulated over a long and distinguished career. Meinolf's love of aviation extended to motor gliders, which he often piloted above his beloved Alps in Germany and nearby Austria. Meinolf was a 'big' man, not only in physical stature but in terms of his contributions and their resulting positive influence on the entire cost estimating community. He was a staunch advocate for parametric analysis, a solid supporter of ISPA and ISPA Deutschland, and a loyal colleague who answered every request for information and advice. I know I speak for many in saying that he will be sorely missed and fondly remembered.

F. KELLY CHAMBERLAIN By Bruce Fad

I knew Kelly well for a two-year period when I was working in the PRICE Los Angeles office (1992 to 1994). Kelly was working as a support contractor assisting the USAF SMC Financial Management (FM) organization with cost estimates of emerging systems. During the time I mention, Kelly was deeply involved in estimating the acquisition costs for a next generation GPS receiver. For some assemblies, he was estimating to the electronic component level. He was among the first people to estimate the forerunner of those little SIM cards that have become commonplace in today's wireless phones. In addition to his day job, Kelly was a finance instructor at the University of Phoenix on weekends and evenings.

He was a humorous, energetic, and engaging man. I always enjoyed working with him and taking extra time to talk about non-work things. One of my prized possessions is an author signed and annotated copy of former Dodgers great Maury Wills autobiography. Kelly was an acquaintance of Maury. Knowing I am a baseball fan, Kelly had Maury put a special note to me in the book, which he gave me as a gift. Kelly and I lost contact in the late 1990s. During a Southern California ISPA workshop a few years back, the late Nina Tahir gave me Kelly's Kitty Hawk, NC contact information. Nina and Kelly were very good friends, which tells you a lot about his character. When Nina passed away earlier this year, I contacted Kelly to let him know the sad news. My family and I have vacationed on the Outer Banks, near Kelly's residence for the past 10 years. Kelly and I agreed to meet during my summer 2011 trek. Sadly, we lost the opportunity when Kelly passed away in May.

PETER KORDA
By Karen McRitchey

Karen McRitchey of Galorath sent a striking account of Peter Korda at work. She writes:

"Peter Korda worked with the Galorath development team from 1993 to 2008. During that time he made many positive contributions to the SEER products, specifically in the area of hardware, IC and manufacturing. I learned so much from Peter in those years! Our current SEER-MFG model originated with Peter's vision of a process based manufacturing model. Not only was it his vision, he also developed all of the original models. He also built the first generation SEER-IC model. Peter also contributed in smaller yet meaningful ways. When he first arrived at Galorath, the SEER-H model had been released, but as with many new products, it had some rough edges. Peter saw the potential in the model, and instead of recommending we re-do it all, he worked with us to smooth out those rough edges. One of the first things he did at Galorath was to rewrite the definitions of the Complexity of Form and Complexity of Fit parameters. What a difference that made! Peter recognized that a model is not just equations and data, but also needs to be well defined and understandable by users".

DEADLINE FOR 2012 AWARD NOMINATIONS: April 1

The Awards Committee is now soliciting nominations for ISPA's society awards described below. You must be an ISPA member to nominate a candidate. Nominations will be verified and reviewed by the Awards Committee and final approval will come from the ISPA Board of Directors. Nominations must be submitted not later than **April 1, 2012**.

- The **Frank Freiman Award** is our highest honor and is presented to an individual who has made outstanding contributions to the theoretical or applied aspects of parametric modeling or cost estimating, promotion of parametrics, or applications of parametric methods over a significant amount of time. A Freiman candidate is expected to have left a legacy to the profession for at least five years. This award was named to honor Frank Freiman for his pioneering work in the development of parametric models and for his role in the founding of the Society. The recipient need not be an ISPA member. The recipient may qualify for this award only once in a lifetime.
- The **Clyde Perry Parametrician of the Year Award** is presented to an individual or group who has made outstanding contributions to the profession of parametric cost analysis during prior years, but for a minimum of two years. This award typifies a leader in the activities of practicing or promoting the use of parametrics. This award was renamed in 2004 to honor Clyde Perry, an ISPA Founder. The recipient need not be an ISPA member. The recipient may qualify for this award only once in a lifetime.
- The **Keith Burbridge Service Award** is presented to a Society Member or participating group who has provided substantial volunteer service to ISPA in a manner supporting the principles and goals of the Society. This award was renamed in 1996 to honor Keith Burbridge, an ISPA Founder. The recipient(s) must be ISPA members. Repeat awards are allowed.

Instructions:
Provide the following information by **April 1**:

- Full name of the nominee plus professional affiliation, postal address, and telephone number.
- Full justification for the award with factual and concise substantiating information. Identify previous awards, society affiliations, publications, and professional achievements.
- Describe specifically how the candidate meets the requirements of the award.
- Full name of the nominator plus postal address, email address, and telephone number.
- Submit nomination (and endorsements, if any) by email to:

Joseph Hamaker
2012 ISPA Society
Awards Chair
joehamaker@yahoo.com
321.200.3809

Previous ISPA Award Winners

Year Presented	Clyde Perry Parametrician of the Year Award	Keith Burbridge Service Award	Frank Freiman Award
1981	Robert Gafney		
1982	Keith Burbridge		
1983	Jim Wilder		Larry Putnam
1984	Darryl Webb		Randy Jensen
1985	Sylvan Pinsky		Bill Cheadle
1986	Henry Apgar		
1987	Clyde Perry		
1988	Alan Mayer	Jack Griffin, Seb Botta	Barry Boehm
1989		Henry Apgar	
1990	Dan Ferens	Cindy Castellana	Gerald McNichols
1991	Marilee Wheaton	Clyde Perry	Don Reifer
1992	Peter Korda	Charles Mauro	Keith Burbridge
1993		Nina Tahir	Peter Korda
1994	Gary Constantine	Madeline Ellis	
1995	Bruce Fad	Seb Botta	
1996	Meinolf Wenzel	Marilee Wheaton	
1997	Sherry Stukes	Ron Larson	Tony DeMarco
1998	Pierre Foussier		Henry Apgar
1999	William Rutledge	Paul Lubell	Dan Ferens
2000	Georg Reinbolt	Sherry Stukes, Karen Davies	Don MacKenzie
2001		Tom Brents	Dan Galorath
2002	Arlene Minkiewicz, Karen McRitchie	Gary Constantine	Charles Hopkins
2003	David Eck	Clyde Perry	Darryl Webb
2004	Jairus Hihn	Giancarlo Filippazzo	Joe Hamaker
2005		Georges Teologlou	Steve Book
2006	Richard Stutzke	Quentin Redman	
2007	William Brundick	Diana Patane	Humbolt Mandel
2008	Hérve Joumier	George Stratton	
2009	Christian Smart	Hank Apgar, Madeline Ellis	Dale Shermon
2010	Tom Coonce	Kurt Brunner, Sherry Stukes	Neil Albert
2011	Roy Smoker	Doug Druley	Sherry Stukes

I Remember: Our First Conference

By Hank Apgar

Does anyone else remember our first conference? It was staged in Washington DC, the city of our charter, at the Crystal City Stouffer's Concourse Hotel (now the Hilton Hotel), during April 23-25, 1979. This forum was initially organized as the PRICE Users Association (and hosted by RCA PRICE Systems). However the event was eclipsed by the coming-out of the new society, ISPA. The year 1979 proved to be our watershed.

The most popular conference workshop track was a well-attended session of international papers (typically European space and military) in support of the conference slogan, 'The World is Uniform.' Over 300 attendees (from eight countries) applauded the opening general session during which the ISPA charter was presented to President Bryant Barnes of the Harris Corporation. Our resolve was simply stated: "…to educate managers and analysts on the creation and application of parametric models to solve real-world problems." Registration fee was $50. Annual dues were set at $10 (only $5 for students).

During the closing minutes of this first conference we shared an emotional presentation (see photo 1) to Frank Freiman, uniquely naming him 'Life Member and Honorary Director'. In the 33 years of our society, no other person has been so honored.

Members at this conference elected our first slate of officers and directors (see photo 2), shown in this photo taken at the June 1980 board meeting. They were:

First row, L-R: Henry Apgar, Executive Vice President; Mamie Holloway, Director of Administrative Services, Clyde Perry,

Board Co-Chair; Louise Williams, Legislative Chair; Frank Freiman, Honorary Director.

Second row, L-R: Tom Masters, Educational Chair; Joe Ennis, Standardization Chair; Joe Landis; Barbara Verica, Programs Coordinator; Charlie Hopkins, Editor of ISPA News; Al Owens; David Mizer; Keith Burbridge, Secretary/Treasurer; Pilgrim McRaven, Membership Chair.

Not pictured: Bryant Barnes, President; Rick Hillyer, Board Co-Chair; Bernd Madauss, European Liaison and founder of the first European Chapter; Jacob Sachs; Wesley Tarrant; Noel Hargrove; Harvey Slovin; Daniel Ferens; Don Bader.

Dave Mizer introduced the tradition of a pre-conference reception, which was held in Noel Hargrove's hotel room featuring a bathtub full of ice-cooled beverages. We contracted with the local pizza restaurant to keep delivering as long as the party lasted. Dave was President of the Southern California ISPA chapter (which had been fashioned one year earlier than the national society) and their signature event was the quarterly free all-day workshop — a tradition perfected over the past 33 years. ISPA Southern California still attracts parametric estimators from all Western states (and occasionally from abroad).

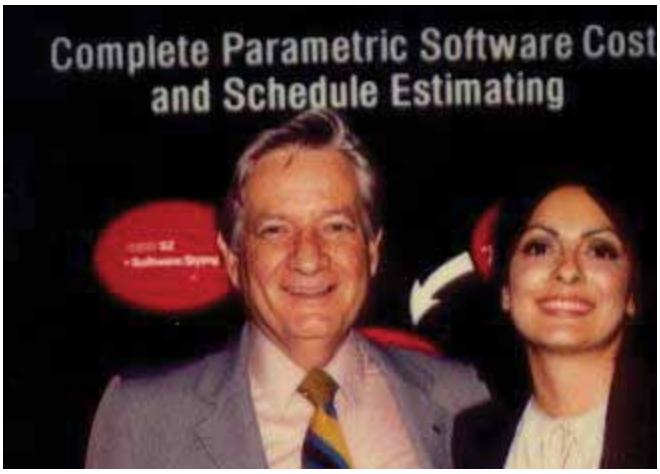
That same year, Dave chaired a joint meeting of the Southern California ISPA chapter and the Greater Los Angeles Chapter of the National Estimating Society (NES) at the 'Tail of the Cock' Restaurant in North Hollywood, thereby introducing the prototypical inter-society meeting. Several years later, ISPA declined an invitation from Rod Stewart, National Estimating Society President,

to merge with NES because we were still promoting our mission of proving to the world that top-down parametric estimating techniques were every bit as creditable and auditable as established bottoms-up techniques and we were not yet prepared to dilute our focus. But we continued to stage joint meetings with NES until their merger with ICA in 1990 which created SCEA. That 1979 merger opportunity is more interesting today in light of our planned merger with SCEA next year.

The following year, we launched the Baltimore — Washington chapter, also underwriting all-day training workshops, under the leadership of Sylvan Pinsky.

In October 1979, we published the first issue of ISPA News, with Charlie Hopkins as editor. The format was combination technical journal and newsletter. The ISPA News followed retirement of the original newsletter, the PRICE Users Bulletin (PUB), and preceded both the *ISPA Whisper* and *Parametric World*. Issue No.1 of the News included papers by Bob Seldon, Noel Hargrove, Charles Chandler, and Henry Apgar, plus a list of new acquisitions by the ISPA Library.

Our second national conference was soon being planned for the (former) Sheraton Poste, in Cherry



Hill, NJ, for April 1980, with the theme, 'Parametrics — Coming of Age'. It was there that we initiated the ever-popular Guest Program. For this article, I am indebted to David Mizer for stories and photos embedded in his informative article, 'A Visual History of ISPA,' which described our first fifteen years.

In subsequent issues of Parametric World, I will share my memories of: the Parametrics Initiative, the missing trove of very-early photographs, our DCAA connection, and our fascination with San Diego.

Planning & Governance

Bylaws and Constitution Requirements for Proposed ISPA SCEA Merger

By George Stratton

As we approach the potential merger of ISPA with SCEA, some may question what rules and procedures are required by ISPA's governing documents. The Bylaws provide some rules while the Constitution is silent. The applicable section of the Bylaws is as follows:

BYLAWS: ARTICLE XIII - AFFILIATION WITH OTHER ORGANIZATIONS

Section 2. Merger or Acquisition. Any proposed merger or acquisition (whether ISPA is the acquiring or acquired party) shall require the approval of two-thirds (2/3) of all members of the Board of Directors eligible to vote. Such merger or acquisition shall also require a two-thirds (2/3) affirmative vote of the eligible members responding to a mail ballot, unless a greater majority is required by law.

Procedures using rules from the Bylaws:

- Negotiations per board approval: No procedures or schedule specified.
- The board must vote in favor of merger: A 2/3 majority of board required.
- Membership 'should' be informed of upcoming vote: 1) *PW* articles explaining situation, rationale and process, 2) Encourage voting!
- Vote to be by mailed ballots: 1) No duration specified (schedule up to board?), 2) Approval if 2/3 of returned ballots are in favor. *Side note, if too few ballots are returned this has potential to cause issues as to the legal standing of the vote.*
- Legal issues? Per general corporation law of the District of Columbia, USA

We as the membership have the opportunity to affirm or disapprove the merger as proposed by the two society boards. So, when given the opportunity, please vote for the option that you see as best for the future of ISPA.

Fuel Cells: Turn Up the Heat

By Arlene Minkiewicz, Chief Scientist, PRICE Systems LLC

INTRODUCTION

A fuel cell is an electrochemical cell that converts some fuel, usually hydrogen, into electric current. It does this through a reaction between the fuel and an oxidant in the presence of an electrolyte. The waste product of this chemical process is water and heat. Fuel cells, unlike conventional batteries, consume reactant from an external source rather than one stored in the battery. They do require a continuous supply of fuel, but given that this supply is available, they will not run out of charge like a conventional battery.

Because fuel cells require neither flame nor combustion to convert fuel to electricity, there is much hope that they will become a viable power source of the future as we try to reduce our carbon footprint. Fuel cells are very reliable and not as likely to be affected by the environment as some more conventional power delivery systems are. Because of this they are being adopted in industries such as the telecommunications industry where outages are particularly problematic. They are also often considered for power generation in remote areas where energy from the grid is expensive and outages are frequent. Because heat is a waste product of the fuel cell electricity generation process, micro combined heat and power systems are gaining popularity for residential and small business needs. Other interesting uses of fuel cell power include material handling, backup power systems and uninterruptable power supplies.

Despite increases in the use of fuel cells, they continue to evade wide spread use because they are expensive. Certainly significant progress has been made through increases in efficiency and improvements in manufacturing processes but it is still more expensive, in most domains, to get electricity from fuel cells than from more conventional methods. According to a report from the Department of Energy in May 2010, the cost of high volume automotive fuel-cell stacks has been reduced from $275/KW in 2002 to $61/KW in 2009 and appears to be on track to reach the $30/KW goal by 2015 [2]. The same report indicates a 24% increase in system power density for stationary fuel cells making it possible to reduce the fuel stack volume, weight and cost.

FUEL CELLS

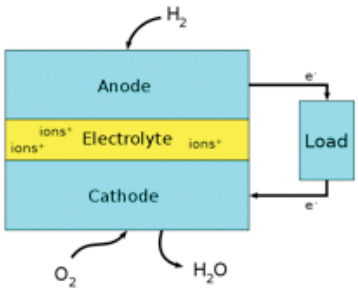


Figure 1.

In general, fuel cells are made up of three primary parts: the anode, the electrolyte and the cathode. Chemical reactions occur at the interfaces of the three different segments. The result of these reactions is that the fuel (usually hydrogen) is used to create electric current and water and/or carbon dioxide is created.

The anode, electrolyte and cathode are layered as shown in Figure 1[3]. A catalyst, generally a fine platinum powder, is used at the anode to oxidize the fuel, creating positively charged ions and negatively charged electrons. The electrolyte allows the ions to pass through but prevents the electrons from passing through, forcing them to travel through the wire to create current. The ions travel through the electrolyte to the cathode and rejoin the electrons where a second chemical reaction, usually with oxygen, creates water and/or carbon dioxide. The cathode catalyst is usually nickel. Fuel cells are generally classified based on the electrolyte substance.

This research focused on the following types of fuel cells.

- **Proton exchange membrane fuel cells (PEMFC)** in which a proton-exchange membrane is the electrolyte substance. Hydrogen fuels the reaction at the anode catalyst and oxygen reacts with the electrons on the cathode catalyst to form water, which is the only waste product. Platinum is generally used as the anode catalyst. PEMFC are used in both stationary and portable fuel cell applications and their lower temperature ranges and power-to-weight ratio makes them suitable targets for transportation applications. These seem to be the most widely used type of fuel cell for the types of power systems studied.
- **Phosphoric Acid Fuel Cells (PAFC).** Liquid phosphorous acid acts as the electrolyte substance. Hydrogen

fuels the reaction at the anode catalyst and electrons react with oxygen at the cathode to form both water and heat. PAFCs tend to be less powerful than many other fuel cells, making stacks larger and heavier. Like PEMFCs, they require expensive platinum catalysts. Typical uses of PAFCs include stationary power with some uses in larger transportation vehicles such as buses.

- **Molten Carbonate Fuel Cells (MCFC)** in which a molten carbonate salt mixture creates the electrolyte substance. MCFCs are able to operate at very high temperatures, making it unnecessary to use precious metals as a catalyst. They tend to be more efficient and less expensive than PEMFC or PAFCs. High operating temperatures limit their uses to primarily large stationary power systems.
- **Solid Oxide Fuel Cells (SOFC)** in which solid oxide materials act as the electrolytic substance. These cells conduct negative oxygen ions from the cathode to the anode. Like MCFCs, this type of fuel cell operates at very high temperatures, thus there is no requirement for expensive platinum catalysts and they do not require pure hydrogen for operation. There uses include commercial and residential power supply and auxiliary power for vehicles.
- **Reformed Methanol Fuel Cells (RMFC).** This is a subset of the PEMFC that uses methanol reformed to hydrogen as the fuel. These fuel cells operate at high temperatures and produce carbon dioxide as waste products. Their small size makes them a good option for portable power delivery systems.

Cost Research Methodology

The goal of this study was to develop credible, defendable cost estimating relationships (CERs) using publically available cost data and to make these relationships available to the cost estimating community through publication in the PRICE TruePlanning® framework. Admittedly, the use of only publically available data is often problematic and can result in a less 'accurate' estimate. But often the most 'accurate' estimate is unusable because the use of proprietary data enforces a 'code of silence' around the genesis of the model, making it unusable to those who need to defend estimates with actual projects. A model built with publically available data, with well-documented ground rules and assumptions, creates an environment of full disclosure.

Fuel cell power systems presented an appealing target for our research because power systems costs are likely to trend well regardless of operating platform making it possible to extend the results beyond the commercial platform from which most of the data was collected. The study focused on the following type of fuel cell power systems:

- Backup power systems: used for emergency backup and uninterruptable power supplies
- Stationary power systems: used to provide electricity (and sometimes heat) to residential and small business consumers
- Material handling power systems: used to provide power for forklifts and other equipment used to move materials and products in large warehouse settings
- Portable power systems: used to provide power to laptops, other small electronics, and battlefield equipment

Not surprisingly, actual cost data was not available for most of the systems studied. Even finding price data was challenging since many manufacturers will not publish these but prefer for potential buyers to call and speak to a sales person. This research relied on on-line catalogs (where they existed), research papers, magazine articles and press releases to discover and confirm prices for the systems studied. Table 1 contains a summary of the data points upon which this research is based.

Initial observations indicated that the primary cost drivers for fuel cell systems include:

- Type of power system (portable, backup, etc)
- Type of fuel cell (PEMFC, RMFC, etc.)
- Power rating of the system
- Weight also appeared to be a cost driver but is very closely correlated to power rating, with power rating appearing slightly more significant.

Continued on page 16.

Continued from page 15.

Manufacturer	Unit	Selling price	First Piece Cost (2010$)	Use	Power	Fuel Cell Type	Length	Width	Height	Weight	Max temp	Min temp	Current	Efficiency	References
ReliOn	1-1000	4500	3388.54411	Backup power	900-1200w	PEMFC	14	21.5	26	98-104	113	113	36@24VDC 25@48VDC		
reliOn	T-2000	9000	6775.111229	backup power	600-2kw	PEMFC	21	21.5	26	124-244	113	113	80@24VDC 40@48VDC		
Horizon	H-1000	4000	3790.283935	backup power	1kw	PEMFC				15			17-84		http://www.fuelcellstore.com/en/pc/viewCategories.asp?sidCategory=58
Horizon	H-3000	10500	13199.49333	Backup power	3kw	pemfc				38					http://www.fuelcellstore.com/en/pc/viewCategories.asp?sidCategory=58
Horizon	H-5000	15000	21711.56475	backup powrr	5kw	pemfc				60					http://www.fuelcellstore.com/en/pc/viewCategories.asp?sidCategory=58
PlugPower GenDrive	GD-240	22-33k	40909.07933	Material Handling	10.5kw	PEMFC	38	31	20	2800	104	-22	36VDC		http://www.hydrogenassociation.org/generalinfo/products/browse_fuelCellsIto250.asp
PlugPower GenDrive	gd-160	32k	47661.83932	Material Handling	8.7kw	PEMFC	38.5	22.42	27.12	2260-3150	104	25	36-48VDC		http://www.hydrogenassociation.org/generalinfo/products/browse_fuelCellsIto250.asp
PlugPower GenDrive	GD-170	35k	50533.59339	Material Handling	10.1kw	PEMFC	38.6	22.87	32.7	3000-400	104	25	36-48VDC		http://www.hydrogenassociation.org/generalinfo/products/browse_fuelCellsIto250.asp
Ballard	FCVelocity 9ssl	39000	34712.25384	Material Handling	4.4kw	PEMFC	31	6	36	17					http://www.ballard.com/files/pdf/Case_Studies/Material_Handling_Economic_Benefits_041510.pdf
Ballard	FCvelocity 9ssl	40000	49434.50568	Material Handling	19.8kw	PEMFC									http://www.fuelcellstore.com/en/pc/viewCategories.asp?sidCategory=58
Ultracell	xx25	5000	4983.206311	Micro/portable	25W	RMFC	5.9	9.1	1.7	2.5	122	-4	16.8	na	http://www.inventorvillage.com/smbd.asp?mb=4597&msb=2834530&pt=msg
Ultracell	xx55	10000	10493.87781	Mobile power - military	50W	RMFC	10.7	9.2	9.2	3.3	122	-4	12v-30v		
Jadoo Power	Ngen	2000	1828.393904	portable - fuel storage	100w	PEMFC	4.3	4.3	7.3	3					http://nstri.nrm.nh.gov/pms/articles/PMC1797861/
Trulite	XH4	2000	2229.259315	portable - military ref	150-250w	PEMFC	8.3	13.7	18.2	23	104	34		na	http://www.trulitetech.com/news/HoustonBusinessJournal-TruliteT.27.07.pdf
Medis technology	Power pack	20-30	30.17422753	Portable power	1w	PEMFC	677mm	99	27	12.1 oz				na	http://news.cnet.com/8301-11128_3-10039102-94.html
PlugPower Gensys	5c,4c	25350	32576.68019	Stationary	5kw	PEMFC	51.3	33.5	74	1213					http://www.communicationstoday.co.in/oct2007/plug-power-brings-fuel-solutions-to-remote-india-2225-41.html
FCE	DFC300	4600/kw	1295910.339	Stationary	300kw	MCFC	20 ft	10	14.5	77K			480vac	up to 75%	http://www.powergenworldwide.com/index/display/articledisplay/303179/articles/powergeneration-and-on-site-power-production/volume-8/issue-4/features/gearing-up-for-the-market-commercialization-of-stationary-fuel-cells-on-the-horizon.html
FCE	DFC1.5M	4300/kw	4195260.393	Stationary	1.5M	MCFC	50	70		242k			480VAC	up to 75%	http://www.powergenworldwide.com/index/display/articledisplay/303179/articles/powergeneration-and-on-site-power-production/volume-8/issue-4/features/gearing-up-for-the-market-commercialization-of-stationary-fuel-cells-on-the-horizon.html
FCE	DFC 3MW	3250/KW	9376481.195	Stationary	2M	MCFC	60	55		252k			13.8K	up to 75%	http://www.powergenworldwide.com/index/display/articledisplay/303179/articles/powergeneration-and-on-site-power-production/volume-8/issue-4/features/gearing-up-for-the-market-commercialization-of-stationary-fuel-cells-on-the-horizon.html
UTC PureCell	400	4500/kw	1828897.638	Stationary	400kw	PAFC	27.5feet	8.5	10	66K			480 VAC	with cogen	http://www.powergenworldwide.com/index/display/articledisplay/303179/articles/powergeneration-and-on-site-power-production/volume-8/issue-4/features/gearing-up-for-the-market-commercialization-of-stationary-fuel-cells-on-the-horizon.html
Bloom box		700k-800k	741367.3816	Stationary	100kw	SOFC									http://news.cnet.com/8301-11128_3-10461339-94.html
Horizon Greenhub	Powerbox 1000	10400	10125.72189	Stationary UPS	1000w	PEMFC	40	60	25cm	20kg			120-230VAC		http://www.thehydrogencompany.com/subs.php/products_94-900.html
Idatech	Igen	5200 (gov price)	5817.008322	Stationary	250w	PEMFC - liquid f	15.5	17.25	17.5	40	50	-20		na	http://www.fc.fed.us/eng/pubs/html/pubs/html09732309/

Table 1. Summary of Fuel Cell Data Collected

Data Normalization

Clearly, significant effort was necessary to make price data a useful proxy for a first piece cost. The study was focused solely on understanding the production costs of the fuel cell power systems. Some assumptions and deduction were necessary to facilitate this process. The literature that was studied supports the assumptions built into this analysis. The following steps were applied to the price data:

1. Price was converted from its base year to 2010 using PRICE Systems published escalation rates.
2. For each unit an assumption was made for volume of production based on size and application of the unit and how widespread its use appears to be based on review of product websites.
3. A markup was determined based on the production volume and this markup was removed from the price
4. For fuel cells that were sold prior to 2010, an adjustment was made to account for the fact that there is confirmed evidence that fuel cell development is getting more cost effective every year. This fact is due primarily to government incentives focused on establishing wider spread use of fuel cells, through lower

costs gained with improved manufacturing processes. Values of 2% cost reduction per year for stationary and backup power systems and 15% cost reduction per year for backup and portable power systems [4],[5] were applied. This adjustment aligned the costs to what they would have been in 2010 based on improvements in technology and processes.

5. For systems where the application was military, costs were adjusted to eliminate the effects on cost of making the units military issue using the relationship used in the PRICE Models for adjusting for such costs. Since most of the data was purely commercial, the data was normalized to that platform.
6. Based on production volume and learning curve assumptions (determined by the size and type of systems), learning curve effect was backed out of the cost to come up with a first-piece cost proxy.

Additional normalization required converting all weights to pounds and all power to Watts. The assumption was made that the costs applied to the entire power delivery system, not just the fuel cells that power the system.

Analysis

Within the stratifications of application and fuel cell type, power was by far the most significant cost driver for these systems. Weight was considered a cost driver but was determined to be too closely correlated to power to add any value to the relationship.

Separate analysis was performed on each of the power system types. Where appropriate, analyses was performed separately for each type of fuel cell. Because not all fuel cell types were represented in all data sets, in some cases more generic algorithms were applied across the fuel cell types. Regression analysis was performed along these stratifications, and cost estimating relationships were developed for production manufacturing costs. Appendix A contains the relationships along with figures of merit.

Delivering the Model

Once CERs for production manufacturing were developed, the next step was to build these into a model that can plug and play in the TruePlanning ® framework. The TruePlanning model development tool was used to create four cost objects, one for each of the power delivery systems studied. These cost objects contain the cost drivers identified and the CERs developed, as well as additional fields for storing other attributes of a fuel cell power system and a field for storing actual costs as shown in Figure 2. This makes it possible for the cost object to support both estimation and the collection of historical data. It also makes it possible to do estimate vs. actual comparisons right in the framework as shown in Figure 3.

Worksheet Set: <Inherited>

		Value	Units	Spread
1	Start Date	1/1/2010		
2	Quantity Per Next Higher Level	1.00		
3	Number of Additional Production Units	0.00		
4	Operating Specification	1.40		
5	Fuel Cell Technology	RMFC		
6	Maximum Power	25	Watts	
7	Weight	2.50	lbs	
8	Learning Curve	97.00%	%	
9	Additional Data Items			
10	Length	2.50	in	
11	Width	9.10	in	
12	Height	1.70	in	
13	Maximum Temperature	5.85	Degrees F	
14	Minimum Temperature	122.00	Degrees F	
15	Electrical Efficiency	0.00%	%	
16	Actual Cost	3,983.00	$ in 2010	

Figure 2. Sample Cost Object Inputs for Portable Power Fuel Cell Systems

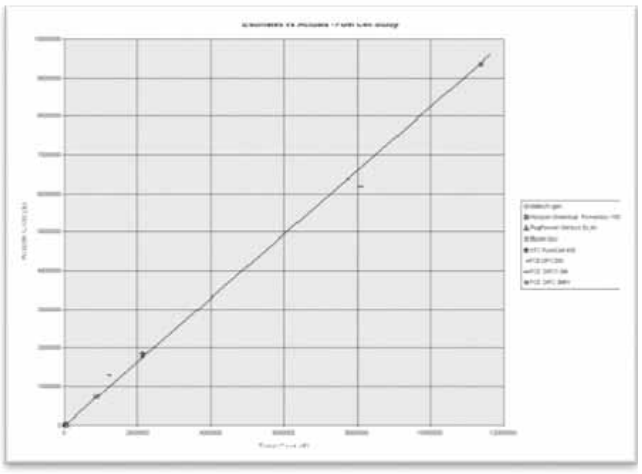


Figure 3. Estimate vs Actual Cost Comparison for Stationary Power Systems

For completeness, the activities of production engineering and production tooling and test are also calculated for the fuel cell cost objects. A study was conducted of systems of similar sizes and complexities to the systems

Continued on page 18.

Continued from page 17.

studied in order to identify how engineering and tooling and test activities vary with respect to production manufacturing. These relationships were used to extend the production manufacturing costs in these models. The cost objects also contain features that allow them to share size and complexity with other cost objects in the product breakdown structure. This shared data makes it possible to estimate not only the costs of the individual fuel cell systems but also the costs of integrating these fuel cell systems with other equipments in an assembly or sub-assembly.

Conclusions

There are many potential advantages of replacing traditional power systems with those employing fuel cells. Fuel cells are highly reliable and efficient means of delivering power. They provide a greener solution because they require no combustion. They are also a viable alternative to help reduce our country's dependence on foreign oil. Despite the many advantages, fuel cells are just starting to get mainstream attention for many applications. The primary reason for this is that they still do not present the best cost solutions. Over the past few years improvements in efficiency and manufacturing processes have brought fuel cell costs down significantly and with further investment they are on target to compete with other energy sources by 2015.

This paper describes a study of fuel cell technology and the costs of some of its applications. The intent of this paper is twofold; describing the results of this research and communicating an effective framework for delivering this research to the cost community in a fashion that they can understand it, use it effectively, defend its results and use it to support good decisions when planning projects.

References

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[2] http://www1.eere.energy.gov/hydrogenandfuelcells/accomplishments.html

[3] http://en.wikipedia.org/wiki/File:Fuel_Cell_Block_Diagram.svg

[4] http://www.fuelcellseminar.com/media/5235/dem42-3_leo.pdf

[5] http://www.itm-power.com/cmsFiles/investors/Tradition_FuelCellReport_Apr2010.pdf

Appendix A. Cost Analysis Results

Portable Power Systems. The fuel cell types used for portable power were of fuel cell types RMFC and PEMFC. The analysis resulting in the following relationships:

For RMFC: $Cost = 32 * power ** 1.384$

For other fuel cell types: $Cost = 15.6 + 151 * power ** 0.5$

What follows summarizes the statistics of these relationships with the original data set.

Stationary Power Systems. Stationary fuel cell power uses the widest variety of fuel cell types of all of the power

System	Power	Fuel Cell Type	First Piece Cost (2010$)	Estimated First Piece Cost (2010$)	GSRQ (r^2)	R^2	adj R^2	StdErr
Ultracell xx25	25	RMFC	3983	3714	0.995924498	0.987943	0.983924	506.6854
Ultracell xx55	50	RMFC	10394	9694				
Jadoo Power Ngen	100	PEMFC	1828	1674				
Trulite KH4	250	PEMFC	2229	2636				
Medis technology Power pack	1	PEMFC	50	183				

Table 2. Portable Power Fuel Cell Results and Statistics

systems studied in this research. There were three data points each for PEMFC and MCFC with one each of SOFC and PAFC. The PEMFC and MCFC analyses are applied to estimates for those types of fuel cells. For the SOFC and PAFC a blended relationship was established while for other fuel cell types an analysis of all the fuel cells applies. SigmaPlot was used for the analysis with the following results.

For PEMFC: $Cost = 4554 + 5.61 * power$

For MCFC: $Cost = 0.305 * power ** 1.19$

For SOFC and PAFC: $Cost = 381500 + 3.59 * power$ else $Cost = 27320 + 4.47 * power$

System	Power	Fuel Cell Type	Actual Cost	Estimated Cost	GSRQ (r^2)		R^2	adj R^2	StdErr
PlugPower Gensys 5c,4c	5000	PEMFC	32577	35820.54	0.997136348		0.982779	0.980318	455394.3
FCE DFC300	300000	MCFC	1295911	1053018.9					
FCE DFC1.5M	1500000	MCFC	6199260	7148426.5					
FCE DFC 3MW	2000000	MCFC	9370481	10066710					
UTC PureCell 400	400000	PAFC	1820898	1904743.2					
Bloom box	100000	SOFC	741368	776045.31					
Horizon Greenhub Powerbox 1000	1000	PEMFC	10330	11160.598					
Idatech igen	250	PEMFC	5817	6536.8592					

Table 3. Stationary Power System with Stats

Material Handling Power Systems. The only types of fuel cells in the material-handling fuel cell data set were of types PEMFC. SigmaPlot was used for the analysis with the following results: $Cost = 1750 * power ** 0.34$

System	Power	Fuel Cell Type	Actual Cost	Estimated Cost	GSRQ (r^2)	R^2	adj R^2	StdErr
PlugPower Gendrive GD-240	10500	PEMFC	40959	47707.48	0.569714892	0.290619	0.054158	10517.37
PlugPower Gendrive gd-160	8700	PEMFC	47661	44693.768				
PlugPower Gendrive GD-170	10100	PEMFC	50534	47068.82				
Ballard FCVelocity 9ssl	4400	PEMFC	28333	40448.07				
Ballard FCVelocity 9ssl	19300	PEMFC	56667	67562.874				

Table 4. Material Handling Power System Stats

Backup Power Systems. All of the data points in this data set used the PEMFC type fuel cells. SigmaPlot was used for analysis with the following results: $Cost = 3.035 * power ** 1.045$

System	Power	Fuel Cell	Actual Cost	Estimated Cost	GSRQ (r^2)	R^2	adj R^2	StdErr
ReliOn t-1000	1200	PEMFC	3389	5496.6596	0.942935717	0.911	0.881333	2637.08
reliOn T-2000	2000	PEMFC	6775	9374.126				
Horizon h-1000	1000	PEMFC	5790	4543.1224				
Horizon h-3000	3000	pemfc	15199	14320.103				
Horizon h-5000	5000	pemfc	21713	24421.824				

Table 5. Backup Power System Stats

COCOMO II Parameter Uncertainty

By Jon Wesick, PhD

INTRODUCTION

The COCOMO II cost model calculates the effort to develop software by taking a multiplier times the code size (in thousands of lines of code or KSLOC) raised to an exponent. (Boehm 2000, 13) Both the multiplier and exponent depend on parameters that describe the type of software being developed and the capabilities of the development organization. Each parameter has five or six selectable settings such as High, Low, or Nominal that correspond, respectively, to numerical values used in the calculation. In the Post Architecture model five parameters, called Scale Factors, affect the exponent and seventeen, called Effort Adjustment Factors, affect the multiplier. Authors have found that the effect of these parameters can outweigh that of calibration against local data. (Menzies 2009). Some authors have suggested that a number of parameters can be consolidated. (Briand 1998) (Subramanian 1993). Others claim that having so many parameters introduces more chance for error. (McConnell 2006, 47). Indeed, variation of these can alter the calculated cost of a software project by a factor of thousands. For an order of magnitude estimate assume each parameter can typically change the cost by a factor of 1.5, then the difference between costliest and most inexpensive would be a factor of 1.5 raised to the 22nd power or roughly 7,500.

There is bound to be some uncertainty in the selection of these parameters as the cost estimator may not know enough about the developing organization to set the values perfectly. Even members of the software development team may disagree about their values. This does not mean that a COCOMO II calculation is doomed to large errors. If one imagines that selecting COCOMO II parameters is a random process, the estimator is more likely to choose a mixture of some parameters being too costly and some too inexpensive rather than choosing most with extreme values.[1] Thus the costly and inexpensive values tend to cancel.[2] This assumes the estimator does not have a systematic bias that is either over optimistic or pessimistic, which can still lead to much larger errors. For example the ratio of the cost of developing 100 KSLOC with all parameters set one step higher is 8 times more costly than with all parameters set to Nominal. This paper will discuss two methods of estimating how much an uncertainty in the parameters affects the effort calculated by COCOMO II.

ANALYTIC CALCULATION

Two assumptions simplify the calculation. First assume that the cost estimator has some idea of the correct parameters settings and can choose the parameter only one step too inexpensive, correctly, or one step too costly. Second assume that each parameter contributes equally. On average, setting each parameter one step too expensive adds 13% to the calculated effort and setting it too inexpensive reduces the effort by 13%.[3] These assumptions will be relaxed on the section that follows this one.

The first assumption simplifies the use of multinomial coefficients to calculate the probability of getting any combination of parameter settings. Let **n** be the number of parameters, a the number set too costly, **b** the number set too inexpensive, and **c** the number set correctly. Also let **p** be the probability that a parameter is set too costly, **q** the probability that a parameter is set too inexpensive, and r the probability that a parameter is set correctly. Then the probability of getting a certain combination is given by **P(n,a,b,c)** where

$$P(n,a,b,c) = [n!/(a!b!c!)]\, p^a\, q^b\, r^c$$

Subject to the constraints: $n = a + b + c$ and $p + q + r = 1$

Taking the second assumption into account the multiplicative error given by a certain combination is $E = 1.13^{(a-b)}$. This is the number multiplying the "correct" estimate (where the cost estimator got every parameter setting right). Notice that the correct estimate has a multiplicative error equal 1.

One can then sum up the various probabilities for a specific error. For example for **n=22** and **E=1.13** one needs

$(a-b) = 1$. Therefore $P_{1.13} = \sum_{a=1}^{10} P(22, a, a-1, 22-2a-1)$

One can write similar sums for all the terms but it's easier to enumerate all possible values of a, b, and c in a spreadsheet; calculate the probability and error for each; sort by error value; and sum probabilities for each. The results for **p=q=r=1/3** are shown below both in a probability density function and a cumulative distribution in Figure 1.

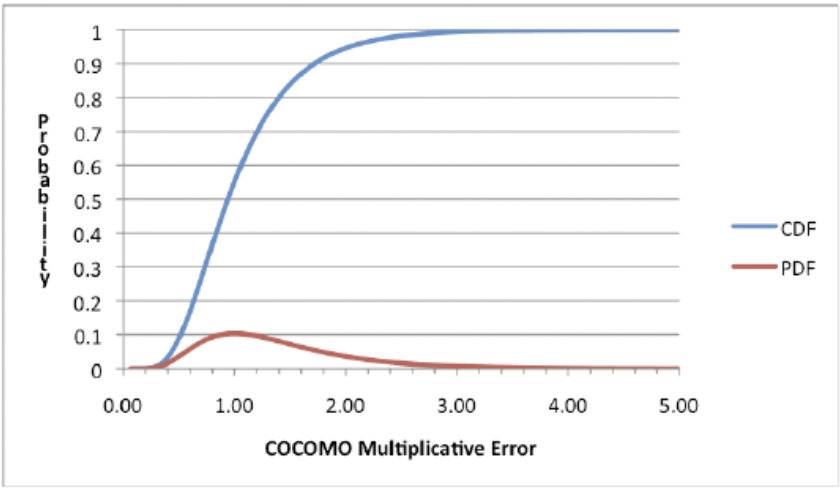

Figure 1. Probability Density Function for Cumulative Distribution from Analytic Calculation

As expected the PDF peaks at 1.0. There's roughly an 80% chance that the multiplicative error (i.e. the COCOMO Multiplicative Factor) lies between 0.6 and 1.4. That is, there's an 80% chance the uncertainty in COCOMO II parameters won't make the effort wrong by more than 40%. This is on the order of magnitude of the 30% uncertainty in a COCOMO II calculation that has been calibrated against local data. (Boehm 2000, 177) While this is not insignificant, it's certainly less than the possible factor-of-two uncertainty when COCOMO II is not calibrated (Madachy 2009), the factor-of-four uncertainty in the early stages of software development (Boehm 1981, 311) and a far cry from the factor of thousands the naïve user might fear.

MONTE CARLO SIMULATION

One could expand the analytic calculation to deal with five parameter choices instead of three as well as to handle the Scale Factors and Effort Adjustment Factors separately but it's simpler to perform a Monte Carlo simulation.

In the simulations described in this paper each parameter was chosen by selecting a random number that corresponds to its setting.[4] That is, any of the five or six choices were equally likely. Thus they represent the worst case of random errors in choosing parameters.[5] The multiplicative error presented is the ratio of the COCOMO II effort relative to that with all parameters set to Nominal.

First, as a crosscheck the analytic calculation with only three choices for each parameter was repeated in Monte Carlo. The results are similar although the Monte Carlo gives a wider distribution with an 80% chance the uncertainty in COCOMO II parameters won't make the effort wrong by more than 60% (instead of 40%).

As expected allowing five or six choices rather than just three makes the distributions wider. Figure 2 presents the results for a 10, 100, and 1000 KSLOC software size project in a Cumulative Distribution Function. For the 100 KSLOC project the median is at 1.88 instead of 1.00 because a few parameters have some costly settings without having inexpensive settings. There is a 67% probability of multiplicative error being within a factor of 2 of the median.

Changing the software size does not have a large effect on the spread. The 10 KSLOC curve has is a 68% probability of multiplicative error being within a factor of 2 of the median while the 1000 KSLOC curve has 65%. The median shifts a bit with software size because some extra inexpensive settings in the Scale Factors have more of an effect for larger KSLOC. The 10 KSLOC curve has a median of 1.99 while the 1,000 KSLOC curve has a median of 1.74.

CONCLUSION

Despite appearances to the contrary, the chance of making huge estimation errors by incorrect choice of COCOMO II parameters is not as great as one might expect. Of course the estimator should try to determine

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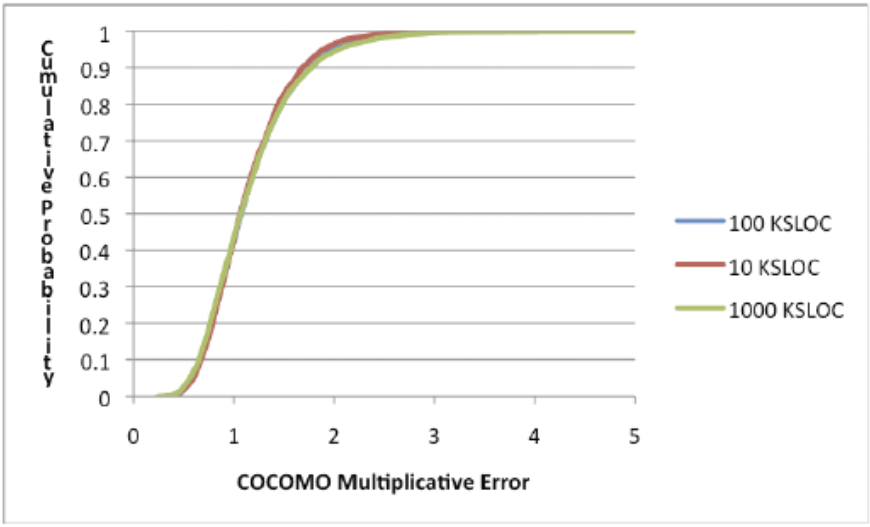

Figure 2. Cumulative Distribution for 10, 100, and 1000 KSLOC Code from Monte Carlo

these as best as possible. However if uncertainty remains, under reasonable assumptions it will most likely contribute no more than a 40% to 60% error in the calculated effort. Table 1 summarizes the uncertainties one can expect from the COCOMO II model.

FOOTNOTES

1. Rather than using the phrases 'too high' or 'too low' for the parameters I use 'too costly' or 'too inexpensive' because some parameters add to cost as they get higher while others reduce cost as they get higher.
2. For example, multiplying the High and Low Effort Adjustment factors together gives an answer close to one. Also averaging the sum of High and Low Scale Factors gives a result close to the sum of the Nominal Scale factors.
3. This number comes from taking the mean of the Productivity Ranges. Since there are typically 5 settings for each parameter we divide the mean minus one by four. For the Scale Factors this assumes the new code is 100 KSLOC. For different code sizes one should separate out the effects of Scale Factors. Note also that we're treating Scale Factors and Effort Adjustment Factors equally.
4. This is easy to do in Microsoft Excel by using the INDEX and RANDBETWEEN functions. It is assumed that the random numbers returned by the latter function are adequate for this situation.
5. One could probably come up with greater inaccuracies by having a cost estimator with a systematic (optimistic or pessimistic) bias or by including statistical dependence among parameters.

Source of Uncertainty	Uncertainty
Lack of project definition in early stage of project	Factor of 4
Not calibrated against local data	Factor of 2
Random Error in Parameter Settings	+/- 40% to 60%
Uncertainty after project defined, parameters set, and local calibration	+/- 30%

Table 1. Uncertainties in COCOMO II Cost Model

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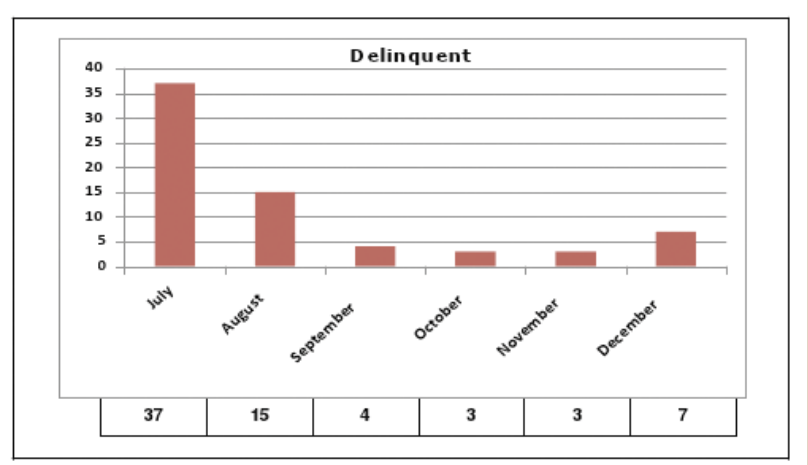
Membership Report

By Steve Sterk

The Membership Team processed 163 renewals over the last four months and added over 24 new members — that's an accomplishment! As I go over the latest report, I still see a couple of folks who are delinquent. If you are uncertain and want to continue being a *Member in Good Standing*, then please do not hesitate to get hold of Erica Wilkening at the Joint Business Office (703) 938-5090, erica@sceaonline.net, or send an email to steve.a.sterk@nasa.gov. We can normally turn your request around within 24 hours. Below is a graph that indicates there are few stragglers from July. Over 70% of the Membership now pays on-line through our secured web site. www.ispa-cost.org

As the Membership Chair, I'm planning to participate in the Annual Conference slated for May 14-17, 2012 in Brussels, Belgium. I realize travel and training budgets will be extremely tight in FY12, so plan early. My shop will only allow Cost Engineers who write a 'White Paper' to travel. Papers are due at the end of the year. Go to our web site for the latest news: www.ispa-cost.org

PS — Hope to see you in Brussels!



Steve Sterk (CPP)
ISPA Membership Chair
steve.a.sterk@nasa.gov
(661) 276-2377

New Members

Ian Davies
General Dynamics UK Ltd

Chantele Dow
Air Force Fleet (AF/A4L)

Steve East
General Dynamics UK Ltd

Mohamed Elghefari
Tecolote Research, Inc.

David Holland
General Dynamics UK Ltd

Steve Hornby
BAE Military Air & Information

Sean Keane
General Dynamics UK Ltd

Darren Miller
BAE Systems Australia

Alan Ree
General Dynamics UK Ltd

Christopher Smith
BAE Military Air & Information

Paul Stanyon
BAE Military Air & Information

Tony Titcombe
General Dynamics UK Ltd

ISPA Southern California Chapter News

By Kurt Brunner, President; Quentin Redman, Vice-President; Sherry Stukes, Secretary/Treasurer

Our Southern California Chapter's workshops continue to promote great interest in parametric analysis, estimating, and cost analysis. We have attendees from across the country and internationally. There is always an impressive group of speakers and an engaged group of attendees, with lively discussions held and probing questions asked throughout the day.

Our **Fall Joint ISPA/SCEA Workshop** was hosted by the **University of Southern California (USC)** located in Los Angeles, CA, on 15 September 2011. The speakers and topics at this workshop included:

Dr. Barry Boehm, USC, Center for Systems & Software Engineering, 'Critical Success Factors for Schedule Estimation and Improvement' ***(Keynote Address)***

JoAnn Lane, USC, Center for Systems & Software Engineering, 'System of Systems Cost Modeling Using COSYSMO'.

Sherry Stukes and John Spagnuolo Jr., JPL, 'Software Cost Estimating Using a Decision Graph – a Knowledge Engineering Approach' ***(2011 Conference Software Track Best Paper)***

Denton Tarbet, Galorath Incorporated, Senior Project Management and Planning Consultant, 'Effective Integration of Project Plans and Project Execution'

Kent Joris, TASC, 'Manufacturing Cost Estimating' ***(Training Topic)***

Anandi Hira, USC Doctoral Student, 'Cost Modeling for Commercial Organizations'

Andy Prince, Chairman of the ISPA Board of Directors, 'Plans for ISPA/SCEA Merger'.

A tour of the campus was held during the lunch break.

If you would like a copy of these or previous workshop briefings please go to our website and login as either a member or a guest and look for the Southern California Chapter. We do our best to get all of the presentations loaded on the web site immediately following the meeting, but if you have an immediate need, feel free to contact the workshop program coordinator, **Henry Apgar** at hapgar@mcri.com

Our Winter Joint ISPA/SCEA workshop planning is well underway. It will be hosted by PRICE Systems in conjunction with the Los Angeles Air Force Base

Workshop Attendees , 15 September 2011 — University of Southern California

Space and Missile Systems Center (LAAFB SMC). It will be held 14 December 2011 at Fort McArthur in San Pedro, California. Another 'Best Paper' winner from the Joint 2011 Conference held in Albuquerque is already scheduled to speak, and a training subject will also be presented. The speakers and topics are:

Brigadier General Kenneth Moran, Director, Program Management and Integration, Space and Missile Systems Center: Keynote Address, 'SMC Cost Estimating Initiatives'

Tony DeMarco, President, PRICE Systems, Welcome Address, 'Targeting Affordability and Controlling Cost Growth through Should-Cost Analysis'

Daniel Schwartz and Nancy Droz, SMC PMAG, 'Using Performance Assessment and Root Cause Analysis to Build a Reliable Performance Measure Baseline (PMB)'

Mohamed Eighefari, Tecolote Research, 'Tecolote Instrument Weight Growth Model'

Sam Toas and Justin Knowles, TASC, 'Cost and Schedule Risk' (Training Topic)

Tom Harwick, Northrop Grumman, 'Multi-Discipline Design Analysis & Optimization (MDAO) Cost Modeling with True Planning'

Doug Howarth, Lockheed Martin Aeronautics Company, 2011 Conference Models & Methods Track Best Paper, 'Trade Space, Product Optimization and Parametric Analysis'.

The agenda has been e-mailed to members and previous attendees, and it contains a location map and driving instructions. The agenda is also posted on the ISPA web site www.ispa-cost.org. You may contact the SMC registration point of contact, Mr. Michael Sato at: Michael.sato@losangeles.af.mil or (310) 653-1013 to register. As always, our workshops are free.

Please consider hosting a workshop or presenting at a workshop. It will be a rewarding experience. If you are interested, please contact **Kurt Brunner, Quentin Redman**, or **Sherry Stukes.** Also, if you are interested in making a presentation at a workshop, please contact our Program Coordinator, Henry Apgar. We look forward to seeing you at the next workshop!

Kurt Brunner

President,
ISPA Southern California Chapter
kbrunner@tecolote.com
(310) 536-0011 x144

Quentin Redman

Vice-President,
ISPA Southern California Chapter
quentin.redman@pricesystems.com
310-692-5926

Sherry Stukes

Secretary/Treasurer,
ISPA Southern California Chapter
sherry.a.stukes@jpl.nasa.gov
(818) 393-7517

Secretary's Report

By Greg Kiviat

As ISPA and SCEA move towards merging the societies to a new, stronger and more responsive organization, the ISPA board has been meeting to help move the process forward and ensure a smooth transition. Here is a summary of the briefings and actions from the committees to the most recent Board of Directors meeting in Los Angeles this past September:

- ***Executive Manager's Report:*** Reviewed number of new memberships (20), award plaque costs, and cost of publications.
- ***2011 Conference Report:*** There were 506 paid attendees at Albuquerque conference (second highest in 10 years), 19 exhibitors and 9 corporate sponsors. Keynote speaker Mike Mullane was well received by the attendees. More attendees were with Air Force than any other group. The conference banquet was attended by 74% of registered attendees. Lesson learned was to be sure to book the keynote speaker as early as possible in process.
- ***Treasurer's Report:*** ISPA showed positive cash flow for first eight months. Committee is working on identifying best alternatives for banking to support the Brussels conference next year; may use Pay Pal.
- ***ISPA/SCEA Merger Report:*** Issues addressed included legal support (which firm to chose) and timely completion of society financial audit. Integration team was named and framework for integrating society was underway with members from both ISPA and SCEA. Compared ISPA and SCEA Board of Directors organizations and members to see how to best align a new society. Compared chapter locations and numbers for aligning-post merger activity. Compared By Laws of each society. Discussed differences in BoD voting of both societies and suggestions for new society. Identified action items and due date for Board members and committee members
- ***Membership Report:*** New membership-committee associate is needed to help with committee work. Noted 4.1% increase in membership in 2011. Team working on post-merger transition of two year and lifetime members (few SCEA members in this category). Discussed ongoing support for ISPA website and member access to membership directory. Discussed whether and how to provide hard copy membership directory on request.
- ***Parametric World Report:*** Reviewed costs for *Parametric World* publication and support staffing
- ***Training and Certification Report:*** ISPA Training materials will be consolidated with SCEA's CeBOK. ISPA CPP certification will continue as a Parametric certification in addition to the SCEA basic cost certification program. All current CPP holders will be carried forward to new society. Brussels 2012 conference training will span three days, not the usual four. The Parametric Estimating Handbook (PEH) is available at no fee to public (different from SCEA CeBOK).
- ***2012 Elections:*** Five Board positions are up for election, four incumbents may rerun. Nominations open 30 October and close 13 January 2012
- ***So. California Chapter Report:*** Noted the need to consolidate ISPA daylong workshops with SCEA's lunchtime series of meetings. Reviewed recent meetings for speakers, attendance and participant surveys.
- ***2012 International Conference Report:*** Engaged professional support to help organize European conference. Contractor was recommended by NATO and is paid for by hotel (not ISPA). Banking selection for bill payment and registration fee collection is in process. A VAT number is needed for Belgian government. Committee is considering a program for guests of conference participants. Sheraton Brussels is the venue for conference. SSCAG conference will follow ISPA. Room rates negotiated with hotel were very competitive. Note: 90% of participants at European conference attend conference banquet. Locations for banquet were considered both onsite and offsite hotel. Both a European and a US speaker were suggested as keynotes
- ***2013 Conference Report:*** Scheduled for June 18-21 in New Orleans. Need to nominate ISPA co-chair.

Both the ISPA and SCEA boards have been busy with the many subcommittees to move the merger process along, but as can be seen from the meeting notes summary there is much to do. With elections upcoming and requests for nominations out, please consider supporting your society by running for office and helping with daily activities to support the ongoing merger planning.

Greg Kiviat
ISPA Deputy Chairman

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Vienna, VA 22180
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