

## **Status of Reliability Education**

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Reliability is an engineering discipline that encompasses a broad array of tools and techniques useful for answering durability and robustness type questions. Product development teams often rely on reliability engineering professionals to guide, advise and manage reliability programs. Reliability is a facet in nearly every function of an organization. This implies the knowledge and skills required for the reliability engineer is comprehensive. The knowledge breadth may span aspects of material science to design constraints to warranty reverse logistics.

How do engineers become reliability professionals? What are the knowledge transfer options available to the reliability profession. How do we get started and maintain our knowledge? In this short paper, I plan on summarizing what's available, a couple of common paths taken to become a reliability professional, and highlight the strengths and a few weaknesses concerning reliability education. This is my view of the state of reliability education.

### **What is available?**

Quite a bit is available actually, maybe too much, concerning tools, techniques, analysis methods, and approaches. As a profession we publish and share our knowledge. There are technical journals, conferences, and books, that capture knowledge in a way we can readily reference. There are seminars, local meetings, discussion groups, forums, and webinars that permit us to listen to lectures and to discuss alternative views and options. There are formal education options, too. Universities and colleges offer seminars, workshops, courses and full degree programs related to reliability engineering.

### **University programs**

The University of Maryland's reliability programs (CALCE and Clark School of Engineering) continue to offer advanced degrees in reliability engineering. University of Arizona has only a few courses with reliability content, since the retirement of Dr. Kececioglu and the declining enrollment in the reliability engineering program.

Other notable programs include Rutgers University, University of Tennessee, Knoxville, Vanderbilt University, University of Arkansas, Arizona State and UT/Monash University. Internationally there are also advanced degree programs, for example from the Indian Institute of Technology. Most of these programs have a particular focus, systems or quality engineering, maintenance or risk management.

There are elements of reliability engineering in many engineering undergraduate programs, yet there are not degrees, that I know about, in reliability engineering at the undergraduate level. Also, many electrical, mechanical, civil, or software engineering programs may only briefly discuss or mention reliability as part of the program of study. More than one student has shied away from the statistical and probability included within reliability engineering after the initial

required probability and statistics class.

An education in reliability engineering may include classes in materials science, design engineering, process engineering, maintenance engineering, finance and accounting, and a dash of marketing and sales, to name just a few. An advance degree is a great start for a career in reliability engineering. Combined with work experience in another engineering discipline makes for very strong resume.

## **Journals**

Technometrics, IEEE Transaction on Reliability, and Quality Engineering (QE) come immediately to mind for me. Many of you may recognize the first two. QE has recently agreed to regularly publish reliability papers and has included a small team of reliability professionals on the editorial board. Whereas the first two journals listed tend to me more on the academic end of technical papers; QE expects to publish applied reliability articles.

There are many other journals. Titles like Reliability Engineering & System Safety by Elsevier or Journal of Machinery Manufacture and Reliability by Springer suggest the focus of the journal's articles. It is safe to say there is a robust peer reviewed technical journal community.

Journals are also published by professional societies, consultancies and businesses. Some of these journals rival the peer-reviewed technical journals mentioned above, and they tend to focus on the sponsoring organization's focus. For example, the RiAC Journal is published by the Reliability Information Analysis Center. And, another example is the Journal of Reliability, Maintainability, Supportability, in Systems Engineering published by the RMS Partnership. Both of these journals tend to focus on military applications.

Businesses related to reliability engineering have a few journals type publications available. For example, ReliaSoft's Reliability Edge Newsletter and DfR Solution's Newsletter both provide technical information and education and are free to join the subscription list.

Trade journals also publish reliability articles. These tend to be more introductory than the scholarly or technical journals, yet tend to have a wider audience outside the reliability profession. The article "Inverter Risk Factors: What to Consider Beyond MTBF Numbers" is in a recent issue of the Solar Industry trade journal. Circuits Assembly provided me with many introductory printed circuit assembly reliability articles over the years.

Whether you want to be published or simple keep up with the reliability profession, journals provide a vibrant, timely and broad spectrum of views across our industry. Most of the technical articles are written for an audience that is well versed in the discipline discussed. And the trade journal and newsletters tend to be more introductory and for a broad range of readership.

## **Conferences**

Over the past 20 years I've explored many reliability conferences. At times, as now via the [www.reliabilitycalendar.org](http://www.reliabilitycalendar.org) site, I've attempted to maintain a calendar of all reliability

conferences. The vast majority of conferences are very focused on a particular industry or discipline. Building and maintaining the site [www.reliabilitycalendar.org](http://www.reliabilitycalendar.org) over the past year has been educational in itself. As you may already know, conferences are typically schedule in the spring or fall and tend not to be located at tropical resorts.

It is almost possible to find at least one conference every week somewhere in the world. A few years ago two conferences on prognostics with respect to product reliability started: IEEE's International Conference on Prognostics and Health Management and Annual Conference of the Prognostics and Health Management Society. The solar industry has recently seen a significant rise in the number of conferences available.

Most professional societies related to reliability have at least one annual conference. Some businesses are also offering conferences, some have a trade journal affiliation and others as a service to the reliability community or as a part of their business strategy.

When asked, I tend to recommend three conferences. Keeping in mind that many working professionals may only attend one conference a year, getting the most for your time is important. Unless your needs are very specific, for example testing color fastness of polymers, you may find these three conferences useful to attend on an ongoing basis.

The Annual Reliability and Maintainability Symposium, in 57th year in 2011, is a multi-track 3.5 days conference complete with technical papers, tutorials and vendor trade show. The conference regularly attracts 400 or more participants, making it a great place for networking. The paper presentations are typically 20 to 30 minutes, making it possible to learn about a wide range of topics from many speakers. The tutorials are typically two hours long and permit time to cover a lot of material. Ten professional societies sponsor the conference. This conference is held at various locations in the US, once a year. If you can only attend one conference a year, go to RAMS.

The International Applied Reliability Symposium (ARS) is a three day multi-track conference with hour long presentations. The longer format provides time for an in-depth treatment of the topic. The speakers are generally experience reliability professionals and tend to provide applied or tutorial type presentations. ARS has annual events in the US, Brazil, Singapore, Amsterdam and Bangalore. Locations vary year to year yet continue to be have a presence around the world.

The Workshop on Accelerated Stress Testing & Reliability (ASTR) focuses on accelerated testing from Highly Accelerated Life Testing to accelerated degradation testing, including the equipment, techniques and measurement equipment necessary for successful testing. This a three day single track conference and tends to include very practical topics.

CARTS, IRPS, and ITSFA would be the next three on my list of recommendations. They focus on passive electronic components, microelectronics, and failure analysis respectively. Of course, depending you your interests, industry and budget, you may find many options for participation.

Conference attendance has been down of the past few years mostly due to the recession. There are signs that attendance will rebound this year, as a reflection of the need for professionals to

continue to learn, network and discuss reliability topics.

## **Books**

To get an idea of how many books are available on the topic of reliability engineering, I searched Google Books for reliability engineering. Two things to note from this exercise, first Google returned 615,000 results. And, second, the two books I use and recommend most often were on the first page.

Ireson, Coombs, and Moss, Handbook of reliability engineering and management, 2nd Edition and, O'Conner, Practical reliability engineering, 4th Edition are both texts that address most of the aspects of reliability engineering. Both discuss the basic approaches to guide professionals across the product life cycle. Both contain brief discussion on a broad range of tools and techniques. And, both are on many reliability professional's bookshelves.

The options for books include general purpose books, plus many very narrowly focused texts on specific tools or industries, or both. For example there are books on Failure Modes and Effects Analysis (FMEA) in a general nature, plus texts on FMEA in the automotive industry or medical industry. The options for reliability statistics also have a very broad range, from introductory treatments for any engineer, to highly specialized, narrow branches of the art.

Like the overall book market, ebooks are becoming increasingly available. Unfortunately at a slow pace. In a few years, it maybe possible to carry a complete library of professional textbooks on your favorite ereader.

## **Seminars**

Small, local and personal meetings to learn about a topic seem to be thriving. Face to face meetings are increasingly being supplemented with a growing calendar of teleconferences and webinars. A broad range of consultants, vendors, laboratories, consortiums, professional societies provide reliability training via seminars. These can range from an hour local meeting to discuss a particular topic to a full week long structured instructor lead course.

courses - These face to face instructor lead classes typically range from a half day to a week in duration. For example, MET Labs offers short seminars on standards based testing methods. A few organizations only offer courses, like Technology Training, Inc (TTI) on a broad range of reliability topics. And others offer courses related to using their primary products, like Relex's or Minitab classes on using their software.

Courses provide by non-academic institutions are increasingly offering certifications. These are typically based on the successful completion of a series of courses. Examples are certification programs offered by ReliaSoft and TTI. Not all seminars or courses offer professional engineers CEU's, although many could.

local meetings/discussion groups/forums - in areas with a sufficient number of active volunteers, local meeting are regularly organized and offered. Most are on a monthly basis and

have invited speakers that cover topics of interest locally. Houston meetings may focus on the oil industry, Wichita on private jets, San Jose on high tech. This is a traditional means to network, learn and contribute to the greater discussion concerning the reliability profession. IEEE, ASQ, and SRE are all active in this area.

online discussion groups and forums - Since the start of the Internet, there have been newsgroups, discussion boards, email lists and forums available for the reliability professional to stay in touch with other professionals. The format is great for the occasional question, permitting possibly hundreds of professionals to address. Often a reasonable response or two is available within a day or two. Discussion boards such as the IEEE Reliability Society Yahoo Group or the ASQ Reliability Division LinkedIn group are open to any interested party. These forums have also attracted regular job posting as the audience is primarily working professionals. Discussions, announcements, and job posting create a fairly light traffic format, yet permits the individual to tap the collective information of the subscribers.

webinars - The combination of a teleconference with the web enabled broadcast of the slides with annotations permits a disperse audience to hear a speaker and see their slides. Tools offered by Webex, GotoMeeting and other others permit seminars to occur via your computer and phone.

Some organizations charge a fee for high quality webinars by noted presenters. Costs typically range from \$50 to \$200 an hour. Hobbs Engineering and Paton Press are two examples. Other organizations offer free webinars either as service to their customers or their members. The ASQ Reliability Division is offering monthly webinars in English and Mandarin, plus short courses for free. These webinars provide a means to receive similar content as attending a conference or local seminar or meeting, without the travel. Some are also recorded and available online on demand.

The pricing, content and presentation styles are all in flux and many groups are experimenting with this relatively new format to provide training. The mix of free or paid, advertising or training, introductory or advance, and formats, durations, etc are all being explored and adapted to find what works. We should expect to see this area continue to evolve and grow.

## **Newsletters**

There seem to be two types of newsletter independent of the source. One provide news of events, products activities and announcements . These newsletters help the professional keep current on what is happening based on the view of the newsletter editors. The second type provide content that is educational in some manner. These newsletters provide tutorials, problem solution approaches, guides, or technical articles. Of course many newsletters combine the two type of content. As far as I know, all newsletter are either free or a benefit of membership.

Ops A La Carte, RiAC, ReliaSoft, Relex, and many others offer free newsletters. Nearly all professional organizations offer a newsletter, often electronically, for their members. Two notable newsletters with great technical content have ceased. It's been a few years since I've received the Society of Reliability Engineers' newsletter. And, the ASQ Reliability Division's

Reliability Review has just published their last issue. Both found it increasingly difficult to find suitable technical articles to publish.

Blogs on reliability are available by a few writers, yet it is not a prevalent practice. Ricky Smith's Maintenance and Reliability blog or The Reliable Plant Blog being examples. A Google search for 'reliability blog' finds an assorted array of blogs with reliability in the title of the particular discussion with only a few blogs devoted to reliability topics exclusively.

## **Mentors**

Having a mentor or two during your career provides an accelerated means to gain experience and guidance. Without a mentor you may learn the 'hard way', meaning you may make your share of mistakes. A mentor provides a sounding board, reality check, insightful guidance and possibly friendship. Some companies provide mentorship as part of the culture. For example an opening for a Reliability Engineering Group Leader job listing recently included the role of 'mentors the development...'

In discussions with other reliability professionals, learning from a mentor is often cited as a major element of their professional development. Courses, seminars and conferences provide the tools, and the mentor provided wisdom in the selection and application of those tools.

## **What is missing?**

From my own experience, I learn from product failures and an understanding of the root cause involved. Henry Petroski has written about design engineers that avoid design failures by a routine of studying failures. A few years ago, the local IEEE Reliability Society chapter meeting was the day prior to Halloween and the discussion topic was 'Reliability Horror Stories'. The intent was to share the best failures in story form with each other.

We are too often thwarted from discussing failures. Product failure discussion may reduce product sales or lead to liability claims. Management or design failures leading to reliability issues may lead to politically charged discussions and reorganizations. While attempting to focus on the data and the root cause, reliability failures still invoke a need to assign blame. Furthermore, discussing failures tends to dwell on the negative aspects of the process. Yes, it provide a much richer learning atmosphere, yet unless done in a safe environment may be career limiting.

Likewise, the discussion of very robust and reliable product achievements is equally rarely discussed. A few products have been notable and marketed accordingly. HP calculators is one example. Very few product are able to maintain a significant edge in the market on the basis of being more reliable. Individual products is even more difficult to identify. The evidence is often the lack of higher than expected field returns.

In general, what is missing is the ability of our professional to talk openly about reliability performance, good or bad. We certainly can learn from failures, and we can emulate the successful achievements, if possible to learn about both.

Failure data and information, not MTBF, is often missing. For a particular design, what is most likely to fail and how? What is the failure mechanism and associated stresses that will limit the useful life? Vendors will gladly list the performance specifications and are often very reluctant (ignorance, embarrassment, perception) to articulate expected failure specifics. Vendors gladly list testing that only has no-failures, leaving the recipient to wonder if the test and associated stress was valid to the most likely failure mechanisms.

Value or ROI guidance is generally missing within our training, textbooks and discussions. What is the value of a well run Design FMEA session? In a culture of tight timelines and budgets the time to conduct a Design FMEA is readily estimated, yet the value received is difficult to predict. The same applies to many of the reliability tools in common use. A general set of guidelines or algorithms is missing to permit the valuation of a specific tool in a specific application.

### **Where do Reliability Engineers come from?**

Other engineering fields provide the majority of reliability professionals. Degrees in physics, math, statistics, electrical or mechanical engineering and many others are common across our profession. In my case, and common with a few I asked how they became a reliability engineer, was by happenstance. The engineering problems that were available and interesting to me were of a reliability nature. Find the projects both interesting and rewarding, I sought additional projects in the reliability area. While working as a design for manufacturing engineer, I found that field reliability improvement often coincided with yield improvements for assembly. And, I found the cost savings by reducing field failures made a compelling argument for process improvement investments then simply yield improvements.

This path to become a reliability professional requires the willingness to continue to learn, the ability to learn quickly and the desire to contribute in the solving of difficult cross discipline design problems.

A few university programs offer degrees in reliability engineering. These programs provide a solid grounding in the wide array of tools and techniques in the reliability profession. The students are a mix of working professionals and students continuing from undergraduate work. Like the above career development path, a formal education also requires the desire to learn. The one complaint I've heard and experienced concerning this path is the over-reliance on advanced tools to address issues. What is missing is the ability to select the appropriate tools and analysis to economically solve an issue - 'Not everything is a thesis' - (Anon by choice).

A few reliability professionals have taken a Hybrid approach. A mix of formal courses, a selection of seminars and conferences, plus self study and experience. If one is lucky then a mentor also.

All three approaches produce excellent reliability professionals along with the full spectrum of performance abilities. Those that continue to take advantage of learning opportunities tend to continue to advance their career.

## **Summary**

The reliability profession is rich in learning opportunities. Books, websites, books, conferences, etc. all provide a mix of introductory and advanced materials. As all fields of engineering and design continue to invent new materials and novel assemblies, the reliability professional will have to continue to learn how to best apply the appropriate tools and techniques to solve problems.

Despite the barriers to freely sharing failure information, we do readily share approaches, algorithms, techniques and tools. We share our experience and our wisdom as we enrich our professional community.

In general our education permits us to address two questions of value: What will fail, and when will it fail? It is in the details of providing answers that we provide value. Our profession's rich education opportunities permit us to effectively and efficiently answer these two questions on an ongoing basis.