U.S. Nuclear Quality Problems Persist

The Case for Nuclear Management System Advisors | Designers and a Certification Program

Paul W. Gladieux, Founder | CEO, GQM Advisors

'The Nuclear Quality Problem' 1970 ~ Present
'The Nuclear Quality Problem' ~ Language of Quality
'The Nuclear Quality Problem' ~ Quality Assurance Program Failures
Lessons Learned ~ U.S. NRC NUREG-1055, Report to Congress 1984
Programs | Systems | Quality Management Systems & The NMS
Case for the NMS Advisor | Designer and Certification Program ~ ***Part of The Nuclear Quality Solution***
'What Executive's Should Know About the Management of Nuclear Quality' – White Paper

New work positions are created for business and industry sectors as the needs arise. The reasons vary from span of work control issues, new regulations, cyber security provisions, and new methods of doing work such as robotics. Information Technology did not exist as an organizational function until computer networks and the use of PCs rapidly changed how we process information and communicate. I make the case in this article for two new industry positions in the nuclear industry.

1) I explain the rationale for new industry-based positions that will greatly enhance the effectiveness of your Nuclear Management System (NMS). I explain the basis for the use of NMS and clarify the scope of a Nuclear Quality Assurance Program. I describe the basis for two new positions needed to help organizations reduce the potential for 'The Nuclear Quality Problem.' Roles and responsibilities of the NMS Advisor and NMS Designer are discussed.

2) I discuss the developmental work by GQM Advisors to bring a training course to the global nuclear industry that encompasses **NMS *Concepts | Requirements | Design | Systems Thinking | Integration | Compliance | Effectiveness.*** It is envisioned as an intense short training course that is part of the overall qualification criteria for certification. In the early 1990s, the Project Management Institute (PMI) deployed the Project Management Professional (PMP) certification. Recently, perhaps you've learned that Human Resource Professionals need SHRM certification to demonstrate their body of knowledge. Our goal is professional certification for NMS Advisors.

‘The Nuclear Quality Problem’ 1970 ~ Present

The U.S. nuclear industry encompasses a span of approximately 70 years including commercial, government, private, academic entities, the public rate payers, and a variety of investors. The evolution consists of two general periods of research, development, design, procurement, manufacturing, construction, operations, reactor life-extensions, and most recently decommissioning programs. The periods are 1950~1999 and the “2000 Nuclear Renaissance.” The Nuclear Quality Problem drives the need for the new positions.

Those in the nuclear industry are well aware of the daily emphasis on nuclear safety and nuclear quality. We know about the new advanced reactor concepts and those at various phases of research, design, build, and operation. Fusion reactor research and the desire for deployments are now in the daily news. The achievements in the 70-year period are remarkable to say the least. Small Modular Reactors (SMRs) and now micro-reactors play a part in the future of nuclear applications. The advances in all areas of technology touch our personal lives especially nuclear medicine.

‘The Nuclear Quality Problem’ is used in a broad sense relating to any non-conforming condition that results in a negative impact on the work and the industry. The problems affect the proper Management of Nuclear Quality. It’s understood that all organizations commit to continual improvement. My case for the new positions is another aspect of improvements.

The case for a certification program stems from my forty-fives years developing and upgrading Nuclear Quality Programs and Systems. I recognize the need for full-time experts focused on the design and management of the NMS. There are specific skills and knowledge to define and develop a complete system. Often, The Quality Problem stems from poor system maintenance. Work processes change, new requirements emerge, employee turnover creates weaknesses and mis-interpretations and so on. I see establishing the required body of knowledge to have certified professionals perform in Advisor and Designer roles. Some understanding of the industry foundation is needed for my case.

The U.S. Atomic Energy Commission (AEC) was the original government regulatory body. The name was changed to the U.S. Nuclear Regulatory Commission (NRC) in 974 to ensure the public it was in fact a regulatory body. Industry criteria were enacted by federal regulations and industry committees developed supplemental codes and standards. This mandate triggered the need for writing clear commitment and implementing program documents. Three regulations formed the basis.

- U.S. NRC Title 10 Code of Federal Regulations, Part 50, Energy, “Domestic Licensing of Production and Utilization Facilities.” [1]
- 10 CFR Part 50, Appendix A, General Design Criterion 1, included reference to Quality Assurance Program requirements as “Quality Standards and Records.” [2]
- 10CFR50, B “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Facilities.” [3] This CFR set the precedence for the industry to have formal quality programs among all entities. Practitioners refer to it as Appendix B or the “18 Criteria.”

The second period beginning in 2000 “The Renaissance” was the industry restart since the U.S. commercial nuclear power plant accident at Three Mile Island (TMI), Harrisburg, PA, in 1979. Major investments sustained the first period and helped propel the second period of new reactor concepts, safer designs and materials, small reactor applications, improved constructability, cost reductions and constraints, improved operational safety systems and equipment, a small but consistent supply chain, and a highly knowledgeable workforce and academic offerings for the next generations.

Historically, the industry has used the terms quality, quality policy, quality standard, quality assurance, quality control as delineated in industry regulations and standards. Quality management and quality management systems principles and practices emerged in the early ‘90s world-wide. The industry language usage is primarily still rooted in ‘Quality Assurance discipline. It must be noted that there are four distinct quality disciplines. I address this later.

The term poor quality is still used in the problem statements in corrective action requests and audit findings. Government and industry assessment and inspection reports demonstrate the current understanding that problems and project failures are quality assurance program-related. Is program content in error? Is it a lack of training? Is it poorly written procedures? Is it employee’s attitude about being audited (watched)? Is it about management not engaging enough in the management of quality? Is the company only focused on cost and schedule? I share some quality deficiency types from the Lesson Learned report resulting from the TMI accident later in the article.

The industry is unique. It still faces numerous challenges, public concerns, extensive regulations, ever increasing requirements, and yet offers boundless possibilities. The first design/build period encompassed over 60 sites and 100 power reactors. The 2000 Renaissance plan would to nearly match the first. Small Modular Reactor (SMR) research and development holds the most hope now for the industry to grow as a key part of the energy mix.

Figure 1 is an overview of events and evolving requirements documents from 1955. Three accidents occurred between 1979 and 2011. Four NPP programs were cancelled due to cost issues as shown between 1984 and 2017 causing negative impacts. Public safety, environmental, and cost concerns are among the top issues facing the future. The advanced designs continue to reduce nuclear accident risk and offer prolonged plant life now for eighty years. Those of us involved in the industry know the technology offers boundless possibilities. If we fix ‘***The Nuclear Quality Problem’*** the industry will keep its place in the energy mix and gain public backing.

My case for new positions is related to negative events since 1970, the poor understanding and perceptions regarding quality, underestimating the complexities to have robust management systems, and not having experts to directly assist executives and operational management with their management system.

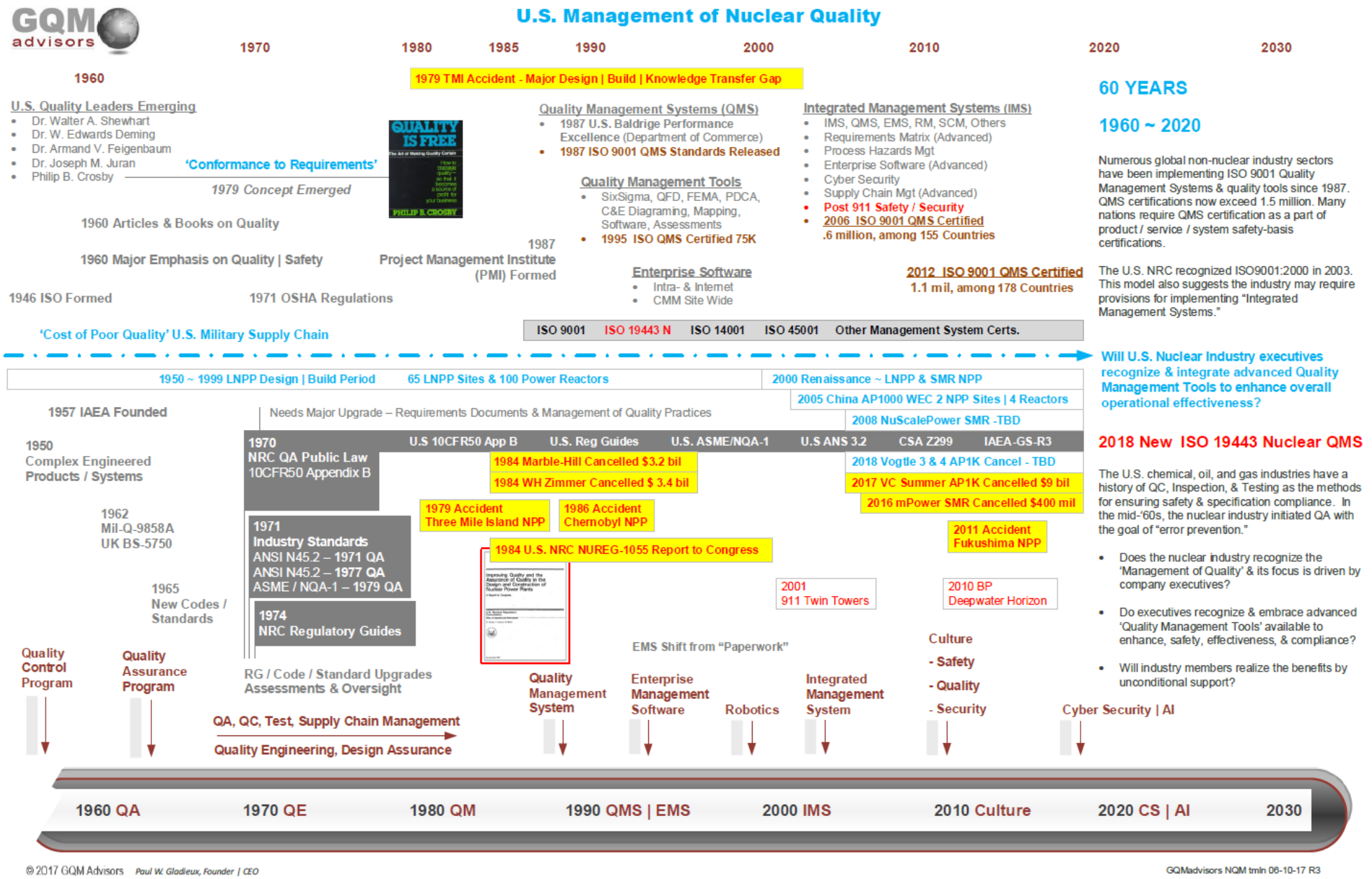


Figure 1

Nuclear Management Systems Focused on Quality Since 1991

'The Nuclear Quality Problem' ~ Language of Quality

First, it's important to share a few of the quality-related terms. Conformance to Requirements is the most common definition of quality and it satisfies the need for simplicity. The four disciplines are equally important and have their own roles and responsibilities. Throughout my career, I have heard people say "quality assurance and quality control are the same thing – quality is quality." "There's no difference between a quality program and quality system." This in itself adds to The Nuclear Quality Problem. Understanding the language of quality is fundamental to effectiveness just like specific terms for other disciplines.

Terms

Quality Conformance to Requirements

Quality Policy The overall quality intentions and direction of an organization regarding quality as formally expressed by top management.

Quality Management System (QMS) The organizational structure, processes, procedures, and resources needed to implement quality management goals, objectives, and requirements.

Four Quality Disciplines

Quality Leadership (QL) The Department of the Navy's definition of QL is based on Dr. W. Edwards Deming's ideas. "The application of quantitative methods and the knowledge of people to assess and improve a) materials and services supplied to the organization, b) all significant processes within the organization, and c) meeting the needs of the end-user, now and in the future."

Quality Management (QM) That aspect of the overall management function that determines and implements quality policy. Quality management includes strategic planning, allocation of resources, and systematic activities for quality such as quality planning, operations, oversight, and evaluation.

Quality Assurance (QA) It comprises all those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. Quality assurance includes quality control, which comprises those quality assurance actions related to the physical characteristics of a material, structure, component, or system which provide a means to control the quality of the material, structure, component, or system to predetermined requirements. Source: 10CFR50 Appendix B. [3]

Quality Control (QC) Those actions that provide a means of control and measure of the characteristics of an item, process, or facility to established requirements (inspection or source surveillance, or both).

Source: GQM Advisors Terms & Disciplines [4] https://gqmadvisors.com/disciplines/

'The Nuclear Quality Problem' ~ Quality Assurance Program Failures

Many organizations still believe the QA Program includes everything needed to manage, document, verify, and deliver high-quality products and services. The use of the term QA Program and related terms stem from the 1970 NRC regulations (AEC until 1974) and industry standards. Quality programs 'sound very technical.' Part of this view came from Engineering Design being the organization expected to author and implement the program. This precedence was set

and continued for years. Quality Engineering eventually became the program administrative arm for Engineering Design organization. Everyone was part of the learning curve for this formal approach to the work.

Programs were mainly design and product-focused. Reading and translating numerous requirements in regulations, standards, codes, contracts and committing to applicable requirements was overwhelming. The task of developing the program was usually assigned to the best writer in the group. In many cases, program documents were written by those with high level college degrees because of the technical content in the external requirements documents. Perhaps some were not interested in the challenge.

The industry learned after the 1979 TMI accident that the readability index of most program documents measured 16-18 on the Gunning Fog Index [5] (bachelors and a master's degree). In reality, the nuclear industry was faced with an existing non-nuclear workforce that entered a work environment with a great increase of requirements, procedures, and other controls to ensure conformance to requirements. It was a major increase in complexities in all areas of the work especially administrative due to the added 'paperwork.' The workforce transition contributed to The Nuclear Quality Problem.

Post TMI studies by the Institute of Nuclear Power Operations (INPO) revealed a Fog Index range of 6 to 8 was best for the workforce. Document writing classes emerged as one industry corrective action measure. I spent a total of eight days between General Physics and INPO in the early '80s learning advanced writing skills and new industry requirements such as Job Task Analysis (JTA). Some methods came from the U.S. Air Force man/machine interface human factor programs.

These industry QA Program failures weakened the industry and public confidence. Cost impacts are documented and some design/build efforts were cancelled. Reports reveal a wide range of root causes.

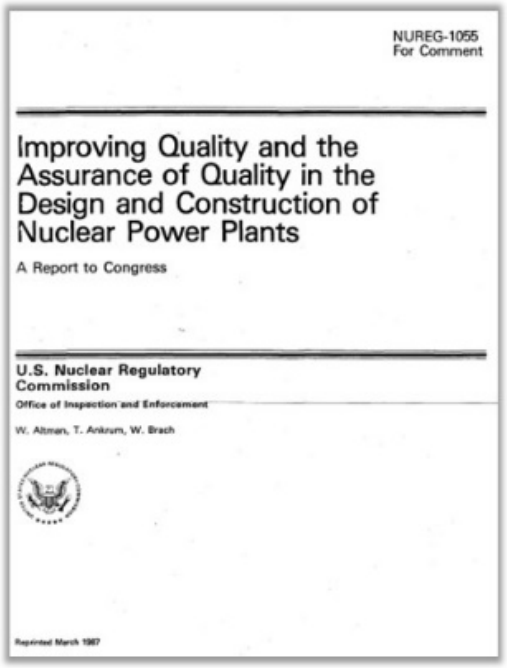
- **1974** **U.S. Power Engineering magazine - A Message to Industry - Became a Perception Problem**
  - First Generation U.S. Fleet NPPs Design / Build - **Major Regulatory Quality Assurance Concerns**
- **1979** **U.S. Three Mile Island Accident in Harrisburg, PA**
  - First U.S. Fleet NPPs - **Quality Failure**
- **1984** **U.S. Marble Hill NPP Indiana**
  - Cancelled (cost in excess of $2 billion) - **Quality Failure**
- **1984** **U.S. WH Zimmer NPP Ohio**
  - Cancelled (cost in excess of $2 billion) - **Quality Failure**
- **1984** **U.S. NRC NUREG-1055-1984,** "Improving Quality & The Assurance of Quality in the Design &
  - Construction of NPPs" First U.S. Fleet NPPs - **Quality Failures & Successes**
- **2008** **U.S. Nuclear Regulatory Commission, NRC Failure Prevention Supplier Workshops**
  - Supply Chain Oversight New Reactor Construction - **Cites U.S. NRC NUREG-1055-1984**

- **2009** **U.S. GAO Report 09-61, DOE Hanford Needs to Strengthen Facility Oversight**
  - Nuclear Safety Oversight Failure - **Quality Failure**
- **2017** **U.S. BWX Technologies mPower SMR NPP Design Development for DCA**
  - **Design Assurance Quality Failure**
- **2017** **U.S. Westinghouse Nuclear AP1000 NPP**
  - VC Summer Columbia, SC - **Design | Build Quality Failures**
- **2018** **U.S. GAO Report 18-241, DOE Hanford Site Waste Treatment Plant (WTP) Washington State**
  - **Quality Assurance Program Failure**, Source: American Nuclear Society NN Article, June 2018

We all strive to improve our performance and do a better job. We make efforts to learn from errors and think of better ways to achieve the stated objectives. The industry has a key document that few people know of and leverage for improvements. The U.S. NRC still points industry organizations the Lesson Learned report.

Lessons Learned - U.S. NRC NUREG-1055, Report to Congress 1984 [6]

U.S. Congress mandated an industry investigation following the TMI accident. NUREG-1055 Report to Congress, “Improving Quality & The Assurance of Quality in the Design & Construction of NPPs,” makes it crystal clear the agency understood the need for improving quality and the management of quality. The investigation encompassed seven sites. Two of the NPP build programs were cancelled in 1984 as previously mentioned. Both lost design control, material traceability control, document/records management, and other non-conforming conditions.


NUREG-1055
For Comment

Improving Quality and the Assurance of Quality in the Design and Construction of Nuclear Power Plants

A Report to Congress

U.S. Nuclear Regulatory Commission

Office of Inspection and Enforcement

W. Altman, T. Ankrum, W. Brach

Reprinted March 1987

Why bring up the first NPP design/build period now and open old wounds? Some believe the first era was just the ‘old school’ of doing things and belongs in the history books. Some believe they noe The Nuclear Quality Problems and they won’t be repeated. This time we will do the job right this time since we use of computers, IT, robotic equipment, electronic devices, design modeling, drones, internet, and instant access to inherent safety systems, improved materials, new construction methods, information.

These improvements will reduce time and costs, but will they improve quality? Figure 2 shows a few quality deficiencies addressed in the 1984 report. Unfortunately, some have already been repeated since the beginning of the 2000 Renaissance. Many of the deficiencies were part of the reason for recent cancelled design/build programs. An effective NMS will prevent these and other non-conformances. The way to make further improvement is new professional positions

focused totally of the NMS with direct assistance for executives and their management. It makes common sense for advisory knowledge at hand for top management just like CPAs for the corporate finances.

Quality-Related Deficiencies

- Inadequate Quality Inspection Documentation
- Inadequate Reporting of Nonconformances
- Drawing Deficiencies
- Inadequate Specifications
- Materials Control Deficiencies
- Inadequate Procedures & Instructions
- Procedure Violation
- Inadequate Licensee Audits
- Inadequate Corrective Action Programs

Figure 2

There are decades of reports revealing technical and administrative quality problems. I continue to hear that administrative quality problems (paperwork) have less impact on design/build programs than technical problems. My view is there is a delicate balance between the technical and administrative aspects of quality. Quality is technical and complex. The complexity stems from the numerous administrative requirements. I believe misunderstandings in this area contribute to The Nuclear Quality Problem.

Professionals in the technical disciplines are focused on research, design, supplier, procurement, build plans, and schedules as they should. Contract administrators, document and records managers are focused on the administrative activities in a support role. My question is who focuses solely on the daily needs of NMS requirements management, proper interpretations of governing documents, consistent communications, information flow across, down, and up the organization, and sustaining the framework and content of the NMS? The quality audit process is only a periodic and very limited sampling of NMS effectiveness after the fact. It only scratches the surface.

The nuclear segment has greatly changed and advanced, but the understanding and effective implementation of quality practices, principles, methods, policies, procedures, and millions of requirements continue to plague its effectiveness. We must continue to keep the concept of doing things right the first time aligned with our simple understanding of ***'Quality – Conformance to Requirements.'***

"Everyone owns responsibility for quality and safety. Everyone owns effective NMS commitments, content, requirements management, implementation, and compliance. This requires understanding system elements as applicable to the work. 'Error Prevention' v. 'Error Detection' must be a core principle for effectiveness."

Quality problems will continue until the Management of Quality is an integral part of the Executive Staff and Board meetings. There must be consistent reporting on NMS effectiveness during weekly operational meetings. If you agree, I believe you will recognize the need for the new industry positions focused on the NMS. Today, a Nuclear QA Program is only one of many limited-scope programs within the NMS.

Information workers in today's dynamic business environment and ever-increasing pace of market competition, rely heavily on reliable computer enterprise networks, PCs, and other devices. We have all experienced incredible changes in just one generation. The advances in all aspects are remarkable and do help mankind. In the nuclear industry, researchers, scientists, designers, engineers, laboratory field technicians, metallurgists, chemists, and other technical experts have paved the way. They do center their efforts on safety, reliability, and the environment even though watch groups will not agree.

Years ago, while developing and implementing Nuclear Quality Programs, I recognized programs were limited in scope using a hierarchy model. Programs were written top down which essentially reflected the organization reporting structure. Discipline interface requirements and communications were defined as well. DuPont in the '50s created the pyramid four-tier model still used today to help visualize the layers of management information in a program. Decades ago the industry found the hierarchy cumbersome resulting in the 'silo effect.'

When it comes to huge numbers of complex legal and process-related requirements, lawyers, accountants, engineers, and researchers come to mind. The hard part today is finding individuals that are big and small picture-oriented, understand requirements management practices, have strong computer network knowledge, while being excellent 'systems thinkers/writers.' These are individuals that read requirements documents, see the dynamic multiple dots (people), and know how to express the how, when, what, where, who of the work. It is a unique skill set which fits the NMS Advisor / Designer roles.

Expert systems thinkers understand the value of visual aids in the right location in documents to enhance reader/user understanding. Many in workplace today believe the enterprise networks, software, and IT experts take care of that burden. I still contend there are knowledge gaps and preventable management system deficiencies. What many don't know is management had researchers, engineers, technicians, and designers write the quality program. That made sense because quality 'sounded so technical.'

"The Nuclear Quality Problem is Rooted in the Nuclear Management System"

Programs | Systems | Quality Management Systems & The NMS

The terms program and system are used today to describe the management of quality among entities throughout the world. The perception that they are one in the same in scope and application is not true. It depends on each person's current work experience, training, academic orientation, contract language, business sector, and perceptions.

My position on using program and system as defined and intended is not new. I'm compelled to share it now in light of news about continued program failures, recurring deficiencies from those during the first design/build period, and prevention options as Small Modular Reactor (SMR) programs rapidly move forward. Lessons learned from the first period offer the SMR designers and builders the insights for preventive measures.

Program v. System - Some believe a quality program and a quality system are the same and use the two terms to address the same thing. This is at the heart of not understanding the proper of use of quality terminology and the perception.

For simplicity, a program is limited in scope regarding a function or discipline such as personal safety, nuclear safety, engineering/design, quality, contract management, supply chain management, training, software code controls, etc. A system is dynamic and full-scope to encompass the spectrum of operations such as plans, policies, programs, activities, tasks, projects, procedures, and instructions in a company. It is open ended by design to allow additions and modifications as directed by the CEO and other executives.

Quality Management System (QMS) - Term usage began after the release of the international standard ISO 9001 "Quality Management Systems – Requirements Standard," 1987. [7] Its use is generic across all business sectors. U.S. nuclear industry companies began evaluations of requirements in the standard and aligning existing quality program commitments in the late 1990s. The American Society of Mechanical Engineers (ASME) QA committee has compared the requirements in ASME NQA-1, "Quality Assurance Requirements for Nuclear Facility Applications" [8] with ISO 9001. The NRC includes position statements for use in application. Westinghouse Nuclear was the first major supplier (NSSS) to achieve ISO 9001 QMS certification. There are over one million companies that have their QMS certified.

Nuclear Management System (NMS) - I see the use of Nuclear Management System v. Quality Management System as the most effective way to eliminate the probability of an individual or groups confusing the intent, scope, applicability, content, commitments, and ownership of the Management System. The word quality can infer that management system ownership belongs to the quality department or group. Using the term nuclear management system greatly reduces the probability of confusion and reinforces ownership by company executives. Executives that do this internal and external to the company will be taking a much clearer position on the ownership and scope of their management system.

"Our Nuclear Management System is Focused on Quality"

If asked “is your NMS the same as a QMS” the answer is Yes. “We eliminate confusion about who has complete ownership of our system.” If asked about a QA Program the answer is Yes. “We know QA is our discipline for systematic methods of verifying and reporting conformance to requirements. This is one of our programs in our NMS.” If asked about a QC Program the answer is Yes. “We know QC is part of QA for ensuring physical characteristics conform to requirements using inspection and testing methods. This is one of our programs in our NMS.”

Figure 3 should help with understanding the system is full-scope. Any number of programs are defined, implemented, and managed within the NMS. **Nuclear Management System** should be the industry standard term with the variety of programs defined & managed within its scope.

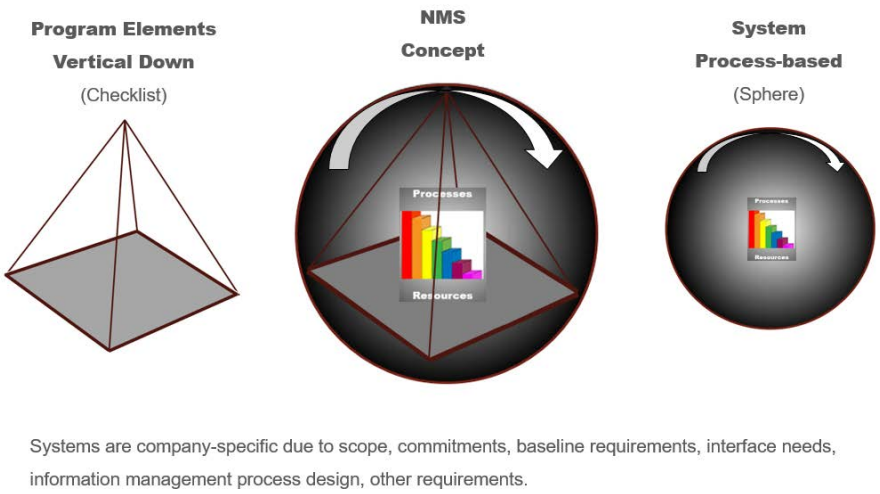


Figure 3

Case for the NMS Advisor | Designer and Certification Program

~ Part of The Nuclear Quality Solution

Workers today need to be ’systems thinkers’ and do their work while thinking systemically ‘connecting the dots’ as we say these days. This means effectively communicating across, up, and down the various internal and external locations of the work. Don’t just pass the work on to the next in line; instead verify your work and ask peers to challenge your work often. The information flow today is dynamic internal and external to the programs and operations.

Poor communications and requirements management can be catastrophic as the number of in individuals increase. Communication models demonstrate the geometric progression factor. A meeting of six individuals demonstrates the dynamic. Figure 4 shows the potential for thirty lines of communication. It wouldn’t take much to calculate the vast potential lines as more individuals are included.

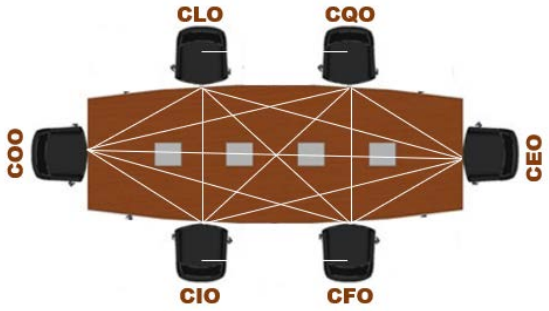


Figure 4

Over the past twenty-five years the role of a "Computer Software Architect" emerged from the need to define and layout the network structure of complex enterprise software. The internet and personal computer era entered the workplace ~~in the~~ and our personal lives in the '90s. I remember it well. We began discussions about learning and using the computer system. That term fast became part of the American and global lexicon. When using the term system today, most people think of a computer system. When using the term management system most people think of a computer system. The goal of using the term NMS is for people to think of the company system of policies, plans, process descriptions, procedures, instructions, and other business documents. The information that drives the business.

It's interesting that people grasp what computer system workers do, but typically do not grasp what a management system worker does. Major challenges include working through the layers of requirements, ensuring effective interfaces among the disciplines, and documenting what is required based upon commitments and procedures in the system. Just as the software architect role emerged, now there is a need for specific NMS expertise. I believe the best position titles are NMS Advisor and NMS Designer.

NMS Advisor - The role requires an extensive body of knowledge encompassing administrative and technical skills. The individual must know how to design an NMS, be an excellent communicator, demonstrate word mastery, have technical flexibility, and be requirements management oriented among other skills. Prior to gaining Advisors status, an individual needs experience designing systems which encompass numerous aspects including the open management system need for modifications, future integration of programs, and interface with other systems while ensuring requirements are met. Passing the examination is mandatory for certification.

NMS Designer - The role must have top management commitment, unconditional resources, access to virtually all operational elements, be administratively-oriented with skills to work with technical professionals, and realize a software enterprise system has its limits in overall operational effectiveness. This is a pre-requisite to achieve NMS Advisor status.

The positions must be defined using standard roles and responsibilities (R/R) recognized by the industry. The R/Rs should be generic across all industries like those of a CPA, certified PMP, SHRM certified MR professional, certified Quality Engineer, and others. The most ideal management system advisors and designers must always be focused on assisting executives and the workforce to achieve Conformance to Requirements and hopefully strong systems thinkers.

I see an internationally adopted scheme for NMS professionals to achieve NMS Designer qualification status and then achieve NMS Advisor certification status. The concept is similar to the Project Management Institutes PMP Program for professional certification. I have developed course materials encompassing the required body of knowledge for each position. I am pursuing partnering arrangements with industry entities and the U.S. DOE, ANS, NEI, INPO, and the IAEA followed by course accreditation.

"The need for Nuclear Management System Advisors and Designers is no different than the need for highly qualified Engineers and Designers for designing and building bridges, highways, schools, hospitals, refineries, ships, waste treatment facilities, and nuclear power plants. It takes an understanding of requirements while using a systematic approach to achieve the objectives."

'What Executive's Should Know About the Management of Nuclear Quality'

This White Paper expands on my case for the new position and need for a professional certification. It describes the course Goals, Objectives, and Details and is posted on the GQM Advisor website. [9] https://gqmadvisors.com/wp-content/uploads/2018/11/GQMadvisors-EG-MgtNQ-11-04-18-25pgs-WP-mstr.pdf

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Forty-five years of experience in all aspects of defining, developing, deploying, & upgrading effective management systems focused on quality in multiple sectors (14 startups & 5 upgrades). **Founded GQM Associates 1991** to provide quality management system services with primary focus on assisting companies achieve system compliance and certification. **Re-focused GQM as Advisors in 2016** to provide companies a broader range of expertise and offerings of our knowledge with emphasis on the Next Generation. paul@gqmadvisors.com, www.gqmadvisors.com

References

1. U.S. NRC Title 10 Code of Federal Regulations, Part 50, Energy, "Domestic Licensing of Production and Utilization Facilities." [1]
2. 10 CFR Part 50, Appendix A, General Design Criterion 1, included reference to Quality Assurance Program requirements as "Quality Standards and Records." [2]

3. U.S. NRC 10CFR50, 10CFR50, Appendix B "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Facilities." This CFR set the precedence for the industry to have formal quality programs among all entities. Practitioners refer to it as Appendix B or the "18 Criteria."
4. GQM Advisors Terms & Disciplines https://gqmadvisors.com/disciplines/
5. Gunning Fog Index, 1952 Robert Gunning, http://gunning-fog-index.com/
6. U.S. NRC NUREG-1055, "Improving Quality & the Assurance of Quality in Design & Construction of Nuclear Power Plants, Report to Congress, May, 1984."
7. ISO 9001 "Quality Management Systems – Requirements Standard," initial release 1987. The International Organization for Standardization (ISO) HQ is located in Geneva, Switzerland.
8. ASME NQA-1, "Quality Assurance Requirements for Nuclear Facility Applications."
9. 'What Executive's Should Know About the Management of Nuclear Quality' – White Paper posted on the GQM Advisor website November 7, 2018. https://gqmadvisors.com/wp-content/uploads/2018/11/GQMadvisors-EG-MgtNQ-11-04-18-25pgs-WP-mstr.pdf