Responsible Charge in the Era of Advanced Engineering Systems

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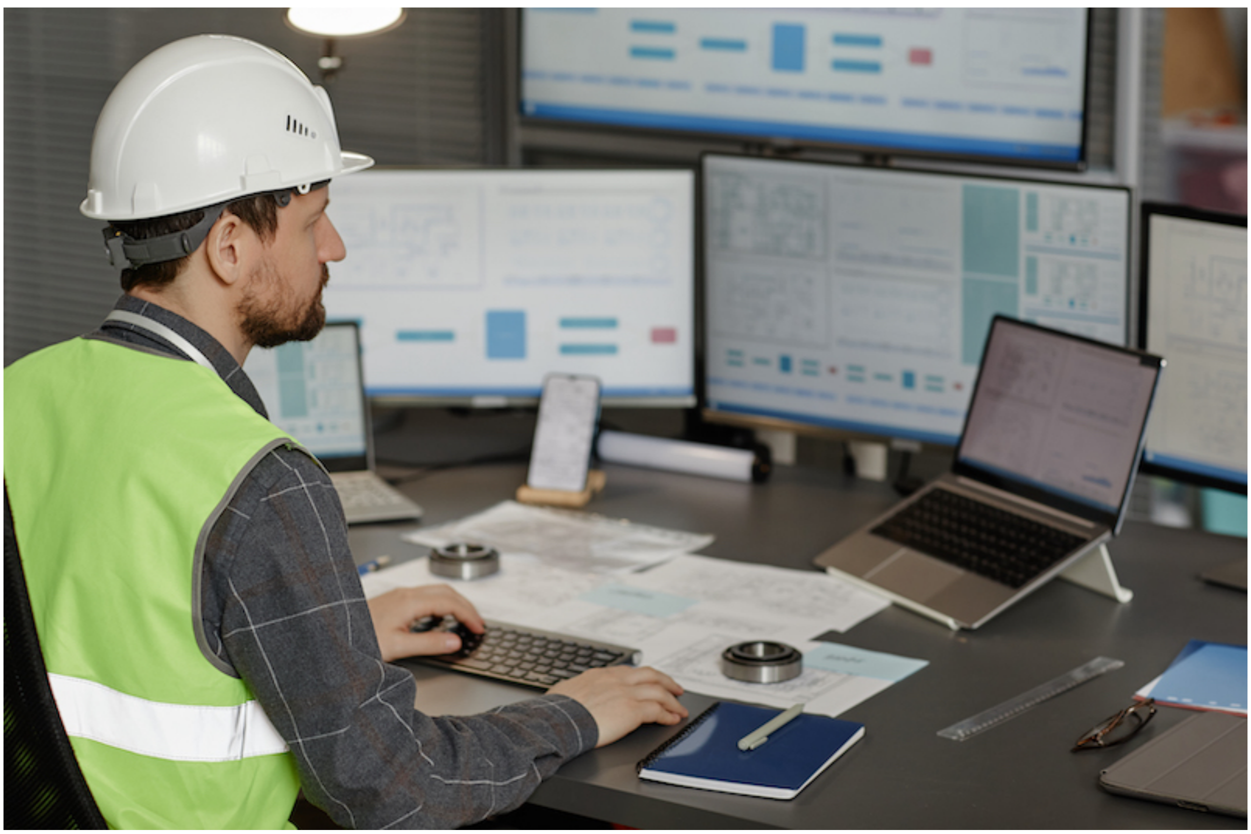

Course Overview

Course Description

This course provides an overview of how the professional duty of responsible charge applies when engineering work is performed with advanced and automated systems.

Engineering practice now runs on software, with analytical platforms, digital models, automated checking tools, and artificial intelligence sitting between the engineer and the result. These tools have widened what engineers can attempt and shortened the time it takes, but they have not changed the obligation that defines the licensed professional: the duty to exercise responsible charge over work that affects public health, safety, and welfare.

This course examines responsible charge as the working mechanism that keeps engineering decisions tied to identifiable, accountable professionals. It addresses professional judgment, the supervision of delegated and technology-assisted work, the difficulties created by opaque or "black-box" tools, the use of artificial intelligence, and the verification practices that let an engineer stand behind a result.

Learning Objectives

Upon successful completion of this course, participants will be able to:

- Explain the professional and ethical foundations of responsible charge.
- Describe how advanced engineering systems are changing engineering practice.
- Distinguish between technological assistance and professional engineering judgment.
- Identify the ethical concerns associated with black-box analytical systems.
- Explain an engineer’s responsibilities when supervising delegated engineering work.
- Apply verification and validation principles to technology-assisted engineering activities.
- Evaluate the opportunities and limitations associated with artificial intelligence in engineering.

- Describe methods for maintaining professional accountability within increasingly automated engineering environments.

Intended Audience

This course is intended for civil, structural, mechanical, electrical, environmental, chemical, geotechnical, transportation, and water resources engineers, as well as professionals who are interested in learning more about how to exercise responsible charge over technology-assisted engineering work.

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CHAPTER 1

Responsible Charge as the Foundation of Engineering Accountability

1.1 The Purpose of Responsible Charge

Responsible charge is one of the oldest organizing ideas in professional engineering, and one of the most durable. It ties engineering authority to engineering accountability by requiring that work affecting the public be performed under the direction and control of a qualified professional who is willing to stand behind the resulting decisions. Tools, methods, and organizational structures have changed beyond recognition over the past century, however, engineering decisions must remain attached to identifiable people who have the competence, the authority, and the obligation to answer for them.

The reason lies in the nature of the work. Engineering decisions reach well past the firms that make them. Bridges, buildings, transit systems, water treatment plants, industrial facilities, and utility networks carry consequences for people who never see a calculation or read a specification. When these systems fail, the result can be injury, loss of life, environmental damage, and a lasting erosion of public confidence. Work with stakes this high needs mechanisms that keep competence and accountability closely aligned.

Licensure identifies individuals who have met a minimum standard through education, experience, and examination, and it binds them to obligations that run beyond the interests of any employer or client (NCEES, 2023). The licensed engineer is expected to place the protection of the public ahead of competing pressures when the two collide (NSPE, 2019). Responsible charge is the practical means by which that expectation gets exercised on real projects.

1.2 Authority and Accountability

Responsible charge is the relationship between authority and accountability. An engineer in responsible charge needs enough authority to direct the work and enough involvement to understand the technical basis of the decisions being made. Strip away the authority and oversight becomes hollow. Strip away the involvement and accountability becomes impossible to defend.

This relationship is what separates responsible charge from ordinary supervision (see Table 1). A manager may run budgets, schedules, and staffing without exercising responsible charge over any technical decision. A specialist engineer may exercise responsible charge over a narrow design effort while holding no managerial authority at all. Rank is not the test. The test is the degree of technical control that is exercised over the engineering work.

Table 1: Administrative supervision compared with responsible charge.

Administrative supervision	**Responsible charge**
Concerned with budgets, schedules, staffing, and delivery	Concerned with the technical basis of engineering decisions
Authority derived from organizational position	Authority derived from technical control over the work
Can be exercised without understanding the analysis	Requires understanding sufficient to evaluate the analysis
Accountability is managerial	Accountability is professional and personal

Accountability of this kind asks for more than a signature applied shortly before a deadline. Responsible charge implies ongoing participation: staying close enough to project objectives, design assumptions, analytical methods, and significant decisions to judge whether the work meets professional standards and whether its conclusions can be supported. The importance of responsibility is highlighted in failure investigations, which repeatedly find responsibility scattered across consultants, contractors, specialists, and teams until no one quite owns the critical assumption. Responsible charge exists in large part to prevent this diffusion by keeping engineering decisions under identifiable professional oversight.

1.3 Professional Judgment and Engineering Responsibility

At the center of responsible charge sits professional judgment. Engineering is sometimes pictured as a discipline run entirely by mathematics, science, codes, and procedures, but these elements do not remove the need for judgment. Real projects rarely match theoretical assumptions cleanly. Engineers work with incomplete information, reconcile requirements that pull in different directions, weigh uncertainties, and decide how a general principle should land on a specific set of facts.

Judgment of this kind develops through education, experience, and repeated contact with problems that did not behave as expected. It lets an engineer ask whether an assumption is reasonable, whether a method suits the situation, and whether a conclusion is actually supported by the evidence in hand. It also flags the cases that call for more investigation, more conservatism, or a second look.

An engineer who simply accepts the conclusions of others, without meaningful evaluation, cannot reasonably claim responsibility for them. Nor can an engineer who approves work whose technical basis they do not understand. Responsible charge asks for active engagement with the engineering process rather than passive receipt of its outputs. The obligation matters most precisely where several solutions are all technically feasible, for example codes typically set a floor, not a single answer, and someone has to decide which feasible option best serves safety, reliability, constructability, maintainability, and compliance at once. No formula closes that gap.

1.4 Responsible Charge as an Ethical Obligation

Responsible charge is a regulatory requirement, but it is an ethical one first. Engineering codes of ethics place the duty to protect public health, safety, and welfare at the top of the professional hierarchy (NSPE, 2019; ASCE, 2017), and that duty shapes how engineers conduct their own work, review the work of others, and put their names to a result.

Honesty about the limits of one's competence is part of this. Engineers are expected to take on assignments only when qualified and to bring in specialized expertise when a project demands it. Responsible charge does not require mastery of every discipline a project touches, but it does require enough understanding to evaluate the work and to recognize when help is needed.

Diligence is the other aspect of the ethical obligation. Approving documents without adequate review, leaning on assumptions that were never examined, or accepting conclusions that were never understood hollows out the protection that licensure is supposed to provide. The ethical principle and the accountability principle require responsibility to stay connected to informed judgment. An engineer who accepts responsibility for a design, analysis, or recommendation needs a reasonable basis for doing so.

1.5 Responsible Charge in Contemporary Practice

The principles of responsible in charge were settled long before computational modeling, cloud collaboration, and artificial intelligence (AI) entered the office. Methods change but the need for accountability does not.

Contemporary projects are often delivered by multidisciplinary teams spread across locations and time zones. Software now performs analyses in minutes that once took weeks. Large volumes of data feed directly into design workflows, and decisions are increasingly shaped by systems of real sophistication and real opacity. These conditions raise genuine questions about how an engineer maintains meaningful oversight. They do not retire the obligation. If anything, rising complexity raises the value of responsible charge, because understanding the assumptions and limits of an advanced system becomes part of engineering judgment rather than a separate technical concern. The engineer in responsible charge still owns the evaluation, still owns the basis for significant decisions, and still decides whether the conclusions can be defended. The methods used to meet those obligations evolve with the technology. The obligations themselves carry forward unchanged, and the chapters ahead trace how they apply as the tools grow more capable.

CHAPTER 2

The Evolution of Engineering Systems and Professional Responsibility

2.1 Engineering as a Technological Profession

Engineering has always advanced alongside its tools. Every generation has reached for the best available means to analyze problems, develop designs, and improve how engineered systems perform, and the profession itself has moved through a series of technological transitions, each one widening capability while adding new responsibilities.

Early engineers worked from empirical knowledge, field observation, hand calculation, and physical testing. Analytical reach was limited by what could be computed by hand, so design methods stayed labor-intensive and conservative. Mechanical calculators, and then electronic computation, broke this constraint. Problems that had demanded weeks of manual effort could be evaluated quickly and in far greater detail.

Computer-aided design marked another advancement, moving drafting off paper and into digital environments that improved accuracy and coordination. As computing power grew, engineering software matured from a calculation aid into an analytical platform able to simulate complex physical behavior and weigh many variables at once. Each step reshaped how the work got done, though none altered the underlying obligation to understand the work for which an engineer accepts responsibility.

2.2 Increasing Complexity in Engineering Systems

Modern projects are markedly more complex than their historical counterparts. Infrastructure has grown larger and more interconnected. Buildings carry advanced mechanical and control systems; transportation networks depend on digital communication and monitoring; industrial plants integrate automation, process control, and real-time operational data; utility systems lean on intelligent networks that respond to changing conditions on their own.

Engineers can now study interactions that were once impossible to analyze. Structural behavior can be modeled in fine detail, environmental systems examined across whole regions, manufacturing processes tuned against extensive operational data, and maintenance guided by continuous monitoring rather than periodic inspection alone.

Complexity cuts the other way as well. As systems grow more sophisticated, no single engineer can hold complete knowledge of every component in a project. Specialization stops being a preference and becomes a necessity, and organizations increasingly assemble multidisciplinary teams whose members each own a slice of the technical territory. Coordination, communication, and oversight carry more weight in these types of setting, because the responsible charge has to function even when the decisive judgments emerge from many specialists working inside one tightly coupled system.

2.3 The Emergence of Integrated Digital Environments

A defining feature of current practice is the move toward integrated digital environments. Calculations, drawings, specifications, schedules, and supporting documents once lived as separate products, generated by different people using different tools. Modern platforms increasingly fold these functions into a single connected environment.

Building Information Modeling offers a clear example. Rather than acting only as a drafting tool, a BIM environment combines geometry, material properties, construction sequencing, and asset data inside a shared model. Comparable integration is underway across disciplines through geographic information systems, digital asset management platforms, process simulation environments, and infrastructure monitoring systems. Information moves more efficiently, conflicts surface earlier, changes propagate in a coordinated way, and participants draw from a common source rather than isolated files.

Integration carries its own exposure. A decision made in one corner of the model can ripple through many others, and a single incorrect assumption, stale dataset, or misconfigured component can spread across the whole environment before anyone notices. The engineer in responsible charge, therefore, needs to understand how information is generated, handed off, and reused across the workflow. Professional responsibility now reaches past the individual calculation to the integrity of the systems that carry it.

2.4 Automation and the Changing Nature of Engineering Work

Automation has become routine. Tasks that once consumed hours of manual effort now run automatically or semi-automatically; design checks, code-compliance reviews, quantity takeoffs, drawing generation, scheduling, and reporting are commonly built into engineering workflows. These functions save time on repetitive work and reduce certain categories of human error by improving consistency.

Automation has also shifted what engineers spend their days doing. Rather than performing every calculation by hand, engineers more often evaluate assumptions, review outputs, coordinate technical activity, and interpret results. The role tilts toward oversight and decision-making and away from direct execution. That shift should not be read as a reduction in responsibility. Generating results faster tends to raise the importance of careful review, not lower it. Automated systems process information at speeds no person can match, yet they remain wholly dependent on the quality of their inputs, the validity of their assumptions, and the appropriateness of their application. Responsible charge then requires understanding not just what an automated system produced, but the conditions under which that output can be trusted.

2.5 Data-Driven Engineering

The volume of available data has grown just as quickly. Sensors, monitoring systems, remote sensing, industrial controls, and digital infrastructure platforms generate enormous quantities of information about how engineered assets behave. Data-driven approaches now support design, operations, maintenance, and asset management, letting engineers track performance trends, watch system behavior in near real time, and catch developing conditions early.

Observed performance is a stronger basis for decisions than assumption alone. Volume, however, is not understanding. Data must be evaluated for accuracy, relevance, completeness, and context, because measurement error, sensor drift, gaps in coverage, and misleading correlations can all distort a conclusion if they go unrecognized. The hard part is rarely obtaining information; it is determining what the information means. Engineers remain responsible for interpreting data within the wider frame of engineering principles and project objectives, which points back to the recurring theme: professional accountability rests not on possession of information but on the ability to evaluate and apply it well.

2.6 Professional Responsibility in a Technological Environment

The evolution of engineering systems has reshaped much of daily engineering practice without touching the profession's core obligations. Whatever the tools, engineers remain responsible for protecting public health, safety, and welfare through competent, ethical work.

Each advance has expanded capability while raising the premium on oversight. Engineers need to understand what their systems can and cannot do, recognize when an extra layer of review is warranted, and stay willing to challenge a result that conflicts with engineering principles or site conditions. The profession has come through earlier transitions intact because engineers adapted their methods while keeping their responsibilities. The same pattern holds now. Advanced systems assist the work; accountability for the decisions stays with the engineers who direct, review, and approve them.

CHAPTER 3

Professional Judgment in Technology-Assisted Engineering

3.1 Why Judgment Still Matters

Professional engineering judgment has always distinguished engineering from calculation. The discipline leans hard on mathematics, science, codes, and analytical methods, yet engineering decisions rarely fall out of a computation on their own. Projects bring uncertainty, simplifying assumptions, competing objectives, missing information, and conditions that call for interpretation no procedure fully prescribes.

Judgment is what bridges technical information and engineering decisions. A calculation can quantify a structural demand, a hydraulic response, an electrical load, or an environmental impact, but the engineer still needs to decide whether the assumptions hold, whether the result is plausible, and whether the conclusion serves the project's purpose. Judgment places that information inside the wider context of safety, reliability, constructability, operability, and long-term performance. Advanced systems have not diminished its role. By producing more information than ever, they have arguably enlarged it, since someone still must interpret the output and decide how it should bear on a professional decision.

3.2 Judgment and Calculation Are Not the Same

A common assumption in technology-heavy environments is that better computation reduces the need for judgment. The reasoning is understandable as modern software can complete in seconds analyses that once took days and processes datasets of a size no team could review by hand. However, it does not give it the capacity to decide.

Engineering calculations answer specific technical questions from defined inputs, assumptions, and methods. Judgment begins where calculation runs out. The engineer decides whether input values are appropriate, whether the modeling assumptions reflect actual conditions, whether unusual circumstances deserve separate treatment, and whether the results match with physical reality. For example, a structural model may report that a member satisfies strength requirements, and the engineer still needs to ask whether the loading assumptions were right, whether serviceability needs a second look, and whether field conditions match what the analysis assumed. Or a hydraulic model may return acceptable results from the available data, while the engineer recognizes a site-specific condition that justifies added conservatism or further investigation. Responsible charge is tied to that judgment rather than to the computation behind it. Software performs the arithmetic; only an engineer can assume professional responsibility for the decisions that follow from it.

3.3 Evaluating Assumptions

Every analysis stands on assumptions. Material properties, environmental conditions, loading scenarios, operational demands, construction tolerances, and expected future performance are all represented through assumptions that compress a messy reality into a workable model. Most are reasonable and necessary, and without them, analysis would grind to a halt. Problems starts when assumptions go unexamined, or when an engineer drifts away from the assumptions buried in the tools they use.

Technology-assisted workflows are particularly good at hiding assumptions, because so many of them live inside software platforms, databases, templates, and automated routines. An engineer may inherit assumptions set by a previous project, a software vendor, an organizational standard, or an analytical default, and any of those may be perfectly suitable. However, they still warrant review. An engineer in responsible charge does not need to read every line of code or trace every internal computation, but they do need to understand the assumptions that materially shape the conclusions and to judge whether they fit the application at hand. That capacity to interrogate assumptions remains one of the clearest expressions of professional judgment.

3.4 Reasonableness Review

Ask experienced engineers to name their most useful skill and many will describe the ability to sense when a result is wrong. It is a quiet skill, built from years of exposure rather than any single course, and it works as an independent check on analytical output. However sophisticated a model may be, the engineer should still be able to ask whether the conclusion is broadly consistent with engineering principles and expected behavior.

Reasonableness review means reading outputs critically and weighing them against trained expectation. A surprising number, an unexpected trend, an abrupt change in behavior, or a conclusion that contradicts experience is a prompt to dig deeper. This check grows more important as systems grow more elaborate, because advanced software produces detailed, polished, authoritative-looking output, and precision is easily mistaken for accuracy. A finely detailed answer built on the wrong assumptions is still wrong. Professional judgment supplies the independent vantage point needed to notice when something deserves a second look, and a structured habit of reasonableness review is one of the more practical ways to keep that vantage point alive on a fast-moving project.

3.5 Understanding the Limits of Models

An engineering model can represent reality, but it is not reality. Whether the model is a structural analysis, a groundwater simulation, a traffic forecast, a process model, or a digital twin, it necessarily simplifies the physical world. Those simplifications are not flaws. They are what make a model useful, letting engineers study systems that could not otherwise be evaluated. The usefulness, though, depends on understanding the boundaries.

Every model has limits past which its reliability falls off. Input data may be incomplete, site conditions may diverge from assumptions, future operations may differ from what was anticipated, and rare events may sit outside the range the analysis ever considered. Technology-assisted environments can encourage misplaced confidence, because rich graphics, detailed reports, and large datasets project an air of certainty that the underlying model may not earn. Treating model complexity as a proxy for model accuracy is a mistake worth highlighting. Responsible charge means knowing what a model can reliably predict, what it cannot, and how the remaining uncertainty should shape the decision.

3.6 Judgment and Emerging Technologies

Newer technologies are adding fresh forms of decision support. AI, machine learning, predictive analytics, automated optimization, and advanced monitoring can identify patterns, generate recommendations, and assist technical evaluation. They allow alternatives to be examined more efficiently, problems caught earlier, insight drawn from data that would otherwise stay opaque. The value of these emerging technologies lies in supporting engineering decisions, not replacing them.

Decision-support technology does not move responsibility off the engineer. A recommendation from an advanced system is still subject to professional review, and the engineer still decides whether it is relevant, technically sound, and right for the specific circumstances. The principle is the same one that runs through responsible charge: technology can inform a decision, but responsibility for that decision stays with the engineer who evaluates and approves it.

3.7 Judgment as a Public Trust

Public confidence in engineering rests largely on the expectation that engineering decisions are reviewed by qualified people capable of independent judgment. Society does not license software platforms, databases, algorithms, or models. It licenses engineers, and that distinction matters because trust depends on accountability. When a decision affects public safety, there needs to be an identifiable professional who can explain its basis and show that appropriate judgment was applied.

Judgment in this sense does work that reaches beyond technical analysis. It assures the public that engineering decisions were weighed by individuals who understand both the technical and the ethical dimensions of practice. As engineering systems keep evolving, that assurance becomes more valuable rather than less. The engineer remains the one who decides whether information from a tool should shape a decision and, if so, how, and the obligation to exercise that independent judgment stays one of the defining marks of responsible charge.

CHAPTER 4

Black-Box Technologies and Ethical Risk

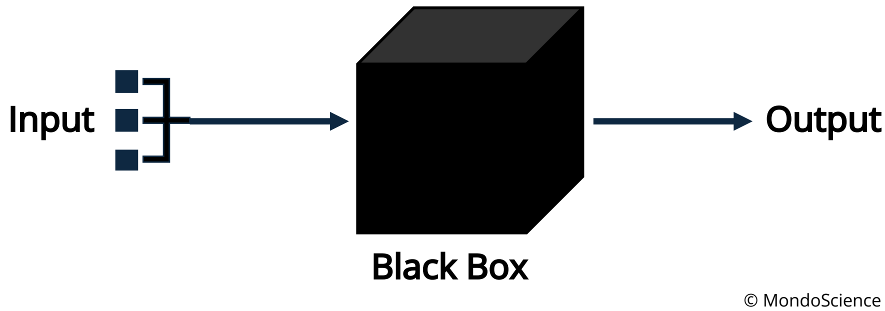

Figure 1: Black Box Systems.

4.1 Transparency and Understanding

Engineering has traditionally used methods that let practitioners see how a conclusion was reached. Working a calculation by hand, applying a design equation, or running conventional software, an engineer could usually inspect the assumptions, the logic, and the steps that produced a result. That transparency supported judgment, because the engineer could examine the reasoning behind a result rather than the result alone.

Advanced systems are loosening this connection. Many modern tools generate output through processes only partly visible to the user. An engineer may see the information going in and the recommendation coming out, while having limited insight into what happens between them. Tools of this kind are described as black-box systems, because significant portions of their operation stay hidden from direct examination (Figure 1). This label is not reserved for AI. Proprietary software, highly complex simulation platforms, automated optimization engines, integrated digital environments, and large-scale analytics tools can all contain elements that are not fully transparent. Many are technically excellent and earn their place in practice. The ethical difficulty arises not from their existence but from the prospect of an engineer relying on output they do not adequately understand. Responsible charge requires understanding the basis of significant decisions, and as systems grow more complex, holding onto that understanding becomes both harder and more important.

4.2 Sources of Black-Box Behavior

Opacity arises for several distinct reasons, and naming them helps an engineer judge how much extra scrutiny a given tool deserves, including:

- Computational scale
- Proprietary development
- Data-pipeline opacity
- Machine learning and AI

Table 2 shows the common sources of black-box behavior and the review each calls for.

Table 2: Common sources of black-box behavior.

Source of opacity	What it calls for
Computational scale: a simulation may run millions of calculations across many interacting variables, so reviewing every step is impractical even when the governing principles are well understood.	Reasonableness review of outputs and checks against independent methods or known benchmarks.
Proprietary development: vendors protect algorithms and source code as intellectual property, so users see the principles but not the implementation.	Confidence that the software has been validated for the intended use, and awareness of its documented limitations.
Data-pipeline opacity: information passes through collection, processing, filtering, and aggregation before reaching the engineer, and errors at any stage can travel unseen.	Attention to the origin and quality of data, not the final result alone.
Machine learning and AI: systems infer patterns and generate recommendations through processes that resist explanation in conventional engineering terms.	Evaluation of whether a plausible-looking recommendation actually fits the engineering principles and project conditions.

Proprietary opacity is the most familiar and the least troubling of the four, provided the software has been properly validated and its limits are understood; engineers have relied on tools they did not write for as long as the tools have existed. The machine learning case is the newest and the hardest. A recommendation may look useful and technically plausible while the path that produced it stays unclear, which leaves the engineer to evaluate a conclusion without a visible chain of reasoning to evaluate alongside it.

4.3 The Risk of Uncritical Reliance

The central ethical concern with black-box tools is uncritical reliance. Engineers have always depended on work done by others. Design manuals, reference standards, software, and established analytical methods are all forms of shared professional knowledge, and the profession functions because engineers can reasonably rely on accepted resources while applying their own judgment to how those resources are used. The danger appears when reliance quietly replaces evaluation.

Advanced systems make this substitution easy. Polished visualizations, extensive reports, predictive models, and confident recommendations all project authority, and the confidence they inspire is often justified. It should never remove the need for review. The 1991 loss of the Sleipner A offshore platform illustrates this point. The concrete base structure failed during a controlled ballasting test and sank, and the subsequent investigation traced the failure to a finite element analysis that used too coarse a mesh in the cell walls, underestimating the shear forces by roughly half (Jakobsen & Rosendahl, 1994). The software ran correctly, and the output looked authoritative. The model simply did not represent the real stress field well enough, and the result was a structure that satisfied its analysis yet could not carry the loads it met in the water. The recurring element in failures of this type is not a defect in the technology used, but a shortage of scrutiny applied to its output. Responsible charge asks engineers to stay engaged with the reasoning behind a conclusion rather than receive it passively.

4.4 Ethical Responsibilities When Using Advanced Systems

The duties that attach to black-box tools are mostly extensions of obligations engineers already hold, rather than a separate code for software. Engineers have always been expected to practice within their competence, understand the methods they use, and apply independent judgment to technical information.

Applied to advanced systems, these duties ask for a working understanding of what a tool can do and where it breaks down. Complete knowledge of every computation is rarely possible or necessary; what is needed is enough understanding to judge whether the system suits the application and whether its output can be trusted. Engineers also need to recognize when added verification is warranted.

The general rule is the more uncertain a system's operation, the more independent review it deserves. Verification might mean comparing results against an alternative method, examining historical performance, revisiting the underlying assumptions, or checking the output against established principles. Communication completes the picture. An engineer should be able to explain the basis of a significant decision, including the part an advanced system played in it. An engineer who cannot say why a recommendation was accepted will struggle to show that any real judgment was exercised. The ethical question is never whether technology was used. It is whether the engineer kept enough understanding and oversight to justify putting their name to the result.

4.5 Preserving Accountability

A bedrock principle of engineering ethics is that accountability attaches to the engineer, not to the tools. Generations of technological change have left it untouched. Software holds no license, algorithms face no disciplinary board, and automated systems accept no legal responsibility for an engineering decision. Accountability stays with the engineers who direct, review, approve, and seal the work.

Advanced technology can blur this, creating an impression that responsibility might pass to the system itself. A recommendation that came from a widely used package or a sophisticated platform can tempt users to treat the tool as the source of authority. Technology supports a decision; it does not absorb the responsibility for evaluating it. Responsible charge exists precisely to keep authority and accountability joined, and as black-box tools grow more capable and more common, holding that line will remain central to preserving public trust in the profession.

CHAPTER 5

Delegation, Supervision, and Accountability

5.1 Delegation Within Engineering Practice

Engineering has always been collaborative. Even modest projects pull in multiple disciplines, specialized expertise, field staff, designers, analysts, inspectors, and contractors, and large infrastructure or industrial work may involve hundreds of contributors across planning, design, construction, commissioning, and operation. As projects grew, delegation became unavoidable.

Delegation does not conflict with responsible charge; it is usually what makes an engineering organization workable. Professional practice has never required a licensed engineer to personally perform every calculation, draw every detail, take every field measurement, or read every document a project generates. What it requires is that delegated work stay under appropriate professional oversight. The distinction that carries the weight is between delegating tasks and delegating responsibility (see Table 3).

Table 3: The distinction between delegating tasks and delegating responsibility.

Can be delegated	Cannot be delegated
Performing calculations and analyses	Responsibility for the engineering decisions they support
Preparing drawings, models, and documents	The professional judgment that the work is sound
Collecting field data and running tests	Accountability for the conclusions drawn from the data
Operating analytical software and automated tools	The duty to evaluate whether the output is appropriate

Tasks can be assigned to others according to their qualifications, experience, and role. Responsibility for the engineering decisions stays with the engineer in responsible charge. Engineering regulation has long drawn this line, because accountability would mean nothing if responsibility could be passed down through enough layers of delegation until it disappeared. Advanced software, automation, AI, and distributed teams all change how work is performed, but none of them alters the obligation to keep meaningful oversight of what is delegated.

5.2 Effective Supervision of Engineering Work

Supervision is the mechanism that holds responsible charge together in a delegated environment. It does not mean watching every action of every team member, which would be impractical and would add little. It means staying involved enough to know that the work is proceeding soundly and that significant technical decisions are getting proper review.

How much supervision is needed depends on the work and the people doing it. Routine, well-understood tasks may need light oversight. Work involving unusual conditions, substantial judgment, public-safety implications, or novel methods generally warrants closer involvement from the responsible engineer.

Meaningful supervision rests on awareness of project objectives, major assumptions, analytical methods, and the decisions that matter, so that the engineer can judge whether the work meets professional standards. None of this requires familiarity with every minor detail; complex projects produce more information than any one person could review, and responsible charge instead asks for enough knowledge to grasp the technical basis of the work and to spot the areas that need a harder look. The aim is informed oversight and not administrative control.

5.3 Accountability in Multidisciplinary Projects

Modern projects increasingly run with multidisciplinary teams. Structural, civil, geotechnical, environmental, electrical, mechanical, controls, software, and operations specialists may all contribute to one project, each exercising professional judgment within their own area. Keeping accountability clear under those conditions takes deliberate effort.

Responsible charge does not make one engineer personally answerable for every technical facet of a complex effort. Responsibility is usually distributed among qualified professionals, each in responsible charge of their own area of competence. Coordination is important, because a decision in one discipline routinely affects another: an assumption developed by one team feeds an analysis run by a second, and data produced in one place becomes an input somewhere else. The engineer in responsible charge should understand both the work directly under their supervision and the interfaces between disciplines that can move an outcome. Failures often originate not inside any single discipline but in the gaps between them, where an assumption, a limit, or a requirement failed to cross an organizational boundary intact. Professional accountability requires enough coordination to see that the significant interactions are understood and handled.

5.4 When Review Becomes a Formality: The Hyatt Regency Walkways

The 1981 collapse of two suspended walkways at the Kansas City Hyatt Regency, which killed 114 people and injured more than 200, remains one of the most instructive cases in the literature of responsible charge (Marshall et al., 1982). The original design hung two walkways from a single set of continuous rods. A change made during shop-drawing development split that detail into two separate rod segments, so that the upper walkway's connection then carried the load of both walkways rather than one. The revised connection had roughly half the capacity the original concept implied, and it failed under the weight of people gathered on the walkways during an event.

The investigations that followed focused less on the arithmetic than on the review process. The connection change moved through the shop-drawing cycle without the kind of independent engineering evaluation the safety-critical detail demanded, and responsibility for checking it became diffuse among the parties involved. The engineers of record had their licenses revoked in Missouri, and the case became a fixture in engineering ethics teaching because the failure was one of oversight rather than ignorance. The detail was reviewable. It was simply not meaningfully reviewed. Decades later, the lesson transfers directly to technology-assisted practice. A change that passes through an automated workflow, a shared model, or a routine approval step still needs an engineer who understands its significance and takes responsibility for evaluating it. Process is not a substitute for judgment, and a signature applied without understanding does not discharge the duty it appears to satisfy.

5.5 Supervision in Technology-Assisted Environments

Technology has changed how supervision happens. Teams once worked in a shared physical space where review occurred naturally in conversation. Practice now spans remote teams, cloud collaboration platforms, shared digital workspaces, and geographically distributed organizations. The operational advantages are clear, and so is the new distance the arrangement can put between the responsible engineer and the work. Information moves quickly among many participants, platforms, and data systems without the direct interaction that used to accompany engineering review.

Maintaining responsible charge in that setting often calls for more deliberate oversight, such as scheduled technical reviews, coordination meetings, model audits, design checkpoints, independent reviews, and documented verification. Technology can help by improving access to information and easing collaboration. It can also manufacture the appearance of oversight where real engagement is thin. Access to project information is not the same as understanding it, and an automated notification is not a technical review. Responsible charge asks for active involvement, not passive awareness, and the Hyatt Regency case is a reminder that the gap between the two can be fatal.

5.6 Accountability and Advanced Engineering Systems

Advanced systems add a further dimension to delegation, because engineers increasingly oversee both people and the technological systems that shape decisions. Automated design tools, optimization algorithms, simulation platforms, AI applications, and integrated data environments now perform functions that engineers, or engineering staff, once handled directly, generating recommendations, identifying alternatives, processing data, and supporting decisions. This efficiency has a continuing need for professional oversight.

The engineer in responsible charge still decides whether system output is appropriate for the application. A recommendation produced by an automated process is still evaluated with engineering judgment, and an assumption embedded in a system is still examined when it materially affects a conclusion. Advanced systems are best treated as contributors to the engineering process rather than as substitutes for professional responsibility. The standing challenge for the profession is to keep rising technological capability from quietly producing falling professional engagement.

5.7 Maintaining Accountability

The lasting value of responsible charge is that it preserves accountability inside increasingly complex environments. Modern projects involve extensive delegation, deep specialization, advanced tools, and distributed structures, and these features will likely intensify as engineering systems evolve. Through all of it, the profession depends on identifiable individuals willing to accept responsibility for engineering decisions, which means understanding the work, evaluating its significant conclusions, exercising independent judgment, and keeping the work consistent with professional obligations. Delegation remains necessary, supervision remains essential and accountability remains nontransferable, and keeping these three in their proper relationship is what allows responsible charge to work with each new technology.

CHAPTER 6

Verification, Validation, and Independent Review

6.1 The Need for Verification

Engineering decisions rarely rest on a single source. Designs, analyses, models, calculations, simulations, field observations, and operational data all feed into the decision. Because each input can carry assumptions, uncertainties, limitations, or outright errors, engineering has long relied on verification to improve reliability and reduce the chance of a wrong decision.

Verification is central to responsible charge. An engineer who accepts responsibility for work needs a reasonable basis for confidence in it, and that confidence comes from review and confirmation rather than from trust alone. Historically, verification meant independent calculations, peer review, design checks, field confirmation, and comparison against experience. Modern delivery has changed many of the mechanics while leaving the purpose intact; the engineer still needs to determine whether a result is technically sound and whether it can support a professional decision. As tools grow more capable, verification becomes more important, not less, because added sophistication brings added layers in which an error can remain unseen until someone looks for it deliberately.

6.2 Understanding Verification and Validation

Verification and validation work together but answer different questions (see Table 4). Verification asks whether the work was done correctly. For example, were the calculations executed properly, the model built appropriately, the data entered accurately, the procedures applied as intended. Validation asks a deeper question: of does the selected model or method actually represent the real-world conditions?

Table 4: Verification and validation address different questions.

	Verification	**Validation**
Question it asks	Was the process performed correctly?	Is the chosen process right for the real conditions?
Typical focus	Calculations executed properly, model built as intended, data entered correctly, procedures applied as planned	Whether the model or method adequately represents the actual situation being studied
A failure looks like	An error in execution: a wrong input, a misapplied step	A correct execution of an inappropriate approach

A model can be verified, in the sense that it runs exactly as designed, and still fail to represent reality, because errors can come from both directions. A flawless execution of an inappropriate assumption produces a misleading answer, and a sound approach implemented incorrectly produces an inaccurate one. The Sleipner A failure described earlier is, in these terms, partly a validation failure. The finite element model ran as built, but its mesh did not represent the true stress field. An engineer in responsible charge has to weigh both questions, because confidence depends on the integrity of the process and the suitability of the method together.

6.3 Independent Review as a Safeguard

One of the most effective forms of verification is independent review. Its purpose is not to redo the original work, but to bring a second perspective capable of catching errors, omissions, inconsistencies, and questionable assumptions. Organizations have long valued it because the people who develop a design grow accustomed to their own assumptions, and familiarity can mask a weakness that a fresh reader could spots immediately.

Independent review takes many forms:

- A senior engineer checking critical calculations
- A separate team evaluating analytical assumptions
- A peer reviewer assessing compliance with standards
- A formal third-party review of major technical decisions on a large project.

None of these transfers responsibility away from the engineer in responsible charge; the responsible engineer still owns the final decision but benefits from the added scrutiny. The 1978 Citicorp Center episode in New York shows how much that scrutiny can be worth. After the tower was complete, its structural engineer reexamined the design of its distinctive braced frame and recognized that a change made during construction, substituting bolted joints for welded ones, left the building vulnerable to certain quartering winds at a frequency that turned out to be uncomfortably high (Morgenstern, 1997). The reexamination prompted a quiet but substantial program of emergency reinforcement while the building remained occupied. The case is usually told as a story about candor under pressure, which it is. But it is equally a story about the value of a serious second examination at a completed design, and about an engineer treating a nagging question as a reason to verify rather than to reassure. As analyses grow more complex, this kind of independent review tends to find more problems, because sophisticated models carry assumptions and interactions that are not obvious during ordinary development.

6.4 Verification in Technology-Assisted Engineering

Technology cuts both ways for verification. Advanced software can automate many review functions, flag inconsistencies, run error checks, and compare results against predefined criteria. These capabilities genuinely improve quality and remove whole categories of mistake. However, they can also breed a false sense that automated checks are enough. An automated routine evaluates only the conditions it was built to detect; it generally will not notice an inappropriate assumption, an unusual project condition, or a place where engineering judgment was required.

Verification in these environments should therefore combine automated and professional review. Automated systems efficiently catch numerical inconsistencies, missing information, and departures from set parameters, while engineers remain responsible for judging whether the underlying conclusions are reasonable and appropriate. The distinction is more pronounced when a system generates recommendations rather than performing calculations, because a recommendation can pass every automated check and still need professional evaluation of its fitness for a specific application. Verification works best when tools and judgment operate together rather than as replacements for one another.

6.5 Reviewing Assumptions and Inputs

Many engineering errors trace back not to the analytical procedure but to the assumptions and the input data behind it. Software can only operate on what it is given, so unrealistic assumptions or inaccurate inputs yield unreliable conclusions no matter how sound the computation. For this reason, verification must reach past the output. Engineers should examine the assumptions, constraints, boundary conditions, material properties, operating conditions, and datasets that form the basis of an analysis, with particular attention to the assumptions that most influence the result.

Reviewing assumptions matters more with advanced systems, because so many assumptions live in software defaults, organizational templates, legacy models, and automated routines. They may be entirely appropriate, but they should not be accepted without a check on whether they suit the project in front of the engineer. Understanding which assumptions carry the most weight, and how a change in them would move the outcome supports better decisions and strengthens the reliability of the conclusions.

6.6 Verification as an Element of Responsible Charge

Responsible charge asks for more than participation; it asks for confidence that the conclusions can be supported professionally, and verification is where much of that confidence comes from. An engineer cannot reasonably accept responsibility for work that has not been reviewed appropriately. How much review is appropriate varies with complexity, technical significance, and potential consequences: routine work may need relatively little, while critical infrastructure, novel designs, or analyses with substantial uncertainty may warrant extensive review.

The guiding idea is proportionality. As uncertainty rises, so does the need for review; as complexity rises, additional verification helps confirm that the important assumptions and conclusions were examined. Within modern practice, verification is both a quality measure and a professional duty tied to responsible charge, keeping engineering decisions grounded in evaluation rather than in unexamined assumptions or unquestioned output. Maintaining it is one of the more concrete ways engineers reinforce the accountability on which public trust depends.

CHAPTER 7

Artificial Intelligence and the Future of Responsible Charge

7.1 Artificial Intelligence as an Engineering Tool

AI is becoming a visible part of engineering practice. Definitions vary, but AI generally refers to computer systems that perform tasks once thought to require human cognition. It includes pattern recognition, classification, prediction, optimization, language processing, and decision support. In engineering, AI-assisted tools are already being used to review drawings, identify design conflicts, process large datasets, monitor infrastructure, predict equipment failures, optimize operations, and assist with technical documentation, and the range of applications keeps widening as computation improves and larger datasets become available.

It helps to place AI within a longer pattern. Computer-aided design, finite element analysis, and digital modeling each transformed practice without replacing the engineer, and AI is likely to occupy the same role as another tool that supports the work. Its significance lies not in displacing professional responsibility but in changing how engineering information is generated, evaluated, and used. Engineers in responsible charge will therefore need to understand the capabilities and limits of AI systems in the same way they already understand other analytical tools.

7.2 Capabilities and Potential Benefits

The core strength of AI is its efficient in handling large quantities of information. Modern projects generate enormous volumes of data through monitoring systems, sensors, operational records, inspection reports, maintenance histories, and design databases, and AI can help surface patterns, relationships, and anomalies that would otherwise stay buried. For example, in infrastructure management, AI may flag developing deterioration and help prioritize inspections. In manufacturing, AI may support maintenance planning by identifying equipment likely to fail. In design, AI may evaluate alternatives, catch conflicts, or automate repetitive tasks that consume engineering time.

These capabilities free engineers to spend more time and attention on work that genuinely needs judgment. The benefit extends beyond speed. Arguably the greater value is help in managing complexity and pulling useful meaning out of datasets that have grown too large and too interconnected to manage by hand.

7.3 Limitations of Artificial Intelligence

Despite the advantages highlighted above, AI carries limitations engineers have to keep in mind. Public discussion tends to dwell on what the technology can do, while saying less about when it produces unreliable or misleading results.

An AI system generally works by finding patterns in data rather than by understanding engineering principles the way a licensed engineer does. It can identify relationships and generate recommendations without any grasp of physical behavior, professional standards, regulatory requirements, or project-specific constraints, and the quality of its output depends heavily on the quality, quantity, and relevance of its data. Such systems can also produce output that looks plausible while containing serious errors, and because recommendations often arrive in confident, coherent form, a user may not catch the inaccuracy. This concern is a familiar from of language-based AI, but it can arise wherever recommendations come from a process that is not fully transparent. Context is another limit. Engineering decisions often turn on site conditions, operational realities, maintenance practices, construction constraints, and stakeholder requirements that may be poorly represented in the available data. Human engineers would fold these factors in through experience, while an AI system may simply not see what is absent from its inputs. Table 5 shows some of the things AI is capable of doing well, and others where it is limited.

Table 5: Capabilities and limitations of AI in engineering practice.

What AI does well	Where AI falls short
Processing very large and interconnected datasets quickly	No understanding of physical principles or professional standards
Detecting patterns, correlations, and anomalies	Output can look authoritative while being wrong
Generating and screening design alternatives	Quality is bounded by the data it was built and run on
Automating repetitive analytical and review tasks	Poor handling of context absent from the data

None of this makes AI unsuitable for engineering. It reinforces the case for oversight and professional evaluation, which the NIST AI Risk Management Framework frames as an organized practice of identifying, measuring, and managing the risks a given AI use introduces (NIST, 2023).

7.4 Responsible Charge and AI-Assisted Decisions

The spread of AI raises an obvious question about responsible charge. If an AI system contributes to a recommendation, who is responsible for the resulting decision? The answer follows directly from the long-established principle. Responsibility belongs to the engineer who evaluates, approves, and relies on the recommendation as part of professional decision-making.

Responsible charge attaches to engineering judgment, not to the tools used along the way. Engineers already rely on information from software, consultants, manufacturers, laboratories, and specialists, and an AI system is one more source of information that may inform a decision. The engineer's job is to decide whether that information fits the intended purpose. This means understanding the role AI played in producing a recommendation, recognizing the system's limits, and judging whether the recommendation aligns with engineering principles and project requirements. Responsibility cannot be handed to an algorithm. However capable a system becomes, the engineer remains accountable for decisions affecting public health, safety, and welfare.

7.5 Risks Associated with Overreliance

The highest professional risk around AI is probably not the technology but overreliance on it. As systems grow more capable and more accurate, users tend to accept recommendations with less independent review, and engineering history shows where this can leads. Engineers have at times accepted incorrect calculations, faulty assumptions, inaccurate measurements, and flawed models because the source seemed credible. AI invites the same error, since extensive computational processing can be mistaken for a guarantee of reliability.

The 737 MAX program offers a sobering and recent illustration of automation outrunning oversight. An automated flight-control function, the Maneuvering Characteristics Augmentation System, could command the aircraft's trim based on input from a single angle-of-attack sensor, and in two accidents it activated on erroneous data in ways the flight crews did not anticipate and could not readily counter (U.S. House Committee on Transportation and Infrastructure, 2020). The congressional review described a system whose behavior, failure modes, and reliance on a single input were not adequately understood or disclosed through the design and certification process.

The engineering setting differs from a typical civil or structural project, but the general lesson shows how an automated system trusted beyond its validated envelope, with too little independent scrutiny of how it could fail, can lead to disaster. Responsible charge asks engineers to resist that pull, to treat recommendations as inputs to professional decision-making rather than replacements for it, and to keep independent evaluation in place wherever a recommendation bears on significant decisions or public safety. The goal is not reflexive skepticism toward technology. The goal is for enough review to keep engineering decisions technically sound and ethically defensible.

7.6 The Future Role of Engineers

Engineering practice will almost certainly fold AI more deeply into design, analysis, operations, maintenance, and asset management, and engineers entering the profession today will work alongside AI-assisted systems throughout their careers. The profession will keep adapting as the technology matures. The qualities that define responsible charge, however, show no sign of becoming obsolete. Professional judgment, ethical responsibility, accountability, technical understanding, and the protection of public welfare, are all human obligations that exist because society needs qualified people who can evaluate information, decide, and answer for the consequences.

AI may change how engineers work without removing the need for engineers. In many respects, rising complexity strengthens the need for professionals who can evaluate technology critically and apply it well. The future of responsible charge will rest on keeping technological advancement under meaningful professional oversight.

CHAPTER 8

Preserving Professional Accountability in an Automated World

8.1 Accountability as the Foundation of Practice

Across engineering history, new materials, analytical techniques, design methods, computational tools, and communication systems have repeatedly altered how engineers solve problems. One principle has held through all of it: decisions affecting public health, safety, and welfare must remain subject to professional accountability.

Responsible charge exists because society needs confidence that engineering decisions come from qualified people willing to answer for them. This need does not vanish when advanced software, automation, or artificial intelligence enters the process. Rising complexity arguably deepens it, because it becomes harder to see how a decision was formed and who evaluated it.

Licensure was built to keep authority and responsibility joined; engineers receive the authority to decide matters affecting critical systems in exchange for accepting the obligation to exercise competence, judgment, and ethical responsibility. This understanding holds regardless of how sophisticated the technology becomes, and the profession's credibility will keep depending on engineers' willingness to stand behind the decisions their tools support.

8.2 Maintaining Meaningful Professional Involvement

A central challenge of advanced systems is keeping professional involvement meaningful. As automation expands, activities tend to drift toward technological processes, and tasks that once took direct engineering effort may end up running through automated workflows with little human intervention. Efficiency alone cannot be the measure of sound practice. The real question is not whether a task can be automated but whether the engineer stays involved enough to understand and evaluate the result.

Meaningful involvement does not require performing every calculation or reviewing every computational step, which would be impractical. It requires understanding the objectives of the work, the assumptions that drive the significant decisions, the limits of the methods in use, and the basis for the conclusions reached. Responsible charge weakens when engineers lose contact with those elements, and approving work without adequate understanding undermines accountability whether the analysis ran by hand or through advanced technology. The continued effectiveness of responsible charge depends on active engagement with engineering decisions rather than mere oversight of technological processes.

8.3 Competence in an Evolving Profession

Competence has always demanded adaptation. Engineers are expected to maintain and extend their knowledge as technologies, standards, and practices change, and advanced systems simply widen the knowledge that responsible charge now requires. Part of modern competence is understanding what the technologies in use can and cannot do. Engineers need not become software developers, data scientists, or AI researchers because such tools appear in their workflows, but they do need enough understanding to judge a tool's appropriateness and to recognize when extra review is warranted. Engineers have always been expected to understand the methods they employ, whether those methods are traditional design procedures, laboratory testing, analytical software, or AI-assisted systems. As technology keeps evolving, ongoing professional development stays part of responsible charge, and engineers who do not understand the tools shaping their decisions will find their obligations progressively harder to meet.

8.4 Preserving Independent Judgment

The continued importance of independent judgment is one of the through-lines of modern engineering ethics. Advanced systems can generate recommendations, surface alternatives, process vast quantities of information, and support increasingly sophisticated analysis, and none of this removes the engineer's task of judging whether the resulting conclusions are appropriate. Independent judgment means staying willing to question an assumption, investigate an unexpected result, and seek more information when uncertainty remains, and recognizing that even highly sophisticated systems can carry limitations, biases, or inaccuracies in their output.

Protecting public health, safety, and welfare depends on this independent perspective. Public trust does not rest on confidence in software or computation. It rests on confidence that a qualified professionals has reviewed the information critically before making a decision that affect the public. This perspective may grow harder to maintain. As systems improve, engineers increasingly face recommendations backed by extensive analysis and large datasets, and such outputs are easy to accept without question. The ability to weigh such information critically will remain one of the defining marks of responsible charge.

8.5 The Enduring Principles of Responsible Charge

Engineering technology keeps changing while the principles under responsible charge stay strikingly stable. Engineers must understand the work for which they accept responsibility, exercise independent judgment in evaluating engineering information, keep appropriate oversight of delegated activity, verify significant conclusions before relying on them, and accept accountability for decisions affecting public health, safety, and welfare. These hold whether the work runs on hand calculations, conventional software, advanced simulation, digital twins, AI, or technologies not yet built. The methods change but the obligations carry forward.

The future will bring tools more powerful, more integrated, and more automated than anything available today. The profession's task is not to resist those developments but to keep them consistent with the principles that have long defined sound practice. Advanced systems are reshaping how engineering work is done, yet they leave the profession's fundamental responsibilities intact. Responsible charge is the framework that holds authority, accountability, competence, and ethical obligation together as the technology moves.

What this framework asks of the individual engineer does not change. Automation, AI, advanced modeling, and data-driven decision support will bring real opportunities and real challenges. The engineers best placed to meet them will understand these technologies while keeping meaningful involvement, independent judgment, and accountability firmly in their own hands. This is how the profession adopts new technology without giving up the responsibility that makes their work worth trusting.

References

American Society of Civil Engineers. (2017). Code of ethics. ASCE. https://www.asce.org/career-growth/ethics/code-of-ethics

Harris, C. E., Pritchard, M. S., James, R.A., Englehardt, E.E., Rabins, M. J. (2019). Engineering ethics: Concepts and cases (6th ed.). Cengage Learning.

Institute of Electrical and Electronics Engineers. (2020). IEEE code of ethics. IEEE. https://www.ieee.org/about/corporate/governance/p7-8.html

Jakobsen, B., & Rosendahl, F. (1994). The Sleipner platform accident. Structural Engineering International, 4(3), 190–193.

Leveson, N. G. (2011). Engineering a safer world: Systems thinking applied to safety. MIT Press.

Leveson, N. G., & Turner, C. S. (1993). An investigation of the Therac-25 accidents. Computer, 26(7), 18–41.

Marshall, R.D., Pfrang, E.O., Leyendecker, E.V., Woodward, K.A., Reed, R.P., Kasen, M.B., Shives, T.R. (1982). Investigation of the Kansas City Hyatt Regency Walkways Collapse. NBSIR 82-2465 (A). U.S. Department of Commerce, National Bureau of Standards.

Martin, M. W., & Schinzinger, R. (2010). Ethics in engineering (4th ed.). McGraw-Hill.

Morgenstern, J. (1997). The fifty-nine-story crisis. Journal of Professional Issues in Engineering Education and Practice, 123, 23-29.

National Council of Examiners for Engineering and Surveying. (2023). Model rules. NCEES. https://ncees.org/

National Institute of Standards and Technology. (2023). Artificial intelligence risk management framework (AI RMF 1.0) (NIST AI 100-1). U.S. Department of Commerce.

National Society of Professional Engineers. (2019). NSPE code of ethics for engineers. NSPE. https://www.nspe.org/resources/ethics/code-ethics

Petroski, H. (1985). To engineer is human: The role of failure in successful design. St. Martin’s Press.

U.S. House Committee on Transportation and Infrastructure. (2020). Final committee report: The design, development, and certification of the Boeing 737 MAX. U.S. House of Representatives.

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