1. Introduction

On February 24, 2005, the Federal Railroad Administration issued important amendments to the “Rules, Standards and Instructions” for railroad signal and train control systems (amending Parts 209, 234, and 236 of title 49, Code of Federal Regulations). These regulations, published in the Federal Register on March 7, 2005, and effective on June 6, 2005, are collectively known as the ”Standards for Development and Use of Processor-Based Signal and Train Control Systems.” The culmination of over seven years of effort on the part of the government, the railroads, rail labor organizations, and railroad vendors, these new regulations provide an implementation-independent method of promoting the safe operation of trains on railroads that use processor-based signal and train control equipment.

1.1. Background

In 1997, the Railroad Safety Advisory Committee (RSAC) first began to look at the problem of advanced electronic and software control of signal and train control systems in the context of Positive Train Control (PTC) Systems. The consensus efforts of the RSAC, a committee of rail community professionals, chartered to provide advice and recommendations to the Federal Railroad Administration (FRA) regarding the development of the railroad safety regulatory program, resulted in an August 2001 “Notice of Proposed Rulemaking (NPRM) ”Standards for Development and Use of Processor Based Signal and Train Control Systems“. The final regulations are the end result of the regulatory process from that NPRM.

Motivating the development of the rule was the technological change from traditional electromechanical and basic electrical/electronic circuitry used in signal and train control systems to advanced microprocessor and software systems used in Positive Train Control Systems. These changes in technology had taken place without corresponding regulatory changes. The result was the government regulating through the waiver and order process. This trend portended significant burdens on the railroads and the vendors, since they had no clear guidance as to the regulatory requirements.
1.2. **Key Concepts**

The performance standard is simple. There are only two simple conditions in the regulation that must be met. “First, the new must be at least as safe as the old”. “Second, you have to be able to demonstrate that what you say about the First is true”

The regulation is, for the most part, elective. While FRA encourages the introduction of microprocessor and software based technologies, we also recognize that microprocessor and software based technologies are not necessarily the most cost effective solution for every situation. Many railroads may not have the complexity of operations that warrant the implementation of such advanced technologies at this time. To that end, with the exception of software management which is required for all railroads, the new Subpart H (added to 49 CFR Part 236) is only required for railroads implementing new microprocessor based signal and train control systems and some processor based highway grade crossing systems.

The regulation is intended to be cost effective by offering significant flexibility. The regulation is general enough to realize the potential of not only current, but also future advances in microprocessor based hardware and software technologies. It captures the fundamental underlying principles of railroad signaling, as opposed to the implementing technology. Documentation formats are not predetermined, but encouraged to be in the most cost effective format for the railroad and the vendor, consistent with providing the required regulatory information.

It is risk centric. The regulation allows for selection of cost effective analysis techniques and mitigation based on the evaluated probability and frequencies of occurrence for potential mishaps. The complexity of required analysis varies based on the intended operational environment. Conformance to initial risk evaluation estimates is tracked over time to improve subsequent estimates. Absolutism is recognized as unrealistic and unobtainable, and replaced with a more pragmatic realism.

2. **Regulation Changes**

When comparing the final rule text published March 7th, 2005 with the proposed rule text published August 10, 2001, most notable is the absence of significant change. This provides a significant advantage to the railroads and vendors who need to comply with the regulations provisions. The advantage is that voluntary effort previously undertaken to comply with the provisions of the Notice of Proposed Rule Making is transferable to comply with the provisions of the Final Rule. There is a minor disadvantage with having only limited differences between the proposed rule and the final regulation. With limited differences, there is a chance that the changes may be overlooked when reviewing the final regulation. In order to help prevent this, the following subsections will highlight the key differences.
2.1. **Key Calendar Dates**

The NPRM left unspecified several key dates. As indicated in Section 1, the provisions of the rule are effective June 6, 2005. Products that are in revenue service prior to this date are excluded from this rule.

For Highway Grade Crossing Systems under Part 234, the definition of “new or novel technology” High Way Grade Crossing technology that is subject to 236 Subpart H Rules is “technology not previously recognized for use prior to March 7th, 2005”.

General Signal and Train Control Systems products that are in the design and development stage to the requirements 236 Subpart A-G prior to March 7th, 2005 are also exempt provided that FRA is notified in writing of this prior to June 6th, 2005 and the product is placed in service by March 7th, 2008.

2.2. **Software Management Control Plan**

The requirement under 49 CFR 236.18 for a software management control plan, sometimes more commonly known as a software configuration management plans, remains for all railroads. The change made has been an increase in the implementation period. Under the NPRM the period for adopting and implementing the plan was 24 months after the effective date of the rule. Under the final rule, each railroad must create and adopt the plan within 6 months of June 6, 2005, i.e. by December 6, 2005, and implement the plan within additional 30 months, i.e. by June 6, 2008. Railroads who are commencing operations after June 6, 2005 must adopt a plan prior to commencing operations, and have 30 months to implement the plan.

2.3. **Record Keeping**

A slightly more significant change, primarily affecting railroad contractors, has been the addition of their responsibility for establishing and implementing training and qualification programs under 49 CFR 236.921 thru 923 and the PSP. Previously, under the NPRM, this was solely the responsibility of the railroad. In the final rule, this responsibility was changed to reflect any employer. The definition of an employer was added to reflect a railroad, or a contractor to a railroad, that directly compensates:

1. An individual whose duties include installing, maintaining, repairing, modifying, inspecting, and testing safety-critical elements of the railroads products, including central office, wayside, or onboard systems;
2. Persons who dispatch train operations (issue or communicate any mandatory directive that is executed or enforced, or intended to be enforced by a train control system built to Subpart H),
3. Persons who operate trains or engine crew members on trains in territories operating where a train control system built to Subpart H is;
4. Roadway workers whose duties require them to know and understand how a train control system affects their safety and how to avoid interfering with its proper functioning; and
5. The preceding direct supervisors.
2.4. Software Hazard Reporting

Vendor and railroad software hazard reporting has been added. The requirements of 49 CFR 236.907(d) requires that the railroad, in conjunction with their supplier, define the contractual arrangements and procedures for this process.

Railroads need to learn of and take appropriate action to address all safety critical software upgrades, patches or revisions for their processor-based system, subsystem, or component, whether or not they have experienced a failure of their system, subsystem, or component. Since not all railroads may experience same software faults or hardware failures, the developer’s software development, configuration management, and fault reporting tracking system play a crucial role in the ability to determine and fully understand risks and their implications. This exchange requires a mechanism to be in place even in the event where a commercial dispute (e.g., over liability) might disrupt communication between a railroad and supplier. This mechanism must ensure:

1. That faults in safety critical software are reported to the software developer,
2. The safety critical faults (and any temporary mitigations) are reported to all other users of the same software,
3. Fixes to the affected safety critical software are completed by the developer,
4. Fixes are pushed to all users of that safety critical software.

2.5. Abbreviated Risk Assessments

Under the NPRM, abbreviated risk assessments of 236.909(d) were authorized in lieu of a full risk assessment only if the following conditions were met:

1. No new hazards were introduced,
2. The severity of each hazard stayed the same,
3. The exposure to hazard remained the same, and
4. The Mean Time To Hazardous Event (MTTTE) of the Proposed System was greater than the Mean Time to Hazard Event of the Current System.

In the final rule, FRA incorporated an alternate to condition 4 that applies when there is no reason to believe that differences in MTTTE estimates reflect the potential for an actual degradation of safety. This flexibility was requested by major signal suppliers to avoid excessive cost in building safety cases.

This alternate condition eliminates the calculation of MTTHE if the system development is in compliance to AREMA Communications & Signaling Manual Part 17.3.1, Part 17.3.3, and Part 17.3.5. These Manual parts define Safety Assurance Programs for Electronic/ Software Based Products, Practices for Hardware Analysis, and Procedures Hazard Identification and Management in the application of safety principles and procedures in the design of railway signal equipment. When coupled with compliance with the other principles set forth in 49 CFR 236 Appendix C, this alternative condition should help eliminate paper exercises in theoretical risk when the products involved have been engineered to strictly limit the possibility of unsafe failures.
FRA is indebted to AREMA for constructing its new C&S Manual chapter in parallel with development of this new Federal rule.

2.6. **State Inspectors**

In the NPRM, personnel authorized to inspect records did not specifically include FRA certified State inspectors. In the final rule, this oversight has been corrected.

2.7. **Improved Roadway Worker Training**

Roadway worker training in the NPRM did not include instructions concerning the recognition of system failures and the provision of alternative methods of on-track safety in case the train control system fails, including periodic practical exercises or simulations to ensure that the roadway workers are free of the danger of being struck by a moving train or other on-track equipment. The requirement for this training was added in the final rule in 49 CR sec. 236.929.

2.8. **Modified Base Case**

The topic of the “base case” to be used in the comparative risk analysis resulted in significant disagreements among the various stakeholders. Because of this, FRA eventually made the final decision, while attempting to address as many of the various stakeholders concerns as possible.

Under the final rule, for passenger trains operating at 59 miles per hour or less, and freight trains running at 49 miles per hour or less, the performance of the system in the adjusted base case will be the system currently utilized under normal practice. For freight speeds exceeding 49 miles per hour and passenger speeds exceeding 59 miles per hour, the performance of the system base case will be that of a traffic control system. For speeds in the range of 80 to 110 miles per hour, automatic cab signals and train control will be employed for the performance of the base case. For speeds above 110 miles per hour, FRA will determine the appropriate base case in light of the characteristics of the planned operation and service.

The base case must also be changed to reflect the performance of at least a traffic control system in the event that the annual average number of trains per day on the line in question is greater than 12 (or the annual average number of passenger trains on the line in question has increased by more than 4). There is an exception process to the change in base case due to changes in volume. If the railroad can show to FRA that the annual average volume is more than 12, but less than 20 trains per day and that the exiting method of operation is adequate, then any change in base case as a result of volume is not required. The base case adjustment based on speed remains the same, however.

2.9. **Commingling of Train and Locomotive Control Functions**

In the NPRM, commingling of these functions was strictly prohibited. The final rule does not preclude the integration of these functions if the overall safety case is presented in the PSP shows and the safety case continues to demonstrate the same high level of confidence.
2.10. Penalties

The final rule contains a Table of Civil Penalties, which the agency adds to each of its regulations upon issuance. The amounts stated are benchmark levels and constitute a statement of agency policy only. The Table is located in Appendix A. Civil penalties are usually never an issue since for the vast majority of people there is never cause to address them. However there are four particular offenses that have particularly high-recommended penalties. For two of the offenses the rationale for the high penalty is straightforward. Field-testing without authorization or approval, and operation of a product without authorization or approval can result in significant risks to the public.

The other two offenses, failure to report an inconsistency, and failure to take prompt countermeasures require a little additional explanation. Under the requirements of 49 CFR 236.917, the railroad is required to “maintain a database of all safety relevant hazards as set out in the PSP and those not previously identified in the PSP. If the frequency of the safety relevant hazards exceeds the thresholds… the railroad shall report the inconsistency”. The purpose of this is to ensure that the original design and risk assumptions made are still valid over time, and that there has not been degradation in safety. Failure to identify when the original assumptions may no longer be valid, and that the actual performance is not meeting the intended performance standard can have a serious impact on the safety of the public. Likewise, failing to take prompt countermeasures when it becomes apparent that intended performance standard is not being met can have a serious impact on the safety of the public.

The regulation notes that falsification of records may be subject criminal penalties.

3. Impacts

The final regulation is limited to processor-based signal and train control systems developed after 7 March 2005, and selected components of Highway Grade Crossing System components. It does not affect systems built using existing technology. Accordingly any impact (with the exception of the software management control plan) is limited to railroads and vendors who are building or implementing new microprocessor based technologies for signal and train control. The greatest impact of this rule, however, is not the changes from the NPRM to the Final Rule, but rests with the fact the NPRM and the Final Rule are performance based, as opposed to prescriptive based, regulations.

Implementing performance-based regulation poses its own challenge, especially when a government agency and a regulated industry need to make a transition from prescriptive-based standards. Performance-based standards, by definition, create uncertainty for both regulators and regulated entities with respect to enforcement and compliance issues. Regulators accustomed to enforcing prescriptive standards are frequently uncomfortable with the discretion inherent in loosely specified performance standards. Regulated entities are uncomfortable with loosely specified performance standards because they believe they give regulators too much discretion when deciding enforcement issues.
In addition to this fundamental challenge that exists for the regulator, and the regulated organization, performance based regulations have significant positive, and some negative impacts over older previous prescriptive approach in for industries subject to technological change.

3.1. **Positive Impacts**

The positive impacts of performance-based rules begin with a lower risk of product failure. The lower risk of product failure is the result of the vendor’s ability to tailor their design, development, manufacturing, and maintenance strategies to best fit the problem space. This is compared to a product designed under a prescriptive rule, where the prescriptive rule does not reflect the latest technological developments and capabilities. In creating products with a lower failure rate, significant benefits accrue to the railroad in terms of reduced maintenance costs, downtime of equipment, and parts inventory requirement. For the vendor, reduced failure rates can result in an improved reputation for reliability in the market place, which can equate to increased market share. It also results in the need for fewer repair inventories to support customer units, decreasing the vendor stock inventory cost.

Another positive impact of performance-based rules is that it fosters the entry of new products into the market place. Companies can create new products that accomplish a performance objective without requiring the same capital investment in infrastructure that may be required to support an existing technology. Since the objective is to meet a performance goal, vice to execute a predefined set of requirements, the ability of a vendor to define a new set of requirements as they see fit virtually guarantees that a product can be new. Railroads benefit by having a greater choice of solutions to their problem, existing vendors have the freedom to create new offerings that allows them to optimize plant and capital expenditures, and new vendors are not unnecessarily excluded from the market place by lack of capital.

Unlike the past, where the railroads level of knowledge may have exceeded that of their vendor, the railroads today often lack this same level of knowledge. Modern microprocessor and software design has become such a specialized field, that railroad is often at a disadvantage in trying to make a purchase decision when trying to evaluate such detailed information. Further, much of the detailed information associated with microprocessor and software is valuable intellectual property of the vendor and often may not be released to the railroad. Performance-based rules reduce the amount of information and evaluation required by the railroad in making a purchase decision by allowing the railroad to simply specify what the product must do, allowing the vendor to determine if their product can or cannot meet the performance requirement. The railroad has legal recourse against the vendor for failures to comply to provide the required performance, while the vendor has recourse while protecting valuable vendor intellectual property.

The performance-based rule is much less intrusive and more flexible when it comes to the railroads and vendors operations. The railroads, and vendors, working with FRA, can
work to develop the least costly method of achieving compliance to the regulatory requirements. This is completely unlike prescriptive based rules, where regulatory requirements were very rigid, and relatively inflexible.

Finally, by minimizing obstacles to competition, and emphasizing a more flexible, results-oriented policy than design standards, the flexibility and choice offered by performance standards can produce significant cost savings for vendors and the railroads, and provide continuing incentives for innovation.

However, this rulemaking also has a broader purpose. In a report entitled *Benefits and Costs of Positive Train Control*, provided to the Congress in August of last year, FRA described the possible benefits that might accrue to the industry and the public, including railroad shippers, should PTC be adopted. (The report is available on the agency’s web site at [www.fra.dot.gov](http://www.fra.dot.gov).) Many of those benefits are hotly contested by the railroads, but several major railroads continue to explore possible implementation of PTC. FRA continues to have confidence that the future of the railroad industry will include use of competent, interoperable train control technology that can serve the interests of safety, efficiency and service, and which will eventually be interfaced with other intelligent transportation systems. The Processor-Based Rule is designed to enable, though not to require, this development.

### 3.2. Negative Impacts

Inappropriately applied, however, performance-based rules may have a negative impact on vendors the railroads, and the government. First, performance-based rules may actually impede innovation and entry of new products into the marketplace. The performance standards requested may be so high that the capital investment required to develop, manufacture, and deploy the products to meet the standards may exceed the market return. Alternatively, the performance standards may be crafted so narrowly that they are in effect prescriptive design standards in disguise, hindering the development and application of new technologies. In all cases the railroad, the vendors, and the government loose thru missed opportunities. All of those involved in this rulemaking sought to minimize this potential.

Performance standards may even be unfair resulting in lower costs for small firms than for larger firms. Smaller firms, with less investment in existing plant and equipment, may have a significant competitive advantage over larger firms. The consequences can be devastating to the industry as a whole, as the larger firms, unable to compete with the smaller firms, are forced out of business. However these larger firms, with their plant and equipment, often are the source of supply for the railroads legacy equipment. With decreasing sources of supply for legacy equipment parts, the railroads are forced into the position of accelerating replacement of their equipment or increased repair costs. Accelerated replacement of equipment may require capital investments that the railroad simply does not have, or cannot obtain. Either could eventually result in degradation in plant and equipment as deferred maintenance liabilities due to insufficient capital. Eventually the deferred maintenance will result in decreases in safety. Although it is appropriate to recognize these possibilities, FRA is not persuaded that a serious concern
is presented in the present case, particularly given the existing, highly competitive international market.

Finally, performance standards can have a subjective element. When coupled with a standard that may not communicate much information about what must be done to comply, it creates uncertainty. Uncertainly increases the element of risk and may raise the cost of compliance for the vendor and the railroads, and also make monitoring compliance more difficult and more costly for the government. Although the RSAC was unable to describe statistical tests that would settle the question of confidence in risk assessment estimates, FRA will work with all parties to minimize the potential for uncertainty associated with this final rule.

4. Summary & Conclusion
With the two simple requirements embodied in 49 CFR 236 Subpart H; the new must be at least as safe as the old, and it must be technically justified – almost ninety years of railroad tradition are changing virtually overnight. The move to risk centric performance based rules by FRA offers the railroads and rail industry an opportunity to innovate. Freeing industry from the design limitations imposed by prescriptive regulation, and allowing the use of virtually any process and technology available establishes the conditions for revolutionary changes, as opposed to evolutionary advancements. As the economist Hazel Henderson said, “If we can recognize that change and uncertainty are basic principles, we can greet the future and the transformation we are undergoing with the understanding that we do not know enough to be pessimistic.”