MAC.

WHEN NUMBERS LIE

Decoding the Safety Mirage in America's Industrial Reawakening

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ABSTRACT

FOR OVER FIVE DECADES, THE TOTAL RECORDABLE INCIDENT RATE (TRIR) HAS BEEN THE CORE SAFETY PERFORMANCE METRIC ACROSS AMERICAN INDUSTRY. ITS CONSISTENT DECLINE IS HAILED AS EVIDENCE THAT U.S. WORKPLACES ARE SAFER THAN EVER.
BUT THIS DECLINE IS NOT A REFLECTION OF IMPROVED SAFETY. IT IS A BYPRODUCT OF DEINDUSTRIALIZATION, OUTSOURCING, AND EXPOSURE DISPLACEMENT.

> AMERICA DIDN'T GET SAFER.
> AMERICA STOPPED DOING THE WORK.

THIS WHITE PAPER DISMANTLES THE TRIR MYTH. IT INTEGRATES THE FINDINGS OF THE STATISTICAL INVALIDITY OF TRIR AS A SAFETY METRIC (2021), AND INTRODUCES A NEW, DATA-DRIVEN MODEL: THE COMPOSITE INDUSTRIAL EXPOSURE INDEX (CIEI). CIEI RESTORES VISIBILITY INTO REAL INDUSTRIAL RISK BY MEASURING THE PRESENCE OF HIGH-CONSEQUENCE WORK — NOT JUST LAGGING INDICATORS OF INJURY.

AS THE UNITED STATES EMBARKS ON AN ERA OF REINDUSTRIALIZATION, CONTINUED RELIANCE ON TRIR WILL LEAD TO BLINDNESS, MISPRICING, AND UNPREPAREDNESS. THIS PAPER IS A CALL TO ADOPT NEW METRICS, NEW SYSTEMS, AND NEW DOCTRINE — BEFORE THE MIRAGE OF SAFETY PERFORMANCE COSTS LIVES.

INTRODUCTION

MAC builds integrated platforms that combine data science (AI), software, and human expertise to transform how organizations understand, measure, and manage risk. For more than two decades, MAC has operated at the intersection of safety management, risk intelligence, and operational execution, serving industrial, energy, healthcare and infrastructure sectors where the cost of failure is measured in lives, capital, and national resilience. Our teams — spanning software engineers, data scientists, and embedded field professionals — work in the most complex and consequential environments, from refineries and manufacturing plants to national-scale infrastructure projects.

By unifying operational data with advanced analytics, our platforms deliver decision-grade intelligence that empowers leaders to see their risk surfaces in real time, anticipate emerging threats, and act with precision. This integration of field knowledge and machine learning allows our clients not only to track incidents, but to quantify exposure, weight hazards by consequence, and deploy resources where they will have the greatest effect.

From our founding, we have been committed to replacing lagging, compliance-driven metrics with systems that reflect the real conditions on the ground — and to building the governance, transparency, and trust required to make those systems operational at scale. We invest heavily in the privacy, security, and integrity of the data entrusted to us, ensuring our clients can fulfill regulatory obligations while achieving the speed, clarity, and accuracy needed to operate in high-consequence domains.

Today, MAC's platforms and people are embedded with some of the most critical operators and insurers in the world, helping them shift from reactive safety to proactive risk management. Whether deployed to a single project or integrated across an enterprise, our solutions connect data, decisions, and execution into a single operational picture — enabling organizations to reduce uncertainty, enhance resilience, and protect both their people and their missions.

This white paper outlines why one of the most widely used safety performance metrics — the Total Recordable Incident Rate (TRIR) — has become both statistically invalid and strategically dangerous, and how MAC's Composite Industrial Exposure Index (CIEI) offers a more accurate and actionable view of industrial risk in an era of U.S. reindustrialization.

TRIR: STATISTICALLY INVALID AND OPERATIONALLY DANGEROUS

THE TOTAL RECORDABLE INCIDENT RATE (TRIR) IS DEFINED AS:

$$TRIR = \left(\frac{\text{RECORDABLE INJURIES X 200,000}}{\text{TOTAL MAN HOURS}} \right)$$

On its face, this is a clean, universal ratio — a single number meant to distill the safety performance of an entire organization, project, or industry. That perceived simplicity is precisely why it became the default currency of safety reporting across the United States.

But in complex, high-consequence systems, simplicity without statistical rigor is not elegance — it's fragility. And TRIR is one of the most fragile performance metrics in industrial use today.
In the 2021 paper, The Statistical Invalidity of TRIR as a Safety Metric, dismantle the mathematical foundation of TRIR with precision. Their findings are not academic quibbles; they are systemic flaws:

- Non-parametric by nature – TRIR data does not follow the normal distribution required for meaningful inferential statistics, yet it is compared and ranked as if it does.
- Volatility from denominator collapse – The formula's sensitivity to hours worked means TRIR can drop even if the number of injuries remains constant — or rises.
- Temporal and cross-population incompatibility – It cannot be reliably compared across years, companies, or sectors, yet it is used as the primary benchmark in all three contexts.
- Zero predictive capacity – It fails to forecast future incidents, making it unsuitable for prevention or proactive decision-making.

This is not just statistical imperfection. It is a structural defect that undermines every decision built on it. TRIR is a lagging ratio of recorded failures, distorted by the volume of work performed and the reporting practices of those performing it. It can be — and often is — improved on paper without any change in the actual safety conditions on the ground.

> THE MOST DANGEROUS THING ABOUT TRIR IS NOT THAT IT IS WRONG — IT'S THAT IT IS WRONG IN A WAY THAT REWARDS THE DISAPPEARANCE OF WORK, NOT THE REDUCTION OF RISK.

Yet despite this, TRIR continues to sit at the center of national safety strategy. It is used to award billion-dollar contracts, determine insurance premiums, and justify regulatory posture. In effect, an entire architecture of industrial decision-making is balanced on a metric that can be gamed by shifting work offshore, automating tasks, or manipulating reporting thresholds.

As long as TRIR remains our primary safety signal, we are not measuring safety performance. We are measuring something far more brittle and far more dangerous: the absence of visible activity. And in an era of reindustrialization, that absence will not last.

THE STRATEGIC THREAT

The AI race will not be won in data centers alone.
It will be won in the physical economy — in the factories, ports, refineries, and energy systems where algorithms are turned into action, and code becomes output.

For the United States to compete at the frontier of AI-enabled industry, it must reindustrialize at scale: building semiconductor fabs, electrifying transport, modernizing the grid, expanding manufacturing, and securing domestic energy. Every major policy signal is pushing in this direction.

But this return to high-consequence work brings with it an unavoidable reality: our exposure to industrial risk will rise. And if that rise is measured and interpreted through the lens of TRIR, the consequences could be strategically crippling.

1. TRIR Will Rise as Exposure Returns
TRIR fell over the last 50 years because we offshored hazardous work. As we bring that work back, the denominator of risk expands. Even if safety systems improve, the recorded rate will climb — not because we are less safe, but because we are doing more dangerous work at home.
This is not a theory. Every historical cycle of industrial buildout — from wartime production surges to the shale boom — has shown the same pattern: more work, more recorded incidents, higher TRIR.

2. The Cost Multiplier of a Rising TRIR
In the 1980s, a higher TRIR was a reputational and compliance problem. In the 2020s, it is a cost detonation device. Medical inflation, indemnity costs, and the economics of modern insurance mean that if TRIR were to climb back toward 1980s levels while we are reindustrializing, the cost curve for U.S. manufacturing and infrastructure could spike violently.
Higher TRIR → higher insurance premiums → higher cost of capital → slower buildout → lost momentum in the AI race.

3. The Strategic Link: TRIR and AI Competitiveness
The nation that wins the AI race will be those that can deploy advanced manufacturing, energy infrastructure, and logistics networks faster and more efficiently than their competitors. If U.S. TRIR spikes during reindustrialization, it won't just be a safety statistic — it will be a drag coefficient on the entire industrial AI flywheel.
China, India, and other industrial competitors will not pause their buildouts because our safety metrics are misaligned with reality. They will leverage their momentum while we drown in the cost implications of a rising TRIR — even if the rise reflects nothing more than the statistical effect of doing more work.

4. The Imperative: Build a New Risk Index Before the Buildout
The U.S. cannot afford to enter the largest industrial expansion in half a century with a 1970s-era metric as its primary safety KPI. We need to measure exposure-adjusted performance — not raw incident ratios — so that our insurance markets, capital allocators, and project owners can separate actual safety degradation from the statistical artifact of increased work volume.

Without this correction, reindustrialization will be choked by risk capital costs, and the U.S. will cede industrial AI dominance to nations with better-aligned measurement systems.
In the AI race, risk intelligence is industrial strategy.

If we fail to modernize how we measure safety performance now, we may find ourselves losing the race not because of a shortage of algorithms — but because we priced ourselves out of building the physical systems those algorithms need to run.

TRIR DECLINE EXPLAINED

From 1972 to 2023, the national TRIR fell nearly 80%. On the surface, that decline appears to be one of the great public policy victories of the modern era — proof that regulation, training, and corporate culture made American industry dramatically safer. But the data tells a different story — one that is less about mitigating danger and more about moving it somewhere else.

1. The Disappearance of the Industrial Workforce

Between 1979 and 2023, U.S. manufacturing employment fell by roughly 7.5 million jobs, a collapse of nearly 75%. Steel mills closed. Foundries went cold. Shipyards shrank to fractions of their former size. Entire industrial towns were gutted, not because the work was made safe, but because the work was gone.

This wasn't just a labor shift — it was an evacuation of risk from the domestic economy. Every manufacturing line shut down in Pennsylvania or Ohio reduced the chance of a U.S.-based injury — but the same tasks, often more dangerous, continued overseas, in jurisdictions with weaker safety regimes and no OSHA logbooks.

2. The Contraction of Energy-Sector Exposure

The Baker Hughes rig count — a simple measure of how many oil and gas rigs are actively drilling — has fallen over 60% from its 1980s peak. With each idled rig, thousands of high-SIF (Serious Injury and Fatality) exposure hours disappeared from U.S. soil.

This didn't mean Americans stopped using oil and gas. It meant we increasingly relied on offshore platforms, foreign drilling programs, and imported refined products. We outsourced the exposure but kept the consumption — a global shell game in which risk was simply rerouted around our own ledgers.

3. Construction Without Industrial Growth

Non-residential construction investment in the U.S., when measured as a share of GDP, has been essentially flat for decades. We have built housing, retail, and office towers — but not the same scale of heavy industrial infrastructure that once dominated capital project spending.

Fewer steel plants, fewer petrochemical complexes, fewer large-scale refineries. This kept the domestic TRIR low not by improving performance, but by reducing the type of work most likely to produce severe incidents.

4. Erosion of Infrastructure Workforces

Rail and utility infrastructure employment — once core to America's economic operating system — has been steadily eroded by deregulation, automation, and privatization. Fewer linemen maintaining high-voltage transmission lines. Fewer crews repairing rail track. Fewer boots on the ground means fewer logged injuries — but not because the hazards disappeared.

The poles still need climbing. The rails still need welding. Increasingly, those tasks are deferred, subcontracted to smaller workforces, or executed in regions with lower reporting visibility.

5. The Illusion Created by Offshoring

From the 1990s through the 2010s, hazardous work moved abroad at unprecedented scale. China's entry into the WTO in 2001 accelerated the migration of manufacturing, processing, and assembly operations out of the U.S. to lower-cost labor markets. In safety reporting terms, this was the perfect illusion: every offshored job meant one fewer domestic exposure hour — and therefore, a mathematically lower TRIR. But the actual global volume of risk didn't decline. It simply shifted beyond the reach of OSHA's data systems.

6. TRIR as a Map of Absence

By the time TRIR had reached its 2023 level of 2.3, the index no longer reflected a safer America — it reflected a smaller America, industrially speaking. The "progress" was, in reality, the statistical shadow cast by the disappearance of high-risk work from U.S. soil. The danger was not eliminated. It was just hidden from view — exported to places where injury rates are less transparent, oversight is weaker, and the costs are not borne in U.S. balance sheets.

> **THIS IS THE HEART OF THE ILLUSION: TRIR HAS BEEN LESS A MEASURE OF SAFETY PERFORMANCE THAN A MEASURE OF HOW MUCH DANGEROUS WORK AMERICA CHOOSES TO PERFORM WITHIN ITS OWN BORDERS. AS WE REINDUSTRIALIZE, THAT CHOICE IS REVERSING — AND WITH IT, THE FALSE COMFORT TRIR HAS PROVIDED FOR HALF A CENTURY.**

INDUSTRIAL EXPOSURE INDEX

In the process of interrogating the TRIR narrative, we built a separate model — the Composite Industrial Exposure Index (CIEI) — to measure the amount of high-consequence industrial work being performed in the U.S. over time.
We didn't set out to replace TRIR. We set out to understand it.
We already know, as documented in The Statistical Invalidity of TRIR as a Safety Metric, that TRIR is not statistically sound for comparing performance across organizations or time periods. Its construction as a lagging ratio makes it inherently volatile and prone to distortion from changes in hours worked.
But our focus here is different. We are not trying to rehabilitate TRIR as a reliable safety metric — we are trying to explain the historical pattern of its decline.
If the number has been dropping for fifty years, the real question isn't "Is TRIR valid?" — it's "Why did it drop?" And when we built the Composite Industrial Exposure Index, we found the answer: TRIR has moved almost perfectly in line with the amount of high-consequence work being done in the United States.

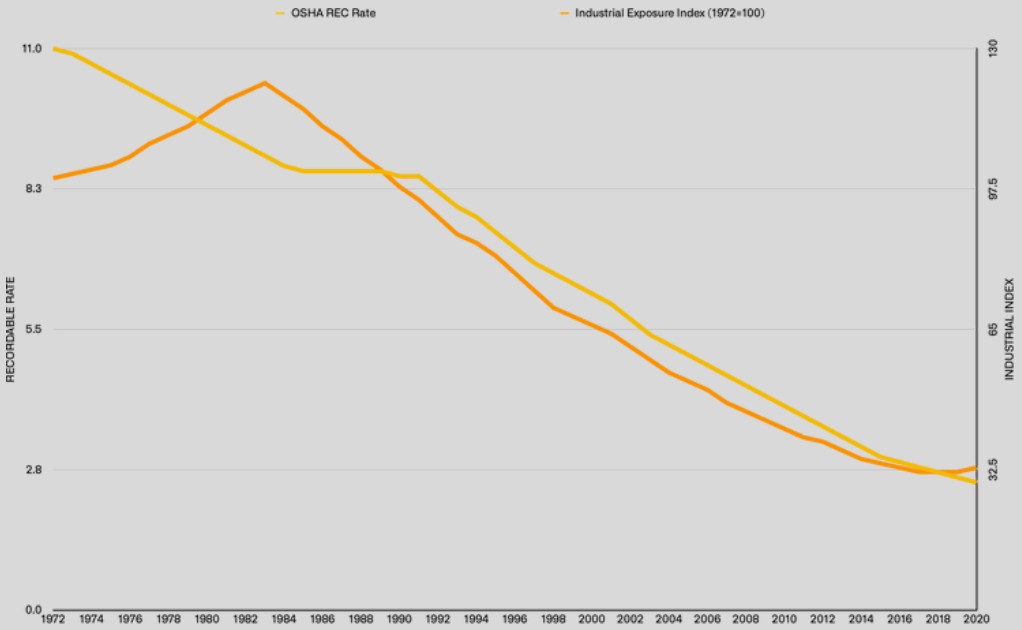
Sector	Activity Measured	Weight
Manufacturing	Employment levels (FRED MANEMP)	30%
Construction	Non-residential & industrial spend (U.S. Census)	20%
Oil & Gas	Employment & rig count (BLS + Baker Hughes)	20%
Utilities	Workforce size (BLS NAICS 221)	15%
Freight/Rail	Tonnage & rail workforce (ATA + AAR)	15%

CIEI tracks five sectors that carry the highest share of serious injury and fatality exposure in the U.S., each weighted according to historical contribution to national risk, workforce size, and GDP relevance:

THE FORMULA IS SIMPLE BUT POWERFUL:

$$CIEI_t = \sum_{i=1}^{5} w_i \times \left(\frac{X_{i,t}}{X_{i,1972}} \right) \times 100$$

Where $X_{i,t}$ = sector activity at year t, and 1972 is set to 100 for normalization.



R^2 = 0.89 — MEANING 89% OF THE MOVEMENT IN TRIR CAN BE STATISTICALLY EXPLAINED BY CHANGES IN DOMESTIC INDUSTRIAL ACTIVITY.

FROM ILLUSION TO INSTRUMENT

For fifty years, TRIR has been the United States' north star for measuring safety performance. It fell, year after year, and we congratulated ourselves. We said it meant we were safer. We said it meant the system was working.

We were wrong.

The Composite Industrial Exposure Index proves the truth: TRIR didn't drop because risk was engineered out of our work. It dropped because we engineered the work out of our borders. We exported the danger. We stopped counting it. And we let ourselves believe the absence was victory.

That era is over.

The United States is reindustrializing at a scale not seen in decades. In the global AI race, the nations that can produce, deploy, and sustain physical systems at speed will lead. This means bringing back high-consequence work — fabs, refineries, ports, grids, manufacturing plants — and with it, the exposure that TRIR quietly mirrored on its way down.
If we continue to misread this metric, we risk three outcomes:

- Inflated insurance and capital costs
- Slowed project execution
- Strategic disadvantage in the AI-enabled industrial economy

We cannot afford that. Which means the way forward must be deliberate and disciplined.

The Reindustrialization Risk Framework

1. Contextualize TRIR with Exposure Intelligence
Stop treating TRIR in isolation. Every reported rate must be paired with an exposure index like CIEI to distinguish between actual safety degradation and the statistical effect of doing more work domestically.

2. Modernize Risk Capital Models
Insurers and lenders must integrate exposure-adjusted performance into underwriting. This avoids penalizing companies for scale, and instead rewards them for managing hazard density effectively as they grow.

3. Embed Real-Time Industrial Risk Mapping
Build CIEI-like logic into operational systems so that project owners, regulators, and policymakers can see where risk is rising, why it's rising, and whether it reflects a problem or a productive surge in industrial activity.

The choice is simple:

We can treat the next rise in TRIR as proof we've lost our way — or we can recognize it as evidence we've found it again.

America will win the AI race by building — at scale, at speed, and with eyes wide open to the true cost of the work. The curve is coming back up.

We must be ready to read it.
We must be ready to manage it.
We must be ready to own it.