RISKOPILOT

Prove it on site

A field manual for piloting safety technology against critical controls

How to run one honest pilot of a safety technology function on one site and reach a written decision. A charter, safe challenges, the statistics of small trials, eight worked dossiers, five further candidates and the forms to complete.

RISKOPILOT RESEARCH
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ABOUT THIS MANUAL

What this is, and what it is not

This is a method for testing a safety technology function on your own site before you rely on it. It turns the fourth decision in our report *Time to act*, "run one bounded pilot, or none", into steps a pilot lead can follow.

It contains no field data. Riskopilot has not run these pilots or tested any equipment. The dossiers are designs to adapt, and every number in a worked example is invented and marked as such.

It names no product. It describes functions: detect a person, read a displacement, confirm an isolation. Supplier documents describe what a product is meant to do. Your pilot finds out what it does on your site.

How to read the labels

FACT A finding from a named source, with its date and scope.

INFERENCE Our reading of what the facts imply.

ILLUSTRATION An invented example or number that explains a method.

RECOMMENDATION What we advise sponsors and pilot leads to do.

Small gold numbers refer to the source register on pages 44 and 45.

Who it is for

The sponsor who signs the pilot charter and reads the result, usually an executive or site director. And the pilot lead who designs the challenges, usually an engineer or HSE lead.

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One rule above all. Never create a real conflict between a person and a machine, a real fall hazard or a hazardous atmosphere to test a system. Use surrogates, closed areas, training copies and approved fixtures.

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SUMMARY FOR SPONSORS

Run one honest pilot, and decide before you see the results what a pass looks like

The system worked, people liked it, roll it out. If that is the only way your pilot could end, the conclusion was available before it began. A pilot earns its cost only if it could have failed.

The decision

RECOMMENDATION Choose one function, one exposure, one owner and one bounded setting. Sign the acceptance criteria before any test. At the end, write one of four decisions: adopt within the tested limits, extend the test, redesign, or withdraw.

Why one pilot

FACT A 2023 mapping review of digital safety interventions in construction kept 24 of 392 records and found low to no evidence of better working conditions or fewer injuries.[2] The Cochrane review of injury prevention in construction rates its evidence as very low quality.[3]

INFERENCE Published research will not tell you whether a function protects people on your site. A site test can, if it is narrow enough to be read. Twelve loose trials produce twelve anecdotes.

What a pilot can show

INFERENCE Whether the function detects what it should, and whether a correct action follows in time, within the conditions you tested. A careful pilot can also show whether exposure fell at the same volume of work. It cannot show that injuries fell. One site does not have enough events.

Five findings that shape the method

1. A clean run proves less than it seems. FACT Thirty trials with no miss still allow a true miss rate of up to 9.5%. Ruling out a rate above 1% takes 299 clean, independent trials.[19]

2. Detection is not the test. FACT In the best field study we found, a radar on a mine truck missed nothing in seven days, and 41% of its 580 alarms called for action or caution.[1]

3. The boundary matters more than the sensor. FACT At DeRidder in 2017 the atmosphere was tested outside a tank. The flammable atmosphere was inside. Three contractors died.[15]

4. The conventional option must be in the test. RECOMMENDATION If a barrier, a layout change or a method removes the exposure, record that and close the technology trial.

5. Criteria written after the results are worthless. RECOMMENDATION The technical authority signs the expected result of every challenge before the first run.

The sponsor's one question

Ask the pilot lead: "What result would make us withdraw this?" If there is no answer, there is no pilot yet.

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SUMMARY FOR SPONSORS

What to sign, and what to refuse

The sponsor does three things: signs the charter, protects the pilot from pressure to pass, and reads the decision paper. Each has a short test.

Before you sign the charter

THE CHARTER STATES	YOU SHOULD BE ABLE TO SEE
The exposure	One fatal risk, one location, one task. Who is exposed, and when the exposure begins.
The comparator	The best conventional control, priced on the same boundary.
The protective action	Who acts on the signal, what they do, and the deadline for doing it.
The operating envelope	The equipment, layout, shifts, light and weather the test covers. Everything else is untested.
The reference	How the truth is established independently of the system under test.
Pass, fail and stop rules	Numbers and conditions, signed and dated before testing.
The data rules	What is collected, who sees it, how long it is kept, and how workers were consulted.

The blank charter is on page 38.

During the pilot

RECOMMENDATION Keep every existing control in place. The pilot adds a function in shadow or advisory mode. It removes nothing.

Have someone with no stake in the result observe a sample of periods, including quiet ones chosen before any dashboard is seen.

Treat a single missed critical condition, a silent loss of coverage or an unauthorised release as a reason to restrict and investigate.

Refuse a decision paper that offers

- A count of devices installed or hours logged.
- A detection rate with no denominator.
- A falling alert count with no explanation.
- Results for day shift only.
- Criteria changed after testing began.
- "No incidents during the pilot" as evidence.

> **Where this sits in the series.** *Time to act* sets out five gates a proposal must pass before it deserves a pilot.[25] This manual starts after gate 5. If the proposal has not been through the gates, go back.

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SUMMARY FOR SPONSORS

The pilot in 90 days

Four stages. Move to the next on evidence, and stop early if a stop rule is met.

STAGE	OWNER	WORK	OUTPUT AND SUCCESS MEASURE
Days 1 to 15 Baseline	Site director, pilot lead	Pick one bounded job or asset. Draw the protected boundary with a worker and an engineer. Locate the last point at which action still protects. Record the best conventional alternative. Choose shifts and denominators.	A marked drawing and a baseline count. **Measure:** the comparator is priced and the exposure has a denominator.
Days 16 to 30 Freeze	Technical authority	Sign the expected result of every challenge, the reference method, the clocks, the uncertainty allowance, the exclusions and the stop rules. Agree the data rules with worker representatives.	A signed charter. **Measure:** signature dated before the first run.
Days 31 to 60 Collect	Pilot lead, independent observer	Run the challenges in closed areas or on training copies. Sample quiet periods as well as alarms. Record version, configuration, light, shift, missing data and who acted. Log every deviation.	An evidence log. **Measure:** no run is missing its reference, and unknowns are counted.
Days 61 to 90 Decide	Sponsor, technical authority, worker representative	Review every miss, late action, stale reading and unknown. Test the fallback at night and with contractors. Write the limits of any acceptance and what invalidates it.	A decision paper. **Measure:** one of four written decisions, with an expiry and a named owner.

What this manual will not tell you

Which product to buy, what miss rate is acceptable, or how many trials your site needs. The technical authority sets the last two for the site and the hazard. We give the arithmetic that shows what each choice implies.

What would change our advice

A published field evaluation of any of these functions with independent references and denominators. We found very few. Page 43 lists what we are looking for.

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PART 1

The method

What a pilot can prove, the charter that makes it honest, how to challenge a system without endangering anyone, and how to read a small number of trials.

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PART 1 · SCOPE

What a pilot can and cannot prove

A site pilot answers a narrow question well. Asked a broad one, it produces confidence without evidence.

EXHIBIT 1

Four levels of proof, and where a site pilot can reach

LEVEL	QUESTION	CAN ONE SITE ANSWER IT?	DENOMINATOR
1. Detection	Did the function detect the condition, against an independent reference?	Yes, within the tested envelope	Eligible encounters
2. Timely action	Did a person or function act before the last safe moment?	Yes, in staged trials	Encounters with a timed response
3. Lower exposure	Were people in danger less often at the same volume of work?	Sometimes, with matched periods	Movements, entries, lifts
4. Harm prevented	Did serious injuries fall?	No	Populations far larger than a site

INFERENCE Riskopilot framing, from *Time to act.* [25]

When to pilot

RECOMMENDATION Pilot when four things are true. The exposure cannot be removed by the date the executive committee has set. The function could change a named decision. A staged test can be run without exposing anyone. And someone has the authority to withdraw the system if it fails.

When not to

RECOMMENDATION Do not pilot to delay a redesign that is already justified. Do not pilot a function whose failure the test could not detect. Do not pilot where the only possible outcome is adoption.

Shadow, advisory, credited

RECOMMENDATION A function passes through three states.

- **Shadow.** It records. Nobody acts on it. Existing controls carry all the protection.
- **Advisory.** People see its output and may act. Nothing is relaxed because of it.
- **Credited.** The site relies on it as part of a control. This needs a separate decision by the technical authority, outside the pilot.

A pilot ends at advisory. Moving to credited is a change to the site's controls and follows the site's change procedure.

A system that slows or stops a machine is an engineering control. Its acceptance belongs with the manufacturer and competent engineering, and is outside this manual.

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PART 1 · THE CHARTER

Seven clauses, signed before the first run

The charter is one page. Its purpose is to make the pilot capable of failing.

CLAUSE	WHAT TO WRITE	COMMON FAILURE
1. Exposure	The fatal risk, the task, the place, who is exposed and the moment exposure begins.	"Improve vehicle safety." No task, no moment.
2. Comparator	The best conventional control for the same exposure, with its cost over the same period.	Comparing the technology with doing nothing.
3. Protective action	The recipient, the action and the deadline, on every shift and for contractors.	A dashboard for managers with no action at the workface.
4. Envelope	Equipment, software revision, mounting, layout, light, weather, speed, shifts. State what is excluded.	Testing one machine by day and accepting for the fleet.
5. Reference	How each trial's true state is established without using the system under test. Who adjudicates disagreement.	Scoring the system against its own log.
6. Pass, fail, stop	The number of trials per challenge, the result that passes, the result that fails, and what halts the pilot at once.	"Performance will be reviewed."
7. Data and people	Data collected, purpose, access, retention, and how workers were consulted. Who can refuse a request to reuse it.	Footage later used to rank individuals.

Who signs

RECOMMENDATION The sponsor, the technical authority for the hazard, the pilot lead and a worker representative. The supplier does not sign and does not hold the reference data.

Any change to a clause after signing is logged with a date and a reason. A changed pass rule restarts the count.

On worker data

FACT Principles published by the EU's safety and health agency in 2024 call for involving workers from the start, collecting only data needed for safety and health, and stating the system's purpose clearly.[6]

FACT In one US survey, 59% of construction field workers would not voluntarily use a location-tracking wearable.[4] INFERENCE One sample, size not visible to us. It is a reason to ask your own workforce early.

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PART 1 · CHALLENGES

Five challenges, none of which endangers anyone

Every dossier in Part 2 uses the same five challenge types. Together they test the function, its limits, its faults and the people around it.

EXHIBIT 2

The five challenge types

CHALLENGE	WHAT IT ASKS	SAFE WAY TO STAGE IT	A FAIL LOOKS LIKE
A. Normal case	Does the function stay quiet, or correct, when nothing is wrong?	Routine work, observed.	Alarms that ask nothing of anyone.
B. Target condition	Does it detect the condition at the edge of its envelope, in time?	Surrogate target, mock-up or seeded training record in a closed area.	A miss, or a detection after the deadline.
C. Outside its view	What happens when the hazard is where the function cannot sense?	Occlusion, wrong location or unlisted source, staged with no one exposed.	A normal indication while the hazard exists.
D. System fault	Does a fault, a frozen reading or a lost link announce itself?	Approved replay, disconnected link or training display.	A stale value that looks live.
E. Human handover	Does the right person hold the decision when shifts change, people disagree or pressure rises?	Tabletop or radio exercise with the real roles.	Release by someone without authority, or nobody acting.

RECOMMENDATION Riskopilot proposal. Challenge C is the one most often left out, and the one the DeRidder case turns on. [15]

Rules for staging

RECOMMENDATION No person enters a hazard zone to act as a target. Use a surrogate the system is specified to detect, and say in the record how it differs from a person.

No protective function is disabled to create a comparison. No hazardous atmosphere, live conductor or unsupported load is created.

If a real hazardous condition arises during a trial, normal site response applies at once and the run is recorded as interrupted.

What a surrogate cannot tell you

INFERENCE A mannequin does not move, crouch or wear what your night shift wears. A seeded error in a training permit is easier to find than a real one. Staged trials set an upper bound on performance. Shadow observation of real work, with all controls in place, narrows the gap.

FACT A 2026 review of computer vision for construction monitoring reports gaps in real-world validation and in how well datasets generalise. [26]

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PART 1 · REFERENCE AND OBSERVATION

Establish the truth without asking the system

A pilot needs a second, independent account of what happened in each trial. Without one, you are measuring how often the system agrees with itself.

The independent reference

RECOMMENDATION For each challenge, name the reference before testing: a surveyed boundary, a synchronised observer record, a competent person's inspection, a second instrument of a different type, or the known content of a seeded training case.

The person who adjudicates a disagreement between system and reference has no interest in the pilot succeeding.

Clocks

RECOMMENDATION Timing claims need synchronised clocks. Check them before and after each session and record the offset. Where you can, time the whole interval from first cue to verified safe state directly. Adding separately measured parts hides overlaps.

State the uncertainty. If the margin is smaller than the uncertainty, the result does not support acceptance.

Look where the alarm did not sound

RECOMMENDATION Reviewing alarm clips cannot find missed events. Choose observation periods at random, before anyone has looked at the system's output, and include periods with no alert.

Count encounters

RECOMMENDATION Define an eligible encounter before testing. One person visible in 60 consecutive frames is one encounter. Counting frames inflates the sample.

Report four numbers for each challenge: correct and in time, correct and late, missed, and unknown. An unknown is a trial whose reference failed. It is never counted as a pass.

Two denominators

RECOMMENDATION Of all movements or tasks, how many produced an alert? Of all alerts, how many needed someone to act? FACT In the mine radar study the answers were 94% and 41%.[1]

FACT UK regulator guidance on alarm management says each alarm should have a clear purpose and a defined response.[5]

Blind what you can

RECOMMENDATION Where the trial compares two workflows, vary the order and keep the adjudicator unaware of which was used. Where people know they are observed, say so in the report. Behaviour under observation is usually better than behaviour without it.

> **Record the conditions.** Version, configuration, mounting, location, light, weather or process state, shift, and who acted. A result with no conditions attached cannot be transferred or repeated.

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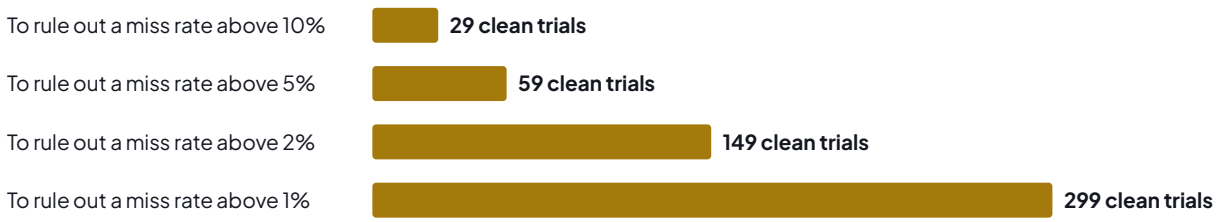
PART 1 · READING RESULTS

How many clean trials, and what they allow you to say

The arithmetic of small trials is unforgiving and simple. Decide the number of trials from the claim you want to make, before you start.

EXHIBIT 3

Clean, independent trials needed to rule out a given miss rate



Smallest n for which 1 – 0.05^(1/n) falls at or below the target. Independent, representative trials, no misses, 95% one-sided.

FACT Exact binomial result, recomputed for this manual. The "rule of three" gives nearly the same answer: after n trials with no event, the upper 95% limit is about 3 divided by n. [19]

What the numbers mean

INFERENCE Thirty staged trials with no miss allow you to say the miss rate is probably below one in ten. They do not allow "it never misses". If the hazard is fatal and the function is the last signal, one in ten is a poor figure to rely on.

RECOMMENDATION Ask the technical authority what miss rate would be tolerable for an advisory function at this exposure. Read the number of trials from the exhibit. If that number cannot be run safely and independently, say that the pilot cannot support the claim.

Independence

INFERENCE The formula assumes each trial is a fresh draw from the conditions that matter. The same target, in the same spot, on the same afternoon, repeated thirty times, is closer to one trial than to thirty.

When there is a miss

RECOMMENDATION One miss in a critical challenge stops that challenge. Investigate the cause, correct, and restart the count from zero under the same rule. Do not average a miss away with later passes.

Late is a category

ILLUSTRATION Example: 47 of 50 staged encounters produce a timely alert, or 94%. Two alerts are late and one encounter is missed. The pass rule in the charter was "no miss and no late alert in 50". The result is a fail, and the paper says so.

Attribution

RECOMMENDATION If layout, training and technology change in the same month, any improvement belongs to the bundle. Stagger them. Compare rates per unit of work, with the shift mix stated.

This manual proposes no universal sample size and no acceptable failure probability. Both are set for the site by its technical authority.

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PART 1 · THE DECISION

Four decisions, and what invalidates a pass

A pilot ends with a written decision that has limits, an owner and an expiry.

DECISION	WHEN	WHAT THE PAPER MUST STATE
Adopt within limits	Every pass rule met, on every tested shift, with the fallback demonstrated.	The exact envelope. The function stays advisory until the technical authority decides otherwise. The retest triggers.
Extend	No fail, and too few independent trials or untested conditions that matter.	What will be added, the new number of trials and a closing date.
Redesign	The exposure can be removed or reduced by layout, method or engineering at comparable cost.	The redesign, its date, and the interim control owed until then.
Withdraw	A fail the supplier cannot correct, a negative time margin, or an action nobody was placed to take.	The reason, and where the budget goes instead.

What invalidates a pass

RECOMMENDATION Write the triggers into the acceptance. A pass lapses, and the function returns to shadow, when any of these occurs:

- A software or firmware revision.
- A change of machine, attachment, sensor position or layout.
- A new shift pattern, contractor or task.
- Service, repair or recalibration.
- The expiry date in the decision paper.

INFERENCE A detector accepted for one layout can have a shorter valid life than its service interval.

Count the whole cost

RECOMMENDATION Price installation and downtime, training for every shift and contractor, cleaning and calibration, connectivity, the hours spent investigating nuisance alarms, revalidation after each change, and removal. Compare with the conventional option over the same period.

Do not transfer a pass

RECOMMENDATION A result from one site supports a pilot at the next. It does not replace it. Repeat the boundary walk, the envelope and the challenges that depend on local conditions.

> **After the pilot.** Keep the evidence log with the decision paper. When the function next changes, the log is the baseline for the retest.

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PART 1 · ROLES

Who does what, and who must stay independent

Pilots fail quietly when the people who want the system to work are also the people who score it.

ROLE	DOES	MUST NOT
Sponsor	Signs the charter. Protects the pilot from schedule pressure. Signs the decision.	Announce adoption before the decision paper.
Technical authority	Sets pass, fail and stop rules for the hazard. Approves the reference. Decides any move to credited use.	Delegate the rules to the supplier.
Pilot lead	Designs the challenges. Keeps the evidence log. Reports unknowns and deviations.	Adjudicate disagreements alone.
Independent observer	Records the reference. Samples quiet periods. Adjudicates system against reference.	Report to the project that proposed the technology.
Control owner	Keeps the existing control in place throughout. Holds the stop decision on shift.	Relax the control because the system is running.
Worker representative	Agrees the data rules. Reports how the function behaves in real work.	Be asked to consent on behalf of individuals where the law requires more.
Supplier	States the envelope and failure states in writing. Supports installation.	Hold the reference data or set the pass rule.

Authority during the pilot

RECOMMENDATION Name one person and one deputy on each shift who can halt the pilot and restrict the area. FACT At the Florida bridge in 2018, the NTSB found that five parties failed to stop work and close the road.[17] INFERENCE A pilot adds a sixth party. Decide in advance that it changes nobody's authority.

Small sites

RECOMMENDATION Where one person holds several roles, keep two apart at least: the person who records the reference and the person who proposed the technology. Borrow an observer from another site or shift if need be.

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PART 2

Eight pilot dossiers

One for each fatal event family in *Time to act*. Each is a design to adapt: the exposure, the control to try first, the function under test, five safe challenges and the rules for stopping.

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PART 2 · DOSSIER 1 · FALLS THROUGH OPENINGS AND EDGES

Edge protection at a floor handover

A guardrail section comes out for a delivery. The delivery team leaves. The next trade arrives. The question is whether anything tells the floor supervisor before the floor reopens.

Exposure and deadline

People are exposed from the moment a trade enters a floor with an unprotected edge. The useful signal is a change to the edge before the floor reopens. A warning after entry may come too late.

Try this first

RECOMMENDATION A protected loading bay that never opens the edge, and a physical gate that stays locked until a competent person has inspected the restored rail.

Function under test

A fixed camera view that flags a missing rail section and raises an exception to the floor supervisor.

Pilot owner: Floor supervisor, with the temporary works coordinator.

Envelope to mark

RECOMMENDATION Floor, bay, camera position and field of view, lighting by shift, stacked materials that can hide the edge, and every edge the camera cannot see. Mark the unseen edges on the drawing.

What published evidence supports

FACT UK regulator guidance on fragile surfaces puts avoidance first: plan the work so that people stay away from them where possible.[7] INFERENCE The same order applies to an open edge. We found no field evaluation of camera-based detection of missing edge protection with an independent reference.

What the pilot cannot show

INFERENCE An image shows that something rail-shaped is present. It does not show strength, fixing or toe-boards. A movable barrier outside the view defeats an image-only release.

Worked decision. ILLUSTRATION In 40 staged removals in a mock-up bay the view flags 38. Both misses are rails removed behind stacked boards. The charter required no miss in 40. Result: fail for any bay where materials can be stacked at the edge. The gate and inspection stay as the control.

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PART 2 · DOSSIER 1 · CHALLENGES AND SHIFT CARD

Edge protection at a floor handover

CHALLENGES

Five challenges, approved before testing

CHALLENGE	SAFE METHOD AND REFERENCE	EXPECTED PROTECTIVE DECISION
A. Intact mock rail in an approved bay.	Mock-up bay, observed.	No exception raised. Floor released by inspection as usual.
B. Rail section removed in clear view, by day and at night.	Mock-up bay at ground level or behind a second barrier.	Exception reaches the floor supervisor before the reopening time.
C. Rail removed behind stacked boards, or present with unknown fixing.	Mock-up with staged materials.	Supervisor keeps the floor closed because the view is obscured. A normal indication fails.
D. View frozen after delivery, or camera knocked out of position.	Approved replay on a training display.	Fault or stale status is shown as such. Release reverts to inspection.
E. Night trade asks to enter on the strength of an earlier photograph.	Tabletop with the real supervisor and trade foreman.	Entry refused until a competent person inspects in person.

RECOMMENDATION Riskopilot design. The technical authority approves the reference, the expected result and the number of runs. Record inconclusive runs and deviations with the passes.

Timing boundary

Edge configuration changes → next trade authorised to enter. Agree the site limit and the uncertainty allowance before collecting data.

Measures

Removals flagged before reopening, of removals staged. Obscured-view periods per shift. Releases made on inspection, of all releases.

Stop at once if

Any release made on an image alone. Any missed removal in clear view.

Shift card

RECOMMENDATION The floor stays closed when a rail is missing, the image is obscured or the floor revision is uncertain. A competent person inspects restored protection in person and tells every trade receiving access.

Retest when

Camera moved, floor cycle advanced, lighting changed, new delivery method.

Keep every existing control active. A separate site decision is needed before anything is relaxed. Forms: pages 38 to 42.

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PART 2 · DOSSIER 2 · VEHICLE AND PEDESTRIAN COLLISION

Vehicles and pedestrians at a delivery gate

A delivery vehicle reverses past a welfare crossing. A parked load hides a pedestrian approach. The driver has a camera or radar alert in the cab.

Exposure and deadline

Exposure begins when the crossing and the reversing manoeuvre are released at the same time. The last useful moment for a driver warning depends on the swept path and the stopping envelope.

Try this first

RECOMMENDATION Separate the routes, or close the crossing for the manoeuvre. One-way flow and delivery windows that remove reversing.

Function under test

A vehicle-mounted camera or radar that alerts the driver to a person in a defined zone behind the vehicle.

Pilot owner: Traffic manager, with the fleet engineer.

Envelope to mark

RECOMMENDATION Vehicle class, rear overhang, attachment, mounting height and angle, approach direction, speed, light, permitted parking. The zone must cover the path into danger before the point of no return. Draw the uncovered space.

What published evidence supports

FACT On one mine haul truck over seven days, a radar system alarmed on 580 of 618 reversing movements and missed none. 41% of alarms needed action or caution.[1]

INFERENCE One truck, one mine. It supports testing alarm relevance on your fleet and transfers little else. FACT In California in 2000 a flagger was killed by a reversing truck whose back-up alarm was working.[18] UK guidance on site traffic puts keeping vehicles and pedestrians apart first.[8]

What the pilot cannot show

INFERENCE A tag system does not cover a visitor without a tag. A camera does not see through a parked load. A cab display still needs the driver to look and act.

Worked decision. ILLUSTRATION A driver receives a warning 2.7 s before the conflict point. Measured recognition, action and stopping total 2.5 s. Clock uncertainty is 0.25 s. The conservative margin is −0.05 s. Result: the warning is late for this approach. Restrict the approach and revisit the layout.

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PART 2 · DOSSIER 2 · CHALLENGES AND SHIFT CARD

Vehicles and pedestrians at a delivery gate

CHALLENGES

Five challenges, approved before testing

CHALLENGE	SAFE METHOD AND REFERENCE	EXPECTED PROTECTIVE DECISION
A. Normal delivery along the separated route.	Closed-area walkdown with a synchronised observer record.	No conflicting release. Irrelevant alarms are classified by the observer.
B. Surrogate at the zone edge, in clear view and partly hidden, at dusk.	Closed course, surrogate only, surveyed boundary.	Warning leaves the approved response margin on every required approach.
C. Parked load creates an approach the sensor cannot see.	Stationary vehicle and surveyed sightline.	Crew identifies the loss of coverage and holds the movement. A silent normal status fails.
D. Camera freezes or loses alignment.	Approved replay or training display.	Fault reaches driver and marshal before reliance. Physical segregation until rechecked.
E. Relief driver disputes an alarm.	Radio exercise with marshal and observer.	Movement suspended, resolved at the location, incoming driver briefed before release.

RECOMMENDATION Riskopilot design. The technical authority approves the reference, the expected result and the number of runs. Record inconclusive runs and deviations with the passes.

Timing boundary

First actionable conflict cue → vehicle in a verified safe state. Agree the site limit and the uncertainty allowance before collecting data.

Measures

Conflicts per 1,000 comparable movements, by gate and shift. Late alerts, misses, unknowns and irrelevant alarms per equipment hour.

Stop at once if

A negative time margin on any required approach. Any miss of the surrogate in clear view.

Shift card

RECOMMENDATION Crossing occupied or uncertain: the marshal holds the movement. A blind approach needs route control. Only the traffic lead releases a changed layout, after a joint field check.

Retest when

Camera cleaned, repaired or realigned. New vehicle class, new approach, relocated gate.

Keep every existing control active. A separate site decision is needed before anything is relaxed. Forms: pages 38 to 42.

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PART 2 · DOSSIER 3 · SUSPENDED LOADS AND FALLING OBJECTS

Exclusion under a lifted load

The lift is ready. An access gate at the landing area is open. The question is whether the signaller knows before release.

Exposure and deadline

The earliest useful cue is loss of exclusion before the lift is released. A person seen under a moving load is an exposure already under way.

Try this first

RECOMMENDATION Route the lift away from occupied areas, or assemble at ground level. Physical control of access to the pick, travel and landing areas.

Function under test

A gate contact and a person-detection view of the exclusion zone that alert the signaller before release.

Pilot owner: Appointed lift supervisor.

Envelope to mark

RECOMMENDATION Pick, travel and landing areas, every access point, camera coverage and contrast, radio channel, other contractors working nearby. Mark the access points with no contact and the areas with no view.

What published evidence supports

FACT UK regulator guidance on lifting operations requires them to be planned, supervised and carried out safely by competent people.[10] INFERENCE A rated-capacity indicator addresses the load. It says nothing about who is underneath. We found no field evaluation of zone-intrusion alerts for lifts with an independent reference.

What the pilot cannot show

INFERENCE A closed gate does not prove an empty zone. A virtual barrier does not establish ground bearing or rigging. A permit can cover the lift and miss another contractor's crew.

Worked decision. ILLUSTRATION In 30 staged releases with a gate left open, the signaller is alerted in all 30. In 10 staged cases with a surrogate already inside a closed gate, the view flags 7. Result: the gate contact passes within its limit of 30 trials. The person view fails. No camera output authorises a lift.

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PART 2 · DOSSIER 3 · CHALLENGES AND SHIFT CARD

Exclusion under a lifted load

CHALLENGES

Five challenges, approved before testing

CHALLENGE	SAFE METHOD AND REFERENCE	EXPECTED PROTECTIVE DECISION
A. All controlled points closed and the area verified.	Dry run with no load.	No alert. Release follows the lift plan.
B. Gate open before release.	Dry run, gate opened by the observer.	Signaller withholds release.
C. Surrogate already inside a closed gate.	Dry run with no load, surrogate placed before the gate closes.	Detected before release, or the test records that the function cannot see it.
D. Camera blinded or radio unavailable.	Lens covered or channel muted in a dry run.	Loss is announced. The lift plan's communication failure rule applies.
E. Landing area changes after the briefing.	Tabletop with lift supervisor and the other contractor.	Lift held until the supervisor re-verifies the zone.

RECOMMENDATION Riskopilot design. The technical authority approves the reference, the expected result and the number of runs. Record inconclusive runs and deviations with the passes.

Timing boundary

Access condition lost → release instruction for the lift. Agree the site limit and the uncertainty allowance before collecting data.

Measures

Lifts with the path confirmed clear in the field, of lifts observed. Open-gate cases alerted, of cases staged.

Stop at once if

Any release with an access point open. Any reliance on the view to declare the zone empty.

Shift card

RECOMMENDATION The signaller withholds release when an access point is open or a person is unaccounted for. Loss of communication invokes the lift plan. The lift supervisor coordinates clearance.

Retest when

New lift path, changed landing area, new contractor in the area, camera moved.

Keep every existing control active. A separate site decision is needed before anything is relaxed. Forms: pages 38 to 42.

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PART 2 · DOSSIER 4 · COLLAPSE OF EXCAVATIONS AND TEMPORARY WORKS

Movement beside a supported excavation

Loading changes beside a supported excavation. Movement at a point that matters to the design may come before loss of stability. Some failure modes give no measurable warning.

Exposure and deadline

People in the excavation are exposed whenever a design assumption stops holding. The decision deadline is exclusion before the assumption fails, which monitoring can support only for mechanisms that move first.

Try this first

RECOMMENDATION A design based on actual loads, sequence and ground. Restrictions on loading at the edge. Battering or stepping that removes the need for support.

Function under test

Displacement or inclination sensors at points chosen by the designer, with trigger levels and an alert to the supervisor.

Pilot owner: Temporary works coordinator, with the designer.

Envelope to mark

RECOMMENDATION The mechanism each instrument is meant to catch, instrument and datum positions, baseline by construction stage, trigger levels, who receives the alert out of hours. Mark the failure modes the instruments cannot see.

What published evidence supports

FACT US excavation rules require inspection by a competent person, including after any event that could increase the hazard.[11] UK guidance describes the role of a temporary works coordinator.[9] FACT At the Florida bridge, cracking was documented and discussed before the collapse and the road stayed open.[17]

What the pilot cannot show

INFERENCE A sensor measures motion at its own position against its own reference. A steady reading elsewhere proves little. A drifting datum can hide movement or invent it.

Worked decision. ILLUSTRATION In a tabletop replay of a staged trend that crosses the amber trigger at 22:40, the night supervisor reaches the designer at 23:25. The charter allowed 15 minutes to exclusion. Result: the instrument passed and the response failed. Assign an out-of-hours closure authority before any reliance.

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PART 2 · DOSSIER 4 · CHALLENGES AND SHIFT CARD

Movement beside a supported excavation

CHALLENGES

Five challenges, approved before testing

CHALLENGE	SAFE METHOD AND REFERENCE	EXPECTED PROTECTIVE DECISION
A. Normal trend through a construction stage.	Replay of baseline data.	No alert. Inspection continues as planned.
B. Gradual movement after a changed load.	Replay of a staged trend on a training display.	Supervisor excludes the area before the trigger for evacuation.
C. Datum and instrument move together, or distress appears where no instrument is fitted.	Tabletop with photographs of field cracking.	Physical distress is escalated even though the display is normal.
D. Sensor stuck at its last value.	Disconnected instrument in a replay.	Stale reading is shown as stale. Inspection frequency rises until restored.
E. Night supervisor cannot reach the designer.	Out-of-hours call exercise, timed.	The named deputy excludes the area within the agreed time.

RECOMMENDATION Riskopilot design. The technical authority approves the reference, the expected result and the number of runs. Record inconclusive runs and deviations with the passes.

Timing boundary

Design trigger or failed assumption → exclusion in place. Agree the site limit and the uncertainty allowance before collecting data.

Measures

Changes followed by a competent reassessment before entry, of changes observed. Minutes from trigger to exclusion in exercises.

Stop at once if

Any entry after a trigger without reassessment. Any case where field distress was dismissed because the display was normal.

Shift card

RECOMMENDATION The supervisor excludes the area on a trigger or a failed assumption. The designer sets the conditions for re-entry. Where the public is affected, a named person holds closure authority out of hours.

Retest when

New construction stage, changed loading, instrument moved or replaced, datum disturbed.

Keep every existing control active. A separate site decision is needed before anything is relaxed. Forms: pages 38 to 42.

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PART 2 · DOSSIER 5 · ELECTRICAL CONTACT

Plant near overhead power lines

A tipper raises its body near an overhead line on a route that changed last week. The cab has a proximity or height alert.

Exposure and deadline

Exposure begins when plant that can reach the line enters the corridor beneath it. The deadline is before the boom, body or load is raised, since contact or flashover leaves no time for a warning.

Try this first

RECOMMENDATION Have the line diverted or made dead by its owner. Route plant away from the line. Barriers and height-restricted crossing points that plant cannot pass with the body raised.

Function under test

A device on the machine that alerts the operator when it approaches an energised line or exceeds a set height in a defined zone.

Pilot owner: Site manager, with the authorised electrical person.

Envelope to mark

RECOMMENDATION Line voltage and height as confirmed by the owner, sag and weather, machine reach in every configuration, zone boundaries, ground level changes, the routes plant can take. Mark the approaches the device does not cover.

What published evidence supports

FACT UK regulator guidance says the most effective way to prevent contact with overhead lines is not to carry out work where there is a risk of contact or close approach.[20] US construction rules require deactivated circuits to be tagged.[12] INFERENCE We found no independent field evaluation of proximity alert devices for overhead lines.

What the pilot cannot show

INFERENCE A height limiter set for one ground level is wrong at another. A field-sensing device may respond differently by voltage, line geometry and weather. An alert does not establish that a line is dead. Only the owner can confirm that.

Worked decision. ILLUSTRATION On a closed course with a height gauge set at the barrier height, the alert sounds in 30 of 30 approaches with the body raised. On the temporary route added last week, outside the configured zone, it sounds in 0 of 5. Result: pass inside the zone, and a finding about route control. The barrier, not the device, is the control.

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PART 2 · DOSSIER 5 · CHALLENGES AND SHIFT CARD

Plant near overhead power lines

CHALLENGES

Five challenges, approved before testing

CHALLENGE	SAFE METHOD AND REFERENCE	EXPECTED PROTECTIVE DECISION
A. Normal passage under the line through the height-restricted crossing.	Observed routine movement, body down.	No alert. Barrier and goalposts intact.
B. Approach with the body or boom raised.	Closed course away from any line, height gauge as surrogate.	Alert before the gauge on every approach and configuration tested.
C. Approach on a route outside the configured zone.	Closed course, device zone left unchanged.	Operator or banksman stops because the route is not authorised. Silence from the device is recorded as a limit.
D. Device unpowered or sensor obscured.	Bench or yard test with power removed.	Loss is announced in the cab before the machine moves.
E. A new subcontractor's delivery arrives by a different route.	Tabletop with the gate, the site manager and the driver.	Vehicle held at the gate until the route is confirmed.

RECOMMENDATION Riskopilot design. The technical authority approves the reference, the expected result and the number of runs. Record inconclusive runs and deviations with the passes.

Timing boundary

Plant enters the corridor → plant stopped with body or boom lowered. Agree the site limit and the uncertainty allowance before collecting data.

Measures

Raised approaches alerted, of approaches staged, by configuration. Movements through authorised crossing points, of movements under the line.

Stop at once if

Any suggestion that the device permits work nearer the line. Any uncontrolled route found under a line.

Shift card

RECOMMENDATION No one raises a body, boom or load in the corridor. On an alert or an unplanned route, stop and lower. Only the line owner confirms a line is dead. If contact occurs, the site emergency procedure applies.

Retest when

Route or ground level changed, new machine or attachment, line works by the owner, device serviced.

Keep every existing control active. A separate site decision is needed before anything is relaxed. Forms: pages 38 to 42.

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PART 2 · DOSSIER 6 · CRUSHING AND ENTANGLEMENT DURING MAINTENANCE

Energy isolation for conveyor maintenance

A crew holds a correct-looking permit for the wrong drive. Material can still arrive from an upstream feeder. The procedure is now on a tablet.

Exposure and deadline

Exposure begins when a person crosses the work boundary. The decision deadline falls before access, and again whenever custody of the isolation changes hands.

Try this first

RECOMMENDATION Access designed so the task is done from outside the danger zone. Physical restraint and isolation of every source, verified for the task.

Function under test

A digital procedure and isolation manager that shows the crew the assets, isolation points and current revision for the task.

Pilot owner: Maintenance superintendent, with the isolation authority.

Envelope to mark

RECOMMENDATION Every energy source and its boundary for one conveyor task, asset identities, drawing revision, upstream feeders, stored energy, who holds custody, the contractor roster, offline behaviour. Mark any source not in the procedure.

What published evidence supports

FACT The US general-industry standard on hazardous energy sets out isolation and verification steps and excludes construction from its scope.[13] INFERENCE Scanning a label retrieves a record. It leaves the physical state unverified. We found no field comparison of digital and paper isolation procedures with seeded errors.

What the pilot cannot show

INFERENCE An opened document is no assurance of a physical state. A replacement panel can inherit the old label. A procedure cannot list a feeder nobody mapped.

Worked decision. ILLUSTRATION In eight seeded training discrepancies, the paper workflow catches six before access, or 75%, and the digital workflow catches seven, or 88%. The one digital miss is an unlisted feeder. Result: release is blocked for that task although the count improved. Correct the energy map and rerun.

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PART 2 · DOSSIER 6 · CHALLENGES AND SHIFT CARD

Energy isolation for conveyor maintenance

CHALLENGES

Five challenges, approved before testing

CHALLENGE	SAFE METHOD AND REFERENCE	EXPECTED PROTECTIVE DECISION
A. Correct asset and current revision.	Training copy of a real task, observed.	Crew verifies the physical state as usual. No time lost to the tool.
B. Duplicate label points to the adjacent drive.	Seeded error in a training copy, on de-energised equipment.	Mismatch between field asset and record holds access.
C. A feeder is absent from the procedure.	Seeded omission in a training copy.	Crew or isolation authority finds the source in the field walk. The tool alone cannot.
D. Two permits diverge during a network loss.	Tablet offline in a training exercise.	Stale or conflicting version is visible as such. Work held until reconciled.
E. Departing contractor cannot confirm handover.	Tabletop with both shifts.	Incoming authorised person verifies custody and state before accepting.

RECOMMENDATION Riskopilot design. The technical authority approves the reference, the expected result and the number of runs. Record inconclusive runs and deviations with the passes.

Timing boundary

First discrepancy visible → access authorised. Agree the site limit and the uncertainty allowance before collecting data.

Measures

Seeded discrepancies caught before access, of discrepancies seeded, by workflow. Independent observations that found a deviation before exposure.

Stop at once if

Any access granted on a record without physical verification. Any shared login used to release.

Shift card

RECOMMENDATION Any disagreement between field asset, diagram and custody record holds access. The isolation authority controls correction. Incoming workers verify custody and state themselves.

Retest when

Asset replaced or relabelled, drawing revised, software updated, new contractor.

Keep every existing control active. A separate site decision is needed before anything is relaxed. Forms: pages 38 to 42.

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PART 2 · DOSSIER 7 · HAZARDOUS ATMOSPHERE IN A CONFINED SPACE

Atmosphere in a confined space

The atmosphere changes, or the sensor cannot measure the gas that is present, or the remote screen stops updating. A green last reading sits on the dashboard while an entrant is inside.

Exposure and deadline

The entrant is exposed for the whole entry. The decision deadline is withdrawal on a local alarm or on loss of required monitoring, before a second person goes in to help.

Try this first

RECOMMENDATION Inspect or clean from outside, or by remote device, so nobody enters.

Function under test

Connected portable gas detectors that share the local alarm with the attendant and a remote screen.

Pilot owner: Entry supervisor.

Envelope to mark

RECOMMENDATION The gases actually possible, the sensors fitted, where the instrument will be relative to the entrant, the communication path, battery and bump-test status, the rescue arrangement. Mark what the sensor cannot detect.

What published evidence supports

FACT US construction rules set out what a permit space program must contain.[14] FACT At La Porte in 2014, four workers died after a toxic release in a building. Two had entered in response to a co-worker's distress call.[16] At DeRidder the atmosphere was tested in the wrong place.[15]

What the pilot cannot show

INFERENCE A successful bump test shows the sensor and alarm respond. It does not show the right gas was selected or that the sample represents where the entrant is. Remote data can inform a manager without warning the person inside.

Worked decision. ILLUSTRATION In 20 staged local alarms using test gas at the attendant's station, the attendant is alerted in 20. In 5 trials with the link dropped, the remote screen shows the last normal value with no stale flag in 5. Result: local alarm passes within its limit. Remote display fails challenge D and is withdrawn from any use until it shows stale data as stale.

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PART 2 · DOSSIER 7 · CHALLENGES AND SHIFT CARD

Atmosphere in a confined space

CHALLENGES

Five challenges, approved before testing

CHALLENGE	SAFE METHOD AND REFERENCE	EXPECTED PROTECTIVE DECISION
A. Correct instrument prepared and bump-tested.	Pre-entry check at the entry point, no entry.	Entry conditions verified by the supervisor as usual.
B. Local alarm while the dashboard shows normal.	Test gas applied outside the space.	Attendant orders withdrawal on the local alarm. The dashboard does not delay it.
C. Target gas outside the sensor's capability.	Tabletop against the hazard assessment.	Supervisor identifies the gap and withholds the permit.
D. Network drops and the remote display freezes.	Link disconnected, no entry.	Stale data shown as stale. Local monitoring and attendant carry the entry.
E. A second worker moves to enter after a simulated collapse.	Rescue drill with no entry to a real space.	Attendant holds the boundary and calls trained rescue.

RECOMMENDATION Riskopilot design. The technical authority approves the reference, the expected result and the number of runs. Record inconclusive runs and deviations with the passes.

Timing boundary

Local alarm or loss of required monitoring → entrant out and accounted for. Agree the site limit and the uncertainty allowance before collecting data.

Measures

Entries with every precondition verified at the entry point, of entries sampled. Staged alarms reaching the attendant. Seconds of unflagged stale data.

Stop at once if

Any stale reading displayed as live. Any drill in which an untrained person enters.

Shift card

RECOMMENDATION On alarm or loss of monitoring, the entrant withdraws and the attendant controls the boundary and summons trained rescue. Re-entry needs fresh authorisation.

Retest when

Different space or contents, new sensor type, changed communication path, firmware update.

Keep every existing control active. A separate site decision is needed before anything is relaxed. Forms: pages 38 to 42.

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PART 2 · DOSSIER 8 · FIRE, EXPLOSION AND HAZARDOUS RELEASE

Heating at a conveyor return station

At a return station an idler degrades under varying load. Sound, vibration or local heat may change. Surface heat may become visible only late in the fault.

Exposure and deadline

The exposure is fire at the conveyor and people sent to look at a running machine. The decision deadline is a planned stop and isolation before the fault escalates, and before anyone is tempted into a hands-on check.

Try this first

RECOMMENDATION Enclosure, housekeeping and belt selection that remove fuel. Planned replacement by condition from routine inspection.

Function under test

A fixed thermal view or contact sensors that flag a persistent local rise and alert the control room.

Pilot owner: Area operations lead, with maintenance.

Envelope to mark

RECOMMENDATION Station, components in view, baseline by operating mode and throughput, dust and spillage, nearby hot material, sightlines, who receives the alert. Mark components the view cannot see.

What published evidence supports

FACT UK regulator guidance on process safety indicators pairs leading evidence that controls are in place with lagging evidence that they failed.[27] INFERENCE A thermal camera measures apparent surface radiation. A contact sensor and a thermal pixel can be looking at different surfaces. We did not verify published lead times for idler faults and make no claim about them.

What the pilot cannot show

INFERENCE A surface reading does not see heating inside a housing. Dust on the lens lowers the reading. A normal image at start-up is not a baseline for full load.

Worked decision. ILLUSTRATION Against 12 heat-source fixtures placed during planned stops, the view flags 12 at clean lens. After one week without cleaning it flags 7 of 12. Result: pass only with a cleaning interval the site can keep. Without a named owner for cleaning, withdraw.

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PART 2 · DOSSIER 8 · CHALLENGES AND SHIFT CARD

Heating at a conveyor return station

CHALLENGES

Five challenges, approved before testing

CHALLENGE	SAFE METHOD AND REFERENCE	EXPECTED PROTECTIVE DECISION
A. Ordinary start-up heating.	Observed start-up against baseline.	No alert, or an alert the operator correctly classifies.
B. Persistent local rise.	Approved heat-source fixture placed during a planned stop, area clear.	Alert reaches the control room. Maintenance plans a stop.
C. Dust obscures the view at peak output, or hot material passes behind.	Lens partly covered in a planned stop. Replay with background source.	Degraded view is announced. Inspection frequency rises.
D. Reading disagrees with the walkdown.	Second instrument of a different type, from a safe position.	Disagreement is logged and resolved by maintenance. Neither reading is dismissed.
E. Night operator receives an alert and nobody answers.	Call exercise, timed.	Escalation reaches someone with authority to stop the belt.

RECOMMENDATION Riskopilot design. The technical authority approves the reference, the expected result and the number of runs. Record inconclusive runs and deviations with the passes.

Timing boundary

First reliable fault indication → planned intervention under isolation. Agree the site limit and the uncertainty allowance before collecting data.

Measures

Fixtures flagged, of fixtures placed, by lens condition. Alerts acknowledged with a recorded action. Hands-on checks of running components: target zero.

Stop at once if

Any hands-on inspection of a running component prompted by an alert. Any unannounced loss of view.

Shift card

RECOMMENDATION The operator records asset, trend and operating state. Maintenance verifies from a safe position. Intervention follows the shutdown and isolation procedure. Nobody touches operating components.

Retest when

Lens cleaned or moved, throughput changed, component type changed, new material.

Keep every existing control active. A separate site decision is needed before anything is relaxed. Forms: pages 38 to 42.

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PART 3

Five further candidates

Hazards outside the eight dossiers where a technology function is often proposed. Each page gives the exposure, the control to try first, the function, three challenges that matter most and the limit of what a pilot could show.

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PART 3 · CANDIDATE 1 · CRUSHING AND ENTANGLEMENT

Safeguarding status after a machine changeover

After a changeover, guard position, locking state or the protective circuit is unresolved. A supervisory screen says production can resume.

Exposure and deadline

A setter or operator is exposed when hazardous movement is enabled with a safeguard unresolved. The deadline is before the enable request.

Try this first

RECOMMENDATION Machine design and guarding that make the changeover possible without access to the danger zone. The safeguarding function as designed and validated by engineering.

Function proposed

A supervisory summary of guard and interlock status, shown to operations and maintenance.

INFERENCE It is popular because it puts many machines on one screen. The risk is that a summary becomes the release.

What published evidence supports

FACT The US general-industry standard on hazardous energy applies to servicing and maintenance and excludes construction.[13]

INFERENCE We cite no source on supervisory safeguarding displays and found no field evaluation.

What a pilot cannot show

INFERENCE A closed gate, a reset acknowledgement and an authorised restart are three different states. A summary screen does not certify the installed safety function. Only the approved validation does.

Measure

Enable requests made with an unresolved safeguard condition, of changeovers observed. Target: none.

CHALLENGES

The three that matter most

CHALLENGE	SAFE METHOD	EXPECTED PROTECTIVE DECISION
Guard-position and locking indications conflict.	Simulated on a training panel.	Setter withholds start. Engineering resolves it.
Supervisory summary stale after a communication loss.	Link disconnected on a stopped machine.	Stale status shown as stale. Local diagnostics govern.
Shift change during an unresolved fault.	Tabletop with both shifts.	Fault and its owner are handed over by name. No restart on the summary.

Shift card. RECOMMENDATION The setter withholds start on any unresolved safeguard fault. Engineering verifies restoration by the approved process. Operations accounts for people and communicates the release.

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PART 3 · CANDIDATE 2 · FIRE, EXPLOSION AND HAZARDOUS RELEASE

Self-heating in stored combustible material

A region inside a stockpile warms. Surface patterns may persist or spread before smoke is visible. A deep-seated process can stay hidden from surface instruments.

Exposure and deadline

The exposure is a fire that grows unseen, and crews sent to probe a pile. The deadline is the response set out in the site fire strategy for that material.

Try this first

RECOMMENDATION Stock rotation, segregation and limits on pile size agreed with the fire engineer. Fire rounds by trained people.

Function proposed

Fixed thermal coverage of pile faces, with an alert to the control room naming the bay.

INFERENCE Thermal cameras are widely offered for stockpiles. The open question is which heating mechanisms a surface view can catch.

What published evidence supports

INFERENCE We cite no source for detection performance on stockpiles. Treat any lead-time claim as untested until your fire engineer has reviewed it for your material.

What a pilot cannot show

INFERENCE A thermal camera measures apparent surface radiation. Sun, changing material or an obscured seat of heating confuse it. Evidence from one material transfers poorly to another.

Measure

Persistent surface regions flagged and confirmed by fire round, of regions flagged. Bays with faces outside the view.

CHALLENGES

The three that matter most

CHALLENGE	SAFE METHOD	EXPECTED PROTECTIVE DECISION
Warm delivered material in the expected receiving area.	Observed deliveries against baseline.	Operator classifies correctly. No false escalation.
Deep internal heating with a normal surface.	Tabletop with the fire engineer, using the material's known behaviour.	The team records that the function cannot see it and keeps the fire rounds.
Night dispatcher receives an ambiguous bay identity.	Call exercise, timed.	Duty lead confirms the bay before any crew moves.

Shift card. RECOMMENDATION The control room identifies the bay and alerts the duty lead under the fire plan. Crews use approved standoff. Nobody probes or disturbs a pile on the strength of an image.

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PART 3 · CANDIDATE 3 · STRUCK BY, HAND AND ARM INJURY

Tool rotation when a drill bit binds

During concrete drilling a bit binds and the tool body rotates. Some tools carry a function that cuts drive when sudden rotation is sensed.

Exposure and deadline

The operator is exposed in the instant the bit binds. Detection and response must happen in the tool. No remote signal can help in time.

Try this first

RECOMMENDATION Drilling method, bit selection and setup that reduce binding. Rigs or stands that take the reaction for larger diameters.

Function proposed

An in-tool function that senses sudden rotation of the tool body and cuts drive.

INFERENCE It is an engineering function, closer to intervention than to warning. The pilot question is narrow: is the right tool issued, is the function available, and what happens after it trips.

What published evidence supports

INFERENCE We cite no independent evaluation. The function is described in manufacturers' instructions, which we do not use as evidence of field performance.

What a pilot cannot show

INFERENCE A site cannot safely provoke binding to test the function, and should not try. The pilot assesses selection, availability, understanding and what follows a trip. It gives no ground for saying kickback is eliminated.

Measure

Tools issued with the specified function, of tools issued for the task. Trips reported and reviewed, of trips reported.

CHALLENGES

The three that matter most

CHALLENGE	SAFE METHOD	EXPECTED PROTECTIVE DECISION
A look-alike hire tool without the function is issued.	Stores exercise with real stock.	Issue is refused or flagged. The crew knows how to tell the variants apart.
A trip is reported during a representative task.	Review of the report with the operator. No attempt to provoke a trip.	Work stops, the setup is reviewed, the tool is checked.
Repeated trips and pressure to finish.	Tabletop with the supervisor.	Supervisor reviews method and tool before reuse.

Shift card. RECOMMENDATION After an abnormal event the driller stops, secures the tool and reports. Suspected defects go to authorised service. Nobody disables a protective function to create a comparison.

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PART 3 · CANDIDATE 4 · STRUCK BY PRESSURISED EQUIPMENT

Hose whip during concrete pumping

Delivery stops without warning. Air in the line or a blockage can make the end hose move violently. An upstream pressure signal may arrive too late or say nothing about the discharge end.

Exposure and deadline

The line hand at the end hose and anyone nearby. The deadline is before restart, and before a line is cleared with compressed air.

Try this first

RECOMMENDATION The approved pumping method, a secured hose, an exclusion zone at the discharge end, a pumpable mix and a slow, coordinated restart.

Function proposed

Pump telemetry offered as an early indicator of conditions that precede hose whip.

INFERENCE Telemetry already exists on many pumps. Whether any signal reliably precedes hose whip at the discharge end is an open question, and the pilot should treat it as one.

What published evidence supports

FACT Queensland's regulator reported in 2011 that a worker was fatally injured after being knocked over by a whipping hose at the end of a mobile concrete placing boom.[21] In 2025 it issued an alert on hose whip when compressed air is used to clean hoses on piling rigs.[22]

What a pilot cannot show

INFERENCE Hose whip cannot be staged safely. The pilot is a reconstruction exercise. It can show whether a signal existed before past events on your equipment. It cannot validate a predictor.

Measure

Past events with a distinguishable signal before the latest safe action, of events reconstructed.

CHALLENGES

The three that matter most

CHALLENGE	SAFE METHOD	EXPECTED PROTECTIVE DECISION
Routine pressure transient at the pump.	Review of recorded pump data.	No alert. Operator recognises it as normal.
A downstream event with a delayed or absent upstream signal.	Reconstruction of past events from records. No staging.	The team records whether any signal came first. Absence is a finding.
Restart requested from one end only.	Radio exercise with pump operator and placing crew.	No restart until both ends confirm and the hose area is controlled.

Shift card. RECOMMENDATION On abnormal flow, operators follow the site and manufacturer procedure and coordinate with the placing crew. No restart while the hose area is uncontrolled. Local controls protect the hose area whatever the signal says.

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PART 3 · CANDIDATE 5 · STRUCK BY FALLING OBJECT

Attachment retention on a quick coupler

A changed bucket looks engaged. A cab light or a hydraulic command may be reporting a condition upstream of the mechanical lock.

Exposure and deadline

Anyone within the drop and swing envelope. The deadline is before the attachment is lifted or put to work.

Try this first

RECOMMENDATION Fewer attachment changes. A controlled change area. Compatible coupler and attachment pairs, and the manufacturer's verification method followed every time.

Function proposed

A supplementary indication, in the cab or on the coupler, that the attachment is retained.

INFERENCE Indicators are attractive because the physical check takes time. The risk is that the light replaces the check.

What published evidence supports

FACT A US regulator bulletin of 2005 counted 15 incidents since January 1998 in which excavator buckets released unexpectedly from quick couplers. Eight were fatal. It found that in most cases the couplers had not been properly engaged and locked.[23] INFERENCE Old data, from one country. It establishes the hazard, not current rates.

What a pilot cannot show

INFERENCE An indication does not prove mechanical engagement unless the manufacturer says it does for that exact pair. Nobody enters the drop zone to look.

Measure

Changes followed by the manufacturer's verification, of changes observed. Changes made with people inside the envelope: target zero.

CHALLENGES

The three that matter most

CHALLENGE	SAFE METHOD	EXPECTED PROTECTIVE DECISION
Cab indication present with retention uncertain.	Demonstration by the competent fleet person, attachment grounded, area clear.	Operator performs the manufacturer's check and holds release until it passes.
Substitute attachment with no compatibility record.	Stores and yard exercise.	Use refused until compatibility is confirmed.
Supervisor presses for release after a shift change.	Tabletop with both shifts.	Operator holds. The check is repeated by the incoming operator.

Shift card. RECOMMENDATION The operator holds release whenever retention is uncertain. The exclusion area stays controlled. Wear, ambiguity or incompatibility goes to the competent fleet authority.

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PART 4

Forms to complete

Five blank pages to print or fill in on screen: the charter, the configuration sheet, the evidence log, the shift card with its acceptance record, and the decision paper.

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PART 4 · FORM 1

Pilot charter

Complete and sign before the first run. Any later change is logged with a date and a reason. A changed pass rule restarts the count.

Site, area and task	
1. Exposure Fatal risk, who is exposed, the moment exposure begins	
2. Comparator Best conventional control and its cost over the same period	
3. Protective action Recipient, action, deadline, on every shift	
4. Envelope Equipment, revision, mounting, layout, light, weather, shifts. What is excluded	
5. Reference How the true state is established. Who adjudicates	
6. Pass rule Runs per challenge and the result that passes	
6. Fail and stop rules The result that fails. What halts the pilot at once	
7. Data and people Data, purpose, access, retention, consultation	
Start date and decision date	

Sponsor	Technical authority	Pilot lead	Worker representative
Name, signature, date	Name, signature, date	Name, signature, date	Name, signature, date

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PART 4 · FORM 2

Configuration sheet

One sheet per installation. Attach the marked drawing. Freeze before testing.

Decision path

1. Physical condition sensed	
2. Measuring or verification point	
3. Interpretation and recipient	
4. Protective action and authority	

Coverage and boundaries

Drawing reference and revision	
Areas, approaches or sources not covered Mark them on the drawing	
Common dependency Power, network, shared sensor or data source	
Independent fallback and shift owner	

Freeze before testing

Equipment identity	
Model, software or firmware revision, mode	
Mounting position, height and angle	
Response limit or decision deadline	
Uncertainty allowance	
Retest triggers	

Technical authority

Name, signature, date

Pilot lead

Name, signature, date

Do not transfer a pass. A new asset, layout, shift arrangement or software revision may change the protected decision. State what must be repeated.

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PART 4 · FORM 3

Evidence log

One row per run. Record inconclusive runs and deviations with the passes. An unknown is never counted as a pass. Copy the page as needed.

RUN	DATE, SHIFT	CHALLENGE A TO E	CONDITIONS	REFERENCE SAYS	SYSTEM SAYS	TIME TO SAFE STATE	RESULT

Result codes: T correct and in time. L correct and late. M missed. U unknown, reference failed. X interrupted.

Totals	T _____ L _____ M _____ U _____ X _____ of _____ runs
Independent observer	

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PART 4 · FORM 4

Shift card and acceptance record

Shift card

Post at the workface for the duration of the pilot.

This pilot tests	
It does not replace The existing control, named	
If it alerts Who does what	
If it is silent, frozen or faulty Who does what	
Who can stop the work Name and deputy, this shift	
Who can restart Name and deputy	
Report problems to	

Acceptance record

Complete before any acceptance.

Site, work area, asset	
Approved configuration Model, revision, mode, drawing	
Independent reference	
Jobs and shifts covered	
Evidence log reference	
Missed or late events, unknowns	
Failed test, restriction, retest	
Worker feedback	

Decision options: adopt within documented limits, extend testing, redesign, withdraw. Keep the original controls active until a separate site decision authorises any change.

Technical verifier	Control owner	Restart authority
Name, signature, date	Name, signature, date	Name, signature, date

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PART 4 · FORM 5

Decision paper

One page for the sponsor. Attach the charter, the configuration sheet and the evidence log.

Function, exposure and setting	
Decision Adopt within limits, extend, redesign or withdraw	
Results by challenge A to E: runs, in time, late, missed, unknown	
Two denominators Alerts of all tasks. Alerts needing action of all alerts	
What the clean runs allow us to say Upper limit on the miss rate, from page 11	
Conditions not tested Shifts, weather, equipment, contractors	
Comparator result and cost Conventional option on the same boundary	
Limits of any acceptance Envelope, advisory status, expiry date	
Retest triggers	
Fallback demonstrated Night shift and contractors	
Worker consultation outcome	
Owner after the pilot	

Sponsor	Technical authority	Worker representative
Name, signature, date	Name, signature, date	Name, signature, date

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LIMITS

What would change this manual

The method follows from the evidence available in November 2026 and from how small trials behave. These are the findings that would move it.

IF THIS APPEARED	WE WOULD CHANGE
A published field evaluation of any function in Parts 2 and 3, with an independent reference, denominators and missed and late events reported.	Cite it in the dossier, and shorten the challenges it already covers for comparable sites.
Evidence that staged trials with surrogates predict performance in real work for a given function.	Give more weight to challenge B and less to shadow observation for that function.
Evidence that they do not.	Require shadow observation of real work before any acceptance.
A regulator or standards body publishing acceptance criteria for an advisory safety function.	Replace our proposed pass rules with theirs for that function.
Independent outcome data from sites where machine intervention is mandated.	Add a dossier for intervention, which this manual leaves to manufacturers and competent engineering.
A pilot run to this method whose owner is willing to publish it.	Add it as a worked case, with what went wrong.

The strongest case against this manual

"No supplier can afford 299 trials." The number follows from the claim. Claim less and you need fewer. A pilot that supports "probably below one in ten, advisory use only" is honest and affordable.

"Staged trials with surrogates are theatre." Partly true. They set an upper bound, which is why the method adds shadow observation of real work and counts unknowns.

"The pilot is itself the delay. Fund the barrier." Often right. Page 7 says when not to pilot, and every dossier starts with the control to try first.

Limits of this manual

INFERENCE The dossiers are designs. None has been run by Riskopilot. The challenge types, the roles and the pass rules are our proposals, informed by the regulator texts and investigations cited.

Most published studies come from construction and surface mining in the United States and the United Kingdom. In other sectors and countries each dossier is a starting point to adapt.

Critical controls here are meant as in the Riskopilot critical control health method.[24]

Legal and technical scope

RECOMMENDATION Rules differ by jurisdiction and sector. Establish the governing law, the consultation duties and the data protection basis before adapting any form here.

Nothing in this manual is engineering, legal or regulatory advice. Acceptance criteria for actual work are set by the site's technical authority under local law and approved procedures. Manufacturer instructions govern the equipment.

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SOURCES

Source register

Sources 1 to 18, 26 and 27 were opened and checked for *Time to act* on 19 November 2026. Sources 19 to 23 were checked for this manual on the same day. The right-hand column states what we read and any limit on it. Manufacturer documents are not cited. They describe what a product is meant to do, not how it performs on a site.

NO.	SOURCE	TYPE, ACCESS AND LIMITS
1	Ruff, T. (2006). Evaluation of a radar-based proximity warning system for off-highway dump trucks. *Accident Analysis & Prevention* 38(1), 92 to 98. doi:10.1016/j.aap.2005.07.006. https://stacks.cdc.gov/view/cdc/221128/cdc_221128_DS1.pdf	Primary field study. One truck, one mine, seven days. Full text read.
2	Trask, C. and Linderoth, H. (2023). Digital technologies in construction: a systematic mapping review of evidence for improved occupational health and safety. *Journal of Building Engineering* 80, 108082. https://www.sciencedirect.com/science/article/pii/S2352710223022623	Peer-reviewed mapping review. Abstract read. Counts confirmed in a second listing.
3	van der Molen, H. et al. (2018). Interventions to prevent injuries in construction workers. *Cochrane Database of Systematic Reviews*, CD006251.pub4. https://doi.org/10.1002/14651858.CD006251.pub4	Systematic review, search to April 2017. Cochrane summary read. Data older than three years.
4	Fugate, H. and Alzraiee, H. (2023). Quantitative analysis of construction labor acceptance of wearable sensing devices to enhance workers' safety. *Results in Engineering* 17, 100841. https://www.sciencedirect.com/science/article/pii/S2590123022005114	Peer-reviewed survey, United States. Single source. Sample size not visible to us.
5	UK Health and Safety Executive. Alarm management. Human factors topic guidance. https://www.hse.gov.uk/humanfactors/topics/alarm-management.htm	Regulator guidance. Read on 19 November 2026.
6	European Agency for Safety and Health at Work (2024). Principles for implementation and use: smart digital systems to improve workers' safety and health. https://healthy-workplaces.osha.europa.eu/sites/hwc/files/hwc/publication/Principles-implementation-use-smart-digital-systems_EN.pdf	EU agency guidance. Read.
7	UK Health and Safety Executive. Fragile surfaces. Construction safety topic guidance. https://www.hse.gov.uk/construction/safetytopics/fragile.htm	Regulator guidance. Read.
8	UK Health and Safety Executive. Traffic management on site. Construction safety topic guidance. https://www.hse.gov.uk/construction/safetytopics/vehiclestrafficmanagement.htm	Regulator guidance. Read.
9	UK Health and Safety Executive. Temporary works. Construction safety topic guidance. https://www.hse.gov.uk/construction/safetytopics/temporary-works.htm	Regulator guidance. Read.
10	UK Health and Safety Executive. Lifting operations. Construction safety topic guidance. https://www.hse.gov.uk/Construction/safetytopics/lifting-operations.htm	Regulator guidance. Read.
11	US Occupational Safety and Health Administration. 29 CFR 1926.651, Specific excavation requirements. https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.651	US regulation. Read.
12	US Occupational Safety and Health Administration. 29 CFR 1926.417, Lockout and tagging of circuits. https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.417	US regulation. Read.
13	US Occupational Safety and Health Administration. 29 CFR 1910.147, The control of hazardous energy (lockout/tagout). https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.147	US regulation. Read.

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SOURCES

NO.	SOURCE	TYPE, ACCESS AND LIMITS
14	US Occupational Safety and Health Administration. 29 CFR 1926.1204, Permit-required confined space program. https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.1204	US regulation. Read.
15	US Chemical Safety and Hazard Investigation Board (2018). Packaging Corporation of America hot work explosion, DeRidder, Louisiana. Report 2017–03–I-LA. https://www.csb.gov/packaging-corporation-of-america-hot-work-explosion-/	Official investigation. CSB summary and news release read.
16	US Chemical Safety and Hazard Investigation Board (2019). DuPont La Porte facility toxic chemical release. https://www.csb.gov/dupont-la-porte-facility-toxic-chemical-release-/	Official investigation. CSB summary read. Detail on responders confirmed in two trade reports.
17	US National Transportation Safety Board (2019). Pedestrian bridge collapse over SW 8th Street, Miami, Florida, March 15, 2018. Report NTSB/HAR-19/02. https://www.ntsb.gov/investigations/AccidentReports/Reports/HAR1902.pdf	Official investigation. Read.
18	California Fatality Assessment and Control Evaluation Program (2000). A construction flag person dies after being backed over by a truck. FACE report 00CA006. https://stacks.cdc.gov/view/cdc/168956/cdc_168956_DS1.pdf	Official investigation. Read.
19	Hanley, J. and Lippman-Hand, A. (1983). If nothing goes wrong, is everything all right? Interpreting zero numerators. *JAMA* 249(13), 1743 to 1745. doi:10.1001/jama.1983.03330370053031. https://doi.org/10.1001/jama.1983.03330370053031	Peer-reviewed. Abstract read. The rule is confirmed in a later JAMA letter and a BMJ note. The exact figures in this manual are our own calculation.
20	UK Health and Safety Executive (2013). Avoiding danger from overhead power lines. Guidance Note GS6, fourth edition. https://www.hse.gov.uk/pubns/gs6.htm	Regulator guidance. Publication page and text extracts read on 19 November 2026.
21	Workplace Health and Safety Queensland (2011). Hose whip on concrete pumps. Safety alert, 16 March 2011. https://worksafe.qld.gov.au/news-and-events/alerts/workplace-health-and-safety-alerts/2011/hose-whip-on-concrete-pumps	Regulator alert. Extract read on 19 November 2026. Single source for the fatality described.
22	Workplace Health and Safety Queensland (2025). Piling rig concrete pumping hose whip fatality. Safety alert, 1 August 2025. https://www.worksafe.qld.gov.au/news-and-events/alerts/workplace-health-and-safety-alerts/2025/piling-rig-concrete-pumping-hose-whip-fatality	Regulator alert. Extract read on 19 November 2026.
23	US Occupational Safety and Health Administration (2005). Hazards of inadequately securing hydraulic excavator buckets when using quick coupling devices. Safety and Health Information Bulletin SHIB 07–22–2005. https://www.osha.gov/sites/default/files/publications/shib072205a.pdf	Regulator bulletin, advisory. Extracts read. Incident and fatality counts confirmed in the 2004 bulletin and two trade reports. Data older than three years.
24	Hounkpati, B. (2026). Critical control health (CCHI): methodology proposal, and The CCHI rollout playbook. Riskopilot. https://riskopilot.com/riskolabs	Riskopilot's own method.
25	Hounkpati, B. (2026). Time to act: what technology can and cannot add to critical controls. Riskopilot Research, critical controls series. https://riskopilot.com/riskolabs/time-to-act	Riskopilot's own report. The five gates and the four levels of proof are set out there.
26	Li, L., Huang, Z., Wang, J., Du, B. and Dai, L. (2026). Automated construction monitoring based on computer vision: a comprehensive review. *Developments in the Built Environment* 25, 100832. https://www.sciencedirect.com/science/article/pii/S2666165925002327	Peer-reviewed review. Abstract, highlights and introduction read. Single source.
27	UK Health and Safety Executive (2006). Developing process safety indicators: a step-by-step guide for chemical and major hazard industries. HSG254. https://www.hse.gov.uk/pubns/priced/hsg254.pdf	Regulator guidance. Read.

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VERIFICATION, AUTHOR AND LICENCE

Verification note

Confirmed in two independent sources

- Mapping review counts: 392 records, 24 included (source 2).
- Cochrane review: very low quality evidence (source 3).
- DeRidder: three deaths, test location (source 15).
- La Porte: four deaths, responders (source 16).
- Florida bridge: five parties, road left open (source 17).
- Quick couplers: 15 incidents since January 1998, eight fatal (source 23, the 2004 bulletin and two trade reports).
- The rule of three (source 19, a later JAMA letter and a BMJ note).

Resting on a single source

- All radar field-study figures (source 1). The paper was read in full.
- The 59% wearables figure (source 4).
- The computer-vision review (source 26), read at abstract level.
- Regulator guidance and regulations (sources 5 to 14, 20, 27), each read at the official page.
- The Queensland hose whip alerts (sources 21 and 22), read as extracts of the official pages.

Could not be verified, and handled accordingly

- Detection lead times for conveyor idler faults and for self-heating in stockpiles. No figure is given.
- Field performance of any named product. None is named.
- Any published pilot run to this method. We know of none.

Calculations

The trial numbers in Exhibit 3, the zero-miss limits, the percentages and every worked example were recomputed when this document was built. Worked examples are invented.

About the author

Bruno Hounkpati is a CEO and former VP HSE. He is the author of the Riskopilot critical control health method (CCHI) and its rollout playbook.

About Riskopilot

Riskopilot helps organisations in high-hazard industries investigate incidents and verify the controls that prevent fatal ones. Riskolabs is where its methods are published and tested in the open.

How to cite

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Important

This manual is general information. It is not engineering, legal or regulatory advice. Never create a real hazard to test a system. Acceptance criteria for actual work are set by the site's technical authority under local law and approved procedures. Worked numbers marked as illustrations are invented.

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RISKOPILOT

“A pilot that could not have failed has told you nothing.”

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