SMS SHORTFALL ANALYSIS

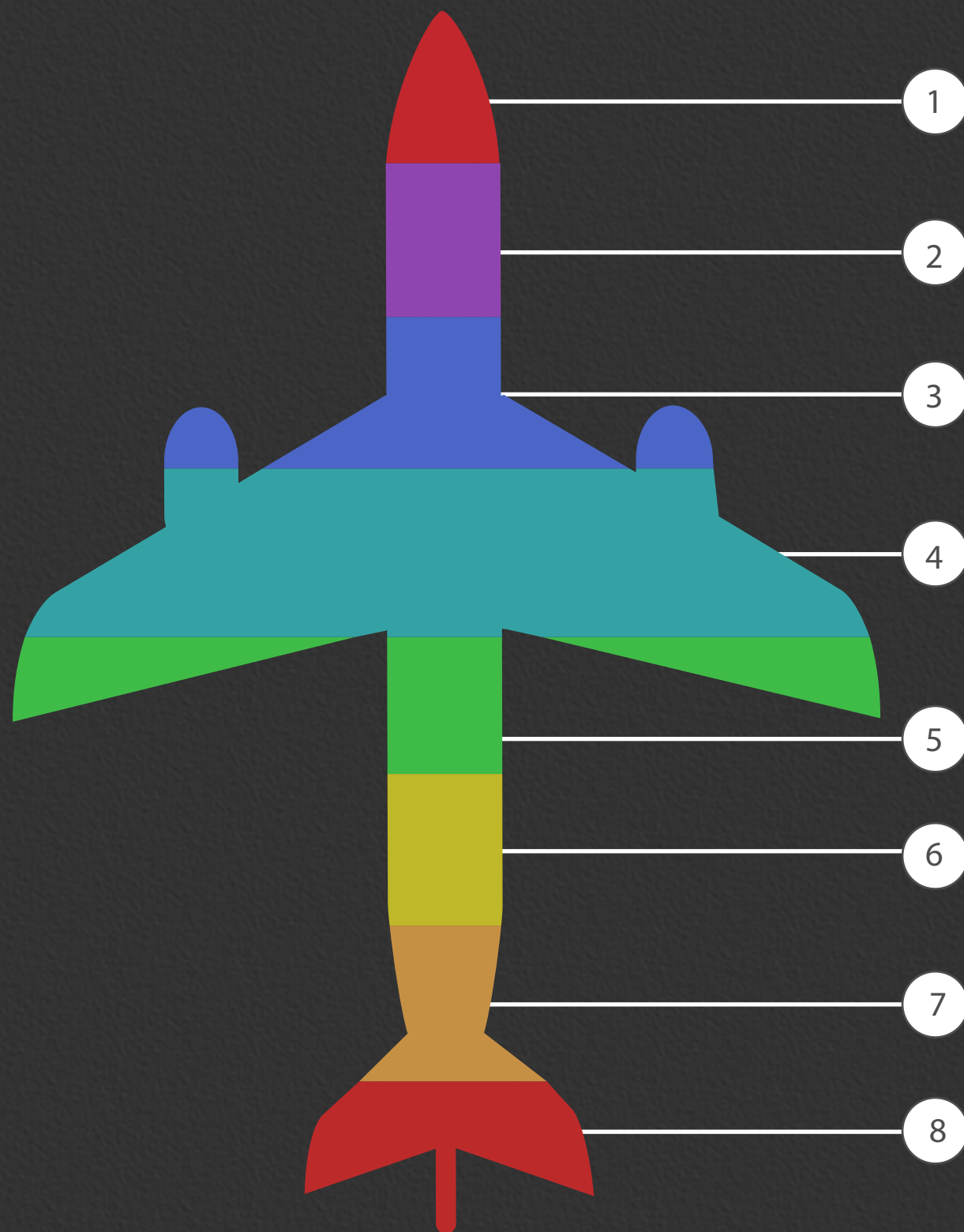## HOW TO UNDERSTAND SMS FAILURES IN SAFETY INCIDENTS

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A NEW RISK MANAGEMENT METHOD

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Purpose and Goals of SMS Shortfall Analysis

There are many risk management tools dedicated to different elements of a safety incident:

- Root cause analysis (fishbone diagrams)
- Behavioral analysis (decision trees)
- Incident flow analysis (bowtie analysis)
- Exposure summary (risk matrix).

The benefit of these approaches is that they present critical safety data as a visual cue. Moreover, they cover many elements of risk that paint a comprehensive picture of "what happened."

However, the question that the above risk management tools either only suggest (bowtie), only partially address (decision trees), or don't address at all (risk matrix), is:

> **Where specifically did the SMS program fail?**

Additionally, while some risk tools analyze how the safety event deteriorated, there are no risk management analysis frameworks dedicated to analyzing SMS program failures.

Proactive and reactive risk management all serve equally valuable safety functions depending on the situation. What SMS programs need is an efficient (i.e., quick and easy) and flexible method of ascertaining:

- How did a safety situation go from a risky situation (see Risk Event below) that was mitigatable, to having adverse consequences?
- Where specifically did major failures in the SMS program occur?
- Where did risk controls fail?

Understanding where the SMS program failed will allow safety management to be more proactive, and better prepared to react.

Hence the newly developed technique called SMS Shortfall Analysis, which is dedicated to answering the above questions. This technique is designed to:

Establish the point at which a risky situation arose - called a Risk Event (click to learn more about Risk Events)

Assess the event timeline that leads from Risk Event to consequences

Analyze risk mangement *after* the Risk Event occurs (though it can be used for events before Risk Event - see last section)

Evaluate the specific failures of the SMS in terms of:

| **Human Action**	**SMS Document.**	**Risk Controls**
human attitude	policies	tools
decisions	procedures	training
interactions	responsibilities	software
other behavior	other docs for safe conduct	environmental variables

Certain models of risk management begin to approach these goals, such as bowtie analysis, but they are time consuming, abstruse, and only point to failures rather than explicitly stating them. SMS Shortfall Analysis addresses these problems by creating a table and diagram that are at once explicit and informative enough to make decisions upon, but simple enough to quickly create.

Shortfall Table

Shortfall Graph
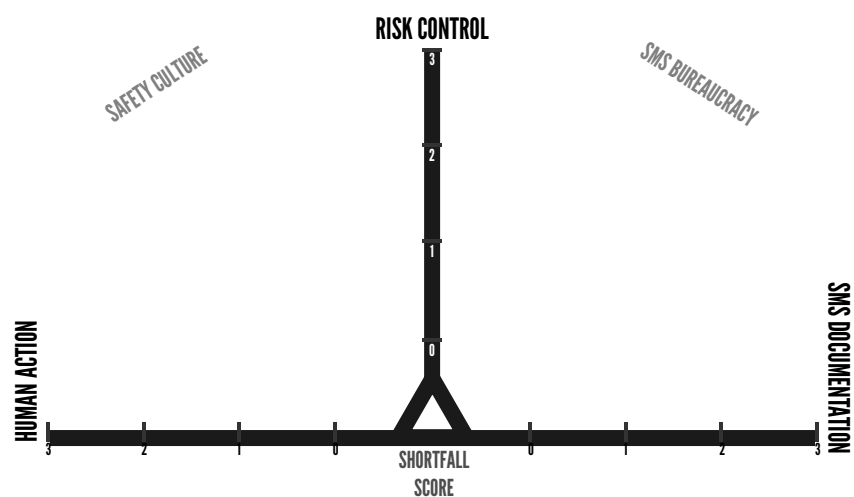
The table to the left will show the timeline of events and explicitly states where shortfalls in the SMS program occurred. The diagram to the right charts this information, summarize the failure, and ranks the severity of failure (similar to how Risk Matrix ranks exposure).

In a way, SMS Shortfall Analysis acts as a counterpart to fishbone diagrams, which only look at safety incidents before Risk Events and analyze the broad spectrum of generally what went wrong. SMS Shortfall Analysis is concerned with establishing the major failures of the SMS program.

It should also be noted that SMS Shortfall Analysis should mostly be used on mitigatable or unacceptable issues that involve negative consequences.

Elements of Shortfall Analysis

Fortunately, the elements needed to conduct SMS Shortfall Analysis are fairly straightforward. There are three elements that SMS Shortfall Analysis considers, and in this order:

1. The Risk Event (and final consequences);
2. Event flow; and
3. SMS failures (risk control, SMS documentation, human action).

1 – Risk Event

Risk Events are an emerging idea in the risk management field. Those of you who are familiar with Top Events in bowtie analysis will already be largely familiar with what a Risk Event is, as they are extremely similar. We highly advocate using Risk Events.

How to Identify the Risk Event

- Single point at which safety control is compromised and required immediate action
- "Single point" is always an action (this differs from Top Event)
- Establishes line between proactive and reactive risk management strategies
- Point AT which a risk(s) "expresses" its danger potential
- Point FROM which negative impacts and consequences arise

Risk Events are incredibly useful waypoints in safety incidents. The important timeline points in real-world safety incidents are usually muddled and unclear which makes it difficult to establish where specific failures occurred. Risk Events make this process significantly more clear.

Examples: flying too close to birds ; breaking hold short line ; miscalibrating tools ; losing control of plane ; engine failure ; pilot falling asleep ; laser strike

2 – Event Flow

The flow of safety events from the point of the Risk Event to final consequences are probably more clear than establishing the Risk Event. Event Flow will establish the size of your table – we recommend 3 (or possibly 4) major events as the most manageable option. As said however, SMS Shortfall Analysis is flexible in that you can analyze an incident with as many events as you would like. Establishing Event Flow Looks like this:

Risk Event   **What happened next**

What happened next

What happened next   **Final Consequences**
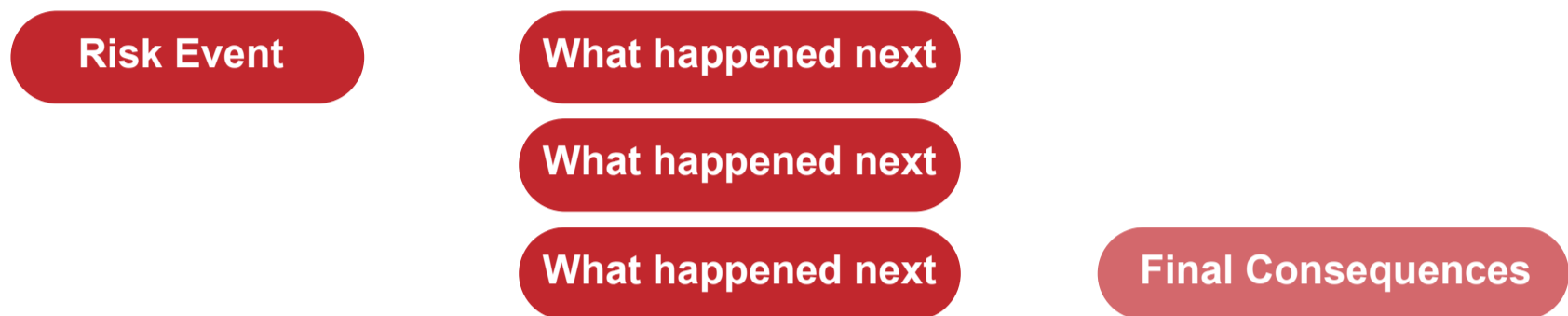
Event Flow simply means **establishing the three major events** (or however many you are using) in between the Risk Event and final consequences. In some safety incident scenarios this will be easier than others. But basically, an event in the Event Flow should satisfy two conditions:

Conditions for an "Event"

Demonstrates a point of greater deterioration in safety from previous event

Marks a point in time where a good decision, control, or documentation could have mitigated the situation (but did not).

The second condition is extremely important as at each event SMS Shortfall Analysis looks for failures in three different areas of the SMS.

3 - SMS Shortfalls (i.e., Failures)

The final element of SMS Shortfall Analysis is the important idea that:

Major Shortfalls will occur at major events

In other words, a major shortfall(s) leads to a heightened state of safety deterioration, and thus directly to a major event in the Event Flow. A shortfall involves one element of the SMS contributing to the increased exposure/safety deterioration in the following areas:

Three Types of Shortfalls

Human Action: poor decision, communication, teamwork, awareness, etc.

Risk Control: dated, inadequate, or lack of risk control (training, tools, software, etc.)

Documentation: dated, inadequate, or lack of policy, procedure, etc.

Shortfalls will always **contribute to exposure**. Points in the Event Flow can have multiple shortfalls, a single shortfall, or no shortfall (sometimes it's just bad luck).

How to Perform SMS Shortfall Analysis

With a proper understanding of the three parts of shortfall analysis, conducting shortfall analysis is not very difficult. The first thing to do before starting Shortfall Analysis is to establish how many Flow Events to use in each analysis. As said, we recommend three events, though the Shortfall Analysis is flexible and you can use more.

Workflow for Shortfall Analysis is broken into two parts:

1. Creating shortfall table
2. Plotting shortfall diagram

1 – Shortfall Table Workflow:
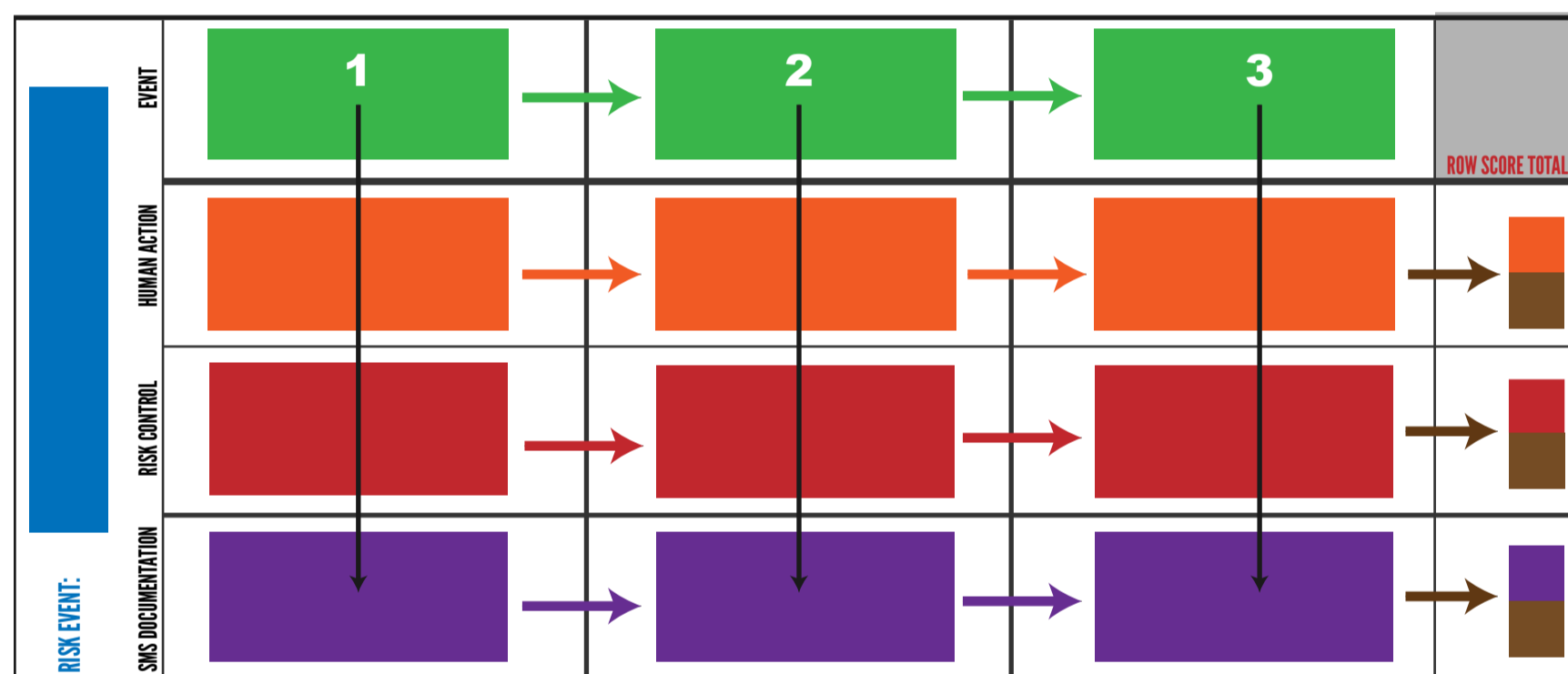
Establish Risk Event

Establish major events in the Event Flow

For each Event ask, "Did Human Action contribute to this?" If yes, write down how; if no leave blank

For each Event ask, "Did Risk Controls contribute to this?" If yes, write down how; if no leave blank

For each Event ask, "Did SMS Documentation contribute to this?" If yes, write down how; if no leave blank

At the end of each row, tally total number of boxes that have failure (0-3 for each row)

2 - Shortfall Diagram Workflow

Shortfall Diagrams are created after the Shortfall Table. Shortfall diagrams give a visual representation of the type of failure that occurred, as well as how severe the failure was. The steps are easy:
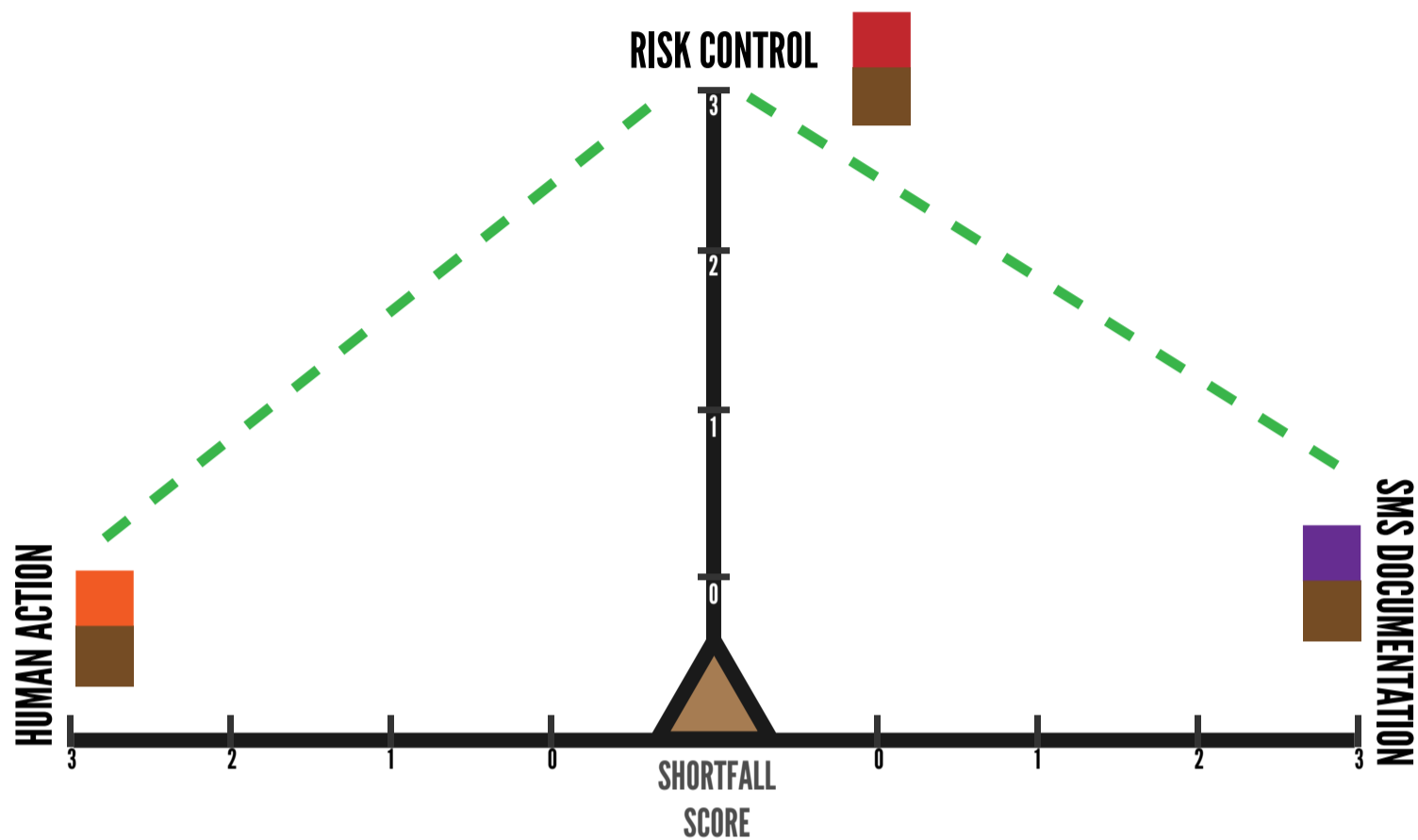
For each row total, mark a dot on each diagram section's total

Connect the dots

Write total of all three rows (should be between 1 and 9)

In a real world situation, you might have a Shortfall Table and Diagram that looks like this for a scenario involving an airport's server going down, and the backup server not being online:

				ROW SCORE TOTAL
EVENT	Backup servers were not online	Security software cannot run without server connection	Airport security checkpoints had to be closed down for 20 minutes	
HUMAN ACTION	IT manager forgot to turn backup servers on after testing		Head of security on lunch break and was unreachable	**2**
RISK CONTROL		Security software does not have "offline" capability		**1**
SMS DOCUMENTATION	No policy on checking server status in morning		No procedure to handling security without servers	**2**

RISK EVENT: Airport main internet servers go down
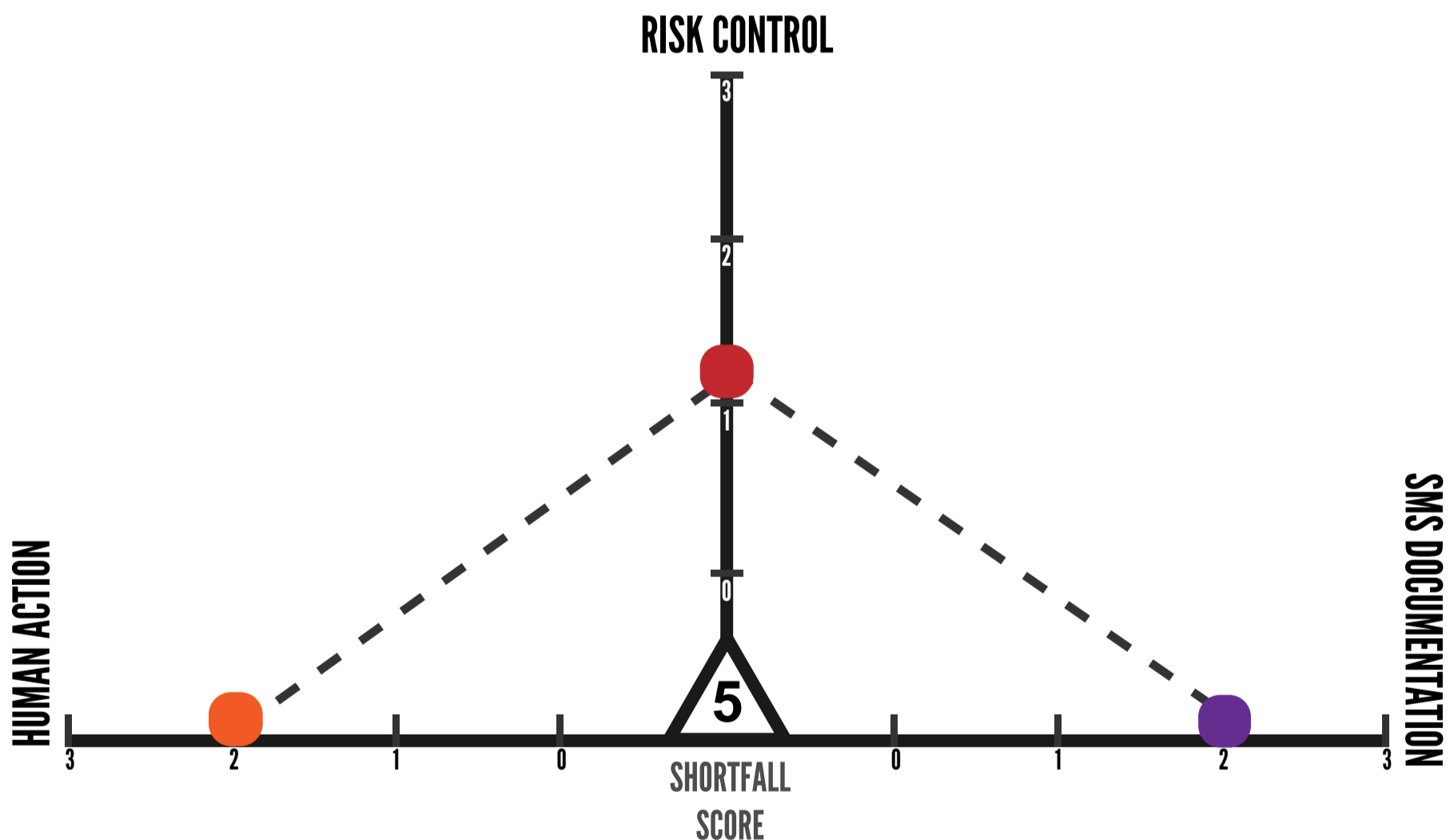
The final table and diagram give us an accurate picture and details of the various major failures from this situation, as well as how severe the failure was.

Example Walkthrough and Interpretation

There are 5 benefits that make SMS Shortfall Analysis outcomes so valuable for risk management operations:

Benefits of Completed Analysis

- Quickly summarize critical information, but provide detail to make decisions
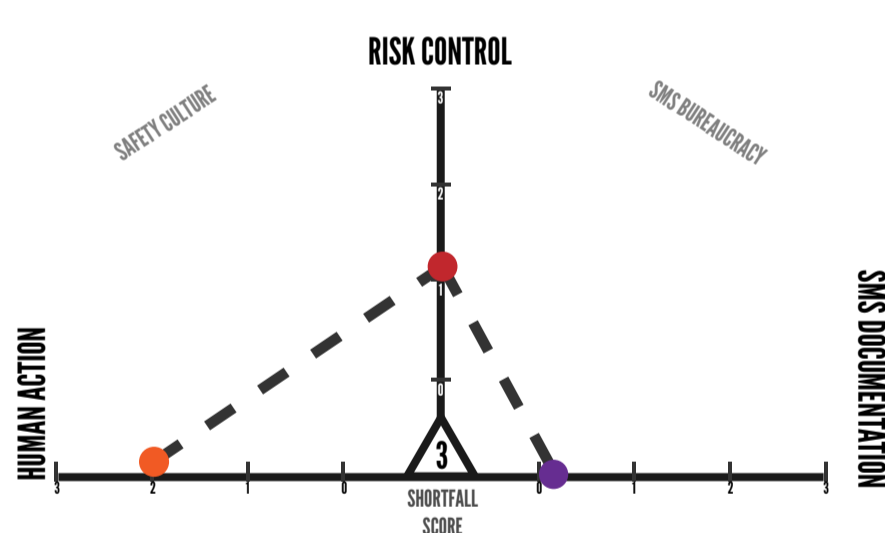- Identify specific failures that need to be fixed
- Rank total failures of SMS for each incident (higher number = greater failure)
- Understand what type of failure - SMS bureaucracy or safety culture
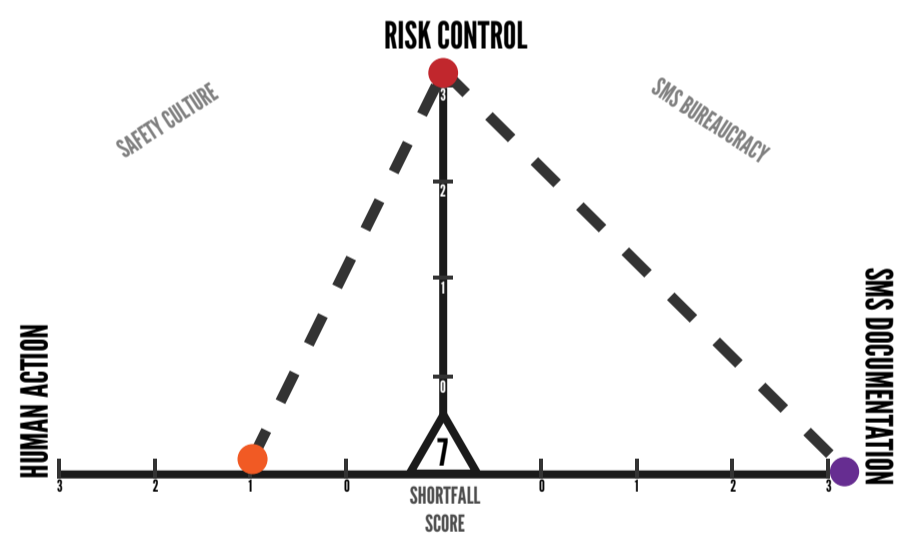- Shortfall Analysis does not take long, nor is it complicated

Let's look at a few examples of final diagrams and what they mean

Smaller SMS failure (total is only 3)

Triangle is human-action heavy, so failure more due to safety culture

Large SMS failure (total is 7)

Triangle is SMS Documentation-heavy, so failure more due to SMS bureaucracy

Based on the above graphs, you will look at the specific failure that took place in the Shortfall table to establish what further actions are needed.

Now let's look at a couple of scenarios to see the whole process in action, and the kind of extremely useful results that are generated.

Scenario 1 - Aircraft Collision (Nighttime)

Bowing 747 approached hold short line but does not clearly understand where it is due to incomplete airport scematic

747 breaches hold short line and rolls into runway due to misidentifying line (glaring runway lights) and being unable to stop quickly enough (speed); runway incursion software does not detect incursion until after incident (30 seconds late)

Meanwhile, Airbus starts takeoff sequence on the same runway. Airbus is given permission by mission control who were late to recognize runway breech. Pilots in 747 did not hear permission given because of distraction, and did not raise alarm

Airbus goes through entire takeoff sequence, only noticing 747 at last minute after being alerted by mission control ; Airbus initiated emergency takeoff maneuver and clipped the very top of 747's tail, narrowly avoiding total disaster

Incident resulted in major media fallout for 747

With this scenario, our Shortfall Table

RISK EVENT: 747 breaches hold short line	EVENT	747 moves all the way into runway	Airbus begins takeoff sequence	Airbus emergency takeoff maneuver and clips 747	ROW SCORE TOTAL
	HUMAN ACTION	747 moving much too fast given the circumstances	747 lack of communication because of distraction	Airbus doesn't do visual check of runway before moving though takeoff sequence	3
	RISK CONTROL	Runway ways too illuminated	Runway incursion software does not detect runway incursion		2
	SMS DOCUMENTATION			747 no policy for handling being stuck on runway	1

Now that we have our Shortfall Table, we just need to plug in the data points, which gives us:
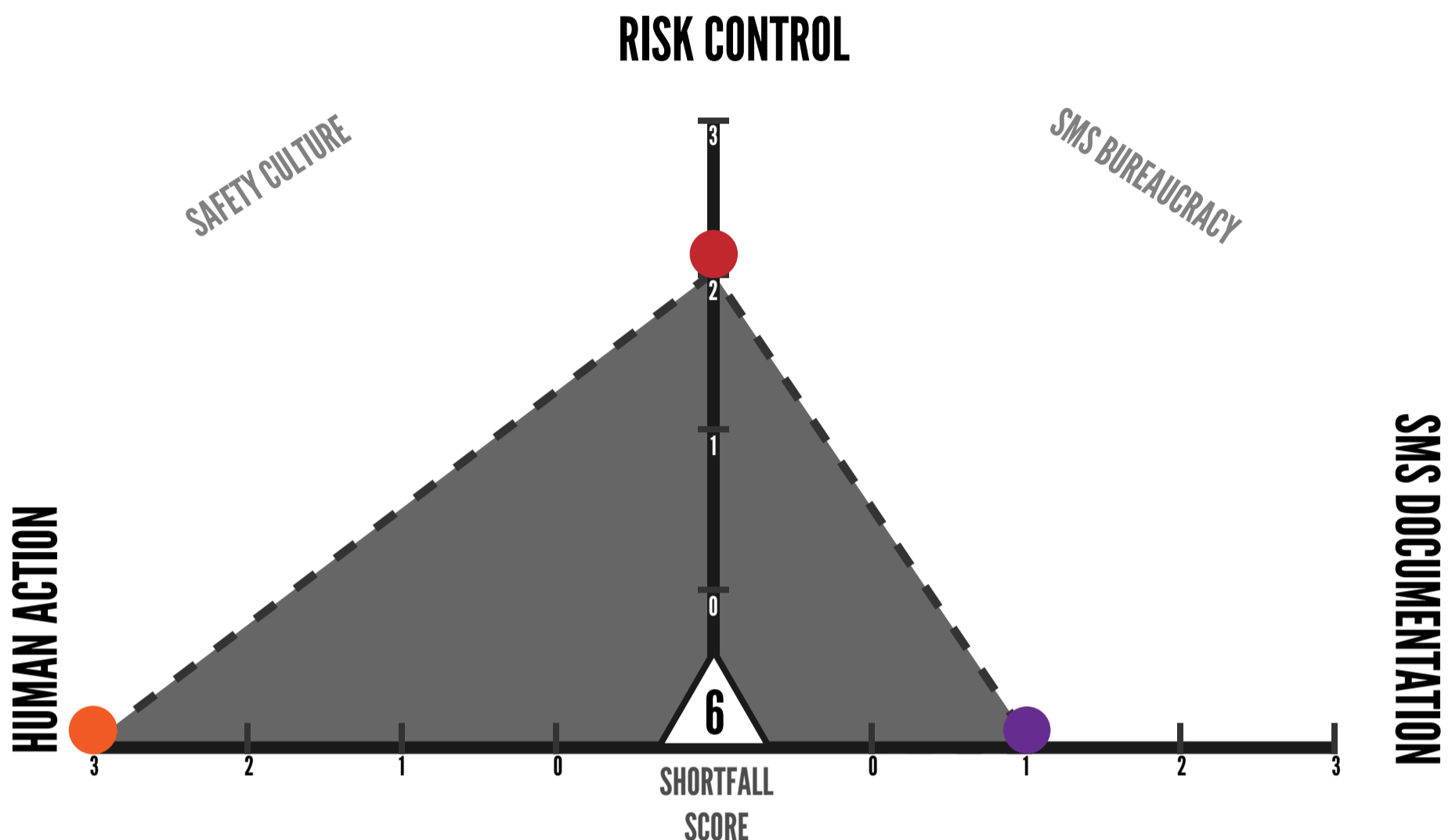
Our Shortfall Score is 6, which is moderately high. Based on the Human Action orientatio of our triange, we can understand that this failure had more to do with safety culture than SMS bureaucracy.

This process is slightly subject, so there may be minor variations in tables and diagrams from safety manager to safety manager. Also, you may have noticed that this diagram is filled in - this is an optional practice you can use to highlight the shape/orientation of the Shortfall triangle.

Blank Table/Diagram and Further Uses

Lastly, it's important to understand that while SMS Shortfall Analysis was designed for the portion of safety incidents after the Risk Event occurs. However, you can repeat this process for before the Risk Event occurs as well, giving you a complete picture of failures across the entire incident.
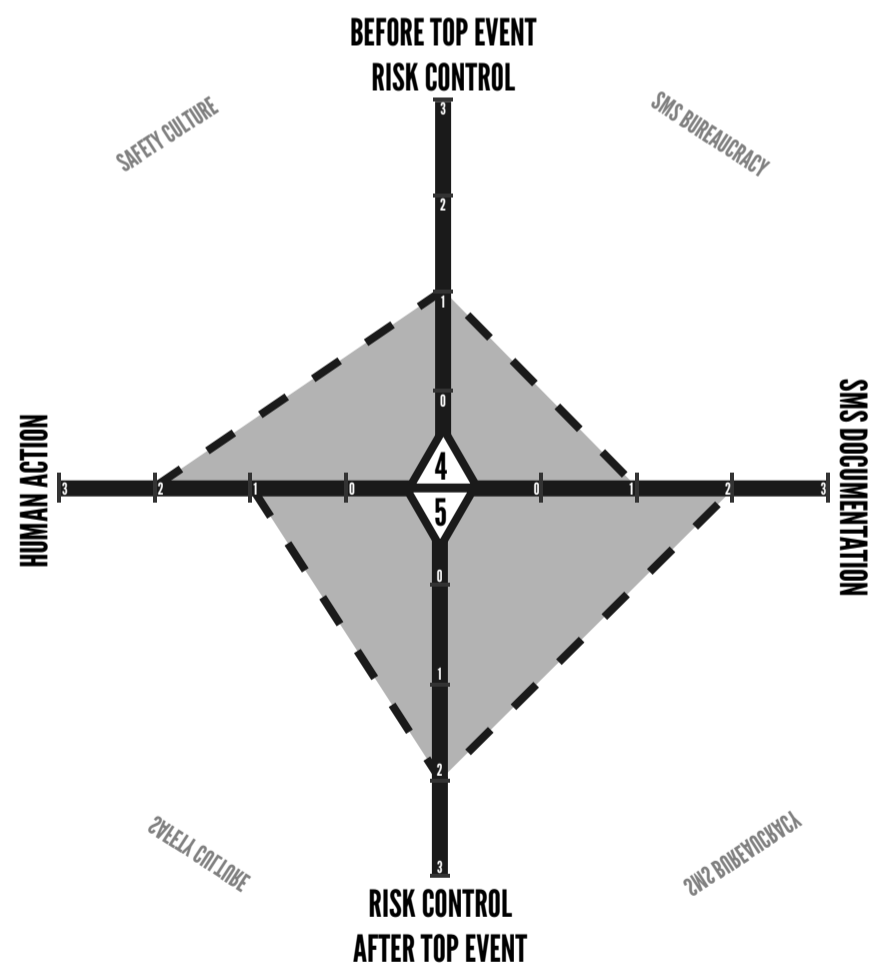
To do this you simply create two tables, one for all event between hazards and the Risk Event, and the table for events between the Risk Event and consequences.

Next, you would create the Shortfall Diagram, but duplicate the Risk Control Y axis downward (creating a cross), and then entering your before Top Event data points/triagle on top, and your After Risk Event data points/triangle on the bottom.
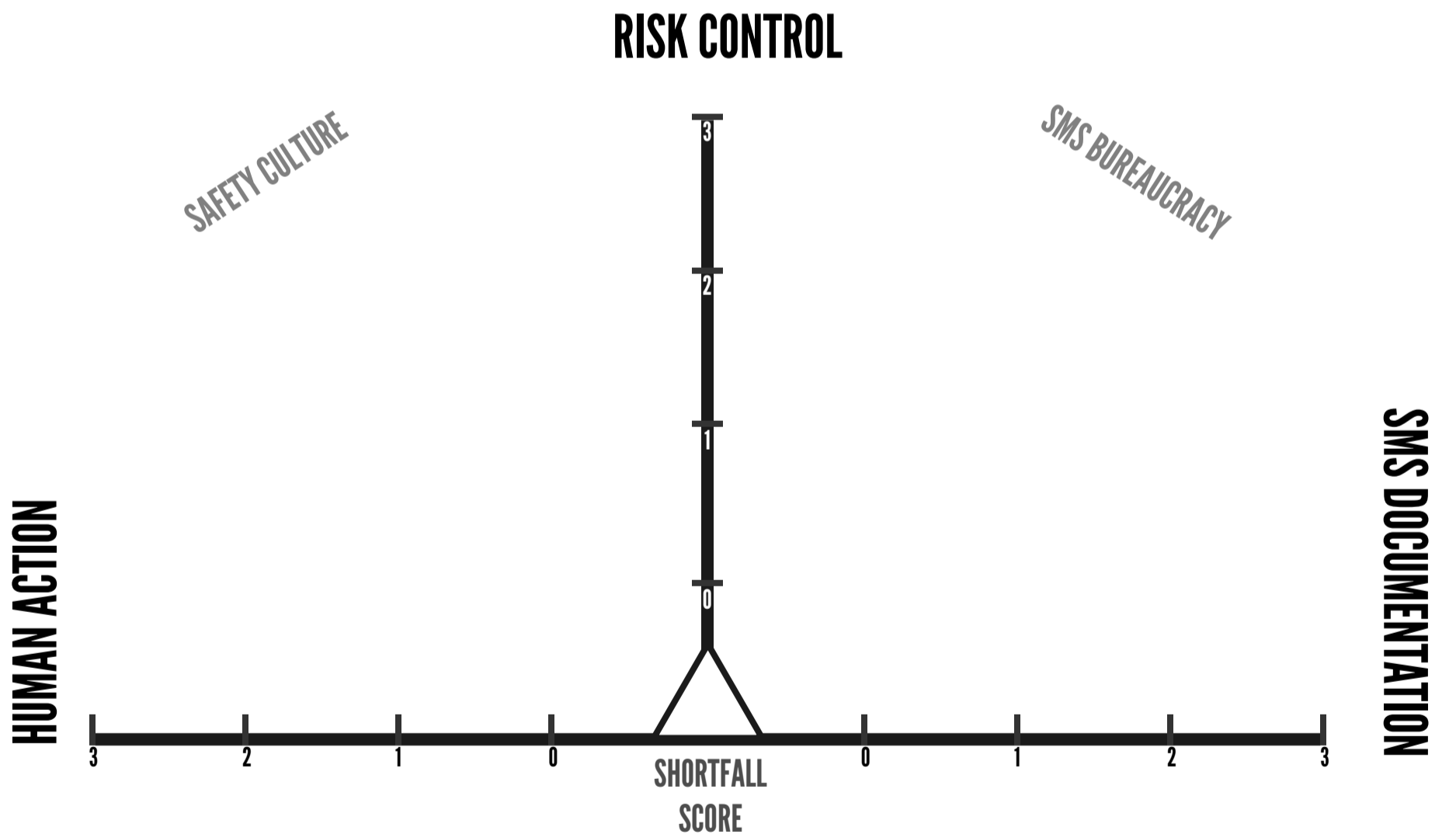

Shortfall Tables

Shortfall Graph

On the next pages you will find the blank tables and diagrams

RISK EVENT:	EVENT ✓			ROW SCORE TOTAL
HUMAN ACTION				
RISK CONTROL				
SMS DOCUMENTATION				

RISK CONTROL

SAFETY CULTURE

SMS BUREAUCRACY

3

2

1

0

HUMAN ACTION

SMS DOCUMENTATION

3   2   1   0   0   1   2   3

SHORTFALL
SCORE

BEFORE RISK EVENT

	EVENT	HUMAN ACTION	RISK CONTROL	SMS DOCUMENTATION
ROW SCORE TOTAL				
HAZARDS:				

AFTER RISK EVENT

	EVENT	HUMAN ACTION	RISK CONTROL	SMS DOCUMENTATION
ROW SCORE TOTAL				
RISK EVENT:				

BEFORE TOP EVENT
RISK CONTROL

SAFETY CULTURE

SMS BUREAUCRACY

HUMAN ACTION

SMS DOCUMENTATION

3 2 1 0 0 1 2 3

3 2 1 0

0 1 2 3

RISK CONTROL
AFTER TOP EVENT