# Swiss Cheese Challenge: Creating Dialogue on Process Safety Dilemmas

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Shell Malaysia developed a fun and engaging classroom exercise that allows participants to openly discuss dilemmas in balancing between value delivery and risk management in the business. Branded as "Swiss Cheese Challenge", the mechanism is modelled after the risk management concept of Bowtie methodology.

Central to the challenge is a block Tower representing a production facility, made up of different unique blocks that represent the main components of a Bowtie, i.e. Preventive Barrier, Recovery Measure, Process (Critical Activities) and People (Critical Positions). As participants compete, they are required to solve actual day-to-day predicaments and every chosen solution comes with rewards and/or consequences. Rewards are presented in the form of cargoes production and consequences are translated to removal of component block(s) from the block Tower.

This mechanism has proven to be effective in bringing day-to-day dilemma into the room and have the participants debate and make difficult choices we typically face in the business. Most importantly, it embodies the phrase of "Removing Barriers" into perspective through the physical effect of removing the block(s) from Tower and embeds appreciation of what it really does to an actual operating facility - especially as the facility operates over time and the effect of cumulative risk becomes apparent.

Besides being an engaging and fun way of learning Process Safety from the Bowtie methodology perspective, Swiss Cheese Challenge is an effective means in setting the scene for reflective conversations around dilemmas and demonstration of safety leadership in decisions making. Various senior leadership and functional teams in Shell Malaysia have adopted it to support and promote open safety leadership culture in the organization. We aspire for our industry, and other industries in general, to embrace safety leadership through honest and open dilemmas sharing by making safe space and providing support for the organization to speak up.

## Introduction

### Process Safety Risk Management

Process Safety event is defined as “unplanned or uncontrolled release of any material including non-toxic and non-flammable materials (e.g. steam, hot water, nitrogen, compressed $CO_2$, or compressed air) from a process, or an undesired event or condition, that under slightly different circumstances, could have resulted in a release of material.” (API, 2016). These process safety events can potentially result in serious consequences not only to people, the environment and property but also to reputation and financial stability of a company (IOGP, 2018), which are all disruptive and damaging to businesses. It is well noted that process safety events are not likely to be caused by a single point of catastrophic failure, but rather happen due to the occurrence of multiple events or failures that coincide (API, 2016). This notion of coinciding multiple events or failures leading to a unwanted process safety events was first proposed by psychologist James T. Reason (Reason, 1990) and are illustrated and commonly known as the “Swiss Cheese Model”. That model serves as basis for businesses to internalize their operations risk and provide a clearer idea on barrier management to prevent coinciding failures or events.

Aside from the focus on implementing barriers in preventing process safety events, Shell’s Process Safety Narrative outlines the Asset Integrity Principles which include element of Integrity Leadership. This element describes the accountability of leaders to ensure assets are safe throughout its life cycle. Leaders are expected to understand respective Process Safety risks, the required controls, and engage others on Process Safety so that everybody is aware of their personal and collective accountabilities for barrier management. Leaders must set their performance expectations, how controls are verified as working as intended, and what plans exist to maintain and continuously improve Process Safety risk management.

### Safety Leadership & Behavioural Based Safety

The overall safety performance improvement journey, which includes process safety, can generally be differentiated into distinct step changes. The oil & gas industry, as well as other industries, early notable improvement in safety performance are through application of effective technologies and standards. These are evident in the reduction of number of incidents over time, in tandem with the implementation of those technologies and standards. The implementation alone provided momentary positive results until it became apparent that Health, Safety & Environment (HSE) Management Systems are needed to ensure that the technology and standards were applied consistently to sustain and gain further safety performance improvement.

Reflecting on learnings from several serious process safety incidents in the Oil & Gas industry (e.g. Macondo, Texas City, Longford), highlights the importance of behavioural HSE in its widest sense. It also eventually became clear that high technology and standards and effective HSE Management Systems are not enough for achieving incident free operations. The gap to excellence requires a shift in culture, where behaviours and attitudes are safety focused. With the foundation set by implementation of technologies and standards HSE Management Systems, it is believed that incident free operations can be achieved with an improved culture, where people are motivated to want to work safely. Although it has always been disputed whether are managers or employees who are responsible for safety (Petersen, 1999), perhaps the answer is in the middle ground where both managers and employees are responsible to create the right culture for safety. The step changes in safety performance improvement journey described is as illustrate in Figure 1 below.

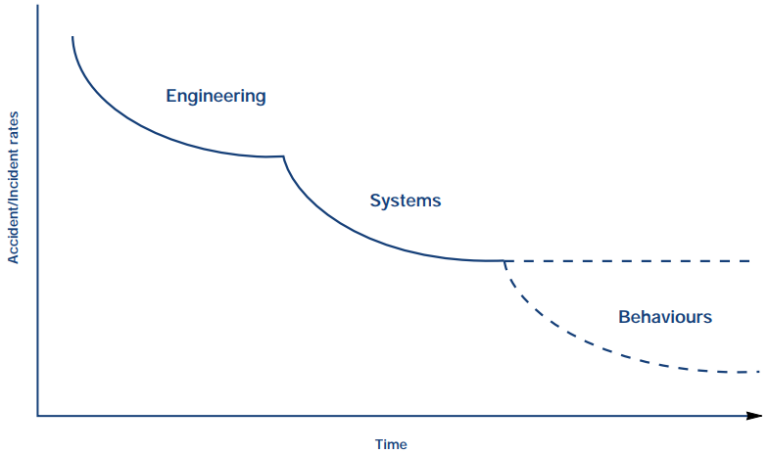


**Figure 1: The Impact of Behaviour on Safety (Step Change in Safety, 2003).**

In many areas within Shell, significant personal safety performance improvements have already been achieved through a focus on leadership behaviours and safety culture programs e.g. Life-Saving Rules, Goal Zero and Hearts and Minds. In addition to being morally the right thing to do, demonstrating care for the people and engaging them on HSE improvement journey through visible and felt leadership, delivers better business performance and prevents incidents. Evidences have shown that creating a mature HSE culture with strong safety leadership visibility at all levels is fundamental to preventing avoidable incidents and contributing to the bottom line of the organizations in many ways such as improved safety performance, as well as indirect benefits in improved quality, productivity, asset integrity and cost savings (Cooper, 2015). It is believed with similar approach with focus on leadership behaviours and safety culture programs, it will contribute to improvement of process safety performance as well.

### Dilemma Management

Despite organizations championing the rhetoric of safety first, majority of employees in various industries will agree on the perception that, production takes precedence over safety, most of the time if not all the time (Pitzer, 1999). This is indeed the major drawback of any behavioural safety improvement initiatives, as the management are unable to convince the workforce that safety is indeed genuinely first priority and the people will perceive any effort as just another way to put the blame to the workers (Hopkins, 2006). It is believed that the organizational environment and culture are the preconditions leading decision-makers to think and act mistakenly as they did (Hopkins, 2012).

In line with initiatives promoting safety leadership to build the right organizational behaviours, Shell has 3 key focus themes in the areas of demonstrating Care, knowing how to deal with Dilemma and addressing Risk Normalization. The whole organisation, from the Executive Committee right through to staff and contractors on the frontline, taking part in focused, personal, team-based conversations with each other on these topics. Teams were encouraged to talk openly and honestly about how they deal with, and manage, the three themes: Care, Dilemmas and Risk Normalisation. Particularly in managing Dilemma, it is clear that the organization needs to focus on achieving deeper conversation on managing difficult questions with no clear answers and acknowledging that we are all humans who will make mistakes, including leaders of the organization. Leaders are especially vulnerable to making mistakes as organizations may have structure where management possesses effective management skills but with limited technical comprehension and are put in position to make decisions with considerations of non-engineering factors (Lighthall, 2015). The greatest challenge on generating deeper conversation on managing dilemma is the ability to manifest the sentiment of dilemma during the conversation to put the conversation into realistic context, instead of depending on recollection of generalized experience.

### Objectives

This initiative aims to address the challenges in embedding genuine safety leadership among all levels of employees to achieve incident free operation through development of an exercise mechanism that enables:

1. Deeper appreciation of risk and associated dilemma, especially in Process Safety;
2. Honest and open conversation on handling dilemmas and the best practices as well as shortfalls in the process of it;
3. Promotion of awareness on application of Bowtie risk management methodology and its relevance to the business; and
4. Promotion of understanding on visible and hidden Cumulative Risk and its effect on the operating facilities.

## Methodology

### Overview

Shell Malaysia developed an in-house tool branded as Swiss Cheese Challenge. It embeds concept of Bowtie risk management methodology and dilemma management into a fun and engaging classroom exercise. This mechanism is designed with the purpose of bringing day-to-day dilemmas into the room and have the participants make difficult choices for a fresh experience on handling dilemma. The tool embodies "Removing Barriers" into perspective through the physical effect of removing the

block(s) from the tower block and manifests appreciation of what it really does to an actual operating facility - especially over time when the effect of cumulative risk becomes apparent. It is also an effective means in setting the scene for reflective conversations around dilemmas and demonstration of safety leadership in decisions making, especially in the space of Process Safety.

The tool is designed with 2 distinct parts in mind. Part 1 is the Swiss Cheese Challenge itself where participants will engage in interactive decision-making activities and Part 2 is the focused and facilitated reflection on the learning from Part 1.

### Swiss Cheese Challenge (Part 1)

The context is built upon a fictional oil & gas reserve development opportunity where participants will be bidding to be chosen as partner of choice to develop said reserve. The bid requires participants to demonstrate their ability on sustainable development and operation particularly on the aspect of safety delivery. In short, they need to deliver the expected bottom line competitive with industry benchmark, while delivering it with a commendable safety performance.

Participants are divided into competing groups with 6 to 10 people per group. Each group are provided with 30 pieces of wooden blocks and are instructed to build a model offshore production facility with all the wooden blocks provided. This model is known as the "*Tower*" in the Challenge and will be referred as such in this article.

The 30 pieces of wooden blocks are made up of 5 different colours, with different quantities each. Each of the colour except for Green, represents a component in a typical Bowtie Diagram, either a type of barrier or critical component as illustrated in Figure 2 below. Representation of each colour is as outlined in Table 1 below.

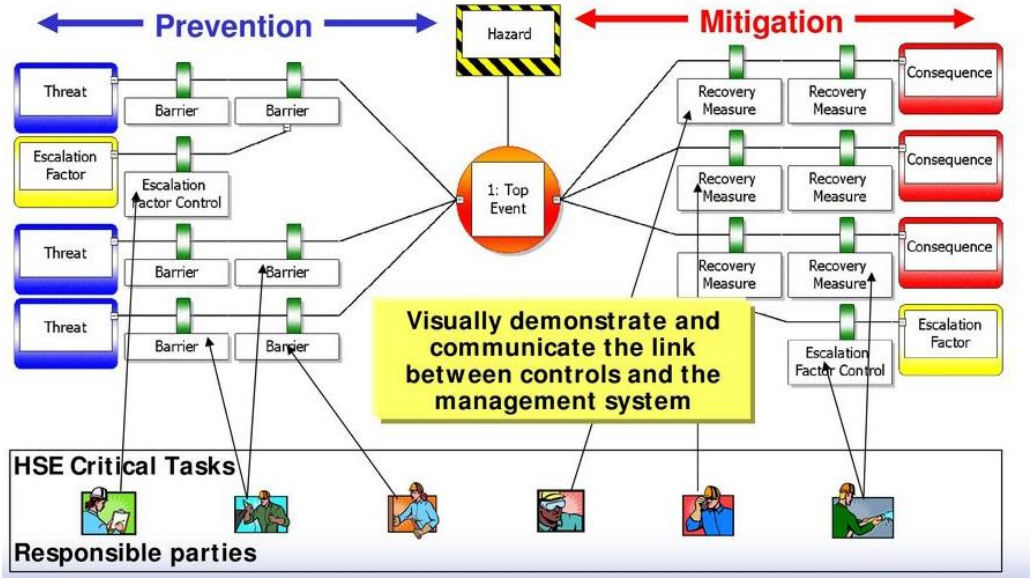


**Figure 2: Bowtie Diagram with Typical Bowtie Components (Book, 2007).**

**Table 1: Blocks' Colour and Its Representation of Bowtie Diagram Component**

| Colour | Representation |
|---|---|
| Blue | Preventive Barrier (Left Hand Side) |
| Yellow | Recovery Measure (Right Hand Sid) |
| Red | HSSE Critical Positions |
| Purple | HSSE Critical Activities |
| Green | Foundation of Tower (Non-Bowtie Diagram Component) |

All wooden blocks except Green are known as "*Barrier*" in the Challenge and will be referred as such in this article.

Each group can design and construct their own Tower by varying the arrangement of the Barrier blocks, like an actual development where the organization will have the opportunity to decide the basis of design.

**Figure 3: A Completed Tower**

Upon completion of the Tower as illustrated in Figure 3, participants will go through the following repetitive process, repeating Step 1 to Step 3 for each scenario (typically a total of 8 to 10 scenarios throughout the challenge) until an incident occurs on their Tower or until the Challenge is completed:

1. Scenario Based Dilemma

Participants will be presented with typical scenarios faced by an organization with productivity versus safety dilemma embedded. Along with the scenario, few decision options are also presented, and each team can choose one preferable decision option. These options will attempt to resolve the scenario faced in different manners, therefore understandably will result in different outcomes. Upon being presented with the scenario, each team is expected to discuss and adjudicate risk-based decision from given options. This simulates business decision making challenges, which often involves risk-based decision with conflicting business priorities.

2. Outcome Driven Decision and Barrier Thinking

Participants are made aware that every chosen option comes with rewards and/or consequences. Rewards are in the form of production cargos delivery and consequences in the form of removing Barrier from the Tower. The Challenge has a specific goal whereby groups are to achieve delivery of minimum 20 cargoes by the end of the Challenge, without any incident on the Tower. Incidents refer to either Tower tilting due to removed blocks or a total collapse of the Tower. Discussion within a group to decide on most favourable option to the current scenario takes place with the degraded Tower in sight (degradation due to Barrier blocks removal from previous scenario). Knowing the current degree of degradation of the Tower, participants can strategize the next best move based on the barrier thinking model by predicting which options will further degrade which type of remaining Barriers.

3. Physical Realization of Barrier Degradation

Only after all groups have submitted their preferred decision option, the outcome of rewards and/or consequences will be made known. At this stage, participants are required to remove the Barriers that have been degraded based on the option they took. Participants are given certain flexibility in removing the Barriers as long as meeting the requirement outlined in the consequences. This allows room for further strategizing. The Challenge will then continue by restarting Step 1, with all groups trying to keep their Tower intact throughout by making the suitable decision for their respective Tower. Figure 4 shows a Tower with few tilted blocks, indicating that an incident has occurred, and the group has failed the Challenge.

**Figure 4: An Example of a Tilted Tower with an "Incident"**

## Reflection and Learning (Part 2)

1. Setting up the Scene

Upon completion of Challenge, participants will need to transition from the excited mood generated during the fun competitive Part 1, into a calm reflective mood and that requires facilitation. Typically, a leader figure from the related business line will play an effective facilitation role by sharing personal work experience related to the emotions and thoughts felt during the Challenge. Drawing examples that are like the scenarios in the Challenge creates stronger connection for meaningful reflection. The sharing will help anchor and set the direction of the reflective conversation within each group at the later stage.

2. Dynamic Conversation

The reflective conversation can be done in small group in their respective table, open plenary, combination of both or any style deemed suitable for the size of the group and type of audiences. Questions can be posed to the participants to trigger reflection on areas such as their own past experiences in difficult decision making, factors that influence those decisions and safety leaders' role in enabling healthy open discussion on dilemmas. Two-way communication enhances the appreciation of learning from the session. This can be done by inviting volunteers to share key insights and facilitator to continue by further adding values to their sharing or invite others to add values. Whenever the discussion seems to stray away, facilitator also plays the role to steer participants back to the main intent of having a deliberation on the right behaviours and culture in managing dilemma, rather than the technicalities of solving the scenario presented itself. Most importantly, facilitator or business leader should take the opportunity at the end of the conversation to provide material closure through key messages on linking the elements of on Safety Leadership and managing Dilemma, especially in the space of Process Safety, and how all of that will create the required behaviours and culture for the organization to achieve the "no harm to people" aspiration.

## Development of the Scenarios and Messaging

These scenarios, decision options and the resulting outcomes of the Swiss Cheese Challenge are developed based on actual incidents as well as learning from incidents within the Shell Malaysia operations experience. The context is much simplified as well as modified where necessary to create the intended value (e.g. productivity versus safety dilemma, reasonable resemblance to actual, appreciation of barrier degradation) while keeping the Challenge at an exciting pace and relevant to its objectives.

Table 2 shows an example of a credible scenario that could take place on an offshore production platform and possible actions to be taken in response to the scenario.

**Table 2: Example of Scenario and Options Presented to Participants**

| **Scenario** | |
|---|---|
| The offshore platform production just started up after completion of Turnaround. The Turnaround scope includes replacement of 8 badly corroded gas flowlines. After 10 hours of production, one of the flowlines parted, resulting in Loss of Containment and subsequent platform Emergency Shutdown (ESD). There is uncertainty on the root cause(s) of the failure as investigation is on-going. According to purchase records, all flowlines were supplied by same manufacturer. What would you do? | |
| **Option A** | **Option B** |
| While pending the outcome of the investigation, isolate the parted flowline and start up again to continue production with the remaining 7 flowlines. | Delay the start up and stop production until investigation is completed and improvement recommendations are implemented. |
| **Outcomes if Option A is selected** | **Outcomes if Option B is selected** |
| Removal of Preventive Barrier(s) and gain Cargo(es) | Status quo. No additional cargo and no removal of blocks from Tower. |

The premise of this scenario is that there has been an incident with unknown root cause(s) and at hand, there are options to either (Option A) continue production while trying to understand the root cause(s) of the incident, with potential risk of the incident recurring due to common mode failure or (Option B) to halt production until it is confirmed that the risk is understood and being managed.

Developing the individual sets of scenarios, options and outcomes, require certain assumptions to be made to derive sensible outcomes. In the case of Option A, knowing that all 8 new flowlines are subjected to similar quality assurance process and are operating in similar condition, yet one of it has failed catastrophically, it is assumed that the remaining 7 has the potential to experience similar common mode failure. With this established, it leads to the assumption that the Preventive Barrier, in this case where the flowlines act as Pressure Containment barrier to prevent Loss of Containment, is partially valid or no longer valid. Therefore, choosing Option A leads to removal of Preventive Barrier blocks from the Tower to symbolize that operation is continued with "absence" of certain Preventive Barriers. Opposite to that, Option B is not operating with a partially valid or invalid Barrier, thus no block removal is required.

As the multiple sets of scenarios, options and outcomes are put together to form the Swiss Cheese Challenge, there is a need to re-evaluate the overall sensibility of all the scenarios, options and its respective outcomes. During the early phase of development, trial and error rounds are conducted to re-adjust scenarios, options and outcomes as appropriately. There are few overarching guiding principles in doing that:

1. In forming the few options to each scenario, the options need to be balanced with no single dominantly preferred option. As example, this can be achieved by avoiding options that are advantageous at all aspects, options that are not credible or options that are easily ruled out (i.e. illegal in nature). The options are also built to create dilemma that can support the Reflection and Learning part, where one of the key messages of the Challenge is about demonstrating Safety Leadership in balancing value delivery and risk management.

2. The quantum of rewards and consequences are consistently realistic between each scenario. In re-adjusting the quantum of the Consequences, the Barrier that is being removed for the option chosen must always be aligned with the Bowtie methodology application;

3. The risk is cumulative, but scenarios are not as scenarios do not build on each other in sequence (scenarios are not related to each other). Although in reality, the barrier degradation caused by each scenario might be independent of each other (i.e. barriers on different Threat to Consequence Line on the Bowtie), but in this Challenge, the risk is presented as cumulating as more Barriers blocks are removed from the same one Tower. This causes an experience that does not reflect actual operation but is necessary to simplify the context of the challenge; and

4. Difficulty level in achieving the objectives of the Challenge (i.e. delivering 20 cargoes without incident on the Tower) should be sufficiently challenging to force the experience of dilemma, yet not too difficult to accomplish causing participants to lose interest. A good indication of a sufficiently challenging difficulty level is when the trial rounds consistently end with at least a quarter to less than half of the total groups successfully completing the Challenge.

## Observations and Learning

Through the multiple Swiss Cheese Challenge sessions with different businesses within Shell Malaysia, a few common generalized themes are observable during the reflective discussion and they are as discussed below.

### Opportunity for Safety Leadership versus Groupthink

The Challenge is designed to only define the basic boundaries of how the activity will run – how is the Bowtie represented in the Challenge, what participants will face along the way, what they need to do in response and the overall objective to achieve. Beyond that, everything else are up to participants' own interpretation. One such area of open interpretation is in the space of roles and responsibilities. The participants are put into groups, where each group are informed that they are expected to achieve certain objectives, yet without information on what role will each participant within the group plays throughout the Challenge.

The lack of clearly defined accountability throughout the Challenge provides an equal opportunity for every member in the group to demonstrate strong and visible sense of leadership, particularly safety leadership. In comparison, this is a scenario not unfamiliar to an actual organization where there will be scope of work that are poorly defined or those that have been defined but have not changed accordingly to reflect the current reality. These uncertainties create grey area where certain important responsibilities might be left unattended, thus creating weaknesses in the organizations' safety barrier systems.

The reflection upon this is that, the right behaviour in responding to this is for every individual to have the sense of ownership in delivering results, where everyone is willing and is courageous to take the lead in owning up unwritten responsibilities. Leadership needs to work on building an organization where everyone feels empowered to intervene or make necessary changes, not because they are told to do so, but because they know it is morally, ethically and professionally the right thing to do. This require creation of space and opportunity for individuals to step up and where leadership acknowledge that they will need to step back to allow the growth of leadership in everyone. It is observable during the Challenge that groups that have individuals stepping up when required, can discourse and make decision collectively as a group. More importantly, the stepping up should not stop there as it is also observable that if only selected few individuals are stepping up to the role of leadership, without effective check and balance from the rest, this may lead to groupthink and confirmation bias. Group decision thrives with presence of informal leadership where all individuals are proactively intervening when necessary to prevent groupthink.

Another notable observation is that communication seems easier and decisions do get made faster when participants of same background are grouped together. The similar experiences and understanding helped to generate meaningful conversation where everyone can comprehend each other easily. This is beneficial to some extent. However, it also means that the group is vulnerable to groupthink as everyone can easily agree with each other without consideration of a comprehensive view.

### Risk Visualization, Cumulative Risk and Mental Model

The physical model of the Tower as a representation of an operating facility help participants appreciate Barriers' role in maintaining a safe and reliable operation. Participants can identify different type and functionality of Bowtie Barriers clearly through implications of each scenario and how Barriers act together as a whole system to keep the Tower incident free. The established relationship between each Barrier and how they affect each other creates a simple risk visualization of the ongoing operation.

Safety practitioners in all industries are banding together to formulate pragmatic approach in visualizing risk as we have yet to adequately quantify or qualitatively assess situational risk to enhance decision making. The whole risk visualization process becomes even more complex as multiple factors or risk contributors come together, in the fashion of Cumulative Risk. The

Challenge clearly shows to the participants that they are able to react accordingly in the next scenarios based on the simple risk visualization available to them at all time, where they can see where the holes are in the Tower or in a way, weaknesses of the system are, and yet they are still bound to make mistakes resulting in causing an incident on the Tower. This shows the importance of a fit for purpose risk visualization as additional value in effective decision making. In an actual operation, an organization might not have the luxury of a real time risk visualization, especially a cumulative one. The nearest meaningful real time risk representation like what is represented by the degraded Tower an organization can have are the leading and lagging safety key performance indicators such as Near Misses, Loss Time Injuries, Tier 1/Tier 2 incidents and maintenance activities progress compliance. Underperforming indicators could somewhat represent the weaknesses in an operation, like holes in the Tower, to a certain accurate extent.

Scenarios also show that process safety risk is comparatively more complicated as it is mostly hidden risk as compared to operational or manual handling risk. Design flaws that are inherently built in during the design stage constrained organizations to make decisions based on what is available or designed, although may not be the most ideal decision to manage the current scenario. This metaphor is clearly amplified by the example where participants within the group are to build the Tower best to their knowledge of how the system should work, and then realizing later that certain Barriers might be positioned unfavourably to manage certain scenarios that develop during facility operational phase. Additionally, process safety risks are not easily identified in actual operations. Through the Challenge, participants learn to appreciate that although incident has yet to happen, they are in fact operating with less barriers than they should have due to the decisions they made. In reality, they might not be aware of barrier degradation extent in a facility as business typically reaps immediate reward from the decision made in terms of continuous facility production and the downside implications of that option usually does not show until a later time.

All these challenges are well known and documented as preconditions to disastrous decision makings. As inherent flaws and effect of past erroneous decision-making compounds on top of each other, this leads to a complex present emergency where humans are not adequately trained to comprehend the complexity of the issue at hand or form appropriate mental model of the situation. Lack of a comprehensive mental model leads to possibly fallacious decision-making during the emergency that might lead to disastrous outcomes. The Swiss Cheese Challenge simulates the limited decision-making time in emergency scenario and the lack of information or knowledge in assessing the most likely outcome therefore reducing the capability of the participants to form the appropriate mental model to manage the dilemma at hand. Participants' reflections result in few conclusions including how an organization needs to carefully consider inherently removing weaknesses during design stage, as well as reducing the complexity of a predictable emergency in advance to allow responders to form appropriate mental model of the cumulative risk in a timely manner to respond effectively.

### Gamification Enhance Appreciation

The tool is consciously designed at a pace to manage the interest of the participants as well as adding staggered new discoveries or surprises to maintain the interest of the participants through new found challenges. The gamification factor of the learning process has allowed the participants to learn on their own as they complete the challenge. In the Bowtie risk management methodology, the degradation of barrier is often referred to as "Removing Barrier". This challenge brings that definition to reality as an elementary process of understanding it - "Removing Barriers" through physically removing Blocks from the Tower and this embed appreciation of what it does to an operating facility – especially over time, as the Cumulative Risk effect becomes apparent.

## Conclusion

Various Shell Malaysia leadership adopted the Swiss Cheese Challenge to promote open safety leadership culture within the organization and together with Contractor Partners. As of date, about 500 leaders across all Businesses from Upstream, Downstream, Integrated Gas to Functional Teams have experienced and gained practical insights in dilemma management from the exercise.

Fresh experience of dilemmas during the exercise anchors the reflection conversation, deep-diving into similarities felt in making actual day-to-day decisions. It surfaces the fact that dilemmas faced by front-liners are often ripple effect of leadership's decisions. More importantly, it offers a glimpse on the flip side, where leadership are accountable to balance value delivery versus risk management and are fallible in that process. It helps create conversation on being aware of the ripple effect in causing dilemma down the line and acknowledging leadership's vulnerability in striving to manage that effect.

Participants appreciate this as a quick learning tool on principles behind Bowtie risk management methodology and the role it plays in decision making.

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