



Optimizing Your Remote HAZOP/LOPA Experience

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Abstract

Although the basic brainstorming concepts in performing a HAZOP Study have not changed over the years, changes in the way business is conducted and the availability of modern communications technologies provide opportunities to enhance the implementation flexibility of a HAZOP/LOPA:

- Today's workers are more comfortable and effective with long-distance communications that include video and computer screen sharing.
- Video and other interactive communications are more readily available in the workplace.
- HAZOP/LOPA documentation almost always involves use of computers.

Nothing is quite as good as a HAZOP/LOPA Team being in the same room together, but the savings in travel costs, the difficulty associated with personnel travel, and the ability to quickly convene and implement a HAZOP/LOPA review can allow remote HAZOP/LOPA, through the use of contemporary technologies, to become an attractive option that can increase overall efficiency, without compromising quality.

A core part of this paper is to focus on tips that can directly be used by the HAZOP/LOPA Facilitator to optimize the logistics to get the most out of a HAZOP/LOPA, where some or all team members are geographically distant.

It should be noted that software package capabilities are continually evolving. The characteristics supporting conclusions reached in March 2018 can easily change. The authors will make periodic updates to this paper striving to make it constantly useful.

1. Focus on Objectives – Why is a Quality Process Hazard Analysis Important

Most people attempt to avoid undesirable outcomes and organize their actions to minimize risk; however, very few of us apply a structured evaluation of potential undesired outcomes to avoid. Whereas this may be a personal decision for the individual, this is unacceptable for a complex process system, where the types of undesired events may be rare and involve a complex set of initiating events, and failure of safety/mitigation systems and these events can have impacts well-beyond the individuals directly involved.

The December 2, 1984 Methyl Isocyanate (MIC) release from the Union Carbide Bhopal Facility is considered a pivotal event in catalyzing the application of Safety Management Systems (SMS) approaches to enhance process safety. The MIC release and the magnitude of the tragedy (3928 fatalities and over 100,000 estimated permanent injuries)^[1],

drew the attention of industry, the public, and the regulatory community to the potential consequences associated with process safety events (Figure 1.1). Industry's response was swift and definitive. The American Institute of Chemical Engineers (AIChE) founded the Center for Chemical Process Safety (CCPS) in 1985, recognizing that the most effective mechanism for addressing process safety was not the application of additional prescriptive mechanisms, or by addressing any specific action, but by effecting changes in the way business is done (i.e., safety culture and management systems). CCPS Guidebooks are currently considered key references in conveying the technologies needed for process safety, and the very first guidebook ("Guidelines for Technical Management of Chemical Process Safety"^[2]) published in 1987 was designed to address this pressing need.

A key part of managing process safety has always been the identification and understanding of potential hazards and their consequences. This need pushed practical techniques for hazard identification, i.e., the Hazard and Operability (HAZOP) Study, developed in the decades prior to the Bhopal tragedy, to the front lines in the effort to manage process safety.

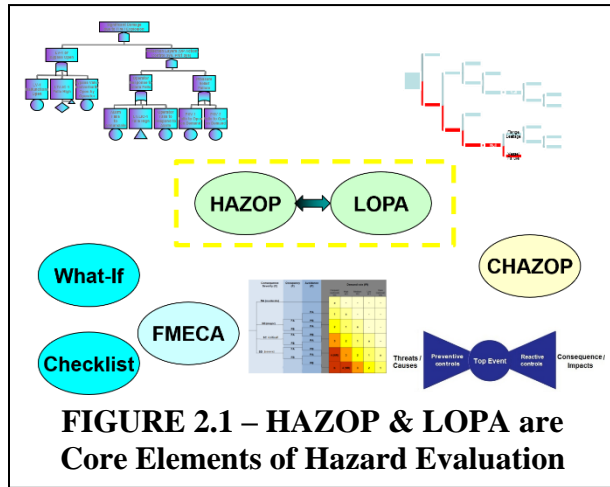
2. Brief History of Key PHA Techniques and Regulatory Requirements

Although there are quite a few tools in the PHA toolkit, the team-oriented, patterned-brainstorming sessions associated with HAZOP Studies^[3] are generally considered the workhorse of the industry (Figure 2.1). Layer of Protection Analysis (LOPA)^[4], frequently integral with the HAZOP Study, is a complimentary tool that is best patterned to integrate with the HAZOP Study, providing



FIGURE 1.1 – Tragedies to Avoid

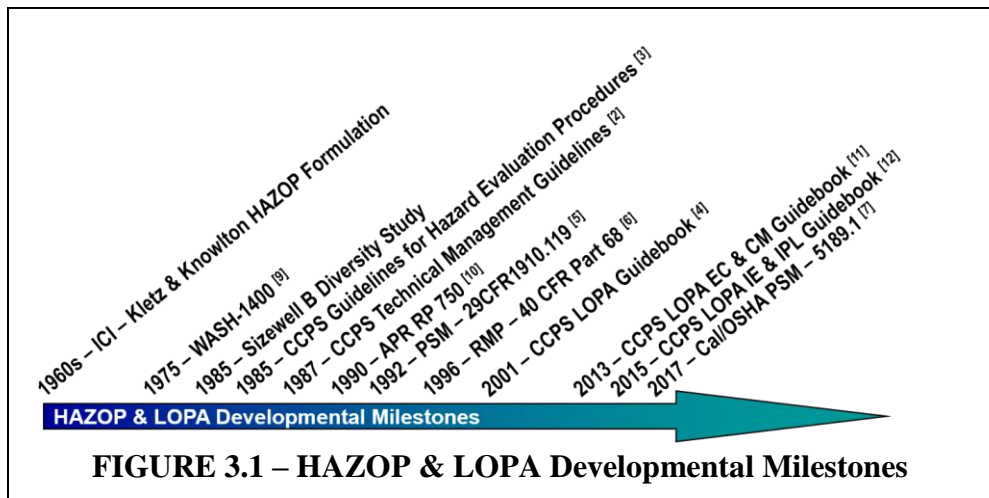
additional insights, some of which can be directly used for identifying appropriate reliability targets for key safety features. Although HAZOP Studies have been a core part of an acceptable hazard evaluation process referenced in various industry guidelines^[2,3], as well as regulatory requirements such as Process Safety Management (PSM)^[5] and Risk Management Programs (RMP)^[6] for onshore facilities in the United States, LOPA is a relatively new tool that simplifies Quantitative Risk Assessment (QRA) techniques to a manageable level to facilitate usage. LOPA applications are gradually becoming best practice for addressing higher consequence/risk events and are especially useful for an initial assessment of the reliability needed for key safety systems. As well as an industry accepted practice for important applications, for California Refineries, PSM^[7] and the California Accidental Release Prevention (CalARP) Program^[8] require the development of Safeguard Protection Analysis (SPA), with LOPA as an acceptable tool.



Although the core of the HAZOP approach hasn't changed, HAZOP and LOPA applications have been evolving, as well as collaboration techniques, communications technologies, and our business culture that includes increased utilization of computers. This provides an opportunity to use contemporary communications techniques to provide flexibility and improved efficiency in the implementation of HAZOP/LOPA for conditions where it may be impractical for a team to assemble in-person.

3. Evolving Technical Platforms, Business Culture, and Collaboration Techniques

The timeline depicted by Figure 3.1 identifies some of the key developmental milestones associated with HAZOP and LOPA, as well as key United States regulatory requirements, over a 40-year period. For a fundamental hazard analysis technique such as HAZOP to remain relevant over such a long period of time is quite a feat. Even with the use of contemporary computer tools for an in-person



HAZOP/LOPA (see Figure 3.2), the essence of the activities is still a patterned brainstorming team session. The core concepts are relatively unchanged; however, the evolving technical environment and culture in industry have already brought about numerous changes that are manifested in the in-person HAZOP/LOPA:

- Access to in-house servers and the Internet improves information availability.
- Increased availability of engineering tools gives real-time access to results.
- Changes in safety culture and better dissemination of Process Safety Information (PSI) result in all participants being able to read P&IDs.
- Key HAZOP/LOPA participants are generally “computer-friendly” (often bringing their own computer to a session) and are accustomed to expedited access to information.
- At a plant site, process information is often available in “real time.”



FIGURE 3.2 – HAZOP/LOPA Requires a Multidisciplinary Approach

In parallel with the implementation of Safety Management Systems and changes in business culture, communications technologies have also evolved to provide more flexibility and options for working. Many of us have experienced the improvements of various audio and video conferencing options, as well as interactive meetings, sharing of computer screens, webinars, etc. The past few years have brought about the increased availability of various collaboration techniques (see Table 3.1 for key features useful for a Remote HAZOP/LOPA that are readily available on top-ranked telecollaboration tools) that use a platform of these new communications technologies.

**TABLE 3.1
FEATURES USEFUL FOR REMOTE
HAZOP/LOPA TELECOLLABORATION**

- Screen Sharing**
- Video Calls with multiple Cameras**
- >50 Participants**
- See www.G2crowd.com for rankings.**

Increased Internet stability and bandwidth, and increased processing power in computers, support the reliable utilization of these tools for more effective collaboration in the business world. Thus, the challenge becomes determining the best way to utilize these collaboration technologies for an important hazard evaluation activity.

4. Changes in Large Capital Project Implementation

When determining the best ways to use new collaboration techniques, it is important to understand that there is a spectrum of possible team dynamics and compositions, which can be substantially different for capital projects compared to an operating process unit at a large industrial facility.

Capital projects normally involve large multi-disciplinary teams, that make improved collaboration techniques especially useful.

The past couple of decades have seen significant changes in the way capital projects are implemented, e.g.:^[13,14]

- Financial pressures to accelerate project schedule
- Use of package vendors to accelerate project schedule and compartmentalize design work
- Increased spreading of financial project risk over many companies
- Financial pressures to avoid re-work and start-up challenges

These changes that are especially pertinent to capital projects can affect the dynamics of the HAZOP/LOPA:

- 1) The number of “stakeholders” who wish to participate in the HAZOP/LOPA has increased.
- 2) These stakeholders are likely geographically separate, which represents logistical challenges for the conduct of in-person HAZOP/LOPA Sessions.
- 3) “Time is Money” – Significant pressure is placed on the design team for maintaining project progress and doing things right the first time. This can manifest itself in a need to start the HAZOP/LOPA process earlier, in an incremental fashion and with periodic sessions, to keep pace with the design process.
- 4) Many large projects make increasing use of “vendor packages” to distribute costs and accelerate progress. Whereas, this modularized approach can allow multiple elements of the project to proceed in parallel, theoretically streamlining completion and allowing the specialist companies to focus on their areas of expertise, this significantly increases the complexity of the project and results in an even greater need for synchronization of activities. HAZOP/LOPA can be a crucial element for binding these activities and flushing out potential weaknesses in the design or its integration, and previous papers have discussed the need for systematic application of HAZOP/LOPA during the design process.^[13,14]



FIGURE 4.1 – Challenges of Vendor Package Integration

Performing the HAZOP/LOPA remotely can increase the ease for the team to assemble, and current collaboration technologies have improved the ease of communicating with the team during the study; however, it is important to recognize what represents an effective application of Remote HAZOP/LOPA.

5. Sensible Applications for Remote HAZOP/LOPA

In-person meetings are generally the most effective, and the same holds true for the HAZOP/LOPA patterned brainstorming team sessions. A key to effectively applying collaboration technologies to the HAZOP/LOPA is to recognize the technology limitations and identify when these limitations do not overshadow the logistical benefits. Examples where telecollaboration and a remote HAZOP/LOPA can be beneficial:

- Involvement of large groups of individuals
- Assembling individuals in the same room is cost-prohibitive
- Logistics of getting the right people in the room either delay the HAZOP/LOPA or become an impediment to infusion of HAZOP/LOPA into the design^[13]
- Additional resources that can't be present are needed (e.g., subject matter experts)^[14]
- Casual observers can “listen in”

During a large design project, engaging the team frequently for shorter periods to allow for better long-term design efforts is another benefit of the Remote HAZOP/LOPA, but large design projects are not the only benefactor of the Remote HAZOP/LOPA. At the opposite end of the spectrum, the remote HAZOP/LOPA can also be very beneficial for:

- **Short PHAs** – Travel time/costs can be a significant fraction of the total effort.
- **Management of Change (MOC) Exercises** – This is also typically a very short effort, and often must be done quickly.

In contrast to capital projects, operating unit HAZOP/LOPA typically involve small teams, for a longer duration. Operating unit HAZOP/LOPA are more conducive to in-person team sessions.

It should be noted that even under the best circumstances, a Remote HAZOP/LOPA Session may be only 80% as effective as an in-person session with respect to time utilization. Many people point to a slight increase in the length of time for a Remote HAZOP/LOPA Session as a financial concern; however, the ability to complete the effort, get results sooner, and minimize

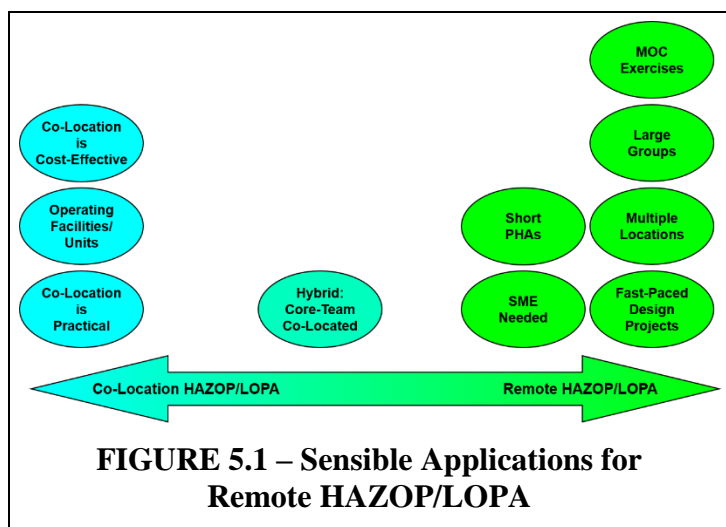


FIGURE 5.1 – Sensible Applications for Remote HAZOP/LOPA

travel would typically neutralize any additional cost associated with a slightly-longer Remote HAZOP/LOPA.

The Remote HAZOP/LOPA can also be applied in a manner which allows everyone to be at the HAZOP/LOPA who needs to be, but also allow observers to participate remotely. A hybrid application would assemble core team members that provide the majority of the participation in the same room for an in-person discussion, and the telecollaboration aspect would be reserved for specialists, casual participants, or individuals with logistical challenges associated with their attendance.

6. Planning Tips for the Remote HAZOP/LOPA

For the Remote HAZOP/LOPA, all of the challenges associated with an in-person HAZOP/LOPA are amplified, as well as the special needs associated with telecollaboration, e.g.: additional computers, communications links, multiple locations, additional individuals, etc. Sections 6 and 7 focus on specific nuances for the planning and preparation of a Remote HAZOP/LOPA, compared to an in-person HAZOP/LOPA.

Planning and preparation are pivotal to a successful (e.g., quality, completeness, effectiveness) HAZOP/LOPA outcome. General planning/preparation activities for a successful outcome are detailed in another GCPS-2018 paper entitled “Preparing for a Successful HAZOP/LOPA (Making or Breaking Quality & Efficiency)”^[15] Planning/preparation efforts are even more important for a successful remote HAZOP/LOPA due to multiple locations and a larger number of technical problems that could materialize. Planning activities such as ensuring the attendance of core personnel are essential and must be done well in-advance. The following paragraphs explain essential planning activities for a successful Remote HAZOP/LOPA Session, and for convenience, these are summarized in the form of a checklist in Table 6.1. Other preparation activities which can be completed with less lead-time before the Remote HAZOP/LOPA Session are detailed in Section 7.

Process Engineer Supporting Interactive P&ID Display

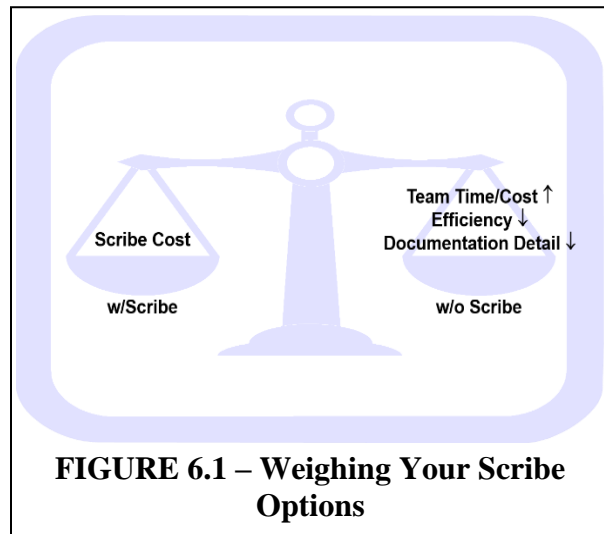
A separate, shared-display for Piping & Instrumentation Diagrams (P&IDs) can be essential for maintaining team focus. Ensure that an individual, typically the process engineer, is assigned to make P&IDs available and display them, interactively. In addition, P&ID corrections during the session are inevitable, but “redlining” a paper copy posted on the wall is not an option for a Remote HAZOP/LOPA. The Process Engineer should also have the ability to annotate P&IDs during the Remote HAZOP/LOPA.

P&ID Grid Format

During a Remote HAZOP/LOPA, the Facilitator will likely need help in focusing the team’s attention to a specific location on the P&ID. If possible, margin grids should be included on all engineering drawings to be used for the Remote HAZOP/LOPA.

Scribe Support for Communications and Software Platforms

For an in-person HAZOP/LOPA, scribing skills include typing, software usage, and computer interfaces with local equipment such as displays. The Facilitator can be tasked with both facilitation and scribing duties depending on various parameters of the HAZOP/LOPA, such as system complexity and team composition. So, for a relatively small, manageable group, a Facilitator might be able to also accommodate scribe duties. The pivotal decision-making parameter is whether the additional cost of a Scribe outweighs the money saved by shortening the HAZOP/LOPA Sessions and the subsequent documentation time. Many professionals, especially in a large company, tend to underestimate the value of their time and that of their peers. The employee time cost can be substantial and shortening the HAZOP/LOPA Sessions could have a significant financial benefit. In most cases, this financial threshold is reached once the team size (excluding Facilitator and Scribe) exceeds 3-4 individuals for local projects and possibly 4-5 individuals if travel costs for the Facilitator and the lower-cost Scribe are considered. As another benchmark, Reference 16 recommends to “use a dedicated Scribe, for meetings longer than 4-total hours” and “Use a well-trained scribe to take the documentation load off of the team. This rule can save 30-50% of meeting time and increases brainstorming (because the team is not daydreaming as they wait for Leader to complete the notes).”



Quality/experienced scribe support can be even more important for a Remote HAZOP/LOPA Session. For a Remote HAZOP/LOPA Session, the additional complexity is likely to further tax the Facilitator’s abilities, which further limits the pool of Facilitators who may be able to accommodate the effort and also lowers the financial break-even threshold where the time/money-saved exceeds the cost of the Scribe. Along with tangible savings, the Scribe can provide an improvement in the quality of the documentation, and the session itself, by allowing the Facilitator to better focus on engineering issues and maintain an optimal “pace” of the HAZOP/LOPA (too fast, the team gets lost, and too slow, the team tires quickly of watching a Facilitator type and shifts their attention to checking e-mail on their cellphone. Thus, if the Remote HAZOP/LOPA Session involves more than 2-3 individuals or more than a single, remote location, consideration should be given to involving a capable Scribe.

Of course, the decision to involve a Scribe pivots on the Scribe’s capabilities. Some key characteristics to look for in a Scribe include:

- Familiarity with HAZOP/LOPA techniques
- Familiarity with reading engineering drawings
- Familiarity with the telecollaboration software

- Robust understanding of the communications environment to properly support the Facilitator, including interface with the other remote locations such as the ability to transfer temporary control of the screen

For a Remote HAZOP/LOPA, avoid offers to provide a scribe at a separate location. This does not work. Typically, a younger engineer that may be undergoing training to become a Facilitator works best.

Remote Location “Deputy”

Establish at least one point-of-contact at each remote group location that has the resources/knowledge to trouble-shoot equipment/communications challenges and resolve any personnel “attendance” or “paying attention” issues. This individual can also play a key role in maintaining order at the remote location.

Minimize Language Barriers

Any communications challenges that may exist during an in-person HAZOP/LOPA are amplified for any verbal communications through a telephone or computer audio connection. This can be especially challenging for a multi-national project, especially if Vendors, or other specialists, are involved who may have important technical skills, but also have challenges with the language of the HAZOP/LOPA. Solutions might include using the better of either the computer or telephone, pairing the expert with an individual that can assist with audio communications, or avoiding use of a speakerphone for a certain individual.

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| <p style="text-align: center;">TABLE 6.1 REMOTE HAZOP/LOPA PLANNING TIPS</p> |
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| <p style="text-align: center;">(Please also see Reference 15 for General HAZOP/LOPA Preparation Tips)</p> |
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| |
|-------------------------|
| <p>PERSONNEL</p> |
|-------------------------|

- | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><input type="checkbox"/> Process Engineer Supporting Interactive P&ID Display<input type="checkbox"/> Scribe Support for Communications and Software Platforms<input type="checkbox"/> Remote Location “Deputy”<input type="checkbox"/> Minimize Language/Accent Challenges |
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|------------------------------------------|
| <p>PROCESS SAFETY INFORMATION</p> |
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|-----------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><input type="checkbox"/> P&ID Grid Format |
|-----------------------------------------------------------------------------------------------|

7. Preparation Tips for the Remote HAZOP/LOPA

Many details need to be ironed out before the first HAZOP/LOPA Session. Longer-term planning activities for a Remote HAZOP/LOPA are reviewed in Section 6. Certain preparation efforts are more important for a successful Remote HAZOP/LOPA than an in-person HAZOP/LOPA due to people being in multiple locations and a larger number of potential technical problems associated with additional equipment. The following paragraphs explain essential preparation activities for a successful Remote HAZOP/LOPA Session, and for convenience, these are summarized in the form of a checklist in Table 7.1.

When it comes to a successful HAZOP/LOPA, there are few activities more important than planning and preparation. Just as we use the HAZOP/LOPA to identify what can go wrong with the chemical process being evaluated, we should postulate potential problems that can arise with the HAZOP/LOPA Remote Sessions and how the problems might be addressed.

Adequate Computers/Displays

To help ensure that remote teams are properly engaged, a minimum of two displays is needed, one for the HAZOP/LOPA notes and one that will typically display P&IDs. It is often helpful for a process engineering representative or the “owner” of the P&IDs to “drive” the display to focus the team’s attention on the portions being evaluated. This additional communication link can also be used by other team members to share other information pertinent to the HAZOP/LOPA, e.g., photographs, other engineering information, etc.

Cameras

Some companies have interactive video conferencing between their sites. This can help the Facilitator verify that the core team members are present and engaged. Even if a dedicated video system is not available, screens with a video feed of team members can be setup and can be integrated with the video software programs that have the characteristics identified in Table 3.1.

| TABLE 7.1 | |
|------------------------------------------------------------------------|-----------------------------------------------------------------------|
| REMOTE HAZOP/LOPA PREPARATION TIPS | |
| (Please also see Reference 15 for General HAZOP/LOPA Preparation Tips) | |
| EQUIPMENT | |
| <input type="checkbox"/> | Adequate Computers/Displays |
| <input type="checkbox"/> | Cameras |
| <input type="checkbox"/> | Pre-arrange Communications Access and IT Support |
| <input type="checkbox"/> | Testing |
| PHYSICAL ACCESS | |
| <input type="checkbox"/> | Physical Site Access and Conference Room Availability |
| ROOM CONFIGURATION/ RESOURCES | |
| <input type="checkbox"/> | Check Power and Communications Connections for All Computer Equipment |
| TECHNICAL PREPARATION | |
| <input type="checkbox"/> | Pre-define Causes |
| <input type="checkbox"/> | Pre-define Questions |

Pre-Arrange Communications Access and IT Support

If bringing computers with specialized software, make arrangements for any necessary login or network permissions, plan on setting up early, and make pre-arrangements for contingency IT support. This may apply to multiple locations.

Testing

Work with “**Deputy**” to verify that equipment and the communications interface are tested before the Remote HAZOP/LOPA Sessions. Not all sites are equipped with wireless Internet access, and if they are, it may be overloaded during peak periods, and thus, should be tested to verify that there are no practical bandwidth constraints that can derail your Remote HAZOP/LOPA.

All computers should have an operating system update performed to avoid last-minute surprises. A single computer at one of the locations that picks your scheduled Remote HAZOP/LOPA Session time to perform an update could idle multiple teams.

Physical Site Access and Conference Room Availability

Make arrangements for site access and reserve meeting locations (e.g., conference rooms) well in advance. This need likely applies to multiple locations.

Check Power and Communications Connections for All Computer Equipment

As for non-remote HAZOP/LOPA, the best spot for the Facilitator and Scribe is at the front of the room next to the displays/screens. Verify that power connections are sufficient and accessible for all equipment, and if wireless Internet access is insufficient, ensure data communications cables can reach.

Pre-Define Causes

Pre-defining causes by the Facilitator is a contentious issue for some professionals. Although some individuals express concerns of putting boundaries on the team's imagination, for an in-person HAZOP/LOPA there can be a number of benefits that include:

- **Completeness** – For a cause-by-cause HAZOP Study, pre-defining causes can help avoid missing an important initiating event. By the Facilitator defining the “obvious” causal events up-front, it frees the team to brainstorm the less-obvious causes and subtle process issues.
- **Future Use** – Rather than random brainstorming, careful patterning of causal events before the interactive chaos of a HAZOP Study can facilitate future use.
- **Quickly Locating Equipment on the P&ID During the Session** – Careful patterning up-front, and including tag numbers and P&ID references, streamlines locating the equipment during the HAZOP/LOPA Session.
- **Grouping Causes** – If carefully patterned, a natural grouping of the initiating events can minimize multiple detailed discussions of the consequences, adding clarity, consistency, and accuracy to the HAZOP/LOPA.

For the Remote HAZOP/LOPA Session, pre-defining causes is even more helpful, and it provides the added advantage of being able to transmit a list of causes that will be discussed to the team ahead of time. The team can be tasked with reviewing the causes and being prepared to explain the associated process dynamics and credible ultimate consequences. From experience, defining the process dynamics and associated ultimate consequences can represent the single largest segment of session time, so if the team can be aided in converging on these issues team focus is improved and the overall HAZOP/LOPA effort streamlined.

Pre-Define Questions

In the same way that pre-defining causes can focus the team's efforts, for many industries and for many countries, the patterned-brainstorming approach to HAZOP/LOPA is unfamiliar and not

consistent with typical business approaches. Especially for members of the team that are inexperienced in HAZOP/LOPA best practices, providing examples of HAZOP/LOPA scenario development and creating a list of specific questions (typically regarding the basis-of-design for the equipment that they are responsible for) can be very helpful. Pre-defining causes and questions can be beneficial for all HAZOP/LOPA efforts and even more beneficial for the Remote HAZOP/LOPA.

8. Summary

Choosing the right application for a Remote HAZOP/LOPA and performing thorough planning and preparation, including equipment setup, and establishing communications links well before the Remote HAZOP/LOPA Session puts a successful framework in place.

Remote HAZOP/LOPA Session applications have been implemented by some practitioners for over a decade, but telecollaboration is still new to many professionals and a focus of skepticism by many more. Performing a HAZOP/LOPA remotely is not the right answer for many applications; however, for some, it can be a very effective solution that can optimize the significant resources that are expended in implementing a HAZOP/LOPA, as well as engage resources (e.g., Vendors or Subject Matter Experts) that wouldn't be available otherwise. All of this can accelerate the progress of efforts such as capital projects, aid in project control, enhance teamwork, and result in tangible savings to the Owner/Operator.

Just as the impact of the infusion of technologies (e.g., personal computers, the Internet, cellphones, advanced “smart” protection systems, etc.) on both business and communications cultures could not have been accurately predicted a couple of decades ago, the evolution of how we perform vital patterned brainstorming sessions such as HAZOP/LOPA will continue to be difficult to predict. However, there are three certainties:

- Communications technologies will continue to evolve.
- The importance of telecollaboration will increase.
- As process safety professionals, we must continue to look for, adapt, and embrace new ways of working to improve the effectiveness of our efforts, which are important for the safety of those within our trust.

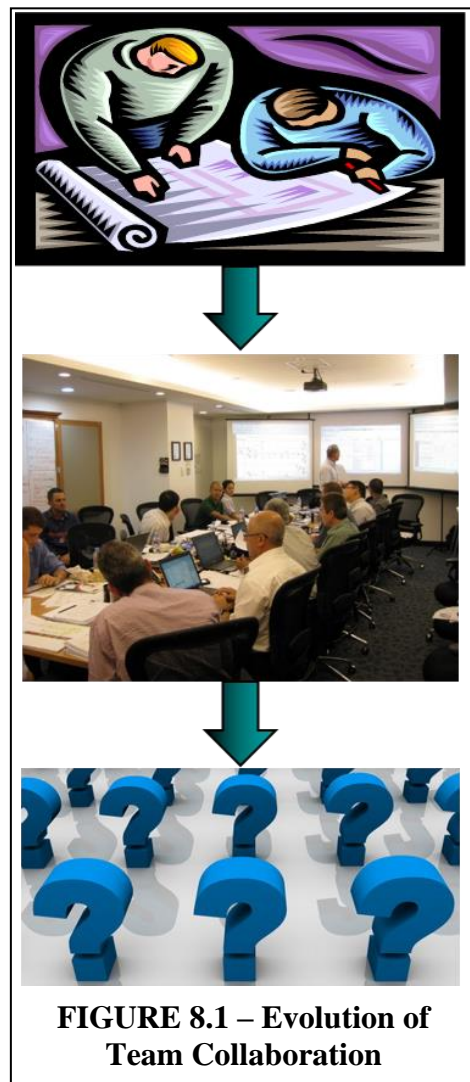


FIGURE 8.1 – Evolution of Team Collaboration

Conducting a Remote HAZOP/LOPA is subject to a number of technical problems that can and will occur; however, for many applications the benefits outweigh the drawbacks, and the definitive recommendation from the authors is to try the Remote HAZOP/LOPA when the opportunity presents itself.

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