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Reliability of Supply Chains and Business Continuity Management

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Abstract

The importance of the adoption of business continuity plans is now well recognized by organizations all over the world. Whatever the business model, organizations are operating in an increasingly global, complex and risky context. Economic, social, political, technical, environment related events can interrupt core business. Natural disasters, diseases, terrorist attacks, strikes, financial crises, unreliable systems, logistics, supply chain failures, as well as unexpected lack of essential production inputs can severely impact growth and performance. The development of well-established plans that consider the identification of business interruption risks, the definition of strategic and tactical plans, proactive management and preparedness to respond should be a goal. Business Continuity plans consider vital issues to be observed by organizations to assure production. Reliability and risk assessment methodologies compose powerful tools to support those plans. With them it is possible to identify potential threats to an organization and their associated impacts to business operations, and to provide a framework for building organizational capability for an effective response that safeguards the interests of its key stakeholders, reputation, brand and value creating activities. This paper presents topics that compose current standards concerning Business Continuity Management programs and examples of the use of reliability modelling, applied to Brazilian gas supply chain, and its importance for supporting BCM programs.

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Keywords: reliability modelling; business continuity, BCM, security of supply; production assurance ;

1. Introduction

The importance of business continuity plans is well recognized by organizations all over the world. Whatever the business model, organizations are operating in an increasingly global, complex and risky context.

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Economic, social, political, technical, environment related events can interrupt core business. Natural disasters, diseases, terrorist attacks, strikes, financial crises, unreliable systems, logistics, supply chain failures, as well as unexpected lack of essential production inputs can severely impact growth and performance.

The development of well-established plans that consider the identification of business interruption risks, the definition of strategic and tactical plans, proactive management and preparedness to respond should be a goal. Business Continuity plans consider among several other topics, the need of different site locations, IT back ups, different suppliers, and provide references for the establishment of policies, procedures, that compose vital issues to be observed by organizations and to assure production.

Reliability and risk assessment methodologies compose powerful tools to be used to support the establishment of related management programs and processes. Through the application of those techniques and models, it is possible to identify potential threats to an organization and their associated impacts to business operations, and to provide a framework for building organizational capability for an effective response that safeguards the interests of its key stakeholders, reputation, brand and value creating activities.

This paper presents some issues related to current international and national standards and publications concerning Business Continuity programs and an illustration of the use of reliability models on gas industry, focusing their importance for building BCM programs.

2. Business Continuity Management Systems

Presently, a key component of risk management framework is the development and implementation of business continuity management systems. They should provide a robust support for managing risks, through the establishment of formal policies, procedures, goals, and priorities for prompt recovery, based on the identification of threats and the associated impacts.

British Standards [1], [2], [3], [4] provide basic reference for describing the elements that compose a Business Continuity Management Program, as will be presented below. Highlights are made by the author, regarding the interrelationship with reliability topics that are going to be addressed further in this paper.

This British Standard [1] specifies requirements for planning, establishing, implementing, operating, monitoring, reviewing, exercising, maintaining and improving a documented BCMS, within the context of managing an organization's overall business risks.

British Standards [2], [3] regarding the objectives of a business continuity management system, emphasize the importance of the following topics:

- understanding the organization's needs and the necessity for establishing business continuity management policy and objectives;
- implementing and operating controls and measures for managing an organization's overall capability to manage disruptive incidents;
- monitoring and reviewing the performance and effectiveness of the BCMS, and
- continuous improvement based on objective measurement.

2.1. Elements of the business continuity management lifecycle

The BCM lifecycle comprises six elements, as described below [1]:

a) BCM program management
b) Understanding the organization
c) Determining business continuity strategy
d) Developing and implementing a BCM response
e) BCM exercising, maintaining and reviewing BCM arrangements
f) Embedding BCM in the organization's culture:

2.2. Business impact analysis (BIA)

One of the most important elements of a BCMS is the performance of a Business Impact Analysis (BIA), when all scenarios that could impact core business activities should be identified, and their impacts evaluated.

Below are presented whatever British Standard [2] determines to be implemented regarding BIA elaboration:

- 'The organization should determine and document the impact of a disruption to the activities that support its key products and services. This process is commonly referred to as a business impact analysis.'
- 'The aim of this element of the BCM lifecycle is to assist the understanding of the organization through the identification of its key products and services and the critical activities and resources that support them. This element ensures that the BCM program is aligned to the organization's objectives, obligations and statutory duties.'

2.2.1 Regarding activity supporting the delivery of key products and services

For each activity supporting the delivery of key products and services within the scope of its BCM program, the organization should [2]:

a) assess over time the impacts that would occur if the activity was disrupted;

b) establish the maximum tolerable period of disruption of each activity by identifying:
   - ✓ the maximum time period after the start of a disruption within which the activity needs to be resumed;
   - ✓ the minimum level at which the activity needs to be performed on its resumption;
   - ✓ the length of time within which normal levels of operation need to be resumed;

c) identify any inter-dependent activities, assets, supporting infrastructure or resources that have also to be maintained continuously or recovered over time.

2.2.2. Assessing Impacts

When assessing impacts, the organization should consider those that relate to its business aims and objectives and its stakeholders. These may include [2]:

- ✓ the impact on staff or public wellbeing;
- ✓ the impact of damage to, or loss of, premises, technology or information;
- ✓ the impact of breaches of statutory duties or regulatory requirements;
- ✓ damage to reputation;
- ✓ damage to financial viability;
- ✓ deterioration of product or service quality;
- ✓ environmental damage.

2.2.3. Identification of critical activities

'The organization may categorize its activities according to their priority for recovery. Those activities whose loss, as identified during the BIA, would have the greatest impact in the shortest time and which need to be recovered most rapidly may be termed "critical activities". Each critical activity supports one or more key products or services.' [1].

3. Business Continuity Management and its relation to Reliability of Supply (Production Assurance)

Reliability engineering and risk assessment techniques and models provide robust technical tools, as well as well-defined key performance indicators, that can be used as key elements to compose production assurance or business continuity management programs. They can give support for the identification of threats or undesired scenarios that could jeopardize business operations and growth; the quantification of the probabilities of occurrence of those scenarios, as well as their impacts; the identification of infrastructure, supply chain and logistics bottlenecks; critical failures from sources; critical systems, equipment and resources. Through the implementation of those programs an organization can recognize what needs to be done to assure production in certain levels and the maximum tolerable recovery periods of time, after a disruption or shortfall occurrence. They also provide well established tools to define: - the minimum levels at which activities need to be performed on its resumption; the length of time within which normal levels of operation need to be resumed; therefore, contributing to minimize negative impacts and loss of revenues. The Standard BS EN ISO 20815, 2010 [5] provides an interesting guide related to production assurance processes, where reliability and risk assessment techniques are well addressed.

In the following sections, a reliability program carried out for Brazilian gas supply chain, focusing *production assurance, security of supply, business continuity*, will be presented.

3.1. Reliability Studies developed for Brazilian Gas Supply Chain

3.1.1. Reliability Modelling

Reliability engineering provides tools to ensure the maximum benefit to project Life Cycle Cost, aiming to achieve:

- Minimization of total cost of ownership, that includes:
  - ✓ Trade-off between CAPEX , OPEX, LOSTREV (Lost Revenue) [6], [7], [8], [9], [10];
  - ✓ Maximum availability and reliability of the asset;
  - ✓ Maximum profits for the asset.

The earlier they are applied, ***the*** more significant the positive impact in LCC.

A reliability modelling was developed for Brazilian gas supply chain, together with Det Norske Veritas (DNV) (Brazil and UK). The main objectives of the implementation of a *"gas security of supply program"* were the following:

- Optimization of global performance since design phase;
- Excellence in operation;
- High reliability levels of supply;
- High safety levels;
- Minimum environmental impacts;
- Reduction of shortfalls and associated losses.

The modelling of Brazilian natural gas supply network was developed utilizing very powerful computational tools. The whole and complex gas supply chain was simulated, step by step, in order to include different gas sources, different consumers. Complete reliability analysis of all the assets that compose it – gas processing units, compressor stations, LNG terminals, city-gates and pipelines were also included in the modelling.

The main modelling steps, as well as the topics that were considered to quantify gas network performance are described below:

✓ Identification of failure scenarios and associated impacts evaluation;
✓ Information and data collection (offer and demand profiles; contingency plans; failures rates; mean times to repair; inspection, maintenance, logistics and spare parts policies and resources; costs; etc.);
✓ Quantification of overall gas network production/ supply efficiency;
✓ Quantification of production/supply efficiency of individual assets, that compose gas supply chain;
✓ Quantification of production/supply efficiency to customers;

- ✓ Quantification of frequency and duration of shortfalls;
- ✓ Identification of key production contributors to shortfalls;
- ✓ Identification of key areas of concern for security of gas supply
- ✓ Evaluation of optimization measures, regarding network performance improvement;
- ✓ Performance of cost-benefit analyses, considering CAPEX, OPEX, LOSTREV, penalties;
- ✓ Generation of contingency plans with anticipation

The performance of the integrated gas supply network has been quantified in terms of gas supply network efficiency, which is defined as the ratio between achieved gas supply and the forecasted gas demand (equation (1)). The achieved gas supply includes random failures and scheduled maintenances.

$$Network\ Production\ Efficiency = \frac{Achieved\ Gas\ Supply}{Gas\ Demand}\ x\ 100 \quad (1)$$

Gas supply network efficiency was calculated over a certain operation time period and several cycles, taking into account aspects, such as production boosting, buffering etc. For a system that is demand driven, the potential production is limited by demand and the gas sales agreement.

Gas supply network efficiency fully accounts for periods of degraded operation resulting from equipment failures and product sales profiles, etc. In addition the performance of the gas supply network is also quantified in terms of the production efficiency, the frequency and duration (average, minimum and maximum times) of shortfalls of gas supply to the specific consumers or group of consumers.

The models are built, considering the network design configuration, conceived for a certain period of time and the associated gas offer and demand profiles. The whole supply chain performance was tracked, from gas sources, through chain components (gas processing units, compressor stations, pipelines, city-gates) to final consumers. Main contributors to losses and 'bottle-necks' were highlighted. Reliability modelling considered detailed equipment failure rates, associated times to repair, and maintenance and inspection policies.

The study incorporated reliability models that were developed for more than fifteen gas processing units that compose Brazilian gas supply chain. Brazilian integrated gas network receives gas from different sources: - from exploration and production fields; from Bolivia, through a gas pipeline (GASBOL); and from LNG vessels. Those suppliers feed several power plants and city-gates, which deliver gas for distribution companies. Gas that comes from E&P sector is treated in gas processing units, before being supplied to several customers.

The supply chain reliability modelling was performed [9], [10], [11], [12] using the software TARO - Total Asset Review & Optimization simulator – developed by Jardine/DNV (UK). More information about TARO is provided below.

As input for the reliability modelling an allocation model was used, in order to optimize gas delivery to customers, focusing revenues maximization. A thermo fluid hydraulic software was also used - Pipeline Studio TGNET (developed by Energy Solutions) - for gas delivering network simulations, taking into account steady and transient states, considering main failure scenarios. The use of these softwares allows the evaluation and validation of best allocation, verifying pressure and delivery conditions for final consumers.

3.1.2. About Reliability Modelling Software - TARO

The whole gas supply chain reliability modelling was performed, by Petrobras, DNV (Brazil and UK) and Jardine (UK), using a software, as mentioned above, named TARO - Total Asset Review & Optimization simulator – developed by Jardine/DNV (UK).

TARO enables the whole supply network to be modelled, considering its complexity, production and demand profiles, their variability, configurations of the network and of the individual assets that compose it, integrating data into a coherent computer simulation model. This model can then be analyzed, parameters altered, performance impact assessed, so that optimizations of key performance drives can be promoted.

At its core TARO functions in a similar way to MAROS software (well known in the upstream oil & gas sector), by creating typical life-cycle scenarios of proposed systems, employing event driven simulation techniques. The main strength of TARO is the ability to handle multiple feedstock and product streams.

Briefly, a life-cycle scenario is a chronological sequence of events which typify the behavior of a system in real-time. TARO can create an infinite number of such scenarios for any given system, each one being unique, yet sharing the commonality of being a feasible representation of how the system will behave in practice. Events are the fundamental occurrences within a system's life, which determine the effectiveness of the system. The events are generated from elements data using random sampling techniques. The elements data comprise equipment failure data, planned activities and its logical operation.

Before life-cycle scenarios can be created for a system, it is necessary for TARO to understand some basic system details; this is achieved via a system logic model, which identifies the main elements of the system and their configuration, e.g. series, parallel, standby, etc.

This simulation technique is commonly referred to as a direct simulation method. The digital system model moves from one distinct state to another governed by the occurrence of a sequence of events. The state of the model at any point in (simulated) time is represented by a series of variables; as each new event occurs, one or more of the variables representing the system changes.

The progress of the simulation is in steps, from the occurrence of one event to the occurrence of the next until the simulated time exceeds the specified design life of the system being modeled.

3.1.3. Gas Supply Chain

At first, gas network study boundaries were established considering gas supply sources and delivery points to consumers (including city-gates). The following gas network facilities were modelled in the study:

- Natural gas processing units
- All pipelines and shutdown valves
- Gas compression stations
- City gates
- LNG terminals

Then, further studies were developed, relating to: - the evaluation of possible gains to security of supply, provided by the inclusion of gas storage systems [11]; the evaluation of LNG vessels logistics of supply [12].

3.1.4. About Contingency Plans

Contingency plans were elaborated for failure scenarios, in a detailed manner. Those scenarios, and the associated contingency plans, were identified and validated by an experienced team, composed by engineers and operators from different company sectors. The key issue of concern was the analysis of possible undesired scenarios that could imply on contract shortfalls, the evaluation of possible maneuvers, taking into account best gas delivery allocation.

Contingency plans, elaborated for failure scenarios, provide among other issues, time and volumes to be shed. Those parameters compose input used for gas network reliability studies.

The ability of being capable of dealing with undesired or crisis scenarios, based on suitable anticipation levels, is, nowadays, a highly valuable attribute to be presented by competitive corporations, for best crisis management and prompt recovery response. Contingency plans, compose a by-project of the reliability gas supply study. It constitutes an essential input for reliability modelling of gas supply chain.

3.1.5. Results and Conclusions of Supply Chain Modelling

The presented modelling was developed for the evaluation of gas chain security of supply, pointing out its vulnerable points (´bottle-necks´) and proposing optimization measures to be adopted, with due anticipation, so that to assure production and business continuity.

Complex reliability models were used to model gas supply network, from gas sources to final costumers, tracking events or failures scenarios that could occur and result on undesired losses, contract shortfalls, and penalties.

Some illustration examples of gas security of supply modelling results (regarding data confidentiality) are presented in figures below.

TARO results can provide the calculation of average production efficiency values over a period of time for overall integrated gas network, as illustrated on figure 1. Main contributors for supply chain efficiency losses can also be identified (figure 1), as well as, efficiency losses by asset (figure 2) [9], [10].

Local and network inserted average efficiencies of gas processing units are shown in figure 3. Local efficiency was calculated considering individual unit performance, e.g., as an individual player in the whole gas supply chain. Then, unit performance was evaluated, considering its inclusion on network modelling and its performance regarding offer and demand profile conditions.

For each asset, critical elements can be identified, as exemplified in figure 4, considering one of the processing gas units analyzed. Those represent the ones that most contribute to local efficiency loss. In that specific case, turnaround policies, valves, horizontal vessel, external supply energy, furnace failures, among others, compose critical elements or to losses.

Reliability modelling was performed in a detailed manner for every processing units, compression station, city-gate and pipeline that constitute gas supply chain. Later on, LNG units were also evaluated and integrated to the reliability model.

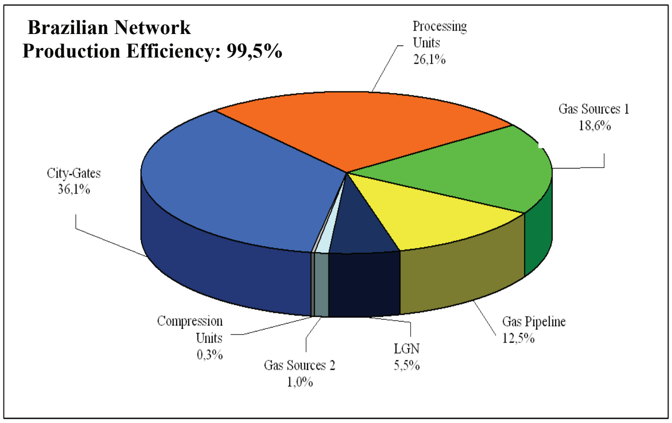

Figure 1 – Example of Results – Main Contributors to Production Losses

After the identification of critical contributors to losses, a sensitivity analysis was elaborated in order to evaluate the efficiency gains that improvement measures could provide.

Figure 5 illustrates an example of an evaluation of optimization measures that was carried out in one of the studies, and their associated production efficiency gains.

For each one of the proposed improvement measures, TARO software was used and a cost benefit analysis was carried out, considering the trade-off between investment costs (CAPEX), operational costs (OPEX) and revenue losses and penalties (*LOSTREV*). Cost benefit analysis is commonly performed with the purpose of prioritizing investments, promoting best allocation of resources and loss reduction.

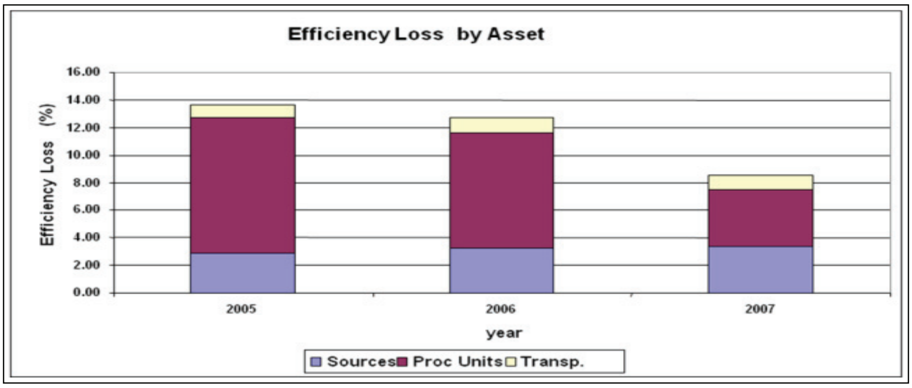

Figure 2 – Example of Results - Efficiency Loss by Asset

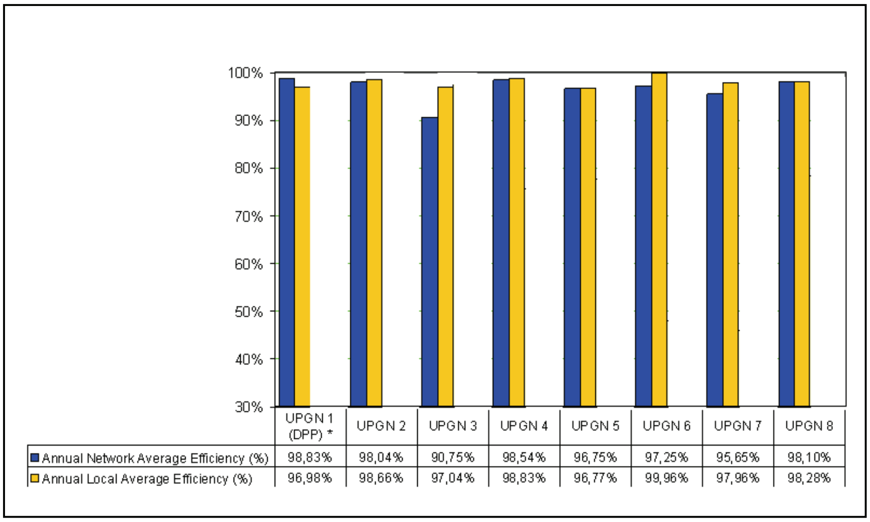

Figure 3 – Example of Results - Average Productive Efficiency- Gas Processing Units

It is important to highlight that the reliability modelling of supply chain requires, as input, lots of information and also the commitment of different areas.

The study constitutes, besides a powerful tool for decision making processes, a way of positive integration through all supply chain players.

Contingency plans that were intended merely to be an input for reliability study, turned to be an important tool for the operational team, providing support for decision making processes and for the establishment of strategies, based on the anticipation of failure scenarios.

Those kind studies should be carried out in a continuous and systemic manner, thinking about future supply network planning and for assuring production goals, and business continuity.

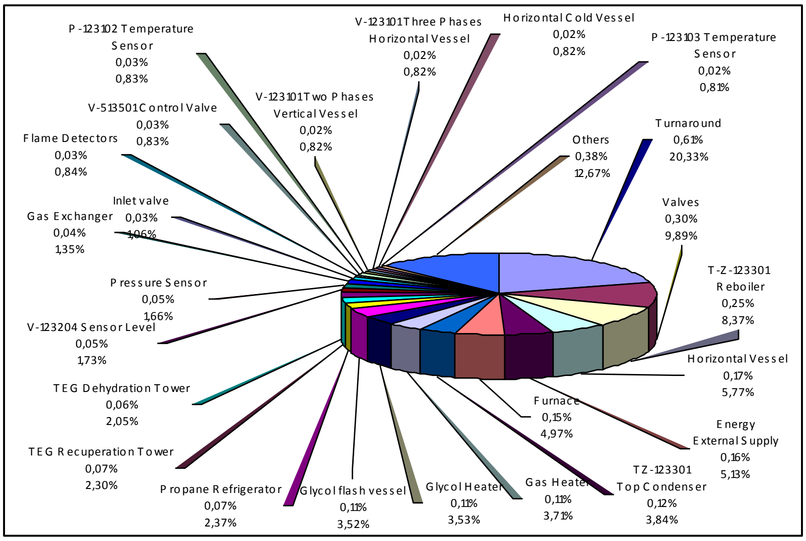

Figure 4 – Example of Results - Resu lts – Critical Elements of UPGN 1

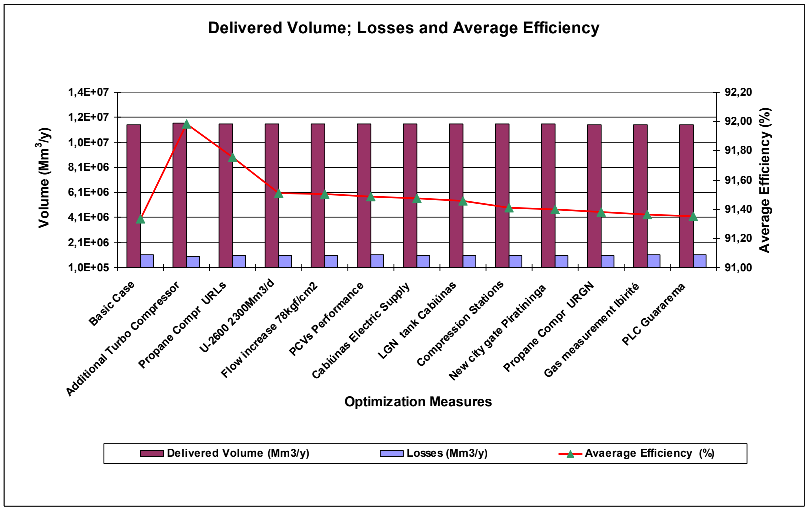

Figure 5 – Example of Results - Optimization Measures Evaluation

4. Final Conclusions

Reliability and risk management is an essential part for the conception and implementation of Business Continuity Management Programs.

As mentioned in this paper, the modelling of supply chain can be extended, amplifying the evaluation scope of risks that could compromise security of supply. It was mentioned that further studies were performed, considering the evaluation of the adoption of gas storage systems and the LNG supply logistics analysis. Both have significant impact on business continuity.

Besides infrastructure related failures, crisis scenarios, associated to national and international economic, social, political, commercial political, financial and scarcity issues should be addressed and treated and contingency plan conceived with due anticipation.

It is possible to address probabilities of occurrence to all of them and to evaluate the associated impacts, gathering suitable expertise.

Once more, it is important to highlight the need of necessary anticipation for the identification of all scenarios that could impact business continuity, here including the ones that could impact safety and environment, and the elaboration of contingency plans, considering due training, exercising, change management, so that the organization be ready for prompt response.

Risk assessment, RAM analysis, reliability centered maintenance, risk based inspection and human reliability techniques have to be considered as key support tools when thinking about business continuity management programs.

Organizations can rely on those tools to compose the best framework and practices, regarding business continuity goals, the best allocation of efforts and resources, aiming to mitigate losses and to proper respond during the occurrence of crises scenarios.

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