



Bow-Tie analysis

The benefits of the graphical representation of a Bow-Tie analysis versus traditional HAZOP - What-if methodologies

October 21, 2019

AGENDA

1. Safety Moment
2. Bow-Tie vs. HAZOP / What-if
3. HAZOP
4. Bow-Tie
5. HAZOP output
6. Bow-Tie output
7. Quantifying Bow-Ties
8. Bow-Ties as a training tool
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10. Questions



Why PSM in Canada?

CSA Z767 Process Safety Management definition

Process safety management (PSM) is the application of management principles and systems for the identification, understanding, avoidance, and control of process hazards to prevent, mitigate, prepare for, respond to, and recover from process-related incidents. These principles and techniques may be applied across industry sectors.

All process hazard analysis techniques have their strengths and weaknesses. It is important to understand these and to mitigate them during the review.

For example, HAZOPs look at single pairs of events, they do not handle interactions between different parts of the system.

Event trees and **Fault trees** are better suited for these interactions.

A HAZOP study looks at what is on the P&ID, and thus address poorly those activities and operations that do not appear on the drawings.

Not one PHA methodology can claim to uncover all hazards in a process. It is essential that other relevant studies are coordinated for the overall program effectiveness.

The system is broken down into nodes, and guide words are applied

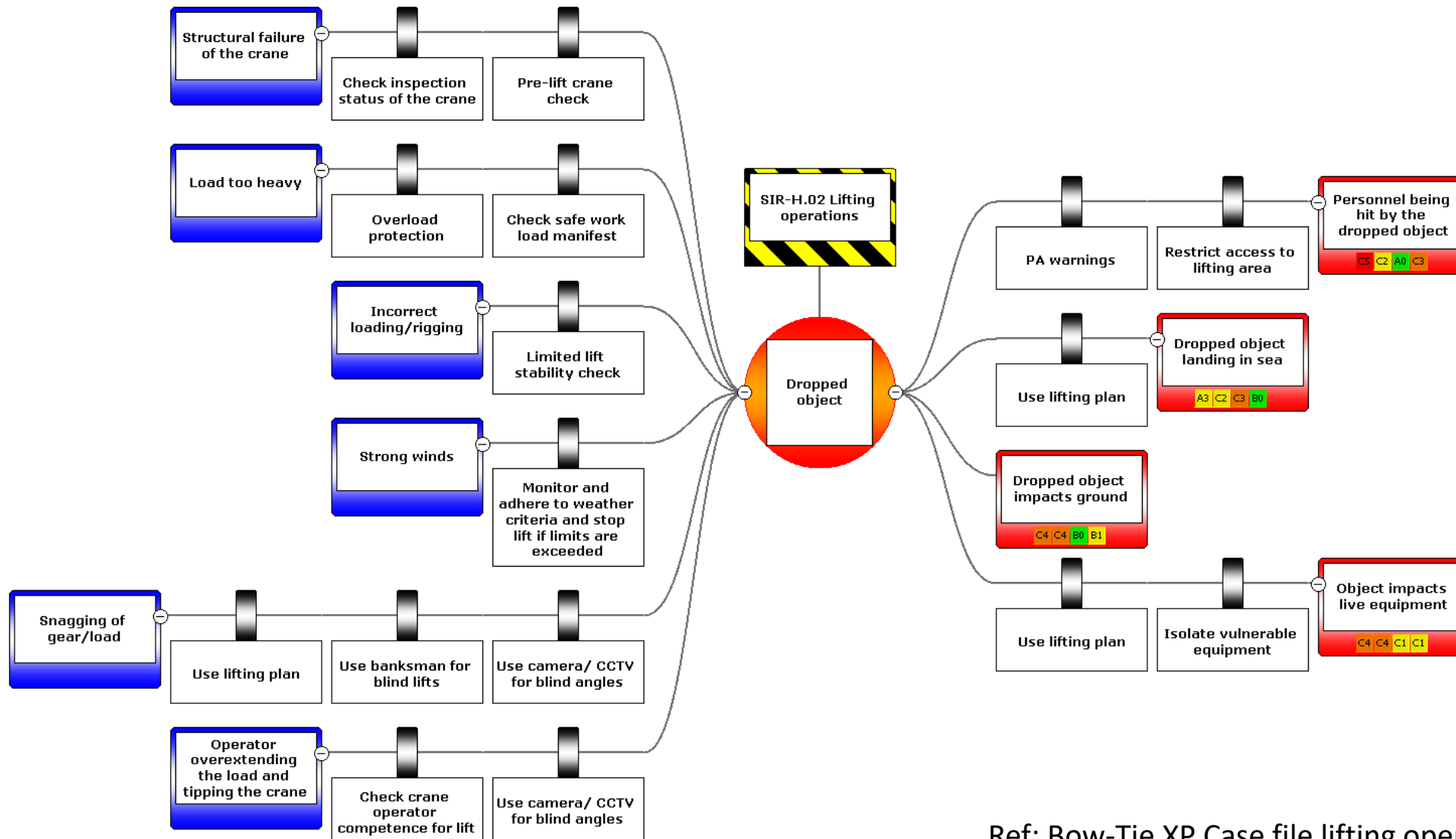
High Flow
Low/No flow
Reverse/Misdirected flow
High Pressure
Low Pressure / Vacuum
High level
Low level
High temperature
Low temperature
Impurities
Loss of utilities
More reaction (runaway)
Less reaction (loss of reaction)
Etc.

The HAZOP is a well-structured approach that relies less on team skill than What-if's.

HAZOP is an industry-accepted methodology that yields good results.

These guide words will yield a report of hundreds of pages for complex systems.

Good tool to understand specific scenarios, hard to get an overall picture



As HAZOPs have evolved from the early 60s to include rules, such as unmitigated risk evaluation to understand the number of safeguards required, so too have Bow-Ties.

Shell is the first large industrial company to have implemented Bow-Ties in its PSM process. Shell Global Solutions train its practitioners to this methodology.

Bow-Ties and CCPS

With the growing interest in applying Bow-Ties, and the many ways they were applied, the CCPS decided to develop a book capturing Bow-Tie best practices.

BOW TIES in RISK MANAGEMENT

A Concept Book for Process Safety



Step

1. Identify hazard

1. In a HAZOP, the node is often the HAZARD lifting of heavy object

2. Identify top event

2. Often loss of control – dropped object

3. Identify threats

3. What failures may lead to loss of control

4. Evaluate consequences

4. What is the unmitigated risk of loss of control

5. Identify preventive barriers

5. What safeguards are present to prevent the top event

6. Identify recovery barriers

6. Release detection or post release mitigation, i.e detectors

7. Identify escalation factors

7. No equivalent

8. Identify escalation factor
barriers

8. No equivalent

In HAZOP worksheets, you may find multiple causes that will lead to loss of control dropped load;

- High wind
- Too much mass
- Structural failure

These failures will be found in several nodes on multiple pages

All information may be presented in one or a few Bow-Ties

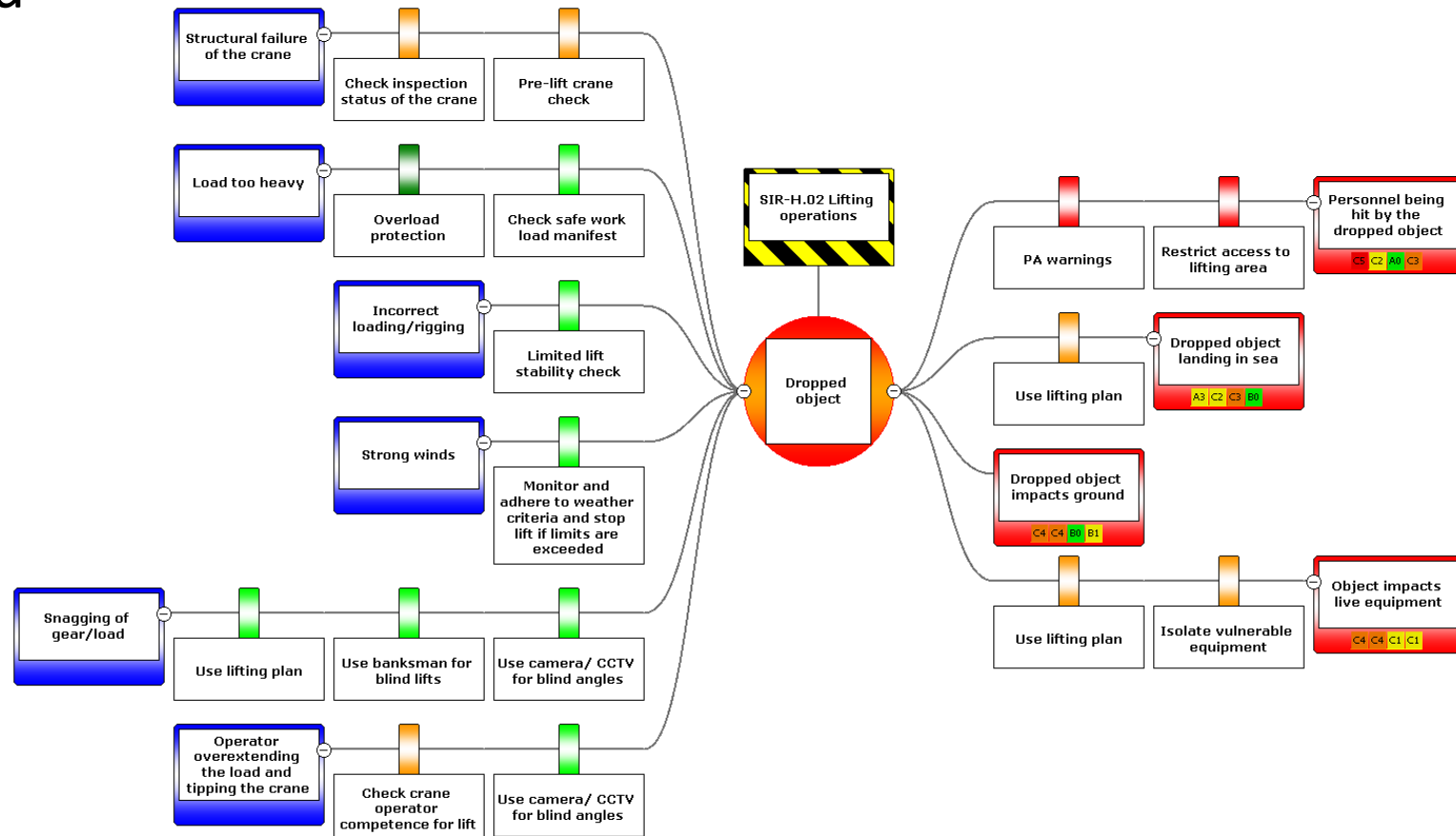
The color coding capability can show different statuses of the barriers, in this case barrier effectiveness:

Dark green – very good

Light green – good

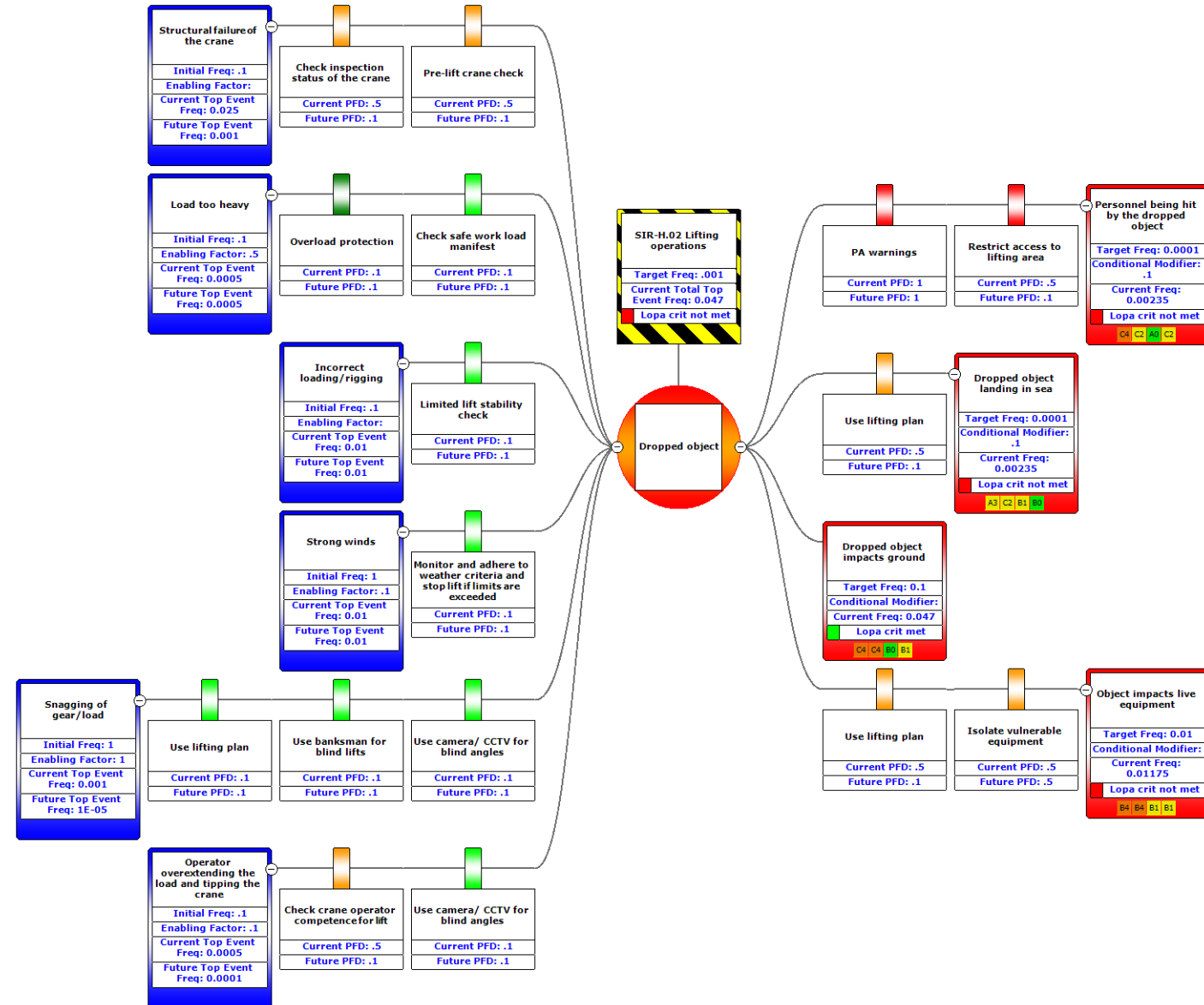
Orange – poor

Red – very poor



By applying the same LOPA rules as in HAZOP (i.e. barrier independence) you will get the same results.

With the Bow Tie, you get an aggregate risk, as well as the risk contribution of each threat (failure of a single control, i.e. level control)



Bow-Ties then become a good training tool, showing:

1. What the safeguards are – Barriers
2. The status of barriers
3. Escalation factors and controls if any
4. Maintenance tasks with frequency
5. Required knowledge of people maintaining the different barriers
6. Weak points that should be addressed first:
 - A HAZOP will give recommendations, but it is hard to see which has the highest contribution to risk reduction
 - If the Bow-Tie review includes a LOPA, we can see the contribution of each improvement (recommendation)

Who is Guy Brouillard?

- PSM Manager @ GCM Consultants
- CSChE – PSMD member
- CSA Z767 Technical committee member
- Actively participating in Z767 rollout

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Thank you!

Questions?

