Communication and Coordination Failures in the Process Industries

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Jason Laberge
Honeywell Advanced Technology
Golden Valley, MN

Peter Bullemer
Human Centered Solutions
Independence, MN

Stephen Whitlow
Honeywell Advanced Technology
Golden Valley, MN

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Introduction and Motivation

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- **Process industries (Wikipedia, 2008)**
  - **…involve extraction of raw materials, their transport and their transformation (conversion) into other products by means of physical, mechanical and/or chemical processes using different technologies…**
  - **Examples: refineries, chemical plants, gas facilities**

Introduction and Motivation

- **Communication and coordination breakdowns are an important source of failures in the process industry (Laberge & Goknur, 2006)**
  - **Weak leadership**
  - **Poor control room design**
  - **Closed communication culture**
  - **Deficient work processes**
  - **Situation and work environment constraints**

- **Nature of these breakdowns and their relative frequency is unknown**

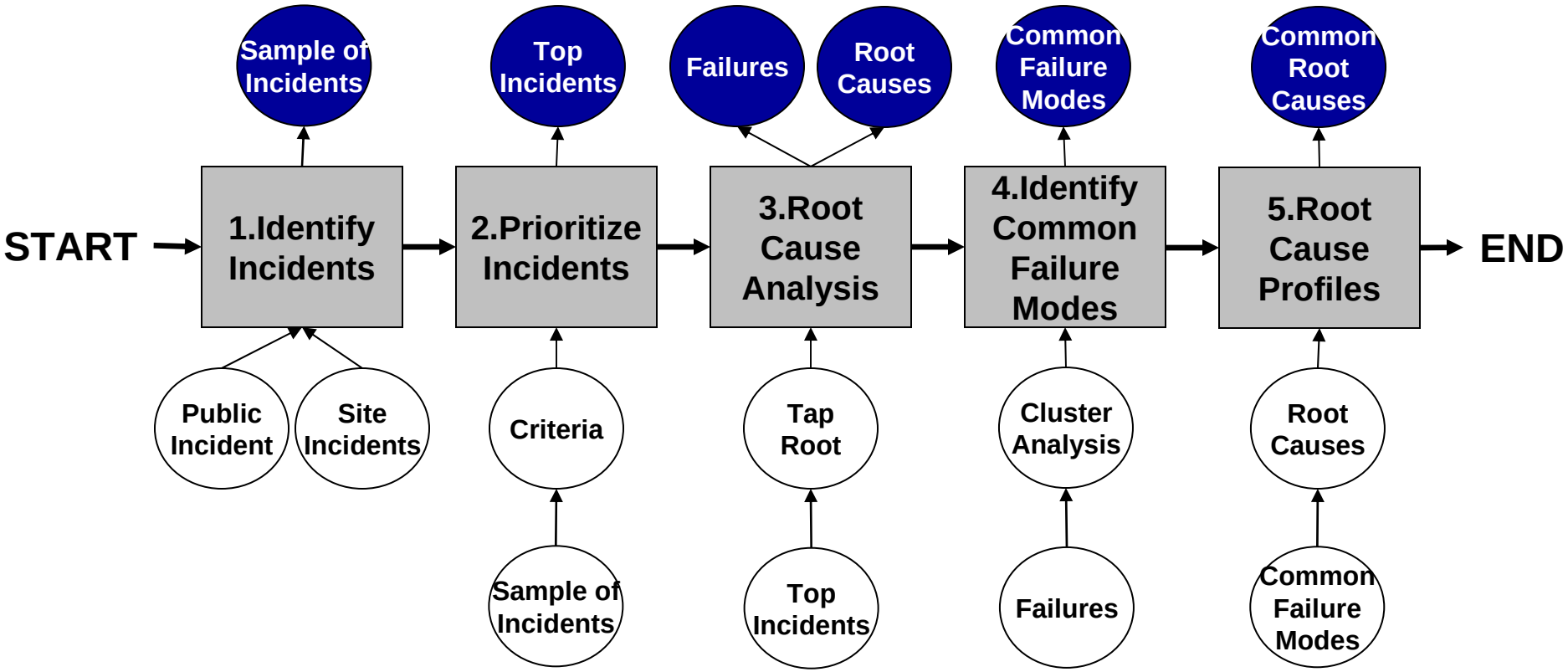
Research Objective

- **Identify common communication and coordination failures and root causes in the process industries**

- **Analyze incident reports to determine:**
  - **Failures = what happened, nature of the breakdown in communication and coordination**
  - **Root causes = reasons why the failure occurred**

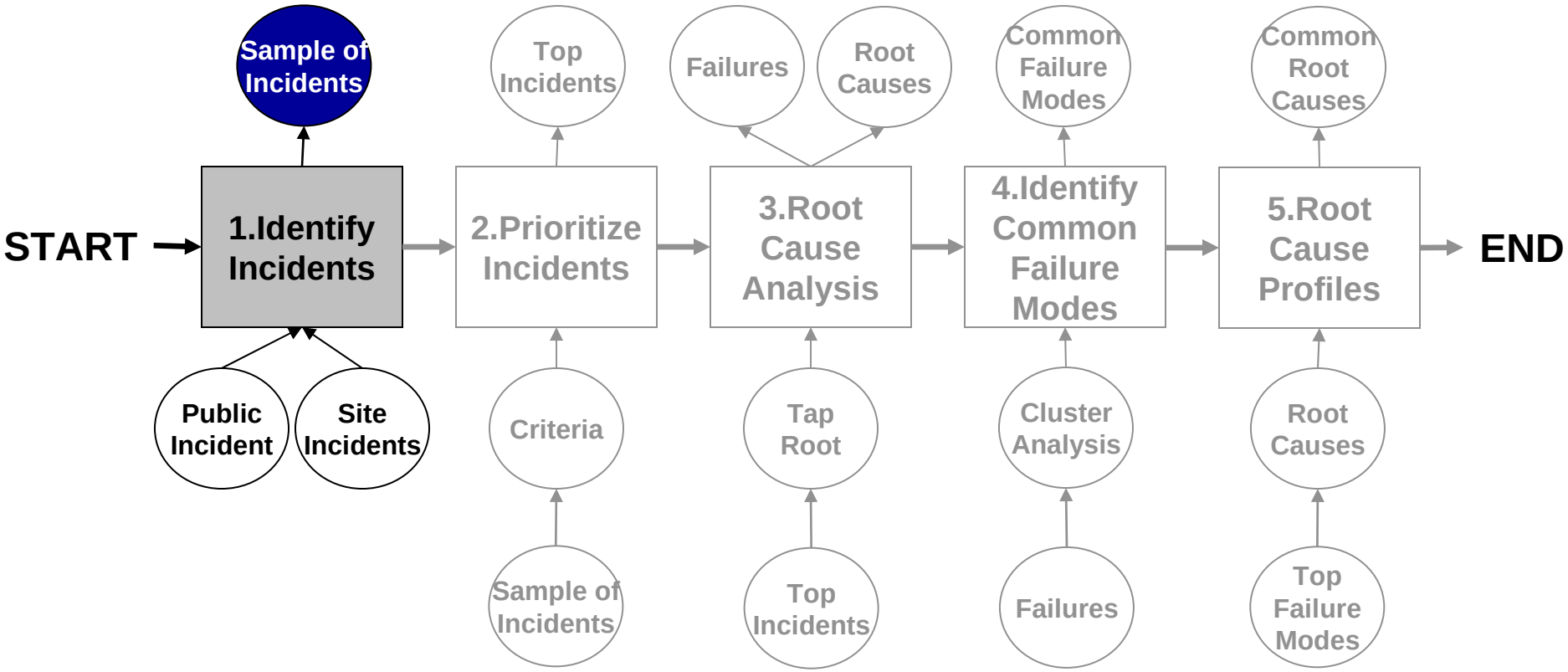
- **Why analyze incident reports:**
  - **Incident reports provide a rich description of how failures and root causes contribute to real-life accident**
  - **Precedent in other industries to analyze incident reports for human factors issues (e.g., aviation, transportation)**

Research Process - Overview



A systematic research approach was developed

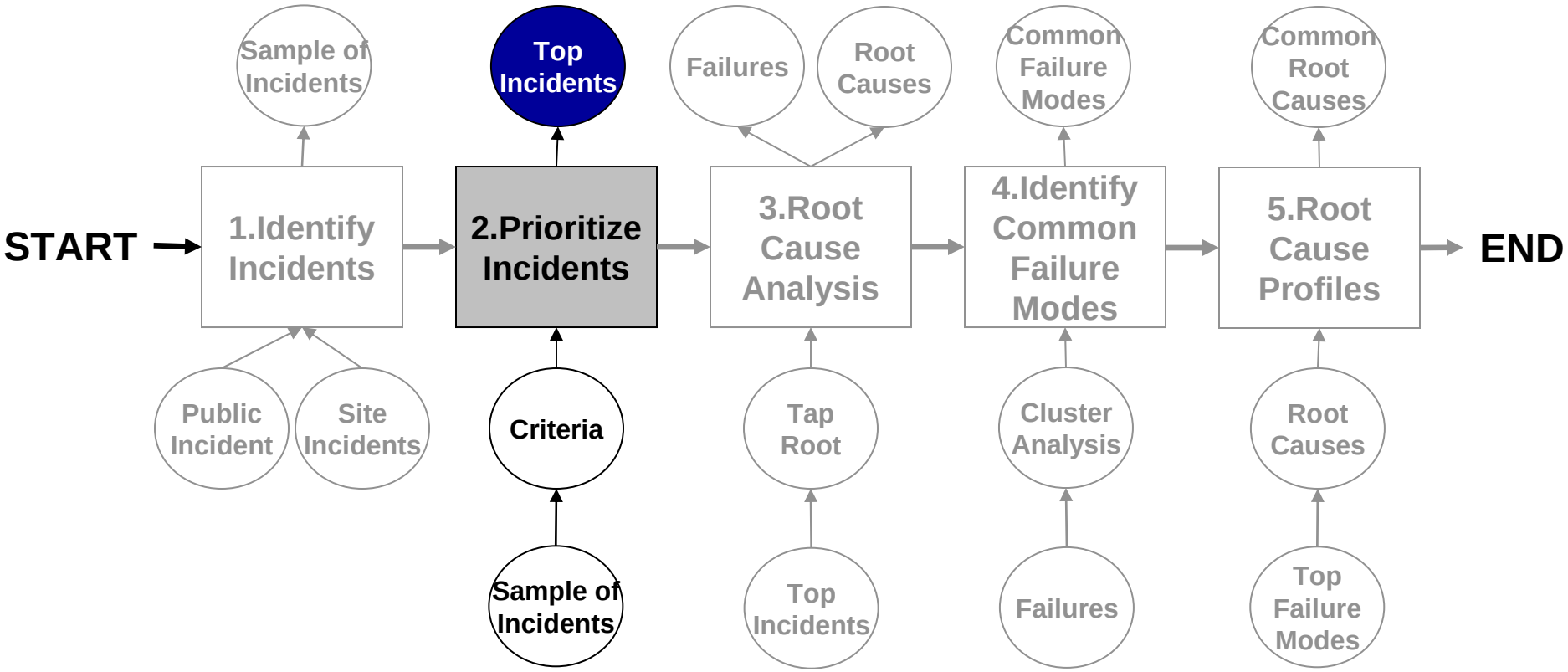
Methods – Identify Incidents



Methods – Identify Incidents

- We could not analyze all the available incident reports
  - Our goal was to identify a sample of incident reports that represent diverse process industries from multiple public and private company sources
- Search criteria:
  - lead to an abnormal situation (i.e., injury, production interruption, equipment damage, environmental release)
  - be described in enough detail so that the sequence of events, conditions, and outcomes could be understood
  - have an identified (documented in the report) or hypothesized (based on our own judgment) communication and coordination failure
- Search results:
  - 32 public incidents
  - 8 site proprietary incidents

Methods – Prioritize Incidents



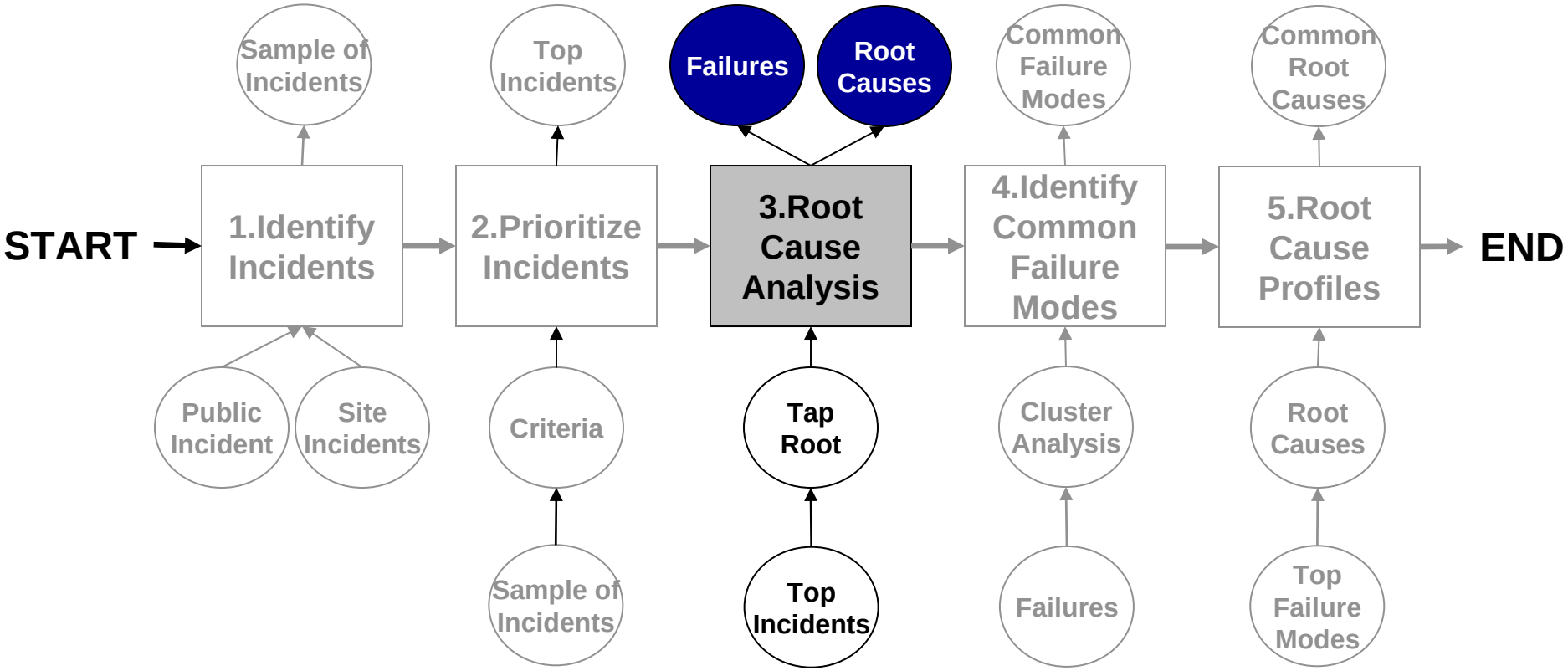
Methods – Prioritize Incidents

- **The incidents were subjectively rated by the research team and were approved by industry representatives:**

Failure 1 = Latent failure 3 = Contributing failure 9 = Causal failure	**Detail** 1 = Insufficient detail (website) 3 = Moderate detail (case study, digest) 9 = Complete detail (full incident report)
Industry 1 = General industrial 3 = Nuclear, Offshore 9 = Refining, Chemical	**Recency** 1 = Before 1990 3 = 1990 to 1999 9 = Since 2000

- **Based on this rating scheme, 14 incidents (10 public, 4 company proprietary) were selected for analysis**
  - **This sample size was considered sufficient to establish a <u>preliminary</u> understanding of the basic causes of incidents associated with communications and coordination failures**

Methods – Root Cause Analysis



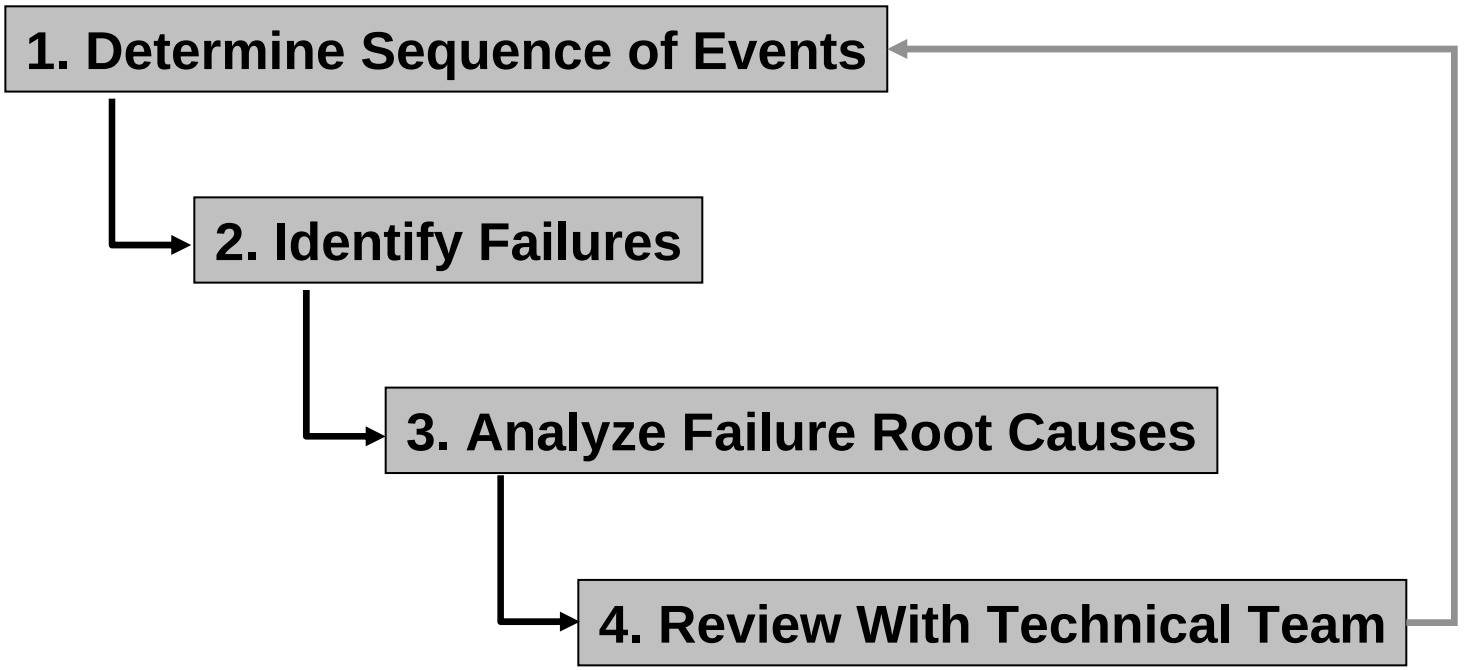
Methods – Root Cause Analysis

- **TapRoot® (www.TapRoot.com) was used to complete the root cause analysis (Paradies & Unger, 2000)**

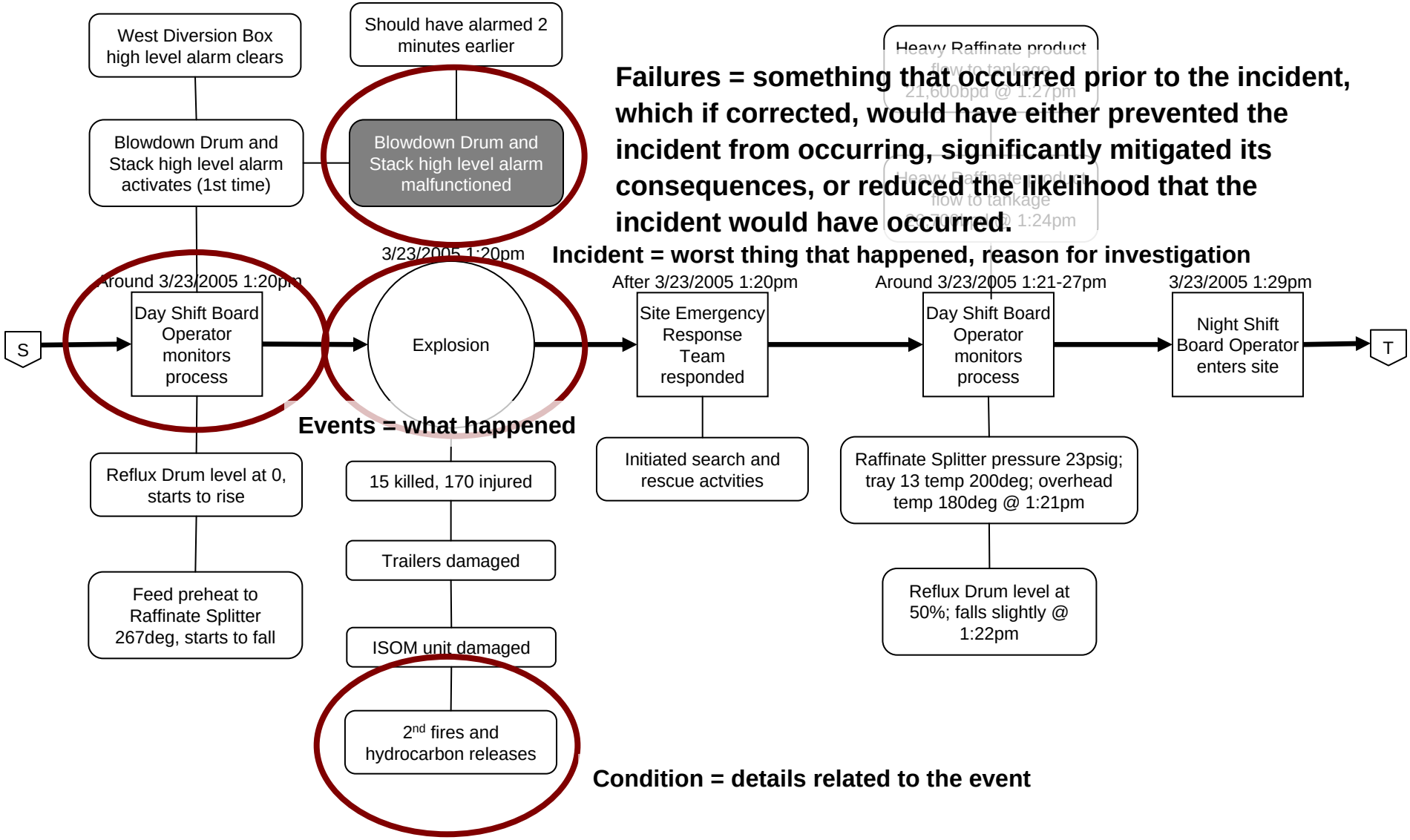
- **We used TapRoot® because it:**
  - **is a structured approach to incident investigations**
  - **is based on sound process safety management principles and lessons learned (CCPS, 2003)**
  - **is systematic and work process driven**
  - **is robust and well grounded in human factors and systems**
  - **has credibility in both research and industry settings**
  - **is generic and not specific to a domain or problem space**

TapRoot® is robust for this kind of analysis

Methods – Root Cause Analysis



Methods – Root Cause Analysis



Methods – Root Cause Analysis

- **A conceptual model was developed to provide common operational definitions for failures (Laberge, 2008)**
  - **Communication failures are any problem involving the content, type, timing, or medium of communication**
  - **Coordination failures are any problem where two or more people must successfully interact to complete a job**

Communication and coordination failures are broad

Methods – Root Cause Analysis

- **Each failure was subject to detailed root cause analysis using the TapRoot ® root cause tree**

Level	Question	Answer	Result
1.Communication	**If people had communicated more effectively, would the issue have been prevented?**	**YES, MORE EFFECTIVE COMMUNICATION OF PROCESS SAFETY INFORMATION**	**Continue to level 1.1 in "Communication" branch**
1.1 No communication or not timely	**Was an issue caused by failure to communicate?**	**YES, MANAGEMENT FAILED TO COMMUNICATE PSM INFORMATION TO PERSONNEL**	**Continue to Level 1.1.1 in "No communication or not timely" branch**
1.1.1 Communication system need improvement (NI)	**Was the system inadequate?**	**YES, EMAIL USED BUT WAS INEFFECTIVE, COMMS DURING MEETINGS AND MEMOS W/SIGN OFF BUT NO PROOF WAS FOUND THAT THIS ACTUALLY OCCURRED**	**Root cause of failure**
1.1.2 Late communication	**Were communications provided too late because events happened too fast to allow time for communications?**	**NO**	**Exclude as root cause**
1.2 Turnover NI	**Did incorrect, incomplete, or otherwise inadequate verbal or written turnover of information during shift/watch relief cause or fail to prevent an error?**	**NO**	**Do not proceed down branch**

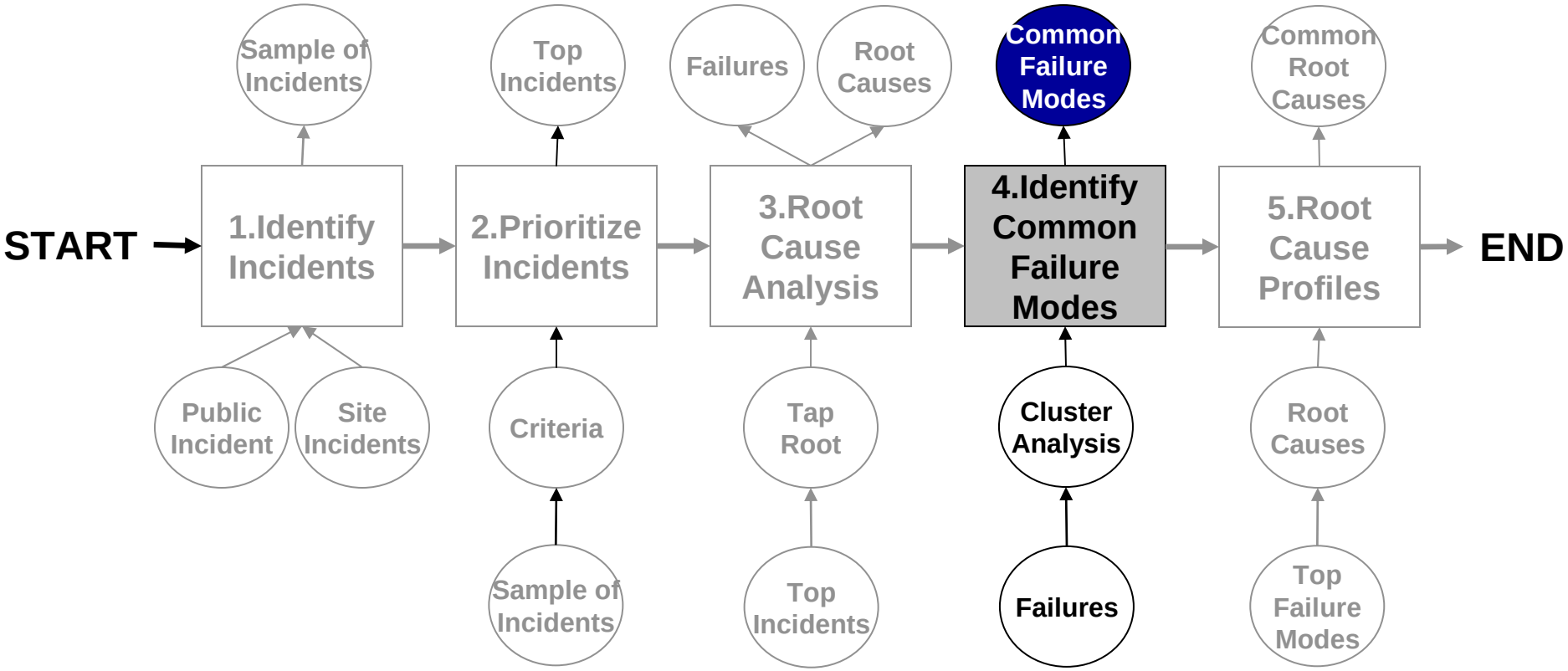
Methods – Root Cause Analysis

- Two investigation team members reviewed all the incident reports, SnapCharts®, list of failures, and root cause analyses

- The two-person team discussed differences of opinion and came to a consensus on the sequence of events, failures, and root causes before analyzing another incident

- This consensus process provided a quality control mechanism to increase the consistency of the results and the reliability of the findings across incidents

Methods – Identify Common Failure Modes



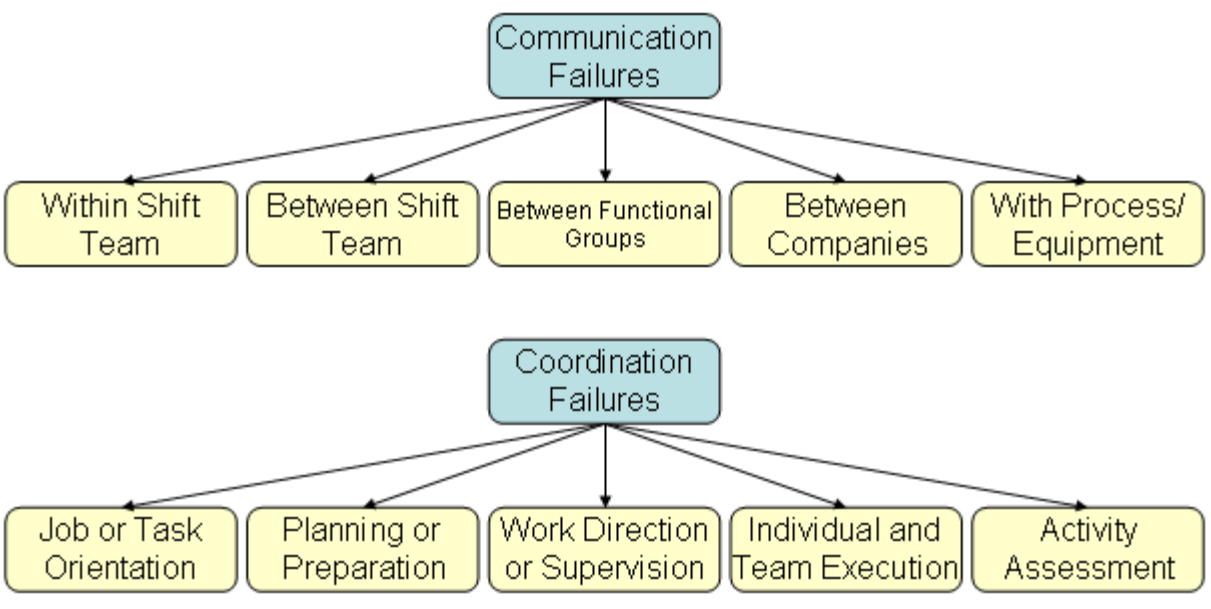
Methods – Identify Common Failure Modes

- **207 individual failures from all the incidents were clustered into common failure modes**
  - **Common failures highlight common problems that were shared across incidents**
  - **Common failures represent the shared problem elements that can be used to develop solutions to prevent future incidents**

Common failures = systemic problems for the industry

Methods – Identify Common Failure Modes

- **A taxonomy of failure modes was developed**

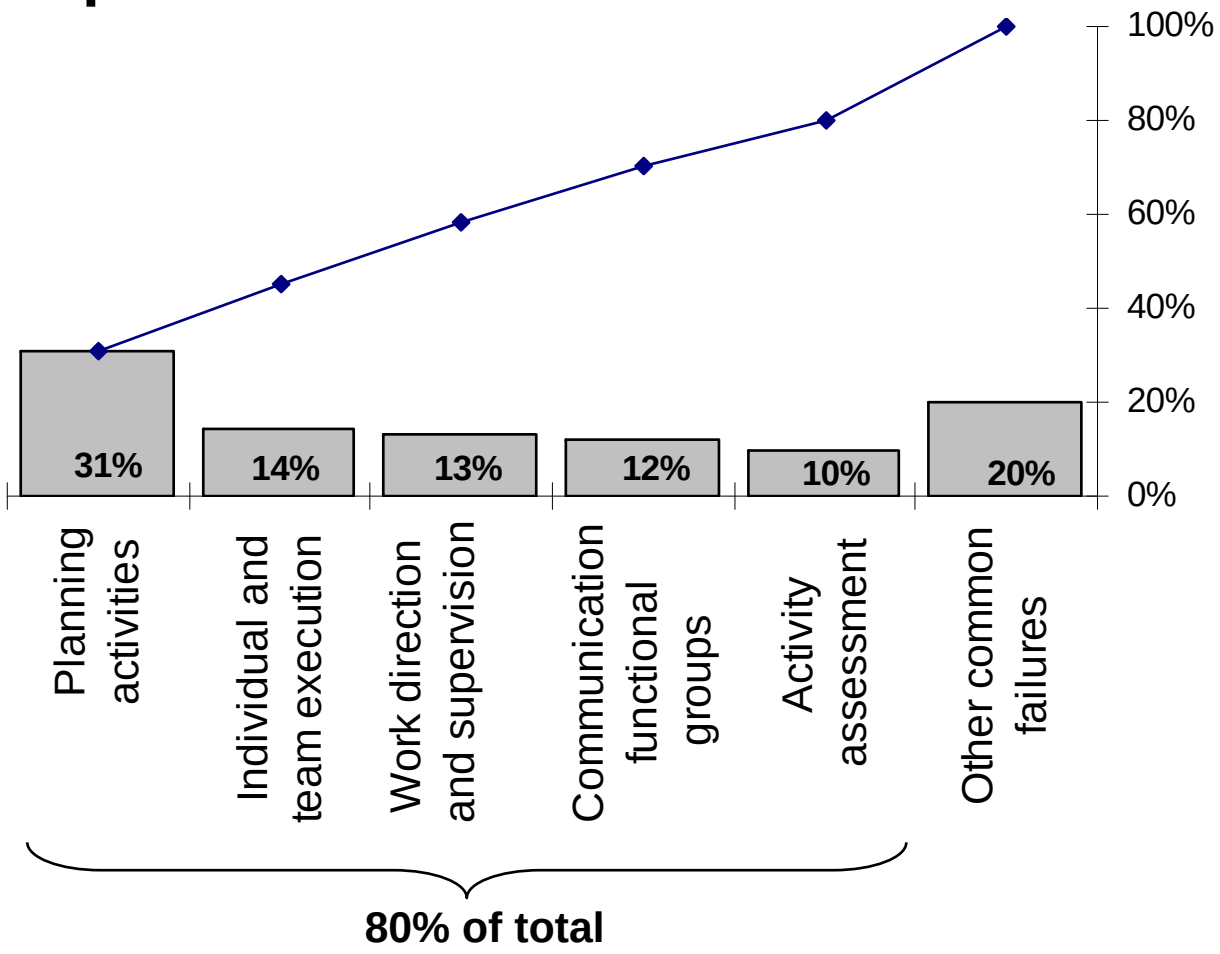


Common failure mode taxonomy was developed using a conceptual model (Laberge, 2008)

- **Four team members independently clustered the individual failures**
  - **Average agreement (inter-rater reliability) was 70%**
  - **The team discussed where there was disagreement and came to a consensus before proceeding**

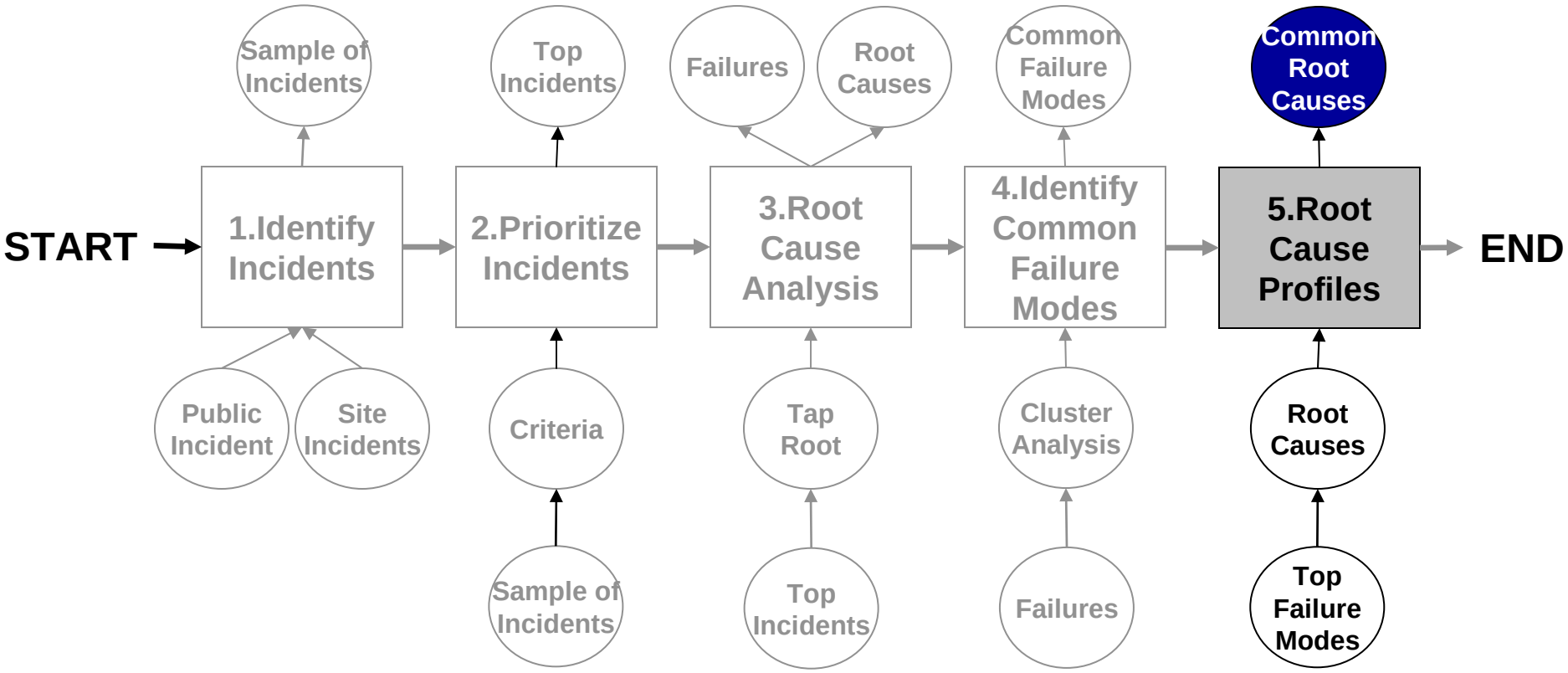
Results – Common Failure Mode Analysis

- **Top 5 common failure modes were:**



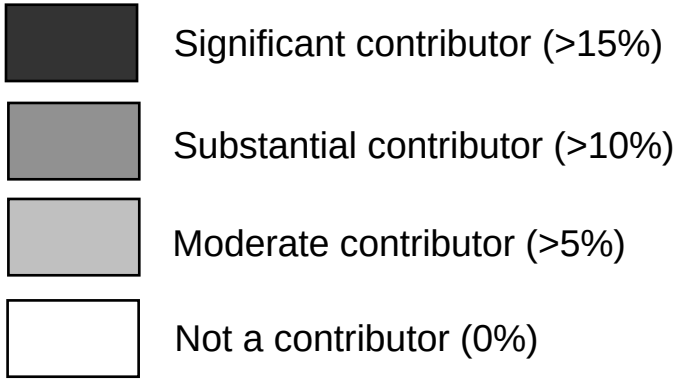
Coordination related failures are more common

Methods – Identify Common Root Causes



Results – Common Root Causes

- **Common root causes show why failures occurred across incidents**



Root Cause	Combined for Top 5 %	Planning activities %	Individual and team execution %	Work direction and supervision %	Communication between functional groups %	Activity assessment %
No SPAC	12.2%	20.4%	8.6%	7.8%		15.2%
Crew teamwork needs improvement	11.1%	7.4%	15.5%	17.6%	6.5%	12.1%
SPAC not followed	8.8%	7.4%	19.0%	7.8%		9.1%
No communication	8.4%	6.5%		5.9%	32.6%	
No supervision	7.4%		12.1%	19.6%		15.2%

SPAC – Standards, Policies, Administrative Controls

Discussion

- **Process industry companies interested in addressing the top 5 common failure modes should consider the following causes:**
  - **Ineffective standards, policies, administrative controls (SPAC)**
    - Enforcement, coverage, clarity, and accountability
  - **Lack of communication**
    - No communication particularly between management, leaders, and employees; poor communication systems
  - **Poor crew teamwork**
    - Not questioning problems, focusing on one problem and losing sight of overall status, person-in-charge leaves problems uncorrected
  - **No supervision**
    - Person-in-charge does not provide support, coverage, or oversight

Causes vary; comprehensive solutions are required

Discussion

- **The ASM Consortium is investigating the following solution areas to address the common failures and root causes identified in this project:**
  - **Team training (CRM-like)**
  - **Requirements for effective team communication and coordination**
  - **Best practices for leaders and supervisors**
  - **Collaboration technologies to support team coordination**
  - **Effective work processes (example of a SPAC) for team activities like work permitting, incident investigations**

Limitations

- **Incidents were mostly public from U.S. companies**
  - The sample may not fully represent the process industries
  - A new ASM® Consortium study is in progress to expand the sample size
- **TapRoot® is a subjective method**
  - Developed systematic research approach
  - Mitigated to some degree through consensus building
- **Incident reports were the only source of information**
  - The consensus building approach and the use of operational definitions for both root causes and common failure modes was a mitigation technique to ensure the analysis was as systematic and objective as possible

Future Research

- **Analysis that goes beyond communication and coordination activities to examine operations practices more generally**
  - Could identify relative causes for problems more generally
  - May identify additional research areas or solution opportunities

- **Compile and analyze near miss incidents**
  - A near miss is "…an occurrence in which an accident (that is, property damage, environmental impact, or human loss) or an operational interruption could have plausibly resulted if circumstances had been slightly different" (CCPS, 2003, p. 61)
  - Near miss reporting is a largely untapped source of information on failures and root causes (CCPS, 2003)
  - Other industries (e.g., aviation, medical) use near miss reporting to proactively identify problems and develop effective solutions before incidents occur

Acknowledgments

- Thanks to the HFES reviewers for their insightful comments

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- Questions?

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