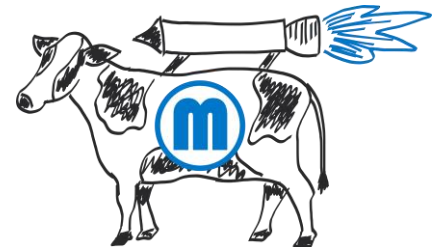




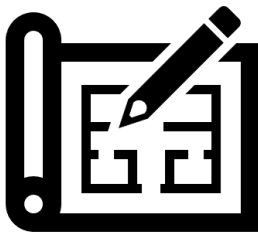
Improving Reliability through Failure Classification: Possible Implementation Paths

K. Loveday Glandon, Casey Eaton, Bryan L. Mesmer, PhD



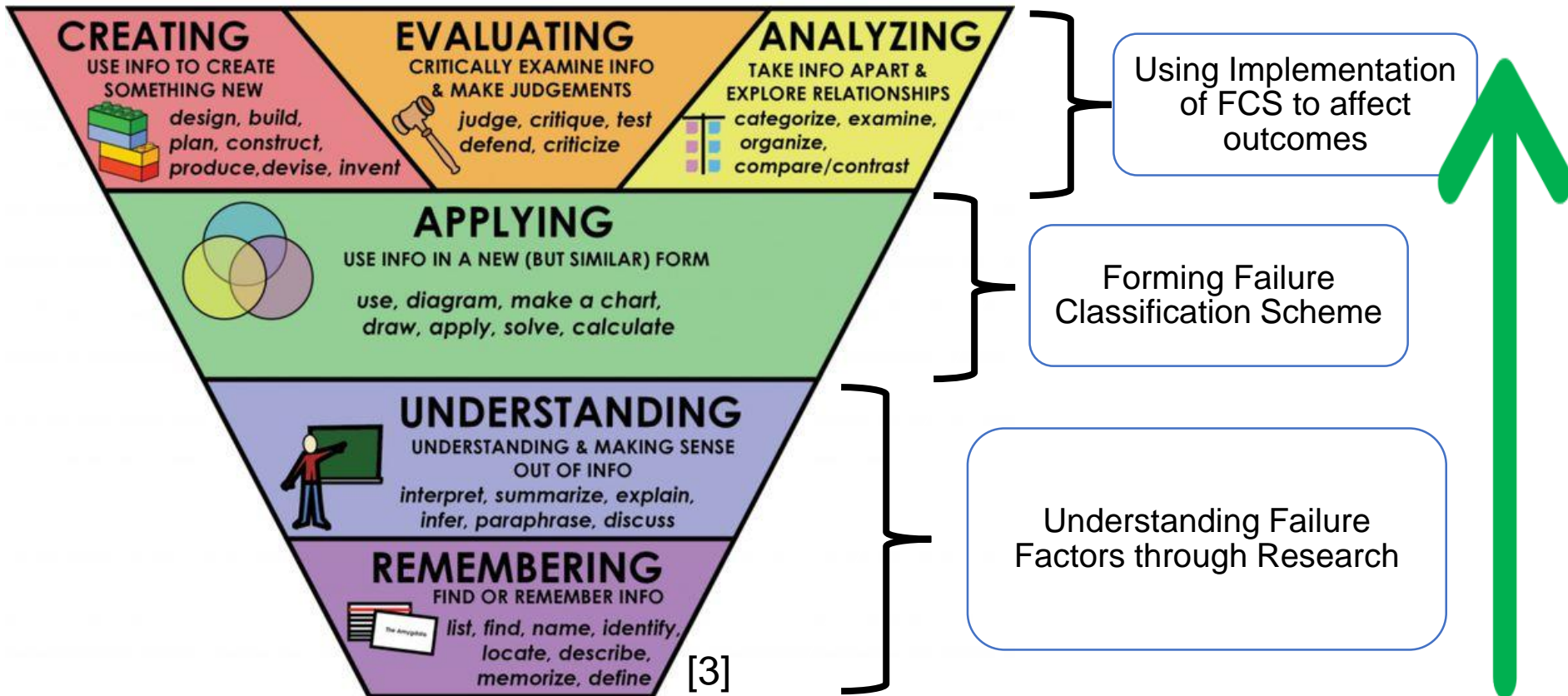
Introduction

- **What is a failure classification scheme (FCS)?**
 - “Failure classification schemes are systematic categorizations of failures. Schemes often categorize failures into the factors that cause failure or the types of failure.” [1]
- **What do we mean by Implementation?**
 - “the act of making something that has been officially decided start to happen or be used”[2]
- **Long-Term Goal:** Implementation of a comprehensive Failure Classification Scheme into NASA using digital engineering to prevent, detect, and ideally even predict failures.



Long-Term Goal

BLOOM'S TAXONOMY

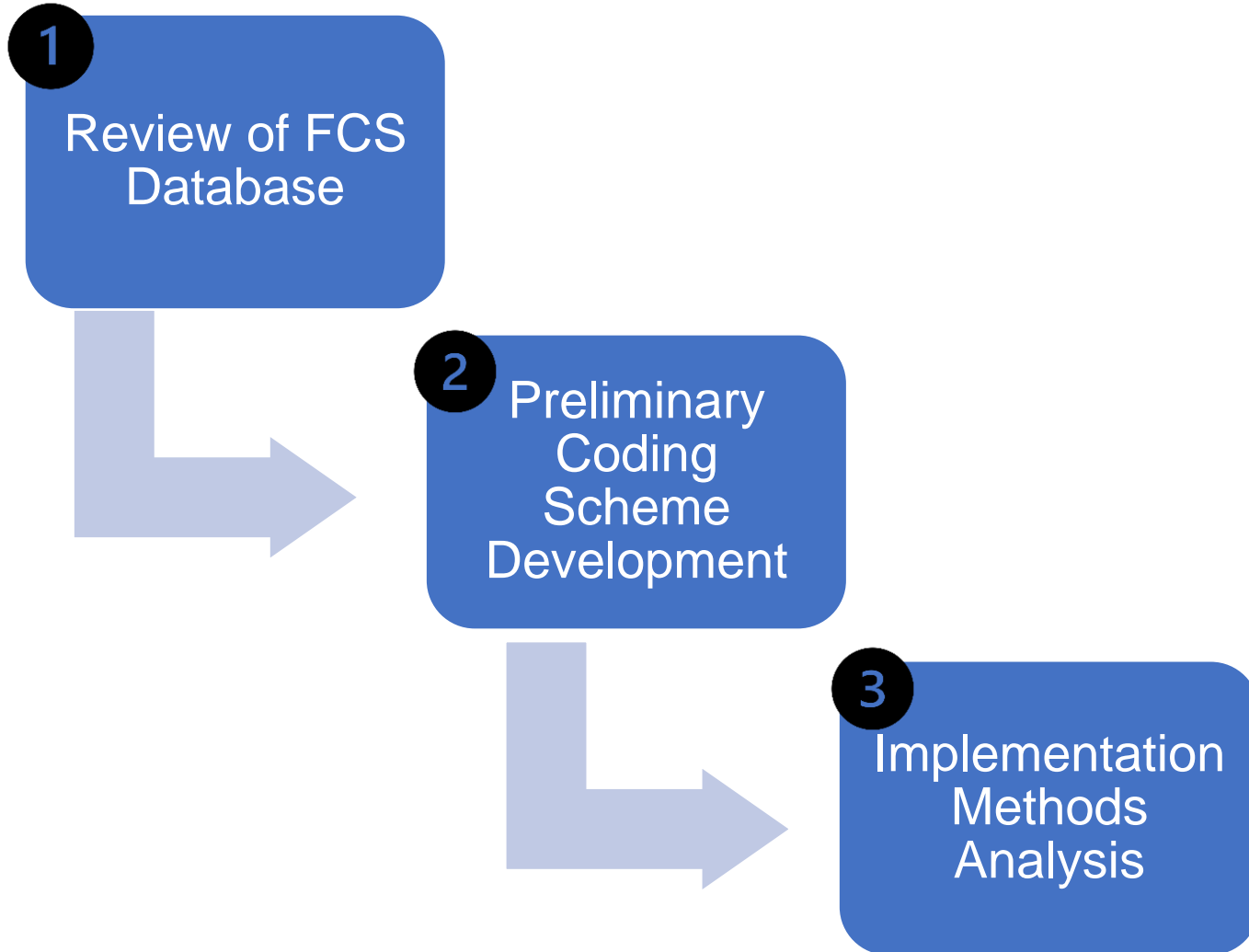


Research Questions

R1: In a collection of academic literature concerning Failure Classification Schemes, to what extent are they being implemented and how?

R2: What possible implementation paths can be identified to inform future work?

Methodology

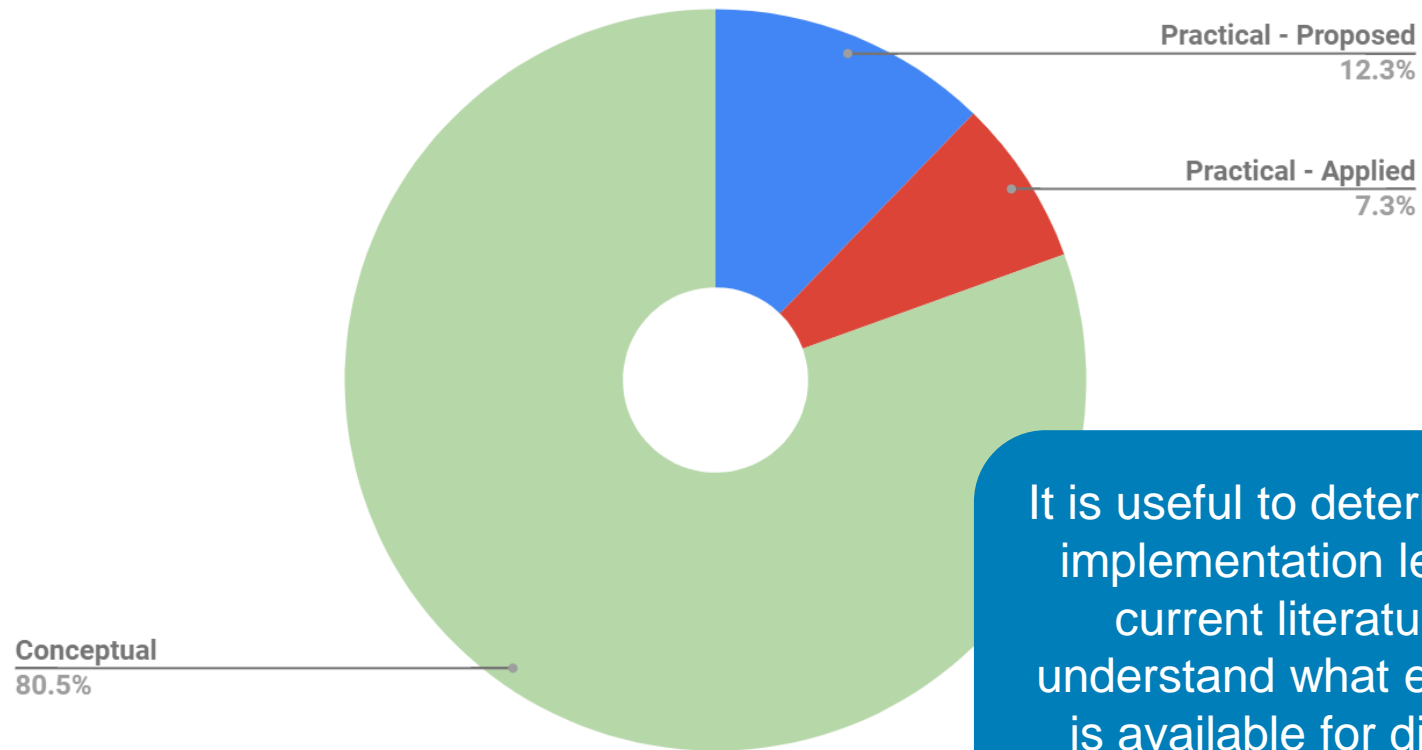


FCS Literature Category Definitions

Level 1: Conceptual

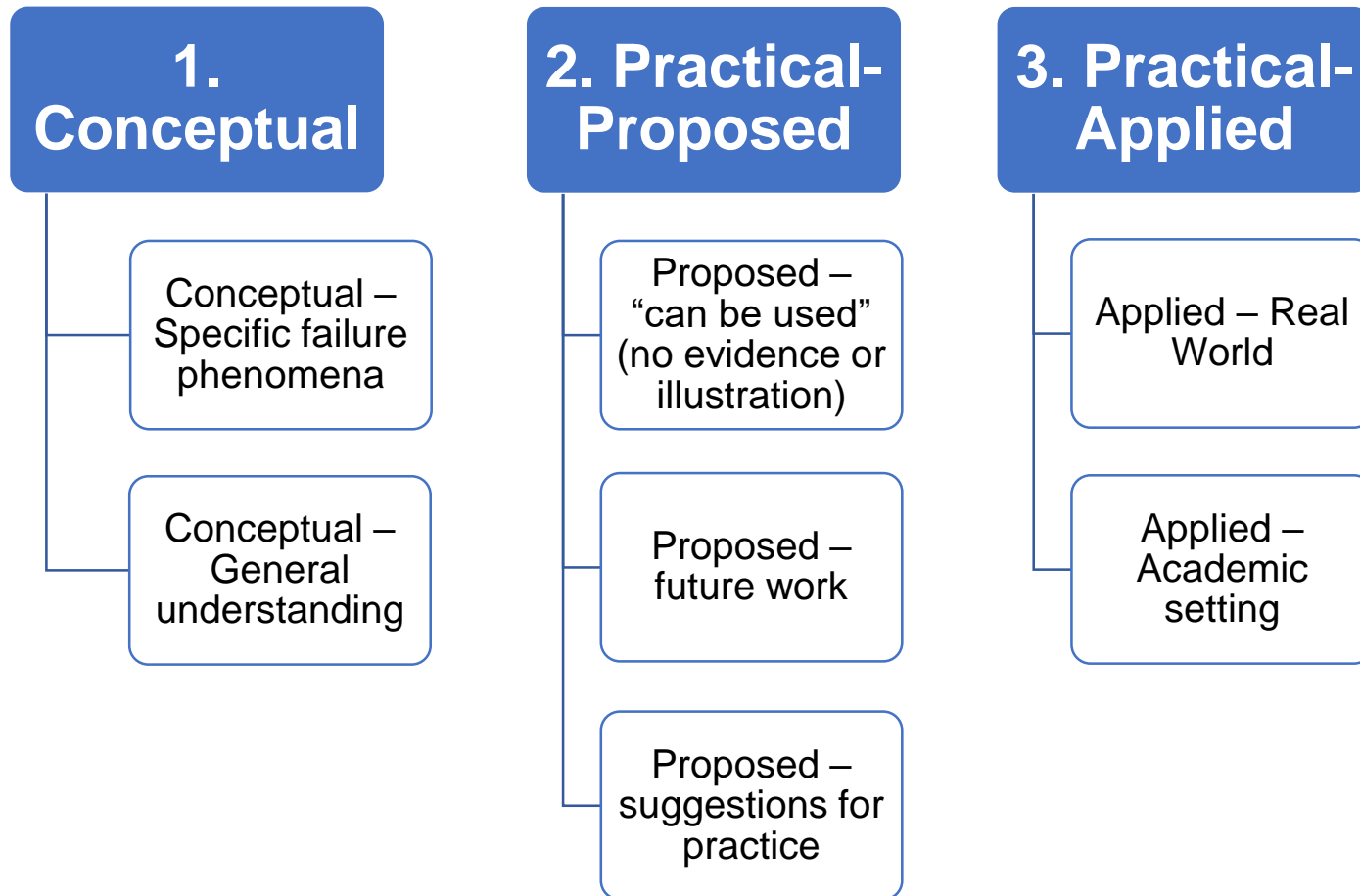
- Example:
 - “The primary focus is to address the various issues responsible for IT projects failure to **understand the root causes** of the failure.” [4]

FCS Database Initial Result Distribution



It is useful to determine the implementation levels in current literature to understand what evidence is available for different approaches.

Determined Sub-Categories

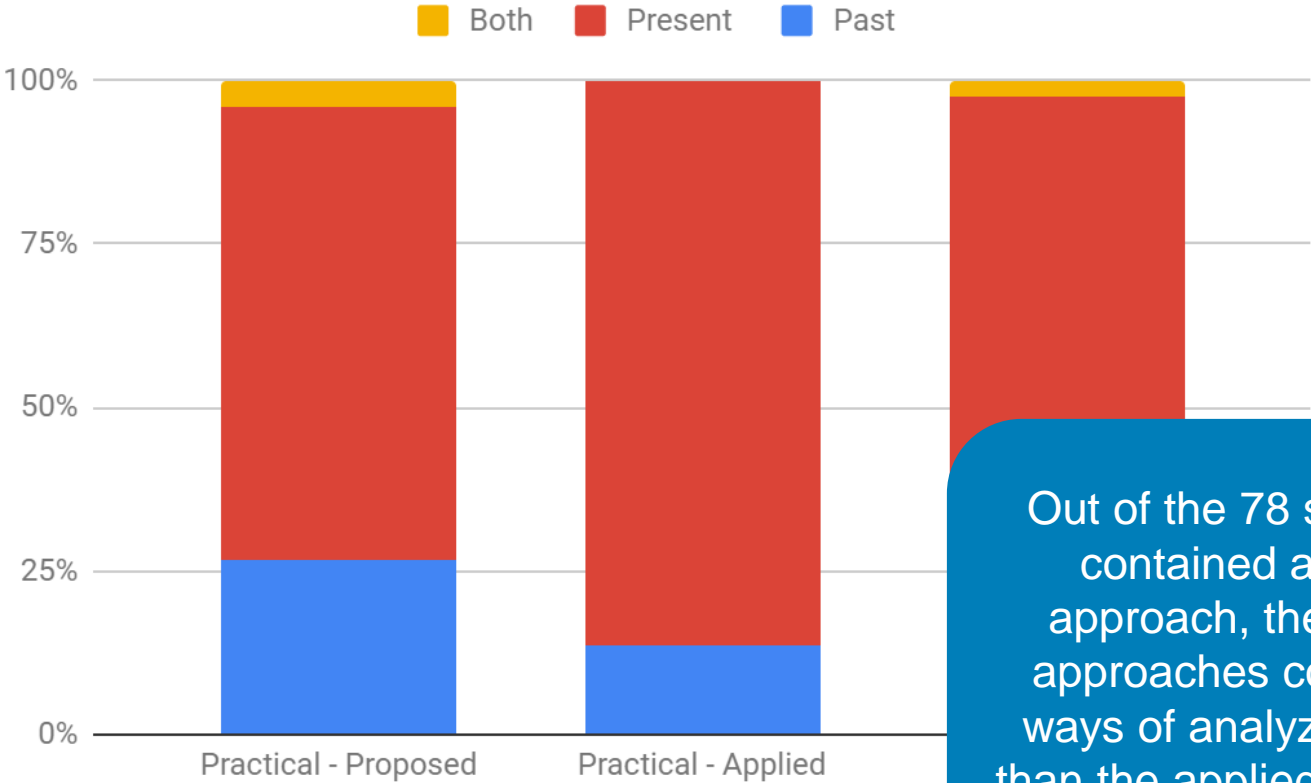


Implementation Path Considerations

- **Who is involved?**
- **When is it used?**
- **What data is needed, how is it collected?**
- **What tools are needed?**
- **What type of failure is addressed?**

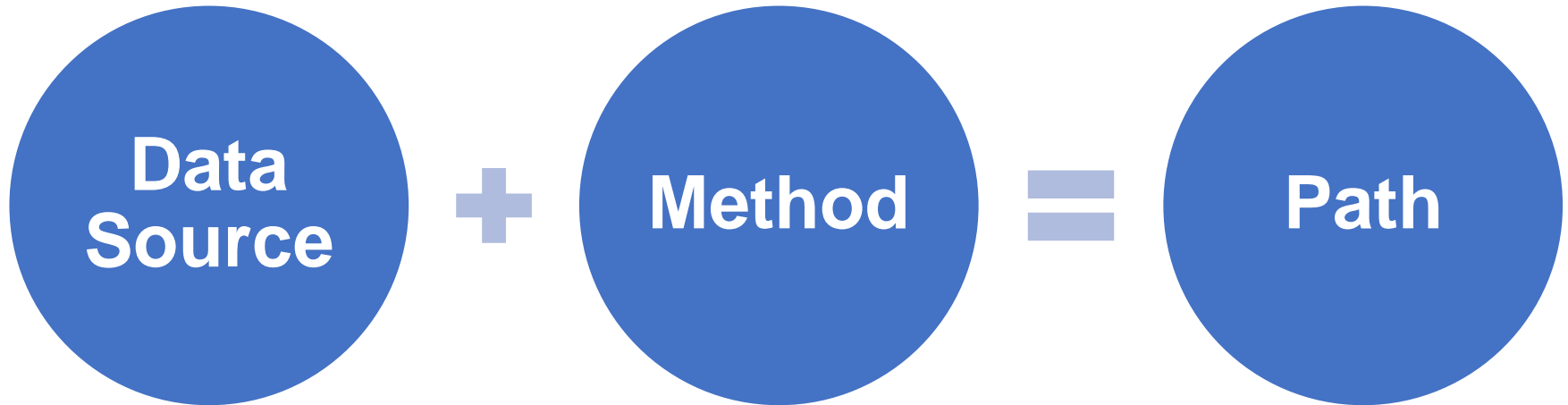


How many practical approaches analyze past data vs. current data?



Out of the 78 sources that contained a practical approach, the proposed approaches contain more ways of analyzing the past than the applied approaches.

Possible Implementation Paths



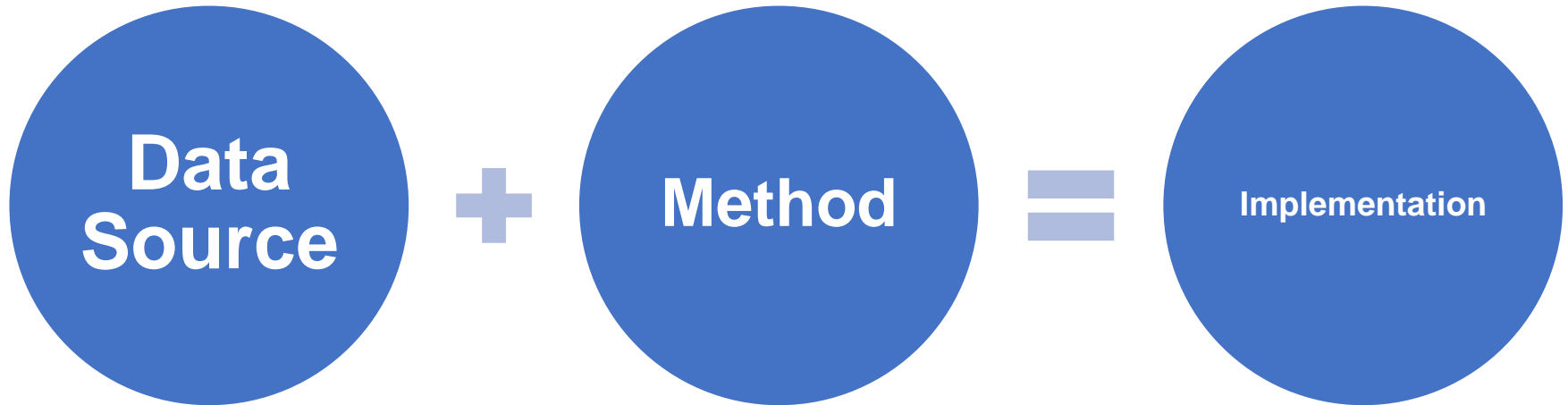
- Database of failure reports
- Survey/Questionnaire
- User Tagging
- Enterprise System Data
- System Data

- Categorization
- Statistical Analysis
- Machine Learning Algorithms
- MBSE
- Step by Step

Example 1

Source Title	“Common-Cause Failure Database and Analysis System: Event Data Collection, Classification, and Coding” [7]
Implemented How?	Used in U.S. commercial nuclear power industry to assess trends + common causes of failures, probabilistic risk assessment for future based on past
Implementation Level	Applied – Real World
Failure Domain	Equipment and plant failures
Data Input	Failure/reliability reports of past failures and events
Possible Limitations	Not all reports created equal, subset of failure types, database creation

Possible Implementation Paths



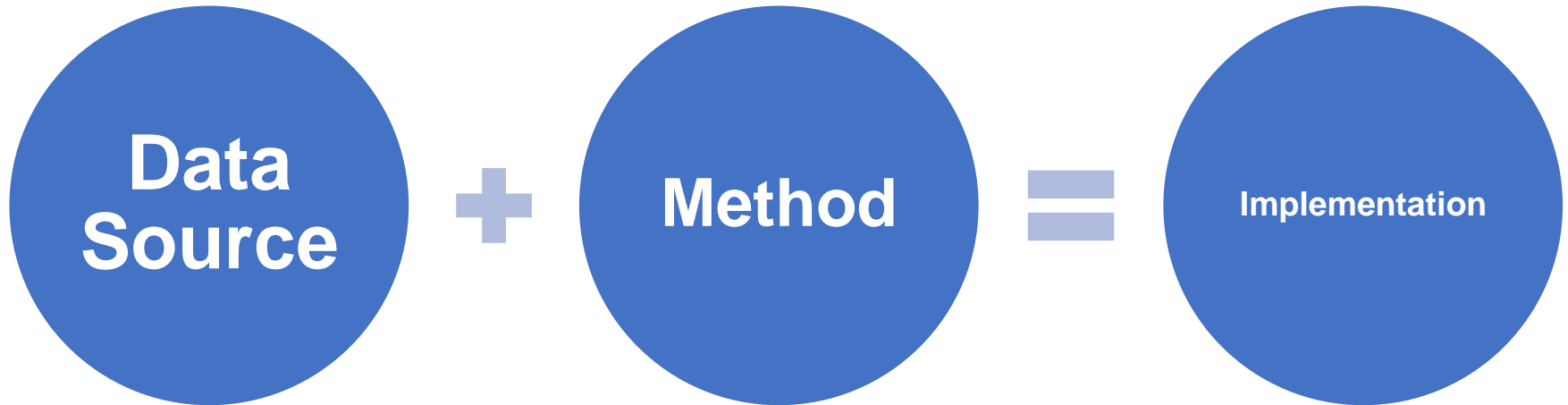
- Database of failure reports
- Survey/Questionnaire
- User Tagging
- Enterprise System Data
- System Data

- Categorization
- Statistical Analysis
- Machine Learning Algorithms
- MBSE
- Step by Step

Example 2

Source Title	“Data Science Approaches to Prevent Failure in Systems Engineering” [8]
Implemented How?	Machine learning on data, app to crowd-source + track project risk and predict failures
Implementation Level	Applied – Academic Setting, college data
Failure Domain	Project Risk, SE Failures
Data Input	Present, continuous. Enterprise Software Data + weekly questionnaires
Possible Limitations	Data Availability

Possible Implementation Paths



- Database of failure reports
- Survey/Questionnaire
- User Tagging
- Enterprise System Data
- System Data

- Categorization
- Statistical Analysis
- Machine Learning Algorithms
- MBSE
- Step by Step

Example 3

Source Title	“Applying STAMP in Accident Analysis” [9]
Implemented How?	MIT developed and tested, training seminars, to determine aspects of system structure that lead to failure, recommendations for prevention
Implementation Level	Applied – Real World
Failure Domain	Accident/Event investigation + analysis
Data Input	Modeling system based on past accident reports, trained analysts
Possible Limitations	Training, rigorous, not all reports created equal

Note on Failure Domains:



The way each Failure Domain assesses failure differs in data input, measurement, and goals..

- How to Unify for a System?

Failure Domain Comparison

Title	“A categorization technique for resolving information system failures reasons” [10]	“Project Risk Management: A combined analytical hierarchy process and decision tree approach” [11]	“Implementation of a Goal-Based Systems Engineering Process Using the Systems Modeling Language (SysML)” [12]
Implemented How?	Company using technique during potential failure reason exploration, mapping project to categories and potential failure categories	Steps using analysis of AHP and Decision Tree	Used for NASA project in SysML
Failure Domain	Information system failure reasons	Risk management	SE failure analysis + coverage, failure scenarios
Data Input	Current project, team evaluation	SMEs + management, project data	System Model creation, continuous system data

Conclusions

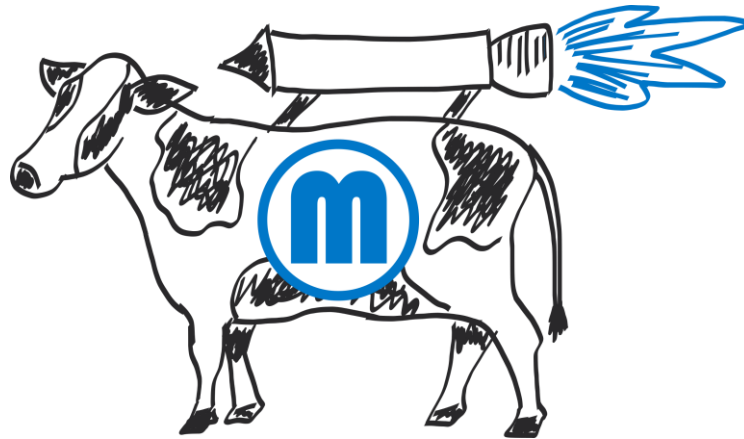
- **R1:** In a collection of academic literature concerning Failure Classification Schemes, to what extent are they being implemented and how?
 - Different levels of implementation
 - Evidence varies at different levels
- **R2:** What possible implementation paths can be identified to inform future work?
 - A complete path can consist of combinations between methods and data sources
 - It may also need different methodologies for different types of failure

Future Work

- A second pass of the failure classification scheme database will be completed for further analysis
- Possible Implementation Formations will continue to be developed and explored throughout the literature
- As potential paths are developed, pros and cons as well as ways to measure and realize them will also be identified.

Questions?

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