# Presentation for ESReDA 45 October 23 Afternoon session

 



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# A brief prologue to this presentation

Thank you for the opportunity to speak to this distinguished audience.

After 42 years of doing, studying, teaching, using and writing about investigations, this is my last public presentation.

I hope I can leave you ideas for further study and action to improve the use of of investigations.

 



Good afternoon. Thank you for inviting me to share my thoughts about how we might achieve better learning from accident investigations. I am very appreciative of my association with this group for the past six years, and am sorry I can not be with you in person today. –I thank my stand in. After 42 years conducting, studying, teaching, using and writing about accident investigations, this will be my last public presentation. My goal today is to share some of the findings during my 40+ years experience.

# Standardizing Safety Investigation Inputs to Reduce Risks

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Prepared for presentation at ESReDA 45th Seminar,
Dynamic Learning from Incidents and Accidents,
Bridging the Gap between Safety Recommendations and Learning
Oporto Portugal October 23, 2013



My presentation will focus on improving investigation processes to bridge the gap between investigation outputs and user learning to reduce risks. - I will describe what I see as fundamental obstacles to achievement of the better learning from investigations, and suggest actions to overcome those obstacles.
- Please be aware that I will use the term “incident” to represent all kinds of unintended and undesired occurrences, including accidents, near misses, fires, explosions, spills, groundings, and so forth.

# **Four** takeaways

I propose that incident investigations should:

- refocus investigation goals on satisfying user information needs and uses – be user centric
- standardize source data documentation at lowest level of abstraction.
- standardize data integration practices with graphical linked building block arrays.
- eventually, replace the accident causation model -based investigation paradigm with an input/output model-based paradigm.



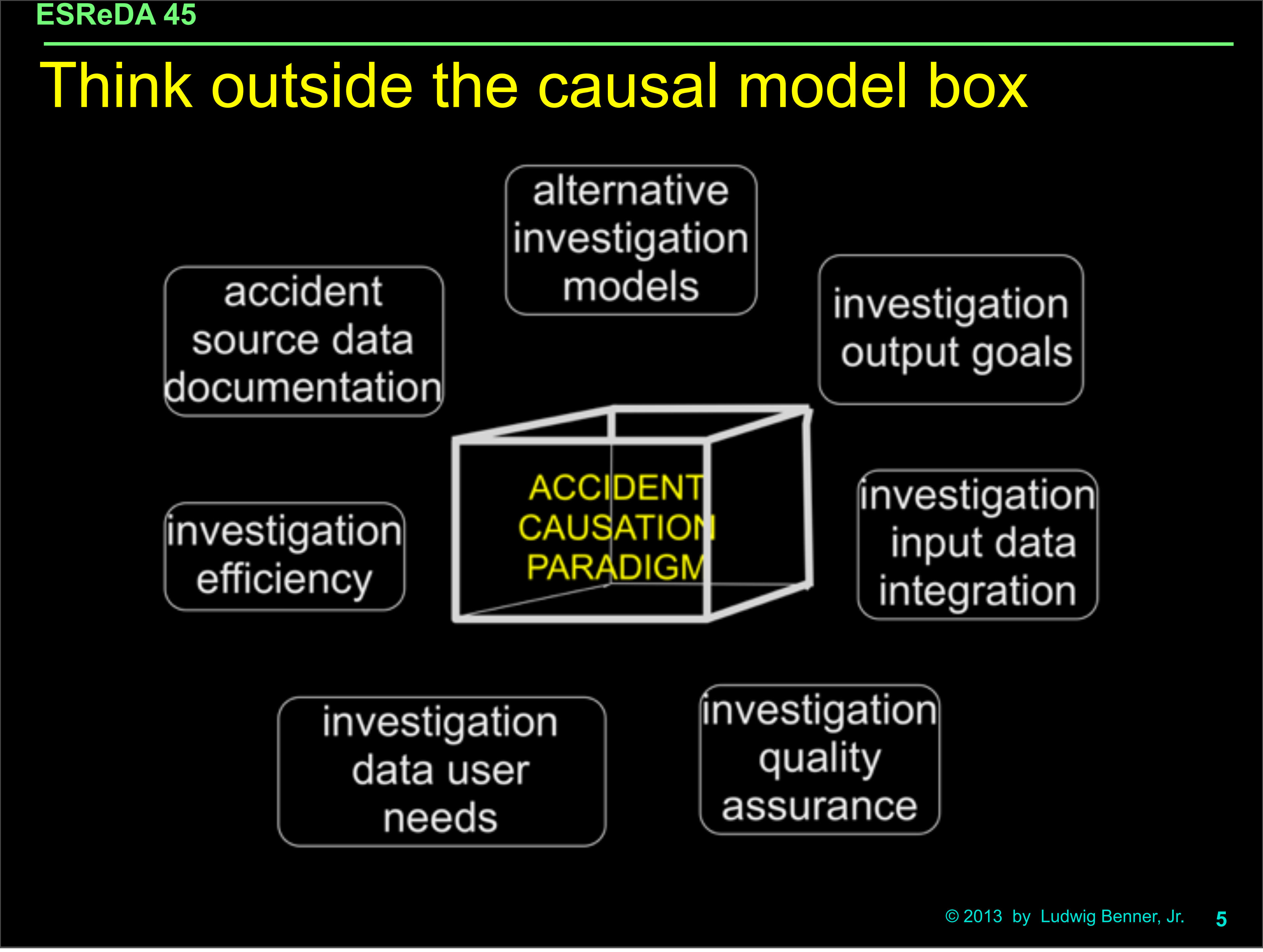
I hope the presentation will stimulate interest in four topics…

First, today's safety investigation practices and recommendations focus on shaping future safety efforts by others. I propose that the focus be redirected to satisfying user investigation information needs, shifting from prevention-centric to a user-centric focus

••• Secondly, today's practices use many diverse investigation data inputs and levels of abstraction. I propose that investigation input data be standardized at the lowest level of abstraction.

•••Third, today's investigations produce cumbersome outputs from cumbersome and inefficient input data processing. I propose alternative source data processing practices.

••• Lastly, today's accident investigation paradigm is based on 2000 year old causal thinking. I propose changing the investigation paradigm from causal to input-output thinking to achieve better learning.






Almost all previous investigation process research for MORT, my own STEP, Why-Because, RCA, SOL, STAMP, FRAM and others was performed within the accident causation model framework. If one is willing to think outside that causation model box, some aspects of investigation data processing practices emerge as candidates to challenge. Each aspect had an influence on this study of alternative investigation processes, as will be seen.

# The Challenge: Improve learning from incidents and accidents

Find alternative investigation source data documentation and processing models that will produce user-centric investigation outputs with improved timeliness, utility, and efficacy for accident data users

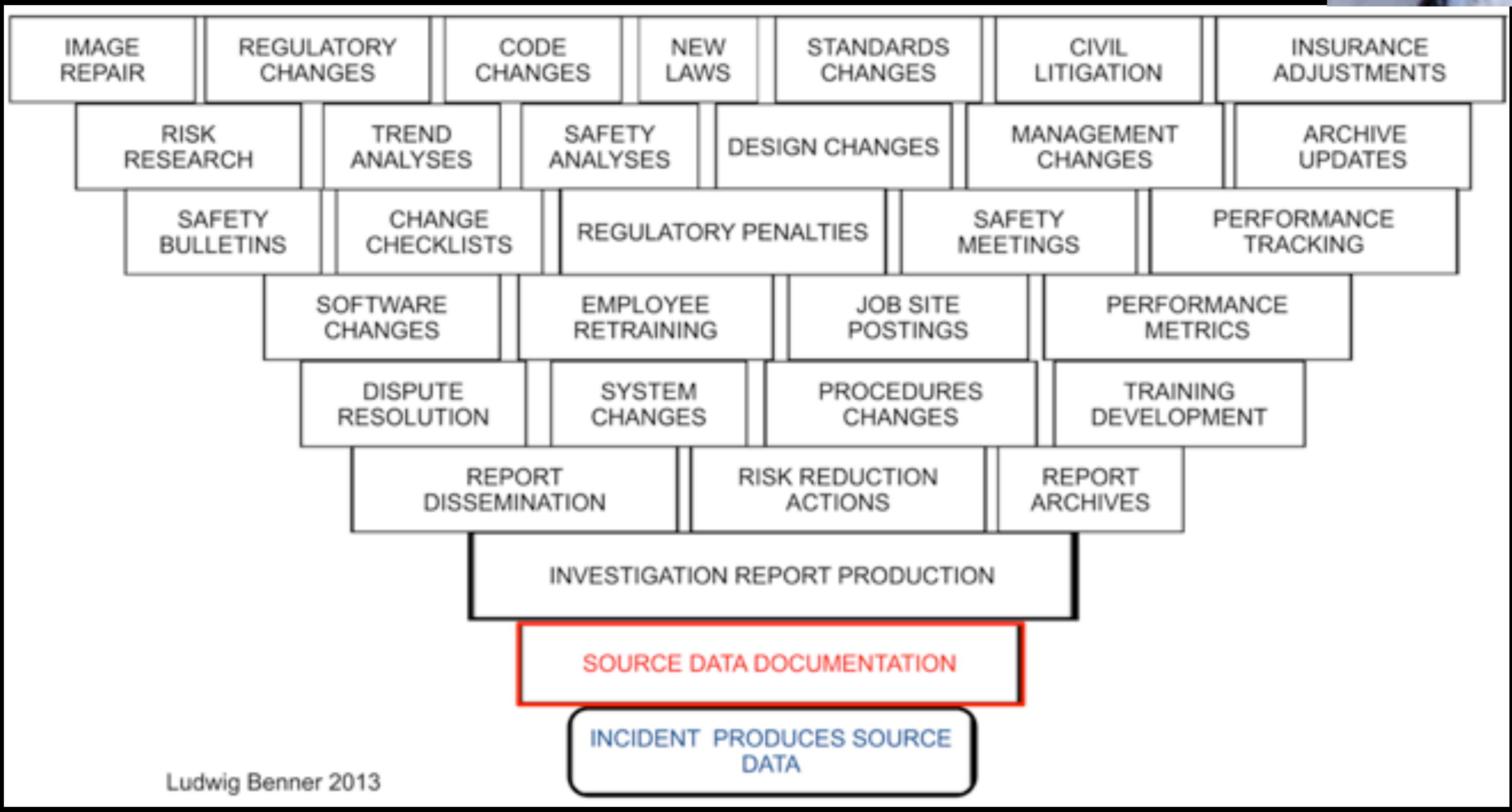
 



I view the challenge facing investigation process researchers as improving the learning from incidents and accidents by finding alternatives to investigation data processing practices now in use.

– Incidents produce new data. But new data about what? In my view, data about what happened and why it happened, or who or what did what when, where and why. – In other words, actions that produced the outcome. – The process description is the data users require so they can act on it to satisfy their needs. The investigation challenge is to deliver that data to users as quickly, accurately, usefully, and efficiently as possible.

# Source Data Dependency Pyramid

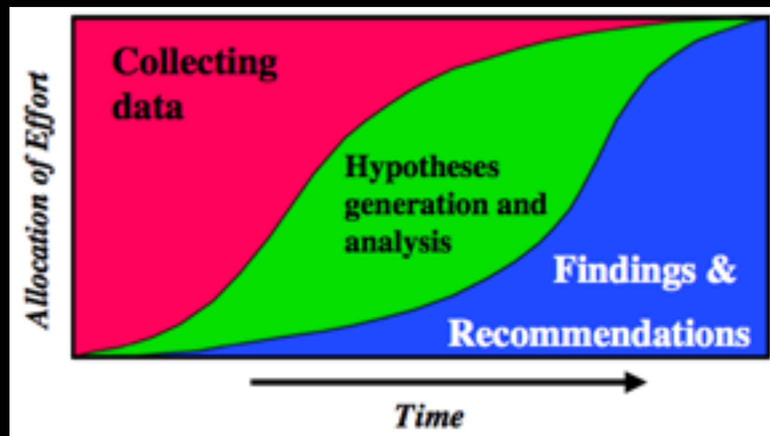




This pyramid gives an indication of the multitude of uses for data from investigations. Prevention-centric investigations are not serving all uses, as evidenced by frequent controversy and additional investigations,among other symptoms. This figure shows the system being addressed. It helps one recognize the need to examine data pathways beyond investigation reports to users on up the pyramid

# Today's problems:




Problem #1: Raw source data documentation

Problem #2: Data integration and processing practices



I view these as the core problems we face. I believe present investigation raw source data documentation and source data integration and processing practices are the primary obstacles to improved use and learning from incidents, primarily because today's investigation causation paradigm is prevention-centric as opposed to user-centric.

# Study’s goal:

Find the most direct pathway from incident source data to end uses


**What to change?**



**So, this paper defines the study’s goal as finding the most direct pathway through the investigation data processing maze, from source data to user.** Current practices, based on causation models, pose various data flow obstacles to users. Are there any alternative models for processing of incident source data that might produce a better pathway to get the incident data to users?

# Study's premises:

- Incidents are processes, consisting of interactions among people, objects and energies, over time, to produce undesired outcomes.
- End users of incident data need explanatory descriptions of what happened, at lowest level of abstraction.



I should mention two premises influencing my approach and the study: the perception of incidents as processes, and specificity of user needs. —— I have found that viewing accidents as processes is a useful perception for investigators and investigation process research.

••• I once managed a large industrial physical distribution system for dangerous goods. My experience being forced to "de-abstract" or interpret reported accident data before I could use it to introduce specific changes to my system, and experience with an unsuccessful research project, described in the paper contributed ,to the second premise for my studies. End users need actionable information about incidents.

# Study's approach:

- Switch focus of investigations from prevention to user needs.
- Identify input source data flow in present investigations to its uses.
- Explore data processing models from other domains that might be adaptable to improve safety investigations and their uses.

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The study approach was to change the present investigation focus from prevention to satisfying investigation data users' needs. ••• The initial task was to identify and document the present investigation source data flow pathway from origin to ultimate uses . •••Then, I explored other domains to see if they might suggest better data flows to adapt to investigation processes.

# Data pathway starts at incident source data:

- Incidents produce raw source data about what people, objects or energies did during the incident process (e.g., their actions).
- Source data documentation by investigators provides investigative “building blocks” (BBs) for constructing the description of what happened.
- Documented source data is then processed through the investigation steps and disseminated to users.

 

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The source data processing pathway originates with production of raw source data during the incident. •••The pathway then leads to investigators’ documentation of the raw source data, into building blocks for constructing a description of what happened. ••• documented source data then passes through investigation data processing steps for eventual dissemination to users.

# Data pathway includes source data integration:

- Source data processing must include data integration to develop an explanatory description of what happened.
- Integrated data should describe objective reality as nearly as possible in a form that provides for scenario validation, quality assurance.
- Integrated data scenario should provide actionable information to users
- Then anyone can analyze the scenario to suit their needs.

 



Once source data is documented as building blocks, the next step on its pathway is building block **integration,** to develop a trustworthy story of what happened and why it happened. ••• The integrated data becomes the scenario that should represent objective reality as nearly as possible, in a form conducive to validation and objective quality assurance.••• Above all scenarios should provide actionable information to its users. ••• Anyone can then analyze the final scenario to determine whatever they need –- like causes, factors, human errors, findings, conclusions, lessons learned, recommendations to impose on others, or whatever.

# Data pathway ends with users' uses

- Users need to be aware of data produced by investigation.
- Investigation data output needs to be conveniently accessible to encourage its use .
- Pathway to user ends when readily assimilable actionable investigation data has been delivered to users, and used.

 

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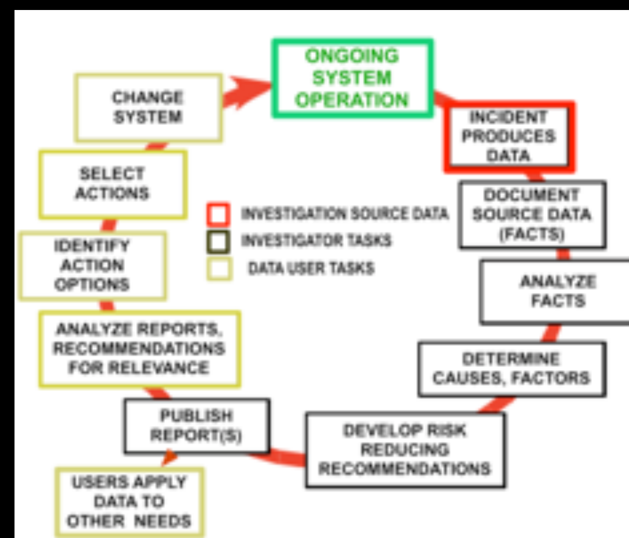
After the source data has been integrated to tell the story of what happened and why it happened, the data pathway needs to lead to a distribution platform where users can become aware of its existence. •••Then the data needs to flow to users, in a conveniently accessible form for timely delivery that encourages user discovery, access and use. ••• The investigation data pathway ends with the delivery of readily assimilable actionable incident data to users, giving them a basis for doing what they need to do as a result of the incident.     How to make that happen?

# Data flow steps

- Analysts introduce additional data from other sources and additional processing steps during and after scenario development to arrive at abstract statements of cause, errors, factors, etc., and recommendations.




- Each step increases delay and inefficiency for the data flow, and the possibility of error or introduction of experiential, methodological or domain bias, levels of abstraction and ambiguities, and wordiness.

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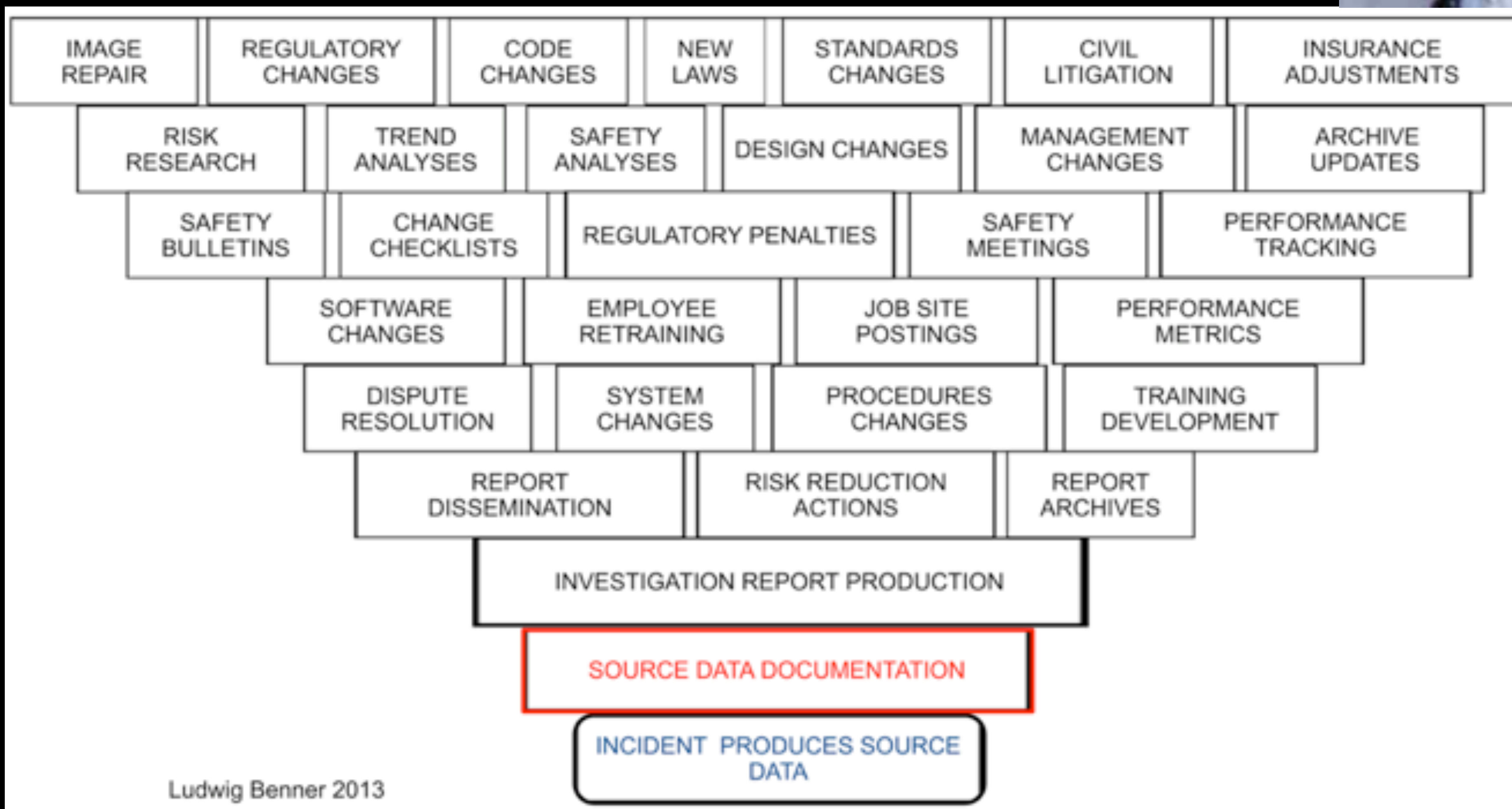
Today's investigation source data flows are complex and cumbersome, with data gathering and analysis practices introducing extraneous data, delay and inefficiency to the data flow along the pathway to users, and at each step, introducing the possibility of error or introduction of experiential, methodological or domain bias, levels of abstraction and ambiguities, and wordiness in the explanatory description. The process reflects the influence of the present accident causation-based paradigm.

# Source Data Dependency Pyramid





Raw source data documentation is a crucial investigation task: all uses that follow depend on that step.— There is very little research on this task. —This upside down pyramid illustrates the dependence of all uses on the documentation of the raw source data, and its significance to users

# Domains considered:

- Industrial work flow analyses
- Social sciences
- Music and thespian arts
- Learning organization development
- Safety research
- Operations research
- Cybernetics
- Economics
- *Software engineering

* not mentioned in paper



To find candidate alternatives for the causation model, numerous domains were considered. Some examples included

**Taylor's** work flow studies; •••**Jacobs**', Suchman's, Klein's and others' behavioral work in the social sciences; •••Western arts documentation; ••• **Stenge**'s learning organization work; ••• **Jean Surry's** and **Bill Johnson's** safety research work; ••• **Forrester's** dynamic system opertions research; ••• **Weiner's** cybernetics input/output modeling; and even ••• **Leontief's** huge economic model. * ••• I did not mention in the paper the software engineering model which my Grandson shared, but should have - I used their "programmer" task, data parsing and concatenation ideas. And **Gordon Pask**'s learning machine studies about adaptive behaviors were also influential. And so was semanticist **Korzypski's** challenge to Aristotelean thinking....

# A noteworthy possibility:

- The arts domain, and music especially, suggest the most complete data documentation, integration and utilization model option to adapt to investigation needs.
- That model is the musical score for producing music.



Of the models considered, the most comprehensive and relevant one I found is the musical score model, because it deals with documenting <u>complete and complex process inputs and interactions</u> required to produce a specific music output, and doing this with extraordinary specificity, clarity, precision and efficiency .
Let’s walk through the model to show you the possibilities I observed...

# Musical score describing a music-making process for 14 instruments



Here is a sample of a musical score for 14 different kinds of instruments, In effect the score defines the actions by every instrument as the music making process advances from beginning on the left to end.

I invite your attention to the fact that it does so quite well without specifying any “causes” or “factors.”

# Rows define the all the actors whose actions contribute to the music- making process



Note that the list of instruments in this column defines every “actor” – the instruments whose actions are required to produce the desired music output.

# The notes are a standardized way to document the score's BBs.



Observe how the score uses only standardized notes to describe the attributes of each action, or combinations of actions like cords, and even silence or no action. This standardization of the building blocks is the key to the system's efficiency.

# The notes on each row are the building blocks (BBs) showing all actions of that actor in the music-making process



Observe how each row of notes defines the <u>sequence and timing</u> of all the actions for each actor involved. Note also the economy of building blocks required to define the necessary actions. The format enables the very **<u>high information density</u>,** which is a desirable attribute of a process description.

# The array of notes on actor rows shows the integrated BBs






All actions are **integrated** by the horizontal position of the notes in rows and their vertical alignment . The scheme permits the testing of individual notes as they are added to the array, and testing of the final array by how the inputs interact to produce desired sound combinations.

A very efficient scenario display – for musicians, conductors, publishers and students. And critics.

# A Musical Score is

- a matrix with time and actor coordinates for arraying each actor’s actions,
- showing individual actions in their temporal sequence,
- integrating actions to show interactive relationships,
- resulting in a replicable description of the music making process .



To summarize what I believe are transferrable aspects of the musical score model to investigations, a musical score is a graphic display, using a time/actor matrix for arraying each actor’s role in the process, using standardized building blocks to define the role, ••• it defines all individual actions for each actor involved in the process, in their temporal sequence , •••it integrates all actions on the matrix by their alignment, showing relationships among the actions, ••• it results in a detailed description of the process, and enables its reproducibility.

# Accident investigations could adapt Musical Score model elements:

- Data Documentation
  - Actor/action building blocks
  - Building blocks standardization
- Data Integration
  - Graphic process display
  - Time/actor matrix
  - Action integration standardization



I'd like to focus on two aspects of the transferability –

First, investigation input data **documentation** – The actor/action BBs are stated very concretely – at the lowest level of abstraction. With standardized notes, musicians and conductors know exactly what each player is to do at all times.

••• Next, data **integration**– BBs are integrated in a standardized graphic process display, using building block placement in a matrix to show the action flow, in easy-to-understand way.

# Musical scores vs. investigations:

Musical score uses vertical alignment of BBs to show their rhythmic timing relationship to other BBs.


BB timing during incidents is not rhythmic.

Showing incident BB input/output relationships will require something else like <u>links</u> from the inputs to outputs, as is done in systems engineering display tools – logic trees, for example.

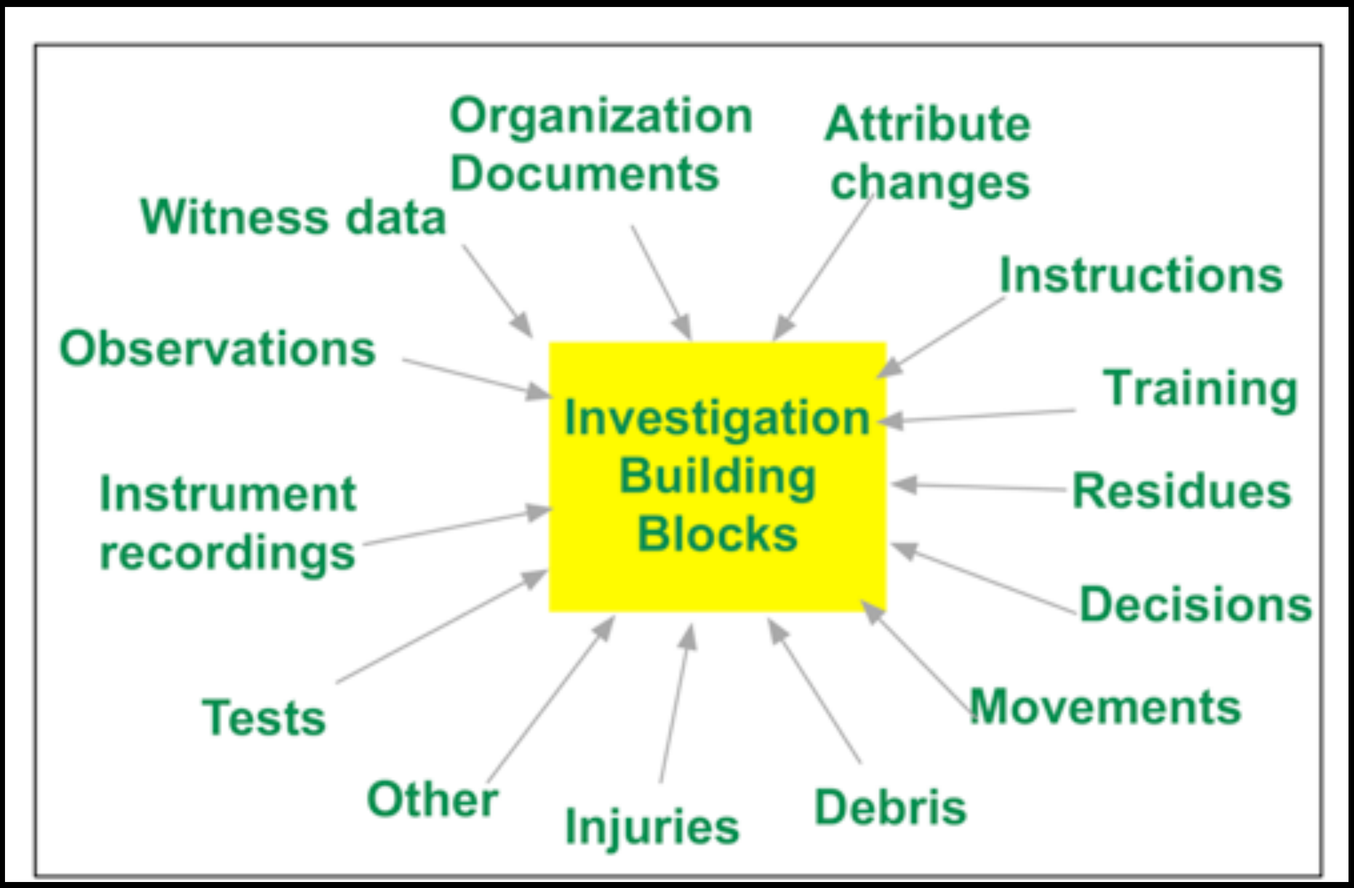
 



- The musical score array adequately depicts BB inputs and rhythmic relationships among BBs by their vertical alignment on the matrix.
- BB timing during incidents is not rhythmic, so incident BB relationships need to be depicted in a different way. This can be done with standardized links from input BBs to output BBs, to show their relationships, as is done with system analysis tools like logic trees, for example.

# Standardize Building Blocks (BBs)

## The source data documentation challenge facing investigators





Transforming raw incident data of numerous kinds into building blocks poses a significant investigative challenge. This is especially true for remote management actions which “programmed” human behaviors that occurred during incidents in complex socio-technical systems. However **specificity** is just as necessary for them as for actions by “objects” if those action must be “re-programmed” later.

# Standardize BB Documentation

A source data documentation standardization criteria should address and define:

- Content and grammar of structure
- Unambiguous data entries
- Temporal and spatial attributes
- Logical coupling of entries
- Completeness testing
- Downstream use by all users



To standardize BBs, several criteria should be addressed and defined, including structure, data entry, temporal and spatial attributes, BB coupling, completeness testing, and downstream use by users.

# Integrate incident source data

- **Organize** source BBs into an integrated graphic display  to create an explanatory description.
- **Standardize** I/O structure to minimize need for abstraction, and minimize introduction of errors ambiguities and biases.
- **Integrate** BBs showing input and output (I/O) relationships for each action needed to help users define problems to address.



Personally, I view data **integration** into a graphic display as a more precise description of the investigator's data organizing task than accident analysis. ••• With a standardized input/output matrix display structure, the BB data integration can array the actions and interactions required to produce the incident outcome at the lowest level of abstraction and with minimal errors
••• showing input/output relationships increases the **assimilability** of the data reported, because it provides input and output specificity and context for each action, so <u>users</u> – or analysts – rather than investigators –  can define problems to address in their systems.

# Integrate incident source data

- A graphic matrix array provides the most efficient way to Integrate investigation input data as it is acquired
- Scenario validation is progressive as BBs and links are added to a matrix
- A completed matrix display provides users a readily assimilable description of what happened, at the low levels of abstraction and with context they need.



Compared to today's data gathering and analysis practices, a graphic matrix offers a demonstrably more efficient way to integrate data into a description as it is acquired during an investigation. This reduces time on the pathway to the scenario description –-a part of our timeliness goal.••• It offers other benefits – like progressive validation tests during the addition of each BB and link, -and, it filters unrelated or conjectural inputs, – and, it exposes missing data, thus optimizing the data selection and acquisition task. ••• when completed, It provides users with a readily assimilable output that helps them determine data relevance, and systematizes problem discovery and definition tasks

# For subsequent analyses, explanatory description on matrix may have to be supplemented in reports by:

- Documentation of objects' attributes
- Record of data sources used and location(s)
- Object test documentation or plan
- Chain of custody documentation
- Investigation data acquisition constraints to explain gaps in scenario

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The input-output data array describes the dynamic process, but supplemental data may be needed by users to enable them to relate an incident to their operations. Here are some examples of the kinds of supplemental data they might want, depending on their activities. Most could be recorded in the suggested BBs in a remarks section, or with appended source documents.

# Transitioning to a user-centric paradigm

1 Adopt a standardized BB structure and grammar for source data inputs

2 Publish source data transformation and documentation standards

| | |
|---|---|
| ACTOR | 1. Person, object or energy that did something |
| ACTION | 2. What Actor did |
| OBJECT/DESCRIPTOR | 3. Additional data defining action |
| LOCATION | 4. Location where action began |
| REMARKS | 5. For remarks about BB or investigation |
| SOURCE | 6. Source of data used in BB creation |
| BEGIN DATE/TIME | 7. Date and time action began/status |
| DURATION | 8. Duration of action |
| END DATE/TIME | 9. Date and time action ended/status |
| LINKS FROM/TO | 10. Links defining interactions among BBs |
| N/S STATUS | 11. Necessary/Sufficient input validation status |

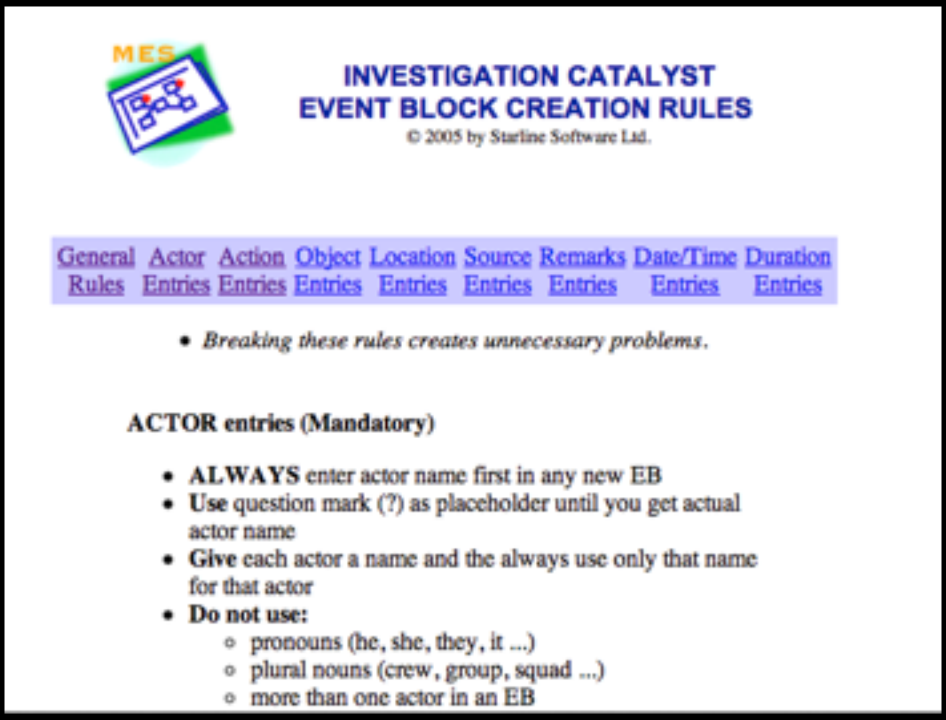
 



How might a shift to user-centric investigations be achieved?
A practical first step could be to introduce BB structure and grammar standardization. Here is a sample of an existing open source BB structure that would fit into today's practices, without disrupting how data is processed now. It would require very modest training. The diversity of today's practices suggests a need for collaboration to develop open source standards for the investigation community. Since this is a small portion of most investigation software applications, it should not create insurmountable commercial conflicts that can frustrate progress.

# Make the rules

3 Define rules for documenting and integrating investigation source data into STANDARDIZED building blocks



INVESTIGATION CATALYST
EVENT BLOCK CREATION RULES
© 2005 by Starline Software Ltd.

General Rules | Actor Entries | Action Entries | Object Entries | Location Entries | Source Entries | Remarks Entries | Date/Time Entries | Duration Entries

- *Breaking these rules creates unnecessary problems.*

**ACTOR entries (Mandatory)**

- **ALWAYS** enter actor name first in any new EB
- **Use** question mark (?) as placeholder until you get actual actor name
- **Give** each actor a name and the always use only that name for that actor
- **Do not use:**
  - pronouns (he, she, they, it ...)
  - plural nouns (crew, group, squad ...)
  - more than one actor in an EB

Source: investigationcatalyst.com

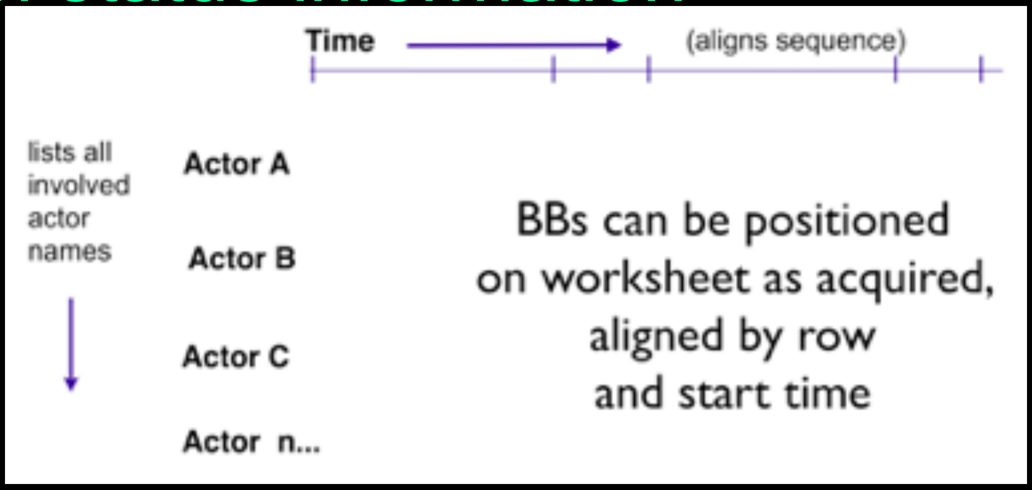


If BBs are standardized, development and wide dissemination of uniform rules for documenting BBs would be a vital part of that effort. Some rules that could provide a starting point for the standardization process exist now, as open source material. Here is an example of rules for actor data entries for the building block example in the paper.

# Standardize BB Integration

## 4 Create standard BB integration matrix to:

- provide continuous data integration and incident description status information
- support rigorous collaborative scenario development




- with links, show interactions that produced outcome

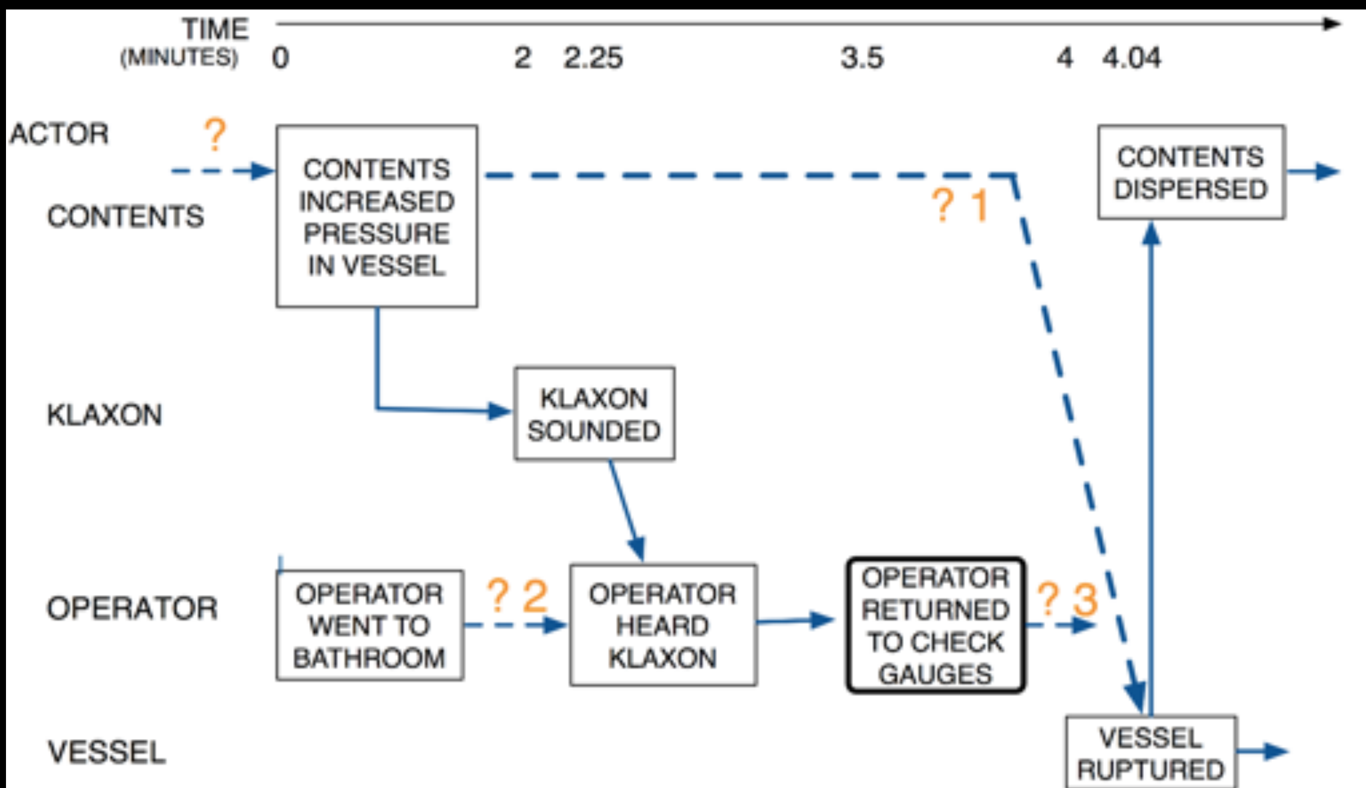
 



As standardized building blocks gain acceptance, the development of a standard for the graphic integration of the BBs would be the next logical step. Here too, existing open source material could provide a starting point for this development. Experience suggests that resistance to adoption of this new tool declines with its use, because its benefits for investigators become evident with use.

# Source Data Integration

## Arrows connect input BBs to output BBs




Investigator workload focuses on adding to known BBs

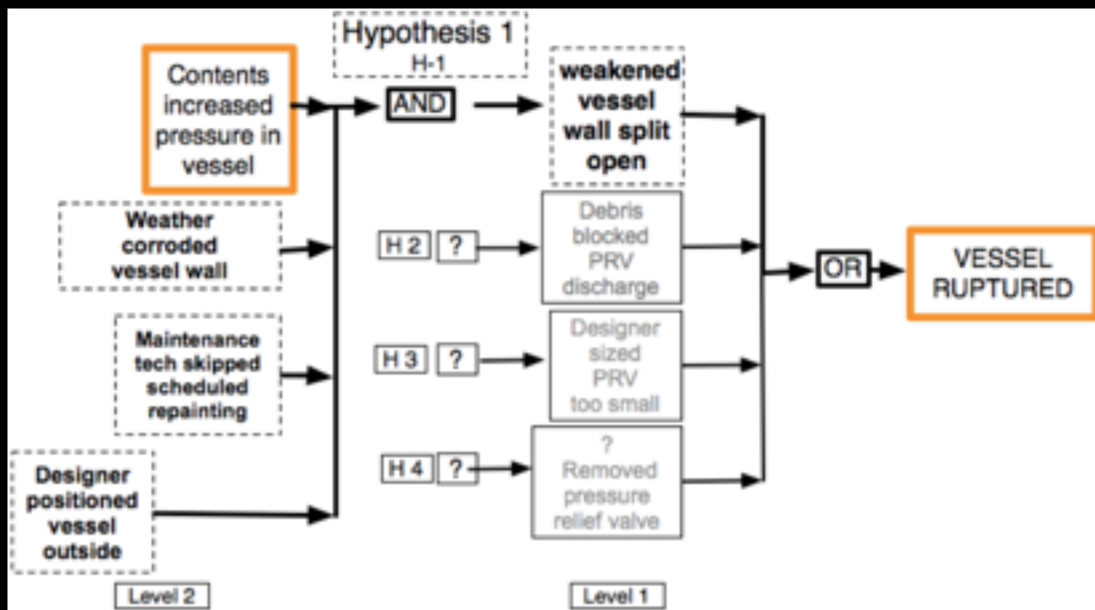


This sample shows the music score model adapted to investigations. Only partial BB data is displayed in each block for this illustration. Dashed links indicate tentative links, for which more input data is required. Machine processing of block data entries is feasible and has been successfully demonstrated.

With the links, necessary and sufficient logic tests can be applied manually to each input-output relationship shown, to identify missing or superfluous data, and define remaining data acquisition needs, thus promoting investigation efficiency.

A completed matrix shows only BBs with solid links unless data to fill gaps is no longer available.

# Data integration drives investigations




- gap-filling is appropriate time to generate hypotheses during investigation
- each hypothesis disciplined by end “anchors” from gap, shown in orange
- hypothesis defines new data needed to find actual or “best fit” scenario

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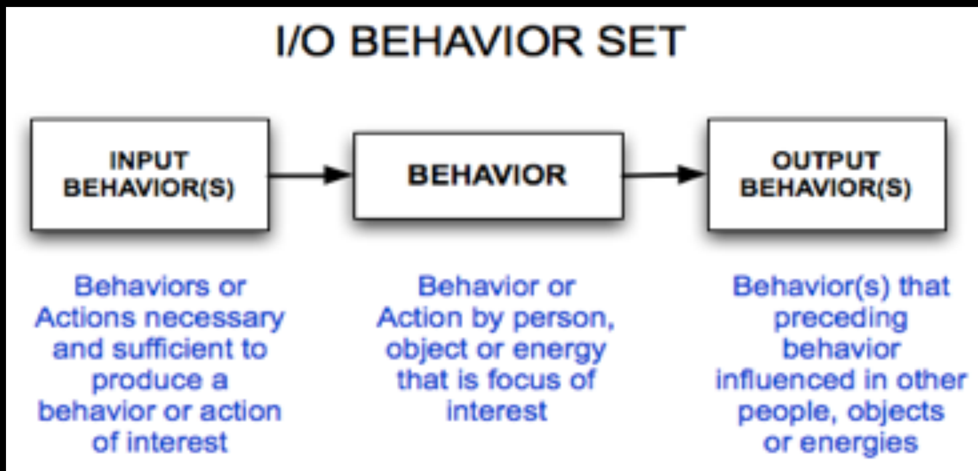
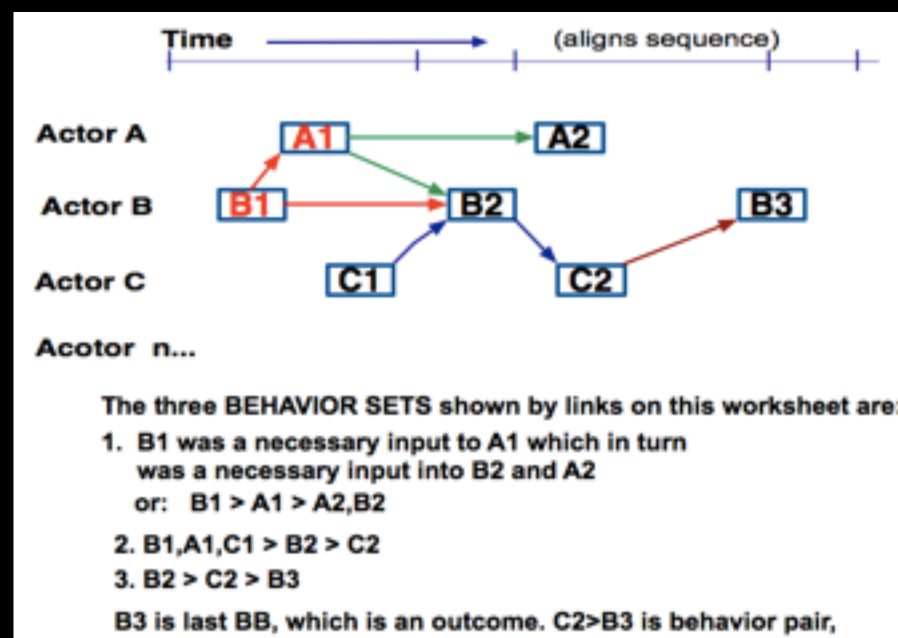
This figure is not in the paper, but logic tree models adapted from systems engineering practices can help develop what I call “anchored” hypotheses, where BB links and logic tests identify gaps in the data flow. —-thus the course of the investigation is driven by the **source data inputs and their step by step integration** on the matrix, rather than by check lists, report formats, accident causation models or theories, or investigator experience, intuition, or expert opinion.




# Finding behavior sets in matrix BB I/O arrays



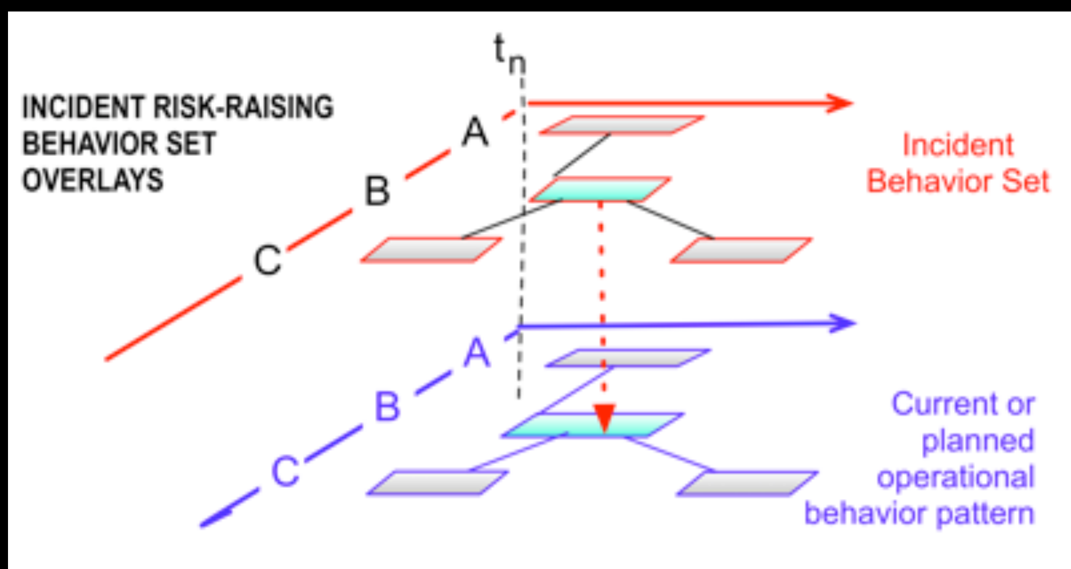

 



The Input/Output model enables the identification of behavior pairs or sets to provide context for each action in an explanatory description. Input-output sets can help users to relate the incident data to behavior sets in their own operations. Applied sequentially to the BB array from beginning to end, the sets systematize users' search for problems exposed by an incident, reducing the likelihood that problem behavior patterns or lessons are overlooked.

# Data behavior set utilization by user

- concept for incident data relevance determination requires “visualization level” of data abstraction
- needs BB, array and link standardization for investigation + design tasks or “as built” descriptions





For safety users, the I/O arrays offer behavior patterns as well as individual actions to look for in users organizations, enabling users to determine relevance of an incident, –-candidates for change, –-analyses of outcomes that might result from each change candidate, –-and specific actions or action sets to implement and monitor in future. In effect, the investigation source data patterns could be used by overlaying them on their operations to locate their risk raisers

# Thank You for Your Attention!
# Want more details?

www.ludwigbenner.org
or
www.iprr.org

or contact the author directly via email to luben at either website listed above

or use open source software at http://code.google.com/p/meslib/



For more details about an alternative paradigm and data processing options, many open source files are available on the internet for browsing or downloading, including at the URLs shown. I would welcome further exchanges or questions about the ideas discussed here. —Thank you for your attention.

# I am finished

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