Association for Crime Scene Reconstruction

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19th INTERNATIONAL TRAINING CONFERENCE

February 10-12, 2010 San Diego, CA

Accident Investigation Data Capture and Analysis Tools

By Ludwig Benner

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By Ludwig Benner

Good afternoon. First, thank you very much for the invitation to be here with you today. I am impressed by the ACSR, its objectives, ethics and actions. Your view of the role of CSAs in the criminal justice system, as understanding and applying appropriate methods in as objective a fashion as possible, strikes a very sympathetic chord with me. Objectivity is a key element of any investigation. Achieving that is the challenge we have both been addressing.

While I was preparing my presentation, I confess that I have learned a lot, and got some fresh insights into my pursuits, so also I thank you for your role in bringing that about. Also my thanks to Stephen DeFrance for inviting me to prepare a paper about MES for your Journal, as I developed the presentation – that was a first for me, and it worked well. He will have my paper as soon as I finish editing it to include the results of this presentation.

Introduction

- Who am I?
- What are our objectives?
- What is my presentation plan?

Well, let's roll.

I'll be telling you about who I am, what I hope to help you accomplish, and how I'll do that

Who am I?

- Ex NTSB Division Chief, Intermodal investigator
- 45 major accident investigations at NTSB Industry,
- Government, Academia; consulting, internet, software program development
- ISASI Fellow, SSS Fellow, investigation researcher
- No crime scene reconstruction experience – until this project.

My experience is with accident investigations and accident investigation research. My intermodal investigation NTSB experience was a major influence on today's presentation.
My other work experiences also helped shape my world view of the topic.
Some have recognized my work by election as a Fellow in their organizations.
~ I have no crime scene investigation or crime reconstruction experience. The only related experience I can claim is that I have
• investigated accidents that led to criminal charges and jail time – that's an interesting story… but not now.
• audited a Criminal Investigation course, and got acquainted with O Hara and O Hara and studied some old FBI crime scene and forensic guides (73, 78) during my AI research
• testified as system safety expert in one civil court case
• served on a jury
• engaged in a lot of table talk about the judicial process with my son – in – law who is a litigator
Also my grandson has given me private tutorials in logic to help me along over the years.
•This presentation has been like a research project for me; in trying to identify what might be useful to you, I had to familiarize myself with what you do and how you do it.

What are our objectives?

When we are finished you should

- Understand what MES is and does
- Recognize some ways MES AI tools might be adapted to your tasks,
- Know how to put the tools to work for you, and
- Recognize challenges the tools pose for CSIs and CSRs if you use them

I am going to talk about MES accident investigation tools. Here's what I hope we can accomplish in the next few hours.
•I'll share with you what they are and how to use them. Then we'll do a demo together to explore how they might be put to work for you. During and after the demo, we'll talk about some of the tradeoffs you'll face if you try to adapt them to your work.
•Bottom line, after exposing you to MES, my hope is that you will discover ways you can use some of the MES concepts, principles and tools to help you achieve the most objective crime scene reconstruction.

What is my Presentation Plan?

Provide background information about AI practices

Briefly compare Accident Investigations with CSR

- SIMILARITIES AND DIFFERENCES
- TERMS USED

Present AI-MES tools

- AI RESEARCH AND FINDINGS
- MES SYSTEM
- MES TOOLS

Show how AI-MES tools can be used by CSRs

My presentation plan is to give you some background information so you recognize the accident investigation problems that led to MES development. You may recognize some of them.
• Then I'll share my findings about similarities and differences between accident investigation and criminal investigations as I was developing this presentation.
• Then we'll cover why MES was needed, the research behind it, what it is and the tools it provides.
• Then we'll work through some case reconstructions with MES and see what develops. So we're setting out on an exploratory trip together, and we'll see where it leads.

AI background information

- Historical framework for AI
- Investigation problems
- Investigation progress
- Investigation prognosis

This is the background information we'll be cruising through for the next couple of minutes, to bring you up to data on the AI field. You'll see how contemporary AIs got to be how they are, the problems they posed, progress that's been occurring, and where it seems to be going.

Brief historical review of AI

- Framework followed legal concepts
- Cause models/prevention/recommendations
- NSC shaped thinking with forms (human error)
- Complexity recognized (multi-causation)
- Performance instrumentation (FDRs, CVRs)
- Human factors/social constructs broadened

Accident and criminal investigation practices have had common roots. AI development flowed from legal concepts and viewpoints. The facts-analysis-conclusions-findings model drove both investigations for a long time.

• As AIs became an element of safety efforts, and prevention became the goal, recommendations entered the picture, further distinguishing accident from criminal investigations.

• As science was becoming more statistically infatuated, the National Safety Council wanted to collect statistics.So they designed a form with 8 of the 10 questions asking about driver-related data. This shaped investigation attitudes for decades, focusing investigations on driver or operator error as the causes of accidents.

• As system complexities were recognized, as in aviation, causal complexity was also recognized, changing what investigators looked for.

• The development of instrumentation to monitor changes of states during operations produced another significant change in investigation capabilities.

• Then the ascendancy of social sciences brought about a further broadening of investigation scope.

Dominant investigation practices

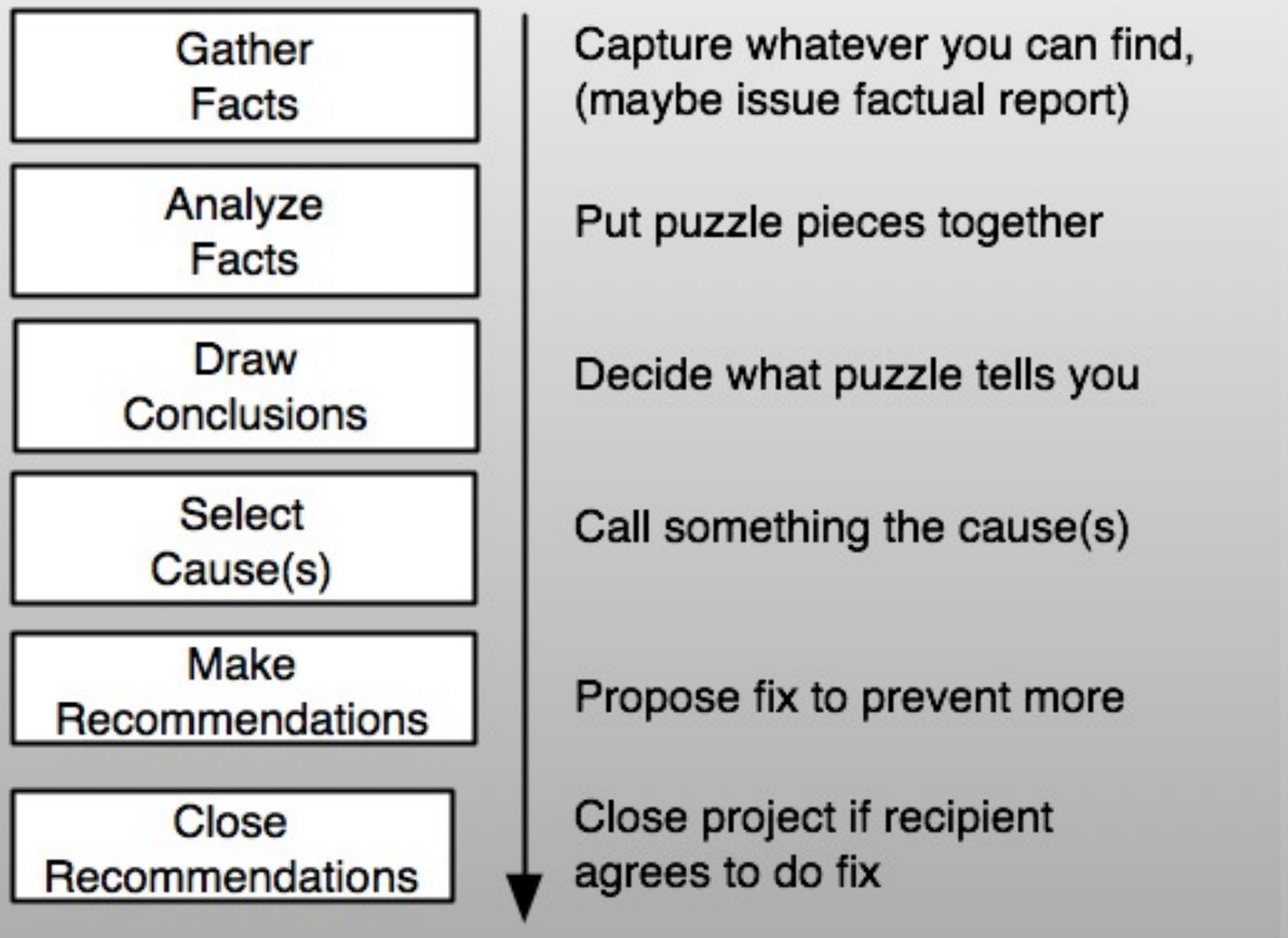
- Gather data
- Analyze data
- Determine cause(s)
- Prepare findings and conclusions
- Propose prevention recommendations
- Record acceptance of recommendations

The are the main general steps in traditional AI practices.
• Gather data
Analyze data
Determine cause(s)
Prepare findings and conclusions
Propose prevention recommendations
Record acceptance of
any look familiar to you?

AI background information

Historical AI framework

Based on popular accident causation model



Investigation is a process. Here's my translation of what the steps are for traditional AI processes.
(Read right column)
capture all the data you can (vacuum cleaner approach), put the puzzle pieces together, decide what puzzle tells you, pick something to call cause or causes, propose fixes for causes, and close project when recipient agrees to do fixes.

AI Improvement Progress

Some progress being made

- increasing research interest in methodologies, tools
- growing recognition of incident complexity, dissatisfaction with “cause”
- more attention to human interactions with machines, environments
- shift toward process perspective
- challenges to logical sloppiness of reports

AI field is changing as traditional ways of thinking about them and doing them are being challenged –
more research, in Europe especially
more people questioning “cause” determination and utility
more research into human, managerial, system contributions to accidents
more people talking about accidents as process
more scientific critiques of reports, results produced

Prognosis: AI practices under scrutiny

- shifting framework for investigations
- digitization of data
- lessons learned developments
- new metrics being introduced
- input data structure changing
- comparative methods research growing

lots of things going on – there's going to be even more scrutiny of
• the framework for thinking about accidents and their investigation – just published a reprint of one of my 20 year old papers describing different "world views"
• AirFrance 447 crash generating review of digital performance data content and dissemination – lost black boxes, CARS transmissions
• Europeans formed a new Project Group to optimize investigation lessons learned performance, which is pretty mediocre now
• growing recognition of need to attack problems with theory and structure of investigation input data
• more papers, groups comparing alternative AI "methodologies" in recent years

Comparing AI & CSR

- Many similarities
  - Both seek “truth” about what happened
  - Both had origins in law
- A few differences
- Little cross-fertilization of tools in past?

AI and CSR are similar in many ways
• AI evolved from legal ways, but AI’s been drifting away in recent years...although judiciary is getting more involved overseas like in Brazil and France.
• there are a few important differences affecting how they’re done, but tools are very similar
• AI not for judicial proceedings, CSR is, for example
• sometimes the two systems create conflict in AI field – TWA 800:accident or sabotage?
• I don’t know of much cross fertilization tried before now. Not much on my end, certainly.

Similarities

As I see it, Accident Investigation and Crime Scene Analysts...

Both deal in similar kinds of occurrences	crimes and accidents are processes consisting of interactions that leave "tracks" as they occur
Have similar task goals	to produce a clear, accurate and complete reconstruction of what happened, supported by persuasive evidence
Use a similar general approach to their tasks	to identify, document, organize, and analyze, and test input data
Use observations as a primary working tool	to acquire date used for their tasks
Produce credible descriptions of what happened	to survive close scrutiny and challenges and maintain confidence in their reputation and work products

This isn't a course on similarities or differences, but a list may help you to recognize them if you are considering applying any AI tools.

These are some of the similarities I found as I was preparing for this presentation. I thought they indicated promise for potential cross-fertilization of our ideas – in both direction.
kinds of occurrences, task goals, general approach, primary working tools, outputs demands

Differences

As I see it, Accident Investigation and Crime Scene Analysts...

have different customers	• public, involved parties, operational, regulatory and legislative entities vs • litigants, judges and juries, victims
use different kinds of data sources	• accidentally generated and historical data vs • perpetrator- generated data
work with different data acquisition and handling rules	•relatively unconstrained data accessibility vs •probable cause, self incrimination, Miranda, Daubert, privacy, chain of custody rules
face different witness data challenges	• cooperative witnesses interviews vs •adversarial suspect interrogation limits
support different goals with their outputs	• ways to prevent recurrence vs • weighing of evidence and judicial verdicts

Some of the differences I discerned are listed here. Right now I just want to mention them because they are some of what I bore in mind as I thought about your using AI tools…
So I tried to keep them in mind as I developed my presentation.
They may have a bearing on whether you try something or not after we're finished. We'll talk about that at the end of the presentation.
different customers, data sources, data acquisition rules, witness challenges, output goals

AI and CSR Vocabularies

Vocabularies used differ, sometimes reflecting similar ideas
Examples:

AI	CSR
field investigation	crime scene processing
scenario	hypothesis
perishable evidence	transitory effects
operator error	perpetrator
interview	interrogation
validity	probative value

Every practice has it's vocabulary and special terms that everyone in the practice gives a common meaning. Vocabularies can be barriers to common understanding.

As I compared the vocabularies, however, it seemed we are not that far apart about the essentials we are referencing. So if I slip into investigator-speak, and you don't understand what I am trying to say, stop me and ask me to explain until we have reached a common understanding.

Accident Investigation Tools

Problems I experienced at NTSB led to scrutiny of investigation practices and processes, and development of new AI tools

- Observed differences among modes and within modes among individual investigator's methods
- Arguments during and after investigations about
  - scope of the investigation
  - what data to collect
  - how to use acquired data
  - attribution of causes
  - report content, wording

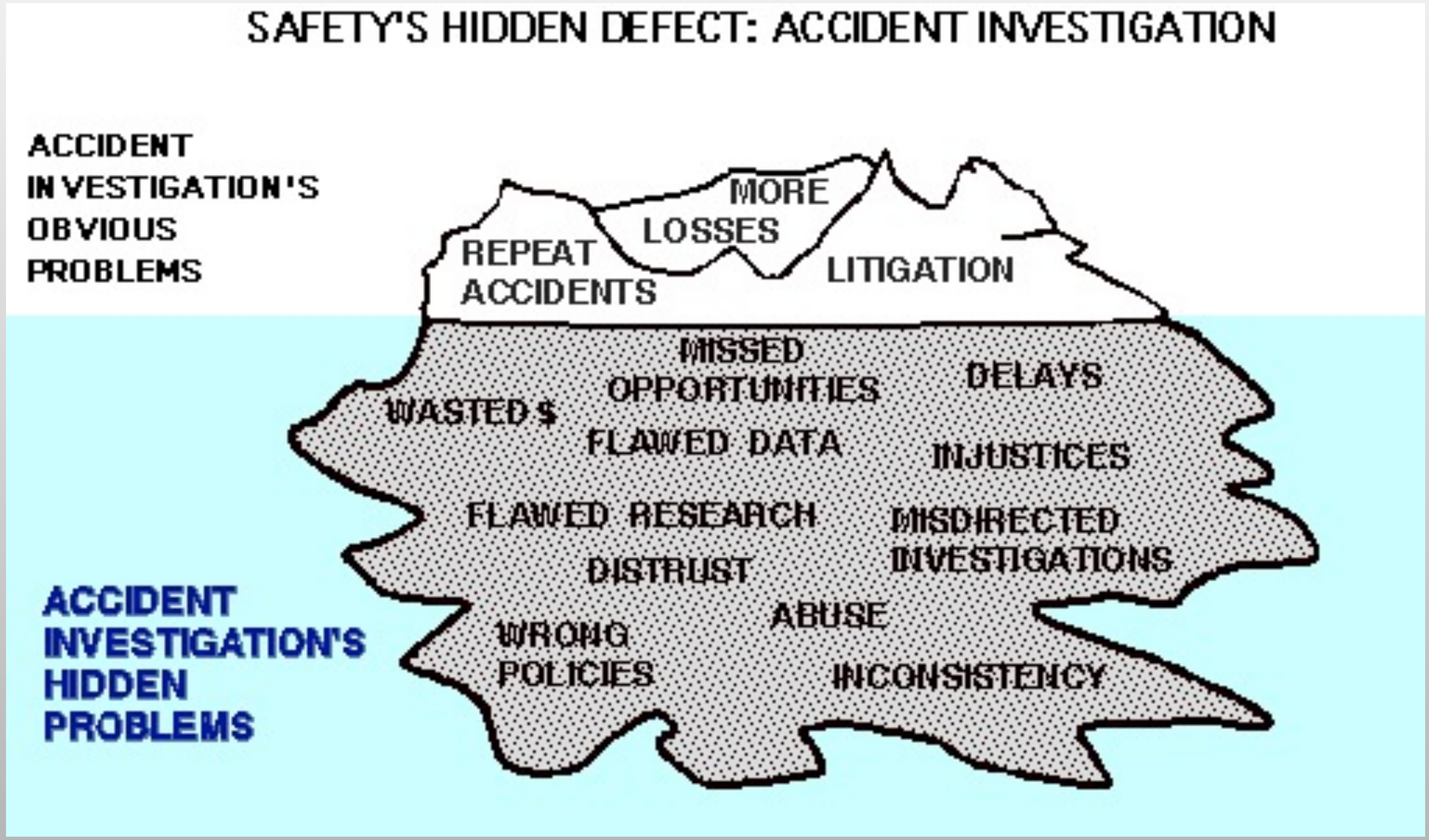
Problems you experience in your work are often the motivation to look for something better. These are what motivated me to start researching AI practices many years ago.
the are the scope, data selection, data use, cause and report content choices.
Recognize any in your field?

Problems I observed at NTSB about...

- How “observed” data were interpreted
- Discovering more data needed after leaving scene
- Terms to use to document what happened
  - ambiguous, judgmental or inflammatory words
- Amount of irrelevant data collected
- Determining what issues to include in reports
- Elapsed time and inefficiency of process
- Effects on others and other activities
- Disputes and litigation about findings

Seemed each investigator and analyst had their own ideas about these issues – and treated them differently.
The problems involved data interpretation, oversights, documentation, and relevance, plus issue selection, inefficiency, unintended consequences and disputes
As I watch the consequences of these problems evolve over time, I tried to document and illustrate why addressing them was important.

Research motivated by observed effects:



Here's a 1980 slide – that's how I summarized what I had found in the 9 prior years I was working on them — if prevention is AI purpose, why do accidents and accidental losses keep happening?

Note commonality of our problems….

- Litigation indicates to much subjectivity!
- Note also the flawed research… gigo problem for anyone using crime statistics? Cause??
- dynamic vs static representation issue, pretty abstract now but gaining recognition….
- yep – there are injustices in AI outputs too… pilot or operator error, for example

seems to me you face most of these effects too if reconstruction is not done well...

Research efforts have produced some progress...

- 1971 NTSB published first accident flow chart
- 1975 my widely referenced paper: introduced MES concept
- later 70s: DOE adopted charting concept (ECFC and T/LA
- 1980 SAE paper: defined problems, called for changes
- 1981 – 09 refined guidelines for MES procedures (still refining
- 1986 book: formalized MES procedures (STEP)
- 1990s – growing interest in AI methodologies
- 2004-7 software: computerized AI support
- 2005– now: refocusing on lessons learning system, digital data streams, social networking for info dissemination
- 2003 – EU organization formed an AI Working Group

Some good things are happening
Here's a list of some of the highlights I've seen
AI challenges are being defined better, good responses are increasingly available, new opportunities are burgeoning.

Special research results:

Development of MES investigation technology

- What is MES technology

  Multilinear Events Sequencing-based investigation technology is an integrated set of concepts, principles and techniques used to investigate occurrences before or after they happen.

MES has been one of the responses to the challenges. Let's talk about MES now, and what it is based on, to help you interpret what you will be hearing about it later. You will need the recognize them to see why MES is done the way it is, and follow the demos of the tools

It's based on some concepts, principles and procedures that produce pretty good results.

MES concepts include...

- Investigators deal with “processes.”
- A process is people, objects and energies interacting to produce an outcome.
- During a process, everyone and everything always has to be somewhere doing something.
- Actions produce or change conditions.
- Actions leave tracks.

Here are some of the concepts behind MES. Each was derived from observations during real time investigations, not so much analysis of other people’s work.

When you think of what your are investigating as a process, a lot of other good stuff follows.

processes are interactions; everyone always doing something; actions produce changes, actions leave tracks.

4 Key MES concepts include...

PROCESS PERSPECTIVE

the way to look at what you are investigating

MES FRAMEWORK

for approach to investigations and data analysis

LOGICAL REASONING

from observations to document descriptions of what happened

EVENT-BASED INVESTIGATION TOOLS

to produce investigation work products

MES involves 4 main concepts, listed here. They pretty much drive how you think about investigations, and how you go about them.

They are the Process perspective, the Multilinear events sequencing framework for documenting and analyzing investigation data, the necessity of applying logical reasoning to the interpretation of observations in investigations, and the concepts governing the design of event based investigation tools used to produce investigation work products.

Each plays vital role in explaining how to achieve the most objective investigation outputs, something a lot of people want and talk about, but few show how to get it done.

We'll discuss each briefly, and then describe how they are applied.

4 Key MES concepts include...

- PROCESS PERSPECTIVE

  the way to look at what you are investigating

  An accident (or crime) is, demonstrably, a process consisting of people, objects and energies interacting over time to produce an undesired outcome.

other views of accidents have included act of God, chain of events, cascading converging chains of events (logic tree structure) stochastic/factors coming together, accident proneness, loss of control, and on and on and on. Each leads to different investigation practices.

I found thinking of incidents as a process is the most valuable way to look at them, based on the results it produced for me.

4 Key MES concepts include...

- MES FRAMEWORK

When dealing with a process,

IF YOU CAN'T FLOW CHART IT, YOU DON'T UNDERSTAND IT !

SOURCE: Benner FOUR ACCIDENT INVESTIGATION GAMES 1978

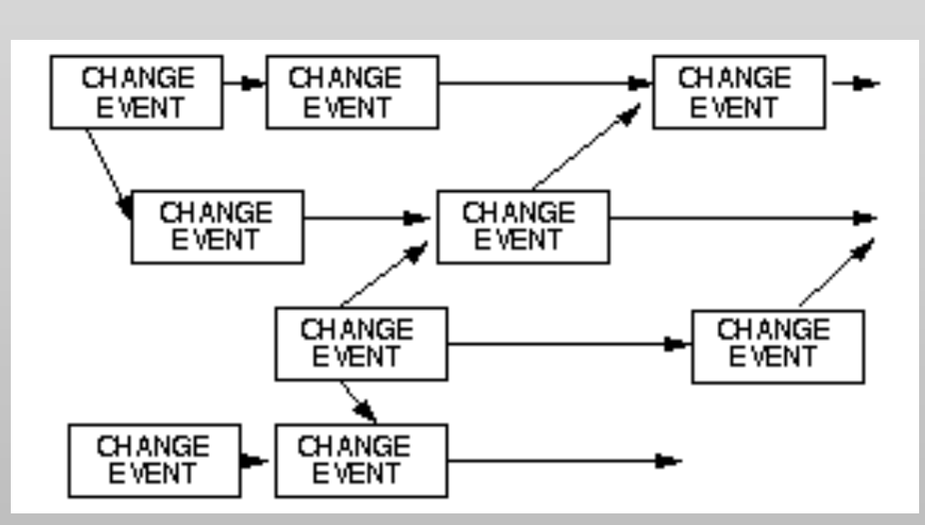
Bill Johnson of AEC shared this with me about 1972, and it has stuck with me over the years. Its too true – I've seen it demonstrated time and time again. In one project, it took me 5 iterations to get system operators to tell me how their system functioned, step by step, so I could flow chart it. They were operating a major military system that they didn't know exactly how it worked. i discovered this by flow charting what they told me, asking them to sign off on the flow chart displaying what they told me, and after 4 rejections, they finally gave me all the information I needed to complete a flow chart of the way it actually was working.
If you don't believe in flow charting, you will be turned off by a lot that follows.

4 Key MES concepts include...

MES FRAMEWORK

for approach to accident investigations

- interactions occur in sequence and in parallel between the beginning and end of the process being investigated



- think of the musical score framework for documenting what happened

What's a good way to look at an accident or crime if we accept that it's a process?

Here's what I finally settled on for my purposes – an MES framework to accommodate the interaction display.

It all came together when I stumbled across the analogy of a musical score – language, structure, linkages, and all...

4 Key MES concepts include...

A COMPARISON BETWEEN A MUSICAL SCORE AND MULTILINEAR EVENTS SEQUENCES CHARTING METHODS FOR ACCIDENT INVESTIGATORS

Actors:

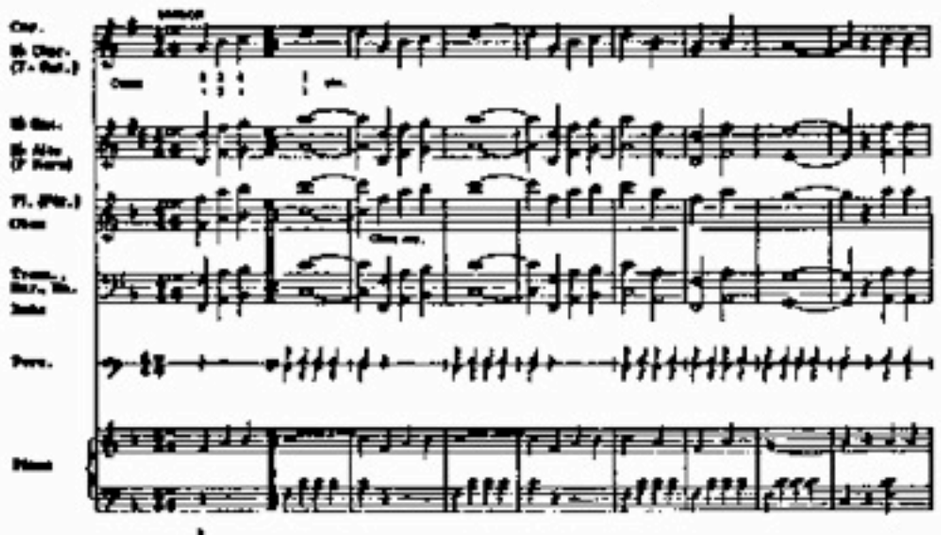
Implicit /Explicit players

1,2,3	cornet b clarinet t sax
4,5,6	e sax e alto Fr. horn
7,8	flute oboe
9,10,11,	trombone bar.,bn. bass
12,13	drums
14	piano

Time reference scale:

t_0 ... t_{end}

When The Saints Go Marching In



Vertical alignments describe dynamic relationships among changes of state and steady states (at successive time units) produced by each events set

Horizontal lines and entries describe the time/locationally-ordered sequences of acts by each actor (events) defining their temporal and spatial sequential logic

By tracking the actions of individual actors from appropriate "records" one can reconstruct the entire sequence of events constituting the "song" and reproduce the "score." The score can then be reexamined and analyzed to serve the needs of the analyst.

By convention, events flow from the left of the page toward the right as time passes.

Notes:*

1. *Clefs indicate the line space and pitch, ie, the arena where the events take place.*

2. *Unison describes a policy for the activity*

3. *"Oboe,etc" (line 3-4) gives a warning sign to reduce the probability of confusion.*

*No pun intended!

4. *"count + 2 + 1 etc" (lines 1,2) leads to coordination of timing of actions by each actor.*

5. *define "location" for each next change of state(by scale + timing) and the duration of each steady state by the symbol used. "rest" symbols do the same.*

6. *defines the rhythm, or the basis for the coordination of the events during the conduct of the activity.*

7. *The "count" and "oboe" can be viewed as safeguards (or countermeasures) instituted by the composer or arranger to reduce the likelihood of mishaps.*

This is an original graphic showing a musical score, put together with a Selectric typewriter and a Xerox copier for one of my AI classes at USC. It handles interactions, timing, prediction, reproduction, validation and all the other desirable capabilities for analysts – in the language and with the vocabulary of the music field.

Notice how the music can be reproduced the way the composer imagined it by displaying the process for doing so this way – a multilinear array of actions at specific times by numerous actors. That led to all kinds of fascinating ideas about the language of investigations, the arraying of data on a time–actor matrix, the reproducibility of the output, its use to identify when someone did something inconsistent with the arrayed building blocks, the special vocabulary used (notes), use as a plan for predictive analysis of tasks, and on and on and on.

No chain of events, act of god, last clear chance or any of that.

4 Key MES concepts include...

LOGICAL REASONING

from observations to transform descriptions of what happened into “logic statements.” Includes use of

DEDUCTIVE REASONING -to transform observations into investigation building blocks, and formulate questions to ask until phenomenon is understood

SEQUENTIAL (BEFORE/AFTER) REASONING to order building blocks accumulated during the investigations

CAUSE -> EFFECT or more recent INPUT/OUTPUT REASONING to find and link actions to create interactions

NECESSARY AND SUFFICIENT REASONING to test completeness and validity of scenario

TRUE-FALSE REASONING – avoid untrue, ambiguous building blocks

LOGIC FALLACIES TESTS – to avoid fallacious building blocks

http://www.iprr.org/papers/logic_fallacies-isasi.pdf.

A third key concept is the idea of transforming observed data into structurally consistent “logic statements” as “building blocks” for accident reconstruction by using logical reasoning tools. Logic statements are sentences that can be determined as true or false from evidence – like observed data - through logical reasoning of the kinds described here.

Logic statements are the building blocks with which you reconstruct past interactions into a description of the process that produced the outcome.

You’re probably familiar with most of these –deductive, sequential, cause and effect or input-output, and necessary and sufficient reasoning, though perhaps not as conversant with the logic statement idea or the logic fallacies as some of the others.

4 Key MES concepts include...

MES-BASED INVESTIGATION PRINCIPLES

for accident investigation

Examples of principles for AI tools:

1. Think Actor + Action, for Investigation building blocks
2. Track essential actors / change makers
3. Transform Data Into Building Blocks
4. Break Down Building Blocks
5. Make Mental Movies

The fourth concept is that AI practices should be governed by congruent principles – that is investigation tasks should all be mutually supportive, theoretically consistent, and compatible with each other. These are the principles governing the design of the MES tools in the investigators' tool box.

The building blocks principle is crucial – as you will see soon. They're what you organize and analyze, and they have to meet certain specifications as to form, structure, grammar and vocabulary among others. Everything else flows from how you create and handle building blocks you use. Yet, today in most AIs almost anything is used as a BB.

I just list them here. You'll learn a lot more about each in the next section and as we do the demo.

4 Key MES concepts include...

- EVENT-BASED INVESTIGATION TOOLS
  to produce accident investigation work products

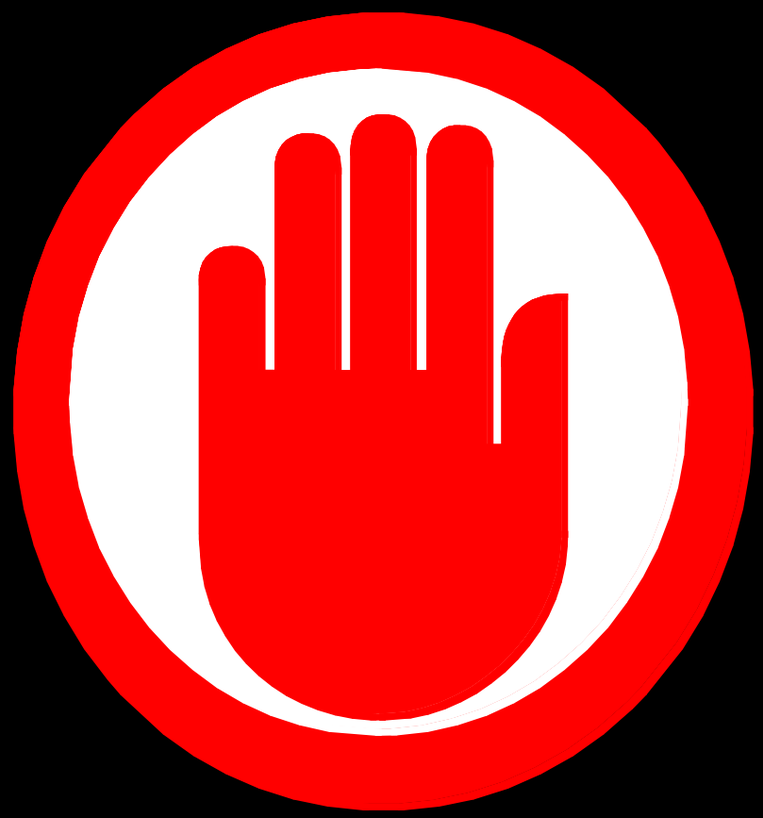
  Examples of principles:

  6. Position building blocks on time / actor matrix worksheet
  7. Link causal or input / output interactions
  8. Test BBs and description with logic tests
  9. *Define problems using linked events
  10. *Identify / evaluate counter-changes

  Prepare reports from worksheets

  * not necessarily applicable to CSR

Remember, these are tools for accident investigators, and include recommendations in reports, which you probably don't have to worry about. All these tools help produce reports of what happened that CAN be bullet proof if you follow the MES rules strictly. Shortcuts will surely get you into trouble by generating challenges due to ambiguities, uncertainties and untreated gaps.



Do you
want to take
a short break before
get into the nuts and bolts of MES?

Want to take a 5 minute stretch before we move on?

An introduction to the *MES - BASED INVESTIGATION SYSTEM

A proven research-based system consisting of concepts, principles and procedures designed to enable the efficient acquisition, analysis and reporting of knowledge gained through investigations.

* **Multilinear events sequencing**

There's a saying that the Devil is in the details. That's were we're headed now – to the devil's den - That's the details.

You have seen generally what's going on and why, now we're going to see how to use some of the tools I've described to you. MES is a pretty finely tuned investigation system, with congruent concepts, principles and procedures behind them. I haven't talked about the deeper scientific and philosophical issues MES addresses, but can if you wish after the day is over. MES is really a comprehensive system that can change investigation practices from art to science.

As we go through this section, watch and try to anticipate how we might adapt each tool to crime investigations and analyses. That's what we'll actually try to do during the demos.

Our Truth Challenge:

Create "LOGIC STATEMENTS" to describe what happened

a statement is a sentence that asserts something which is either true or false

- **Has a subject and a predicate**
- **Can be determined to be true of false**
- **Is supported by evidence of logical reasoning**
- **Can be readily disambiguated**
- **Is not a non-statement like a command, question, word, phrase**

This is a crucial idea that I mentioned before, but I want to spend a little time explaining it to you because you and I both are faced with coming up with statements about what happened that have to be true. We should insist on reciprocity from our critics.
– . We are all trying to answer the question: "How did what we see come to be?" Everything we say about what happened should be truthful AND aid in the understanding of the incident Well, how can we do that? The short answer is by structuring what we say in a special way, called Logic Statements. Who here has studied formal logic???
• Ambiguity is a ever-present enemy – we need to disambiguate words or phrases we use so everybody interprets them the same way. Ambiguous statements are called amphibolies – one of many logic fallacies you should know about.
– Primarily we look to evidence and logic, and try to AVOID saying something is so because • it's a command, or •that's how we define it, • or saying that's what we feel because nobody can assert what we say about our feelings is not true, or • because we cover up shortcomings with abstractions or ambiguous words, or • we're really posing a question.
• But how do you truth test what we say? From evidence, with logic.

Think Actor + Action

WHO or WHAT DID WHAT WHEN WHERE?

DRIVES

- **What you look for during an investigation**
- **What you do with your data during your investigation**
- **How you objectively assure quality**
- **Outputs and followup**

Our view of what we look for when investigating or analyzing an incident drives what we look for. We use this.

Motive, means and opportunity have long been drivers for CIs. The O'Hara's (in 1988) offered a three point aim – identify and locate the guilty party, and provide evidence of his guilt. Crime scene reconstruction (CSR) can support all three, by bringing all the information together in a readily comprehensible form, but it is dependent on inputs from others. So I am going to cover both the inputs and their processing, starting with this first principle.

The principle, Think Actor + Action, is designed to drive what AI practitioners do. Can this help you? Let's see.

Think Actor + Action

TRACK CHANGE MAKERS

- **A procedure used to identify "change makers" that introduced changes during a process, and what they did to produce the next change or outcome.**

- **Procedure begins with the any change and identifies all changes necessary to produce the process outcome.**

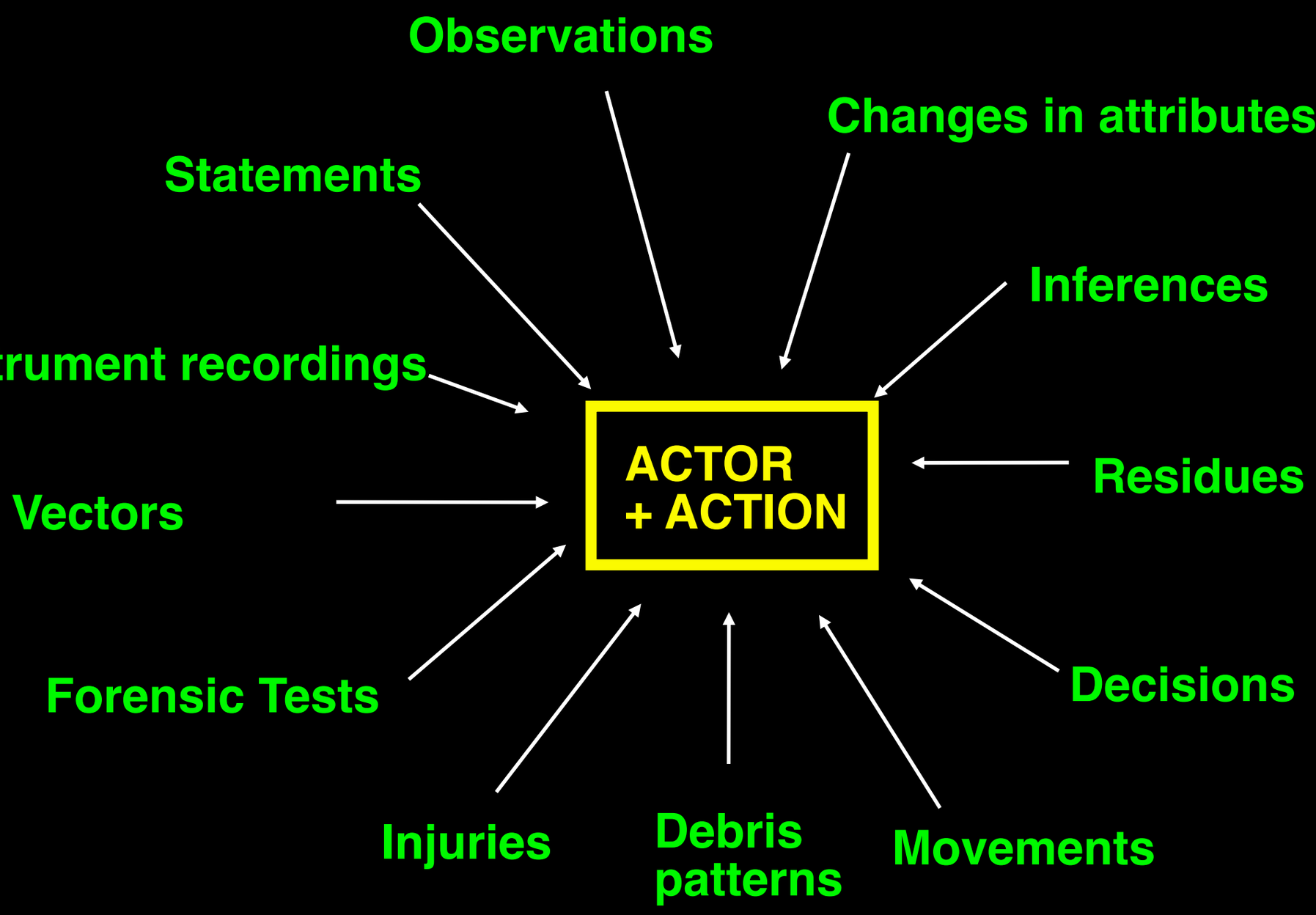
- **Each change is documented in format of actor+action Building Block**

This is something accident investigators do, consciously or unconsciously. Tell you why.

In processes, actions of people, things and energies drive what happens during a process. They do this by bringing about successive changes in other people, objects or energies through their actions, until an outcome is produced.

That's why you want to track the change makers through their actions. The investigator's challenge is to identify and document the actions of the "change makers" from what's available after the accident – or crime.

TRANSFORM DATA INTO INVESTIGATION BUILDING BLOCKS:



The sources of data for identifying and documenting change maker actions can be very diverse. This illustrates examples of sources for AI investigators. Each one could be further expanded – debris patterns in crimes could be expanded to include positions or trajectories of shell casings, overturned furniture, embedded projectiles, broken glass — the list is limited by the debris and the ability of the investigator to “see” it.

But each has to be turned into a “logic statement” to forma a usable piece of the puzzle or building block for reconstructing the puzzle. Remember, that’s a statement that can be shown to be true — or false. How to do that? One more time – transform the input into an actor-action building block.

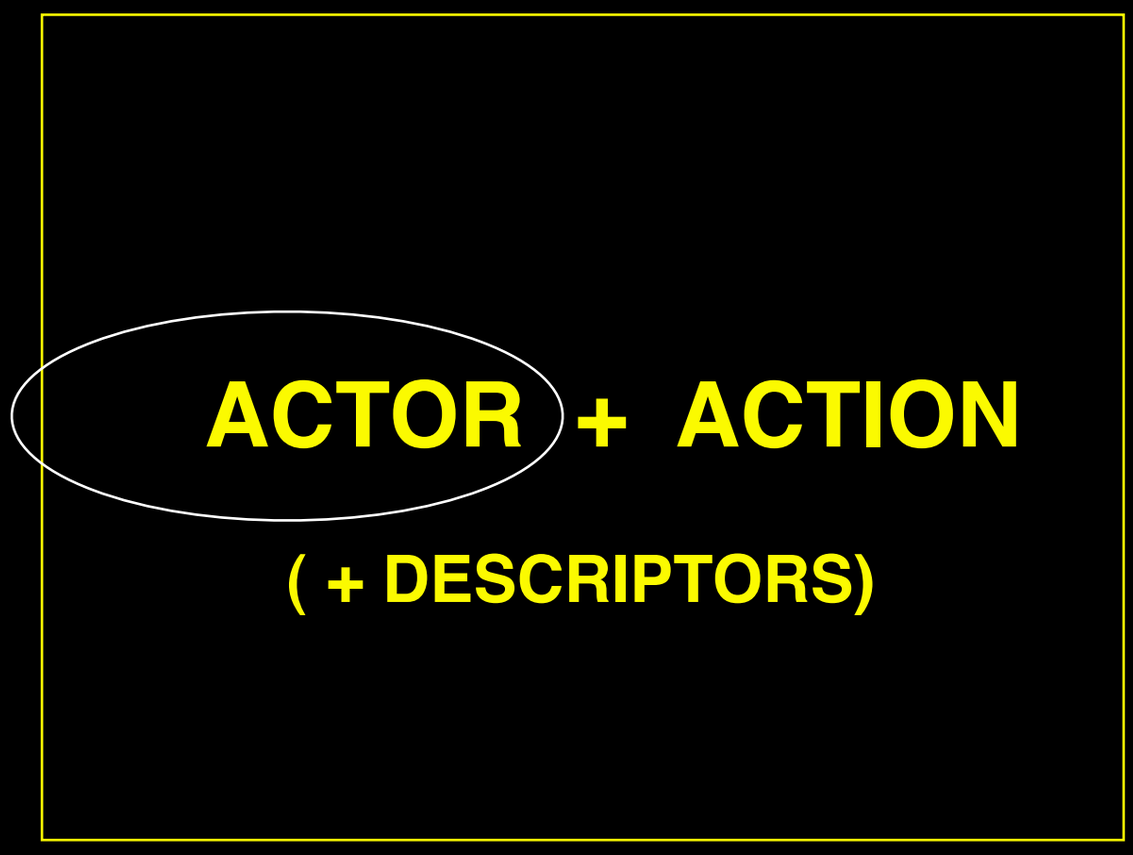
TRANSFORM DATA INTO INVESTIGATION BUILDING BLOCKS:

Building Block (BB) for Reconstruction

Here's the structure for a building block in the MES system. Each element has a specific purpose and role during the investigation and analysis.
The Actor provides an anchor for creating a valid logic statement, and organizing all the data.
Action describes what the actor did to change what follows, and the object or descriptor enables the investigator to record what the action affected. Describing the action unambiguously and precisely are major challenges for both investigators and analysts. (as you will see when you try it during the demo)
The location at which the action started is needed to support the spatial sequencing of the actions
The remarks entry allows for the noting of unanswered questions or reminders to the investigator, so any questions associated with the BB are not left over at the end of the investigation or analysis.
The source is the identifier for the evidence basis on which the BB was created, to ensure each entry is supported by evidence, and to facilitate retrieval of the evidence if the validity, materiality or relevance are challenged.
The begin date and time for the action is needed to support the temporal sequencing of the BB relative to all other BBs developed during the investigation or the analysis. The times used can be observed or estimated from related times if the spatial sequence can be determined, or if a "walk through" at the scene can be timed.
The end time indicates the duration of an action, and is used as part of the testing of the BB – overlapping times or unaccounted for gaps between times can indicate a need for better data or estimates.

Investigation Building Blocks

CRUCIAL: This is always the first entry recorded!



Use unique name or placeholder...

The unique Actor name is absolutely essential for accident or any other process analysis or investigation, because the actors are the change makers who bring about the outcome.
So that's the first think you document when you are capturing evidence or analyzing inputs for analysis or reconstruction. Helps you search for what you should look for, and when you get it, helps you analyze what happened. If you don't know the name yet, use a placeholder. What are placeholders?

Placeholders

- Placeholders = “?”
- Use placeholders to indicate
  - where additional actor, actor name, action or other data is needed to complete a BB
  - uncertainty about a BB entry when used before, in or after a word or phrase

Placeholders are Question marks. Placeholders are your friends. Placeholders are an important MES investigation and analysis tool. They are used for two primary purposes.
They are usually used liberally as an investigation building blocks are being documented, and worksheet are being developed, to nag investigators about the missing or uncertain data until it can be acquired and substituted for the ?, or an explanation saying why remains can be defined.
On final, condensed or abbreviated worksheets, any remaining ?s acknowledge a remaining uncertainty that must be explained with its related importance in the report, to head off challenges and disputes about the uncertainty, and undermining of the entire reconstruction.

AVOID Poison Words in BBs

AND	HE	IT	WAS	...LY
OR	SHE	WE	WERE	FAILED TO
THERE	THEY	THEM	DID NOT	INADEQUATE

plural actor names (firefighters) passive voice (was struck)
opinion verbs (violated) compound actor names (crowd)
conditionals (if, may)

THEY PREVENT PLACEMENT ON MATRIX

W A R N I N G

BREAKING THESE RULES CAN BE FATAL TO YOUR INVESTIGATION

This is a little aside, but important.
Vocabulary matters when you document evidence or analyses or reports. I've been compiling a list of problem words that should be avoided in BBs used for investigations or analysis. I call them poison words because they can be fatal to your investigation logic statements. And, for example, can involve two different times or people building blocks, so that can screw up your sequencing. Was either indicates a state or passive voice, and is usually masks something that is not clear to the accident investigator. I'll be same is true in criminal investigations. If you want me to explain the problem theoretically, I'd be happy to do so by phone or email. The answer was indicated in an earlier slide about logic statements.

MENTAL MOVIES (MM) TOOL

THE CHALLENGE

- In your mind, try to visualize the stage setting, and what each actor did, step by step, in 3-D and color

- Example application: Transfer MM from witness' head into your head

Note: an empty “frame” points to a specific data need

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This tool is one helpful way for investigators and analysts to attack the data needs and data organizing challenges.
When you try to visualize what happened as a “mental movie”, you quickly identify what you know and what you don’t know as you visualize the “stage” on which the action takes place, and then run through your “script” with the actors and actions that you have accumulated thus far.
Gaps – or blank frames – in what you can visualize point directly to what you don’t know and might need to find out. Blurred frames point to ambiguities or uncertainties. As the frames flow from one into another, jerky progression may indicate an unknown unknown or UNK UNK you haven’t yet recognized.
This is particularly relevant to people recollections. We intuitively tend to make mental images of things we see as we see them – which is why good investigators ask witnesses to start at some beginning point, and then walk through what they did and observed step by step. What the investigator is doing is trying to copy the witness’ mental movie into his or her own head.

ORGANIZE BBs

- Next challenge is to ORGANIZE building blocks as they are acquired
- Create time/actor matrix worksheet for arraying BBs
- Add BBs as they are identified
- Do interaction and linking analysis in real time - as data become available
- Try to define unanswered questions
- Identify unknowns and get needed data

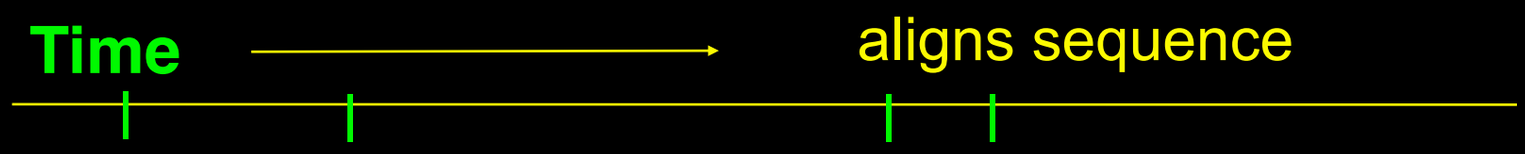
Here's where we shift from data capture to analysis. Good investigators do this iteratively – not sequentially. Get all the facts, then analyze them is lousy advice.

Organizing BBs means to first put them into their spatial and time order. This is done by using a matrix with time and action coordinates that serves as a worksheet for analysts — or investigators if they share the same supporting tools.

For investigation efficiency, the time to do this is on scene, to ensure gaps are filled as much as possible before leaving the scene. But that's not always possible because of the need for forensic examinations of evidence, off site statement document gathering, and so forth. Ideally all the data from any source would be fed into a worksheet as BBs, as the investigation develops.

As they are added to the worksheet, each new BB should be positioned relative to other BBs already in place. If apparent, link the new BB with any other BBs with which they interacted, either as an output from another BB or an input to another BB. It's unlinked BBs just hanging there that help steer you toward the next data input you try to find, to overcome the unknowns.

Basic Investigator's MATRIX worksheet



lists all involved actor names

Actor A

Actor B

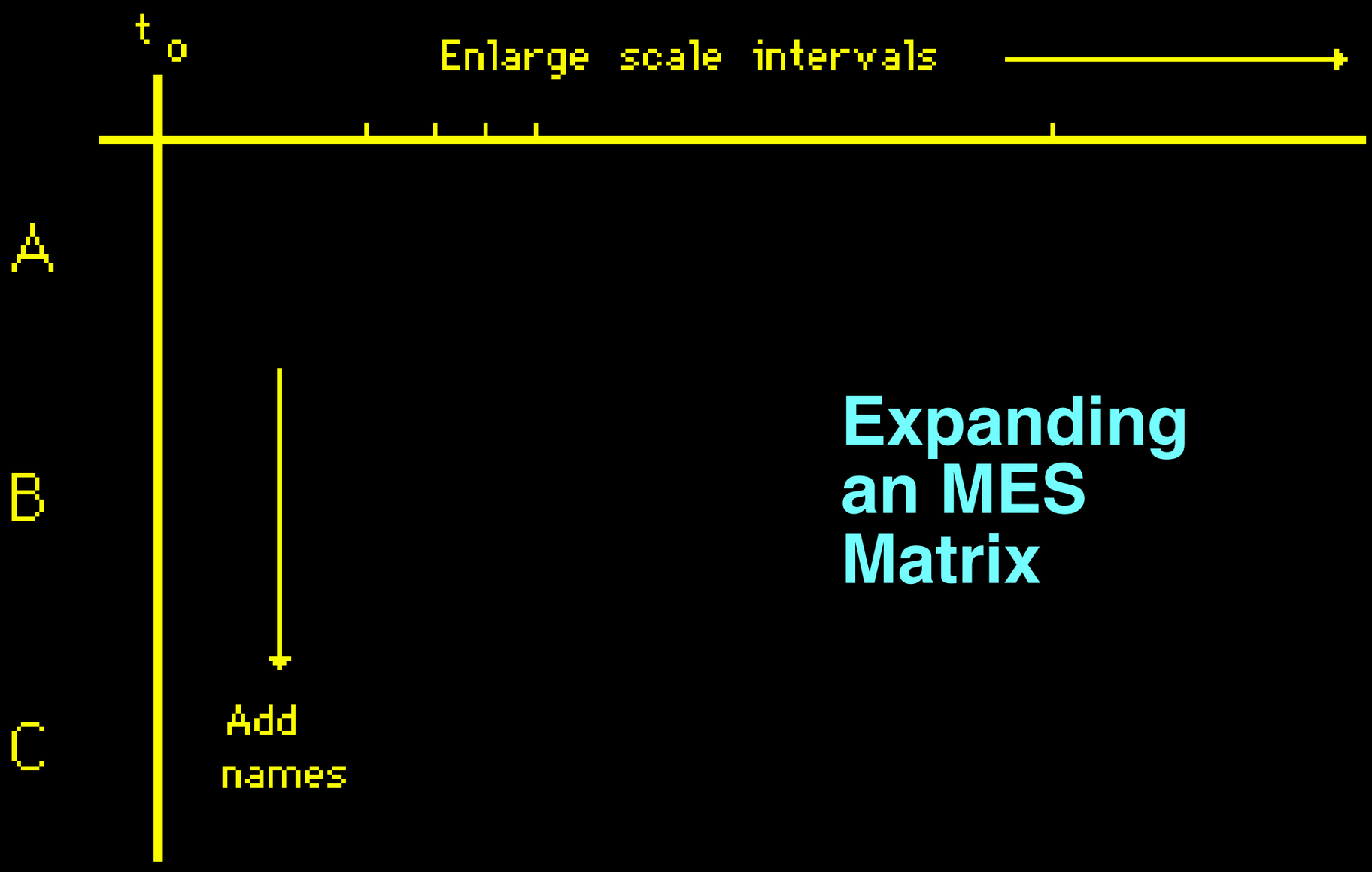
Actor C

etc

Here’s the basic structure of an MES worksheet, with the time/actor matrix coordinates. These displays are dynamic and can get quite complicated during the investigation or analysis stages of a project. They are dynamic because as information arrives, it results not only a new BB, but also may affect the content or need for some previous entries. Adding, editing or removing BBs is part of the MES process – it is really a worksheet!

At one time or another worksheets typically display all the BBs added to the worksheet during an investigation.

To adapt to presentation or court needs, a final BBs displayed could be trimmed to show only the actor and action, for example, while maintaining a completed BB display for purposes of reconstruction or testimony support. You’ll see this during our demo.



Expanding an MES Matrix

As each BB is added, the coordinates can be expanded as need, with no theoretical limits on the times or number of actors added. That's what I mean when I say a worksheet it dynamic – it keeps changing until you are satisfied it's the way it should be.

BB Placement guidance

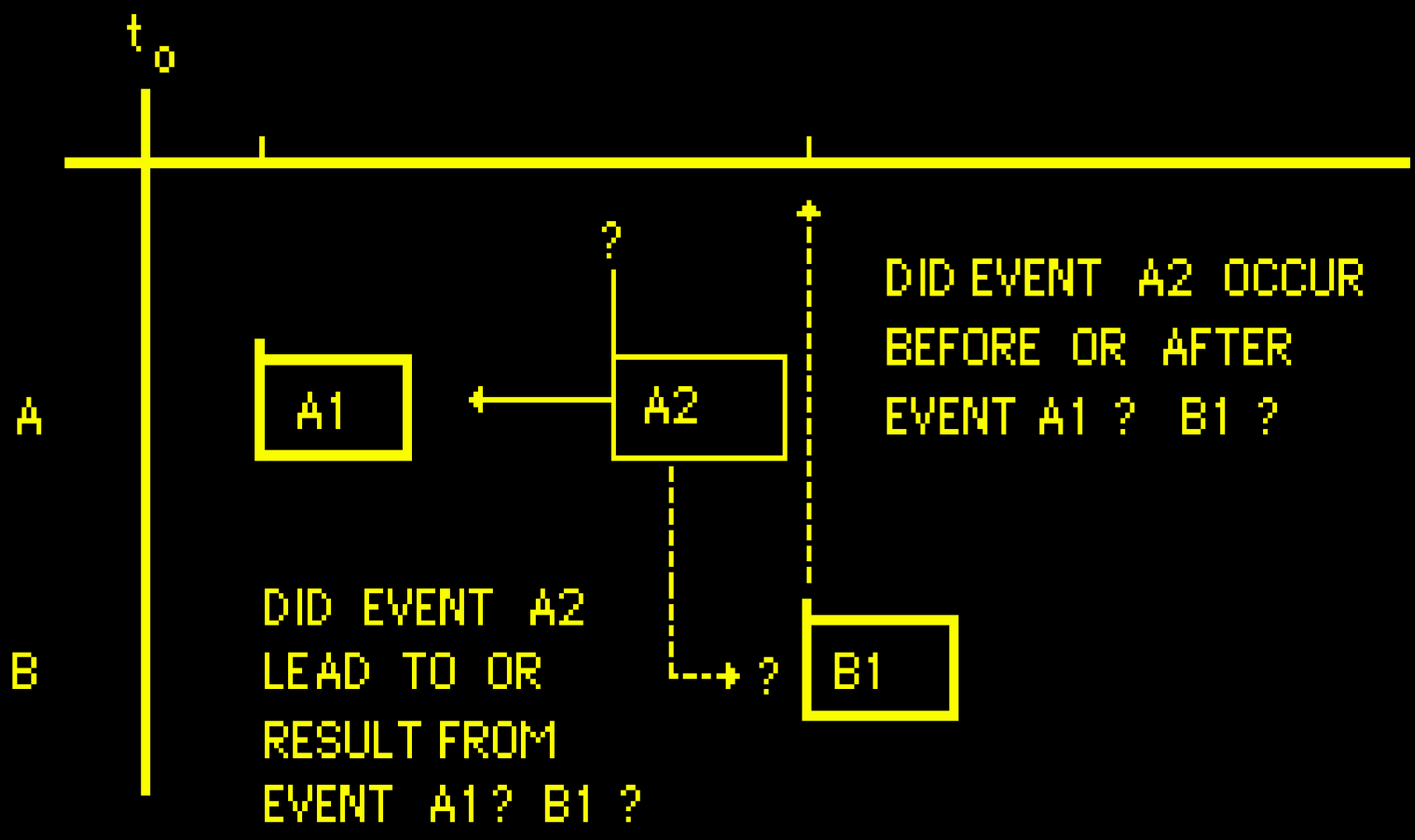
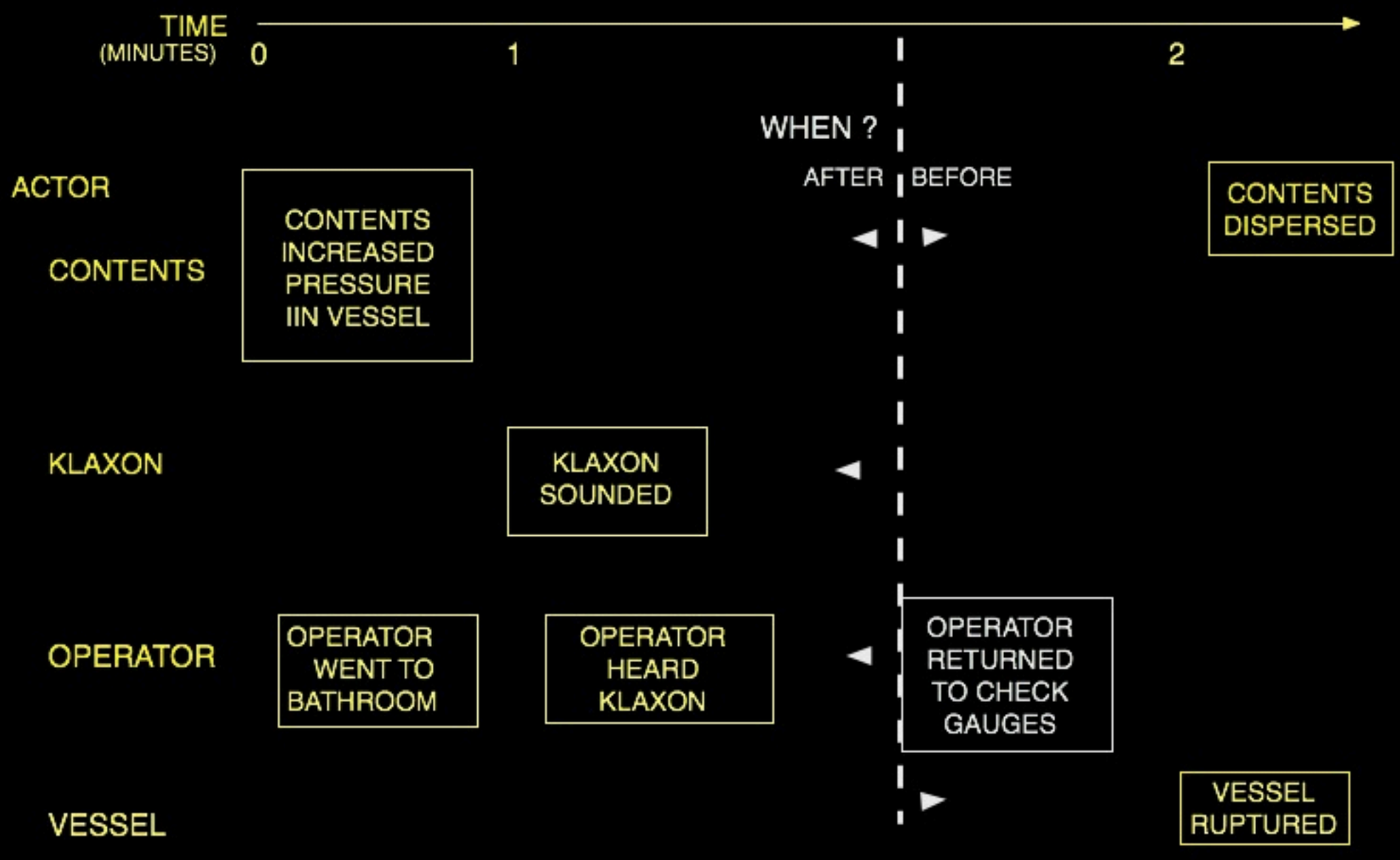


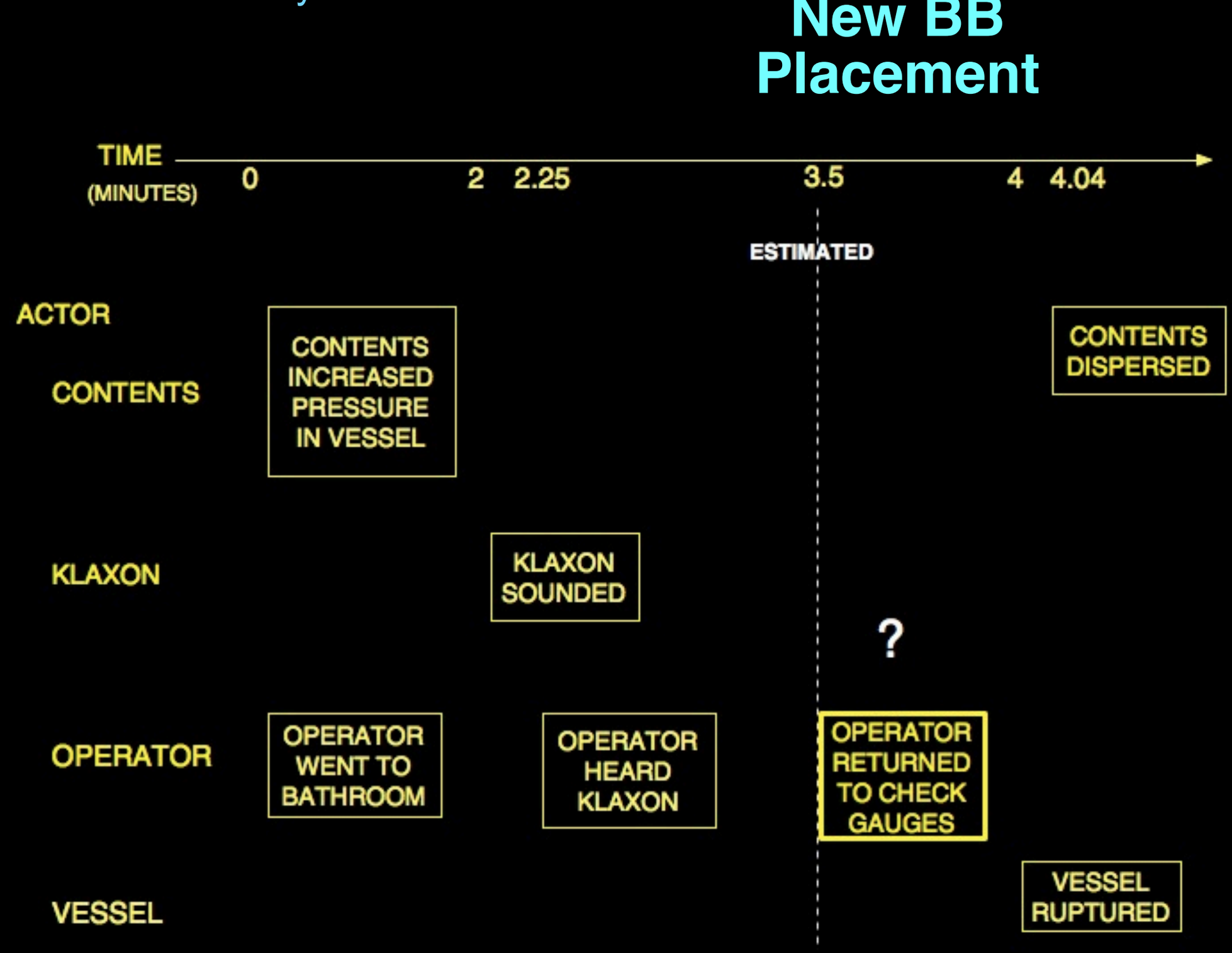
FIGURE 5-10

For efficiency, as each BB is added, it is positioned on the worksheet in its relative sequence to other BBs already in place. This is easy to do on the Matrix worksheet, because placement is determined by sequential logic reasoning about the observed or estimated time and the spatial relationships — where they occurred –- among the BBs.

New BB: Row and Column alighnent



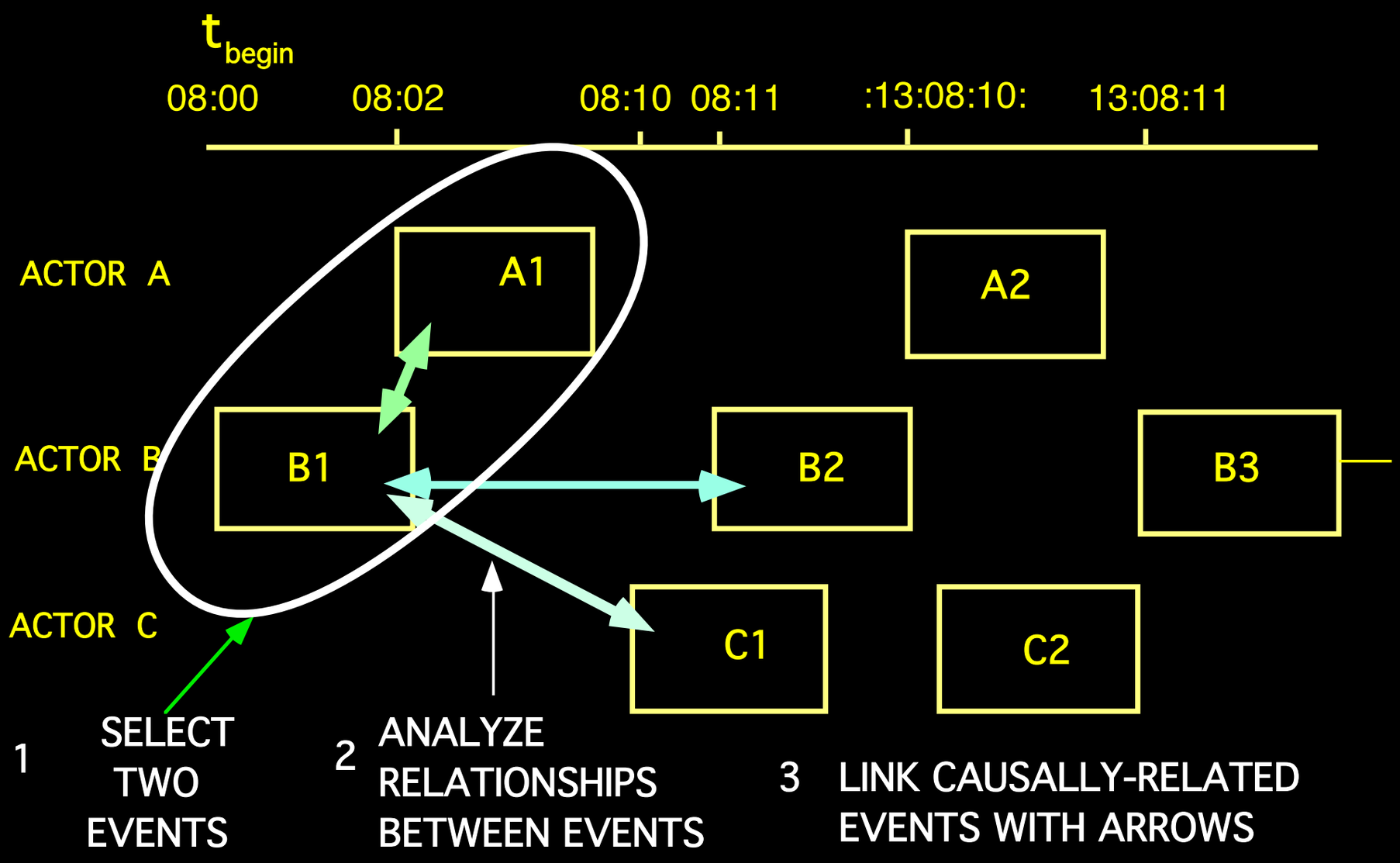
In a growing worksheet, the BB’s row alignment is governed by its actor name; if the name is not already on the worksheet, add a new row.
The column in which a BB is placed is determined by its spatial relationship, or the observed or estimated begin time of the BB, aligned relative to existing BBs on the worksheet. Not rocket science. Nor necessarily the final placement, either. The time coordinate can be expended as necessary when BBs are added,.
As projects evolve a lot of BBs might need to be modified or moved or eliminated.



Matrix form of worksheet forces you to properly sequence any data you want to put on chart. Here, for example, it's not clear when the Operator returned to his control console, so you tentatively put it where you think it might belong, and see if placement holds up when you get new information or start checking the links. An obvious question here is why the operator did not abort the vessel rupture. Can you see how placement of BBs might help define data needs?

As a practical matter, the worksheets usually contain row and column entries that can be discarded for communicating the bare essentials describing what happened. For accident investigations, a completed worksheet should consist of completely linked entries. For criminal investigations, because of different goals, that may not be necessary. We'll see how that develops during or demo.

Linking BBs (logical linkage)

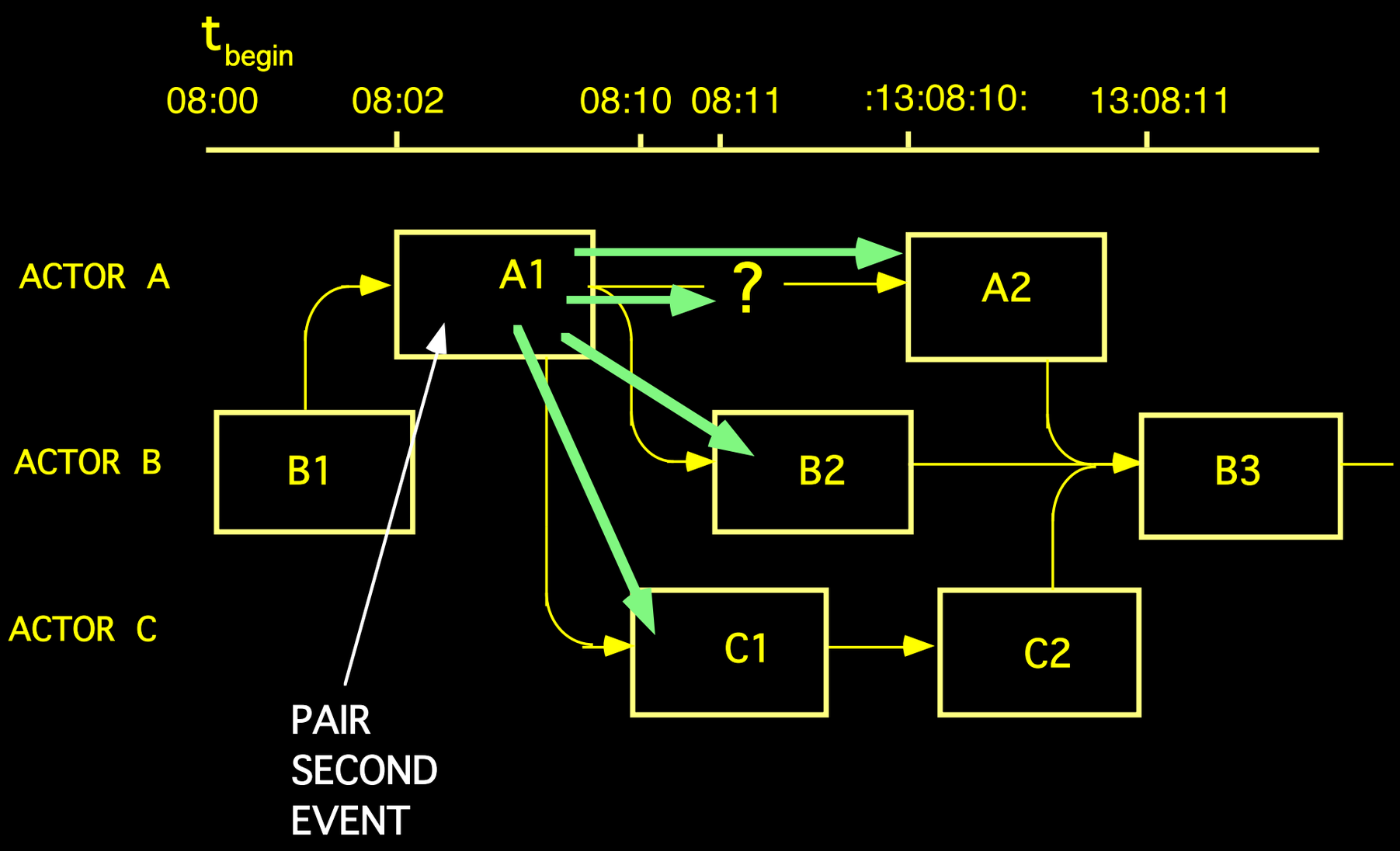


You can use links to couple something like an officers observation of evidence to a statement that suspect did something. The mechanics of the linking task are pretty simple, as illustrated here. The first step is to link a BB to another existing BBs as it is added to the worksheet, if there is a relationship.

Let's say you just added B1. Pair B1 with adjacent BBs, starting with A1. The green double ended arrow indicates the pair that you are examining for a possible relationship between them. Decide if the earlier BB led to or is related to the later BB. If they have an input-output or causal relationship, draw an arrow from B1 to A1. If there is any uncertainty, use a dotted arrow to show tentative links that need to be verified, or show a ? in the link.

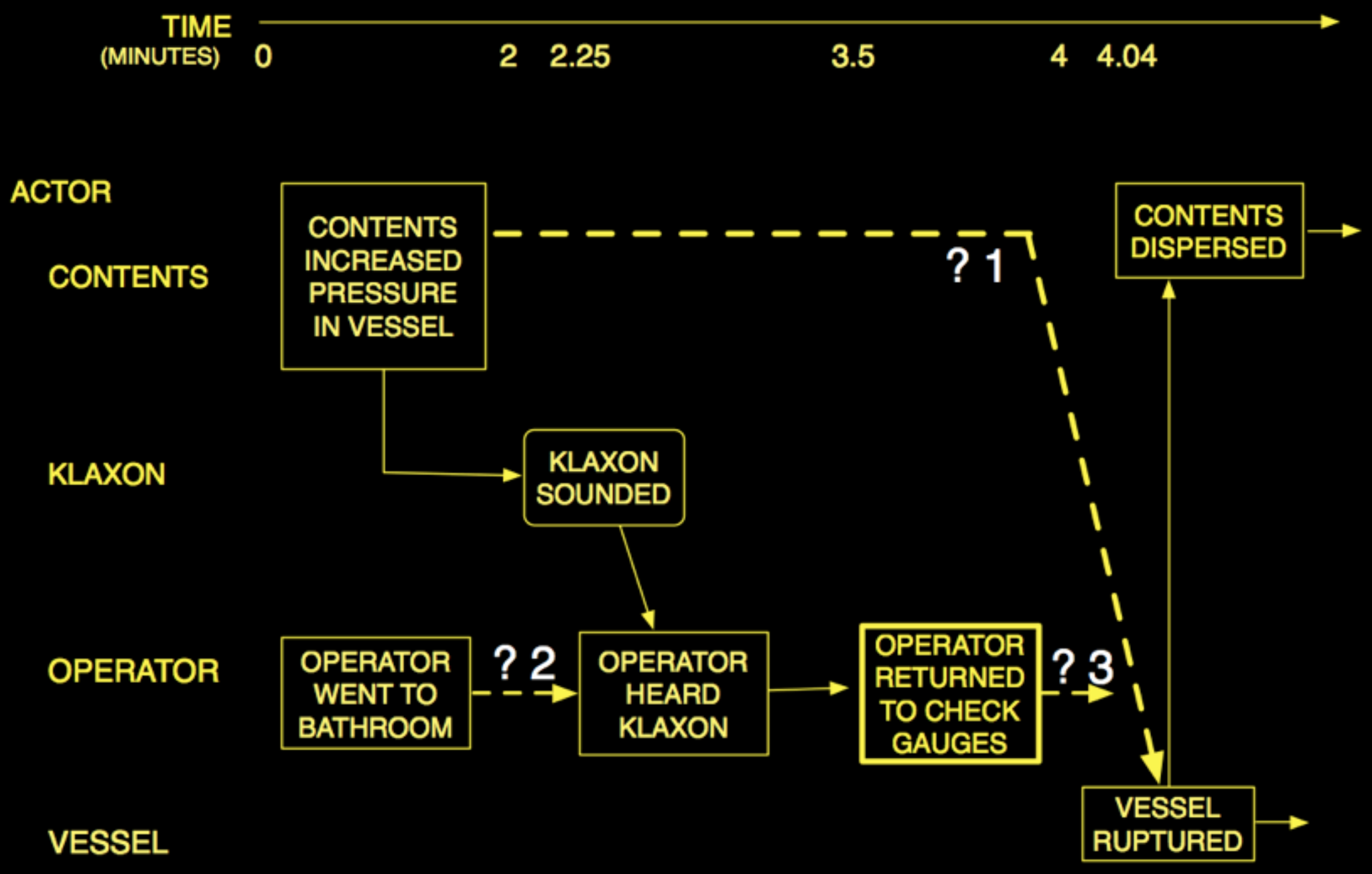
Then pair and consider the potential relationship between B1 with other BBs indicated by the other arrows to determine if they should be linked

Linking More BBs



When most of the BBs are in place and the arrows pointing to the input-output or causal links are in place, repeat the same pairing and linking consideration steps for each BB on the worksheet until you are sure all the relationships are shown.

Linking BBs



SOURCE: Hendrick & Benner, INVESTIGATING ACCIDENTS WITH STEP, © 1986 Marcel Dekker

The linking of BBs is a cerebral reasoning task for investigators or analysts, using input-output reasoning or cause-effect reasoning. In complex accident investigations, this may require the support of experts who understand how some object or system normally behaves or is supposed to behave. This is one role of forensic experts. They take investigator observations or objects, and based on their expertise, specify what the observation or object indicates, in terms of actions that produced the observed states or conditions. Then analysts take that data to reconstruct what happened.

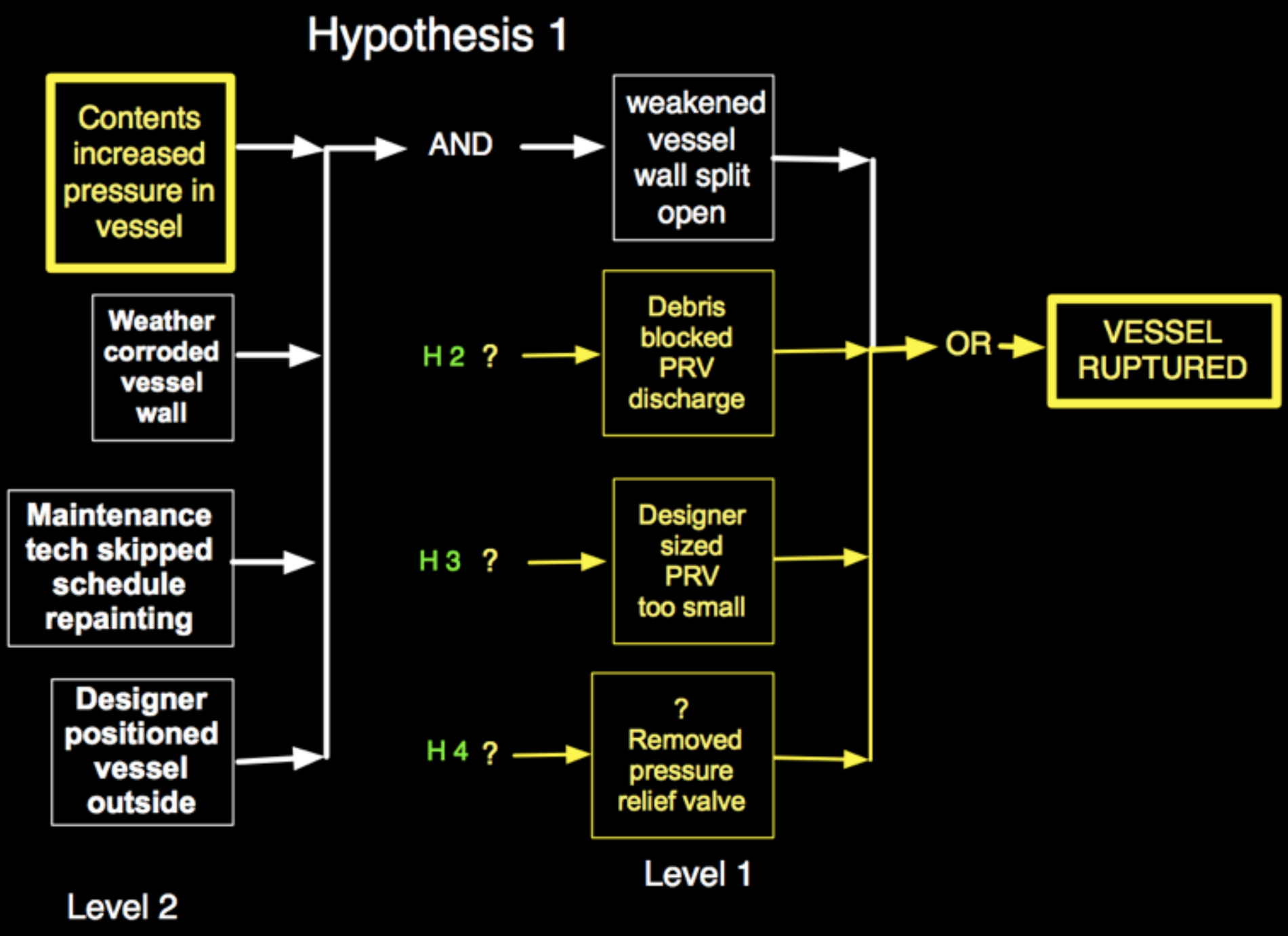
• In this example, the dashed lines indicate why the input-output or causal reasoning is so important. Question ? 1 is raised because by itself pressure increased will not rupture a vessel– something else had to happen in between because we know system has built in over pressure relief devices.

Q ?2 Went to bathroom is tentatively linked, but is it right? We know it had to happen because operator was in bathroom when the klaxon sounded. Don't know yet, but looks like that took him or her away from the controls that might have been exercised to prevent the rupture. Thus it might become an input the the rupture when we know more.

Q ?3 is uncertain because we don' t know yet if if links to anything – did the operator get back in time so he could have prevented the rupture by some action? In that case that action could be linked to the vessel rupture through some other actions that describe why he didn't prevent the rupture.

To paraphrase the Shapiro expression again, "if they don't link, rethink." You' may have a gap in your understanding of what happened. So now what do you do???

Use MES Trees to bridge gaps



Build an MES Tree. This is a neat tool for speculating. Use MES logic trees with two or more BBs to organize your speculation. Here's an example using the gap between the increased pressure and vessel ruptured. The gap exists because increased pressure on vessel is not sufficient to make a vessel rupture.

Lets work ? 1 from the last slide as an example. What had to happen between the contents pressurizing the vessel and the vessel rupturing? You can use separate MES worksheets to build a new MES Tree and merge the final tree with your main worksheet. Do this

1. Select the later BB in time as the "target event" and develop BBs to explain what might have happened to produce the vessel rupture. Start with Level 1 speculations about why vessel ruptured when pressure rose. This shows four possibilities, for example.
2. Go to the next level to speculate why one of the Level 1 actions occurred. Here's an example of a hypothesis that speculates a weakened vessel wall was the input to the rupture, and speculations why the wall split for Level 2. In this case the second BB is included at the second level which contains the earlier BB of the gap.
3. identify input data that would be needed to "prove" each action in each hypothesis, shown as here as H2-H4, and modify MES tree as necessary with the "best fit."
4 When one sequence is the best as supported by all available inputs, add those actions as BBs to the MES worksheet, in their proper rows and columns.
5. Link any new BBs to make sure they are valid.

This format can be used to handle others' speculations, to separate compatible from incompatible speculations.

QA Matrix check for logic flow, gaps

Check Row/Column Continuity

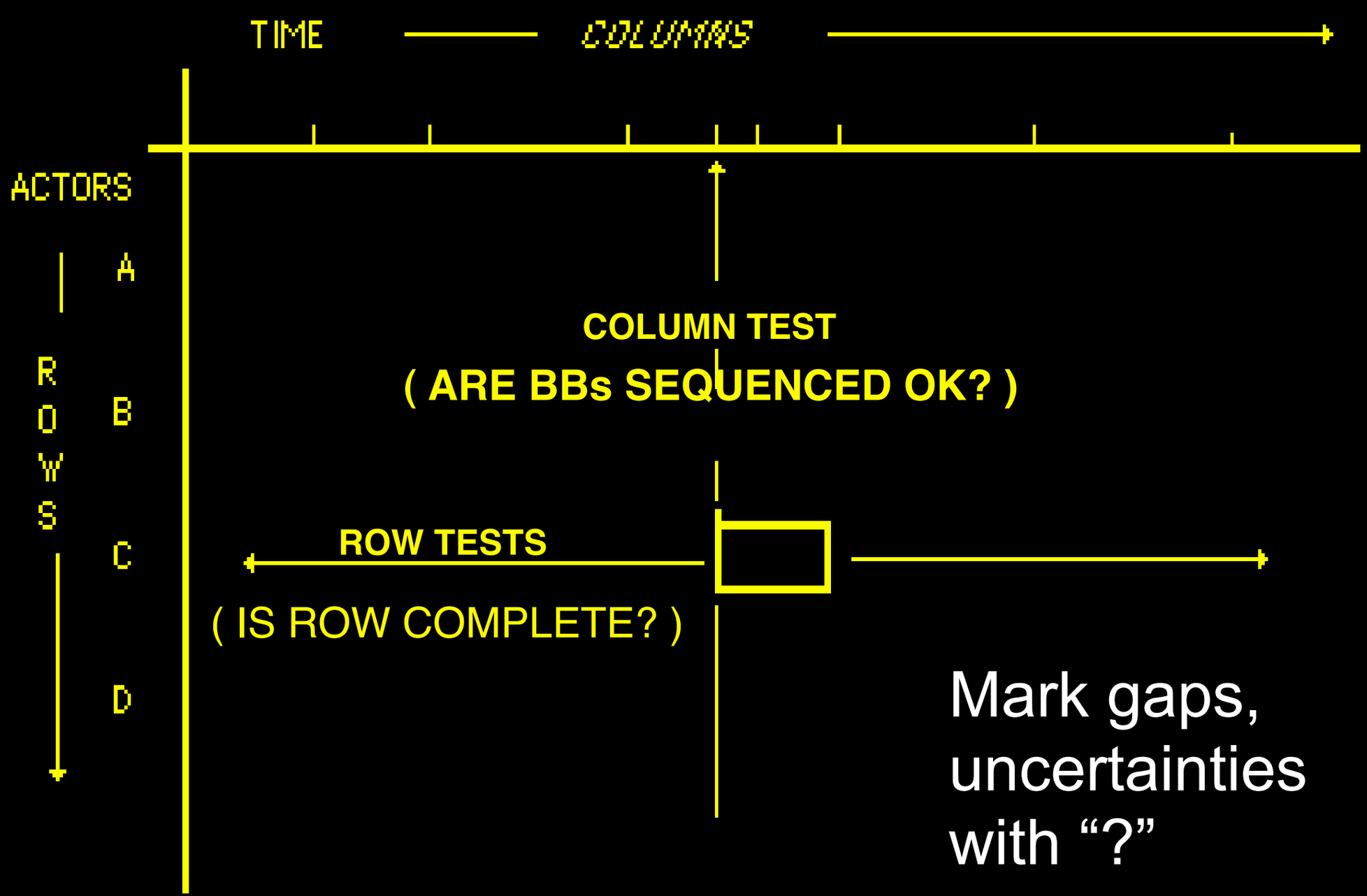
Check "Necessary" links

Check "Sufficient" links

Check remaining GAPS

When you think you have everything you can get for your worksheet, start your final quality assurance or QA check.
QA should be checked constantly as worksheet grows, but a final check for GAPs should be done before completion. Constant checking help prevent you from breaking MES rules.
Just in case you haven’t already guessed, how, here’s what you do.

QA BB Row-Column continuity tests:

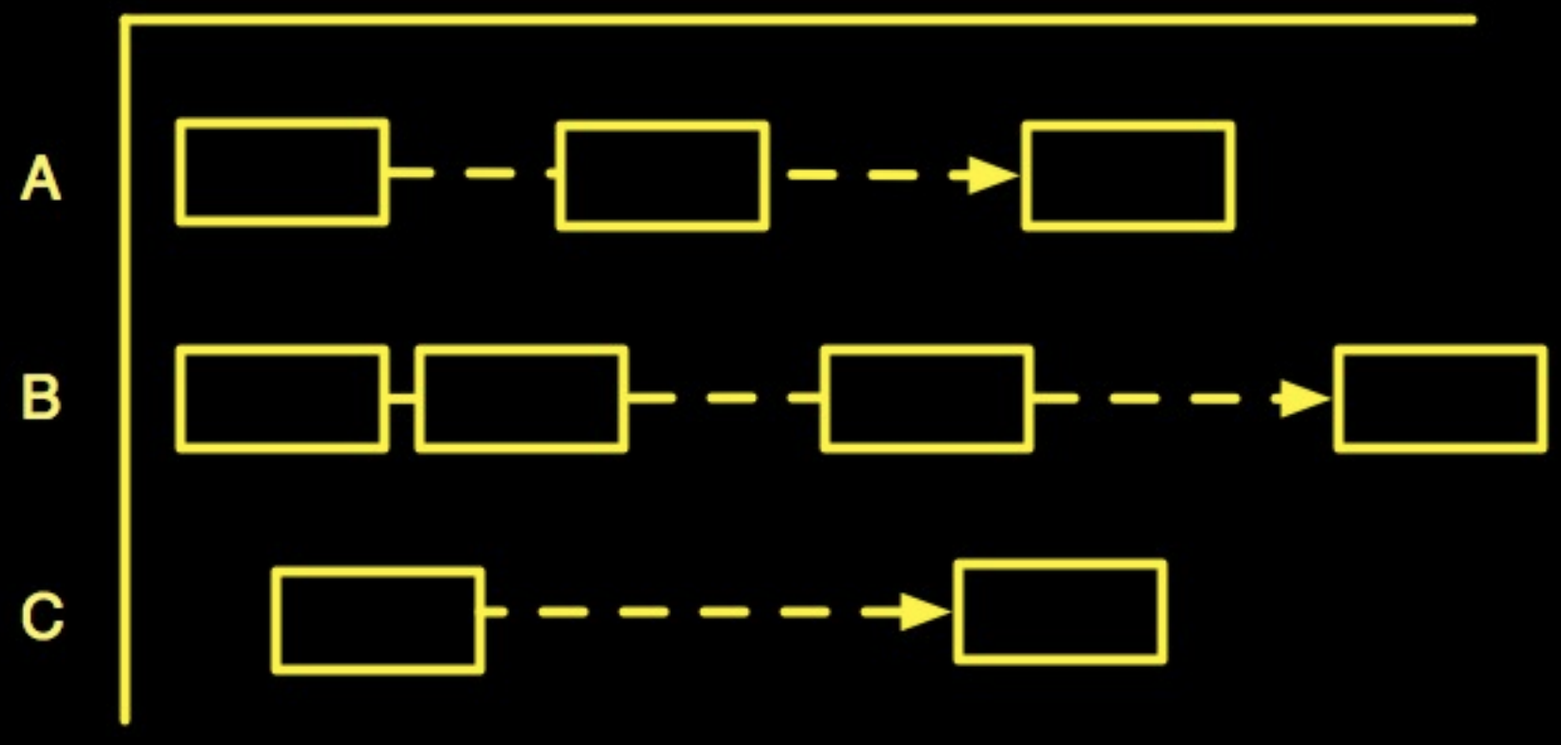


Mark gaps, uncertainties with “?”

2 checks
First, BBs in columns aligned in proper sequence?
Secondly do rows contain only one actor name, and is every row’s actor name unique?
Fix any problems

QA Matrix check for logic flow, gaps

Check Actor Continuity: Can you follow actions of actor on each row?



If not get more BBs?

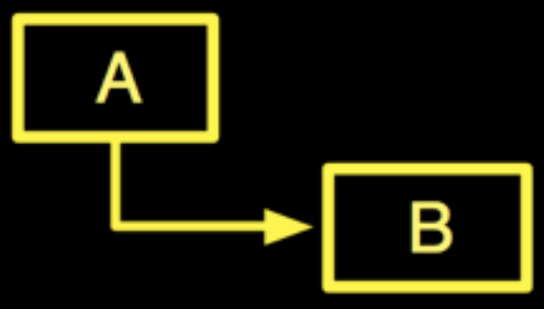
Are the rows complete enough so you can visualize what that person, object or energy did during the time period used, so the “movie” is adequate for your purposes? Do the BBs for a suspect, for example, have ambiguities or gaps that make your movie fuzzy? If so, are the problems worth fixing??
Do the BBs on that row convey an adequate picture of what they did? Does their testimony result in conflicting times when arrayed with others’ testimony – does it discredit or support other evidence?

QA NECESSARY test for each BB

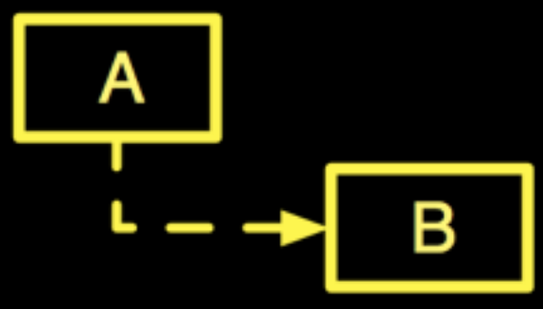
Could B have happened without A happening?

- **If not, is there a linking arrow from A to B?**
- **If you think no, but need to verify that relationship, is there a dotted line?.**
- **If there is no causal or input/output relationship between the two events, is there no arrow?**

Actually linked



May be linked

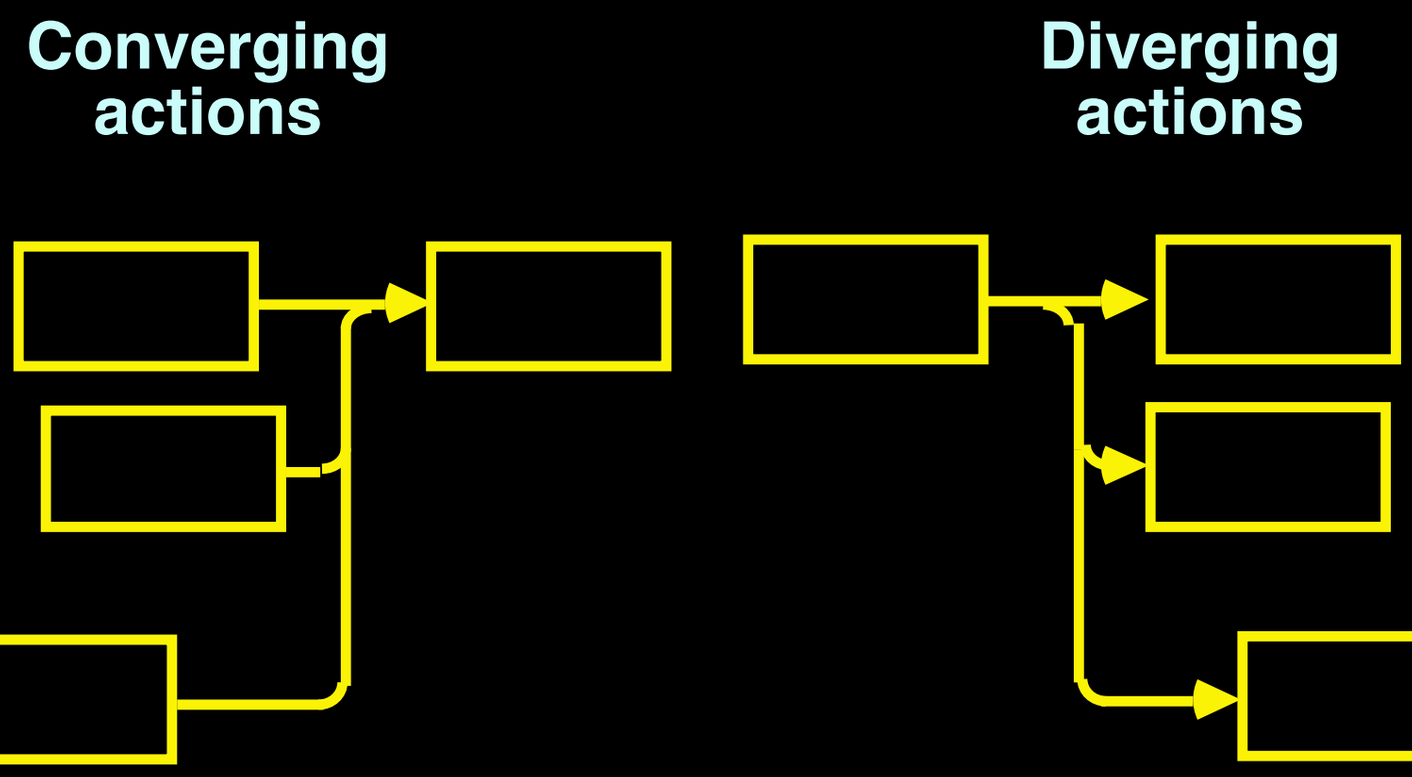


Fix any problems...

This has two parts – it's a combination necessity and link test. First verify that A was needed for B to happen. If A wasn't necessary than it may not be needed – it wasn't necessary. If it was necessary, link is OK. If not necessary, it might be OK to remove the A and the link. If uncertain, try to resolve the relationship.

This is the step where you might be able to eliminate BBs and perhaps some links from your worksheet to simplify it. As you check the linked BB pairs one last time, ask yourself if you have to have every input shown to make the linked BBs happen? On the other hand do you need to have all the inputs for your purposes?? If so make a copy and start pruning BBs you don't need to tell your story.

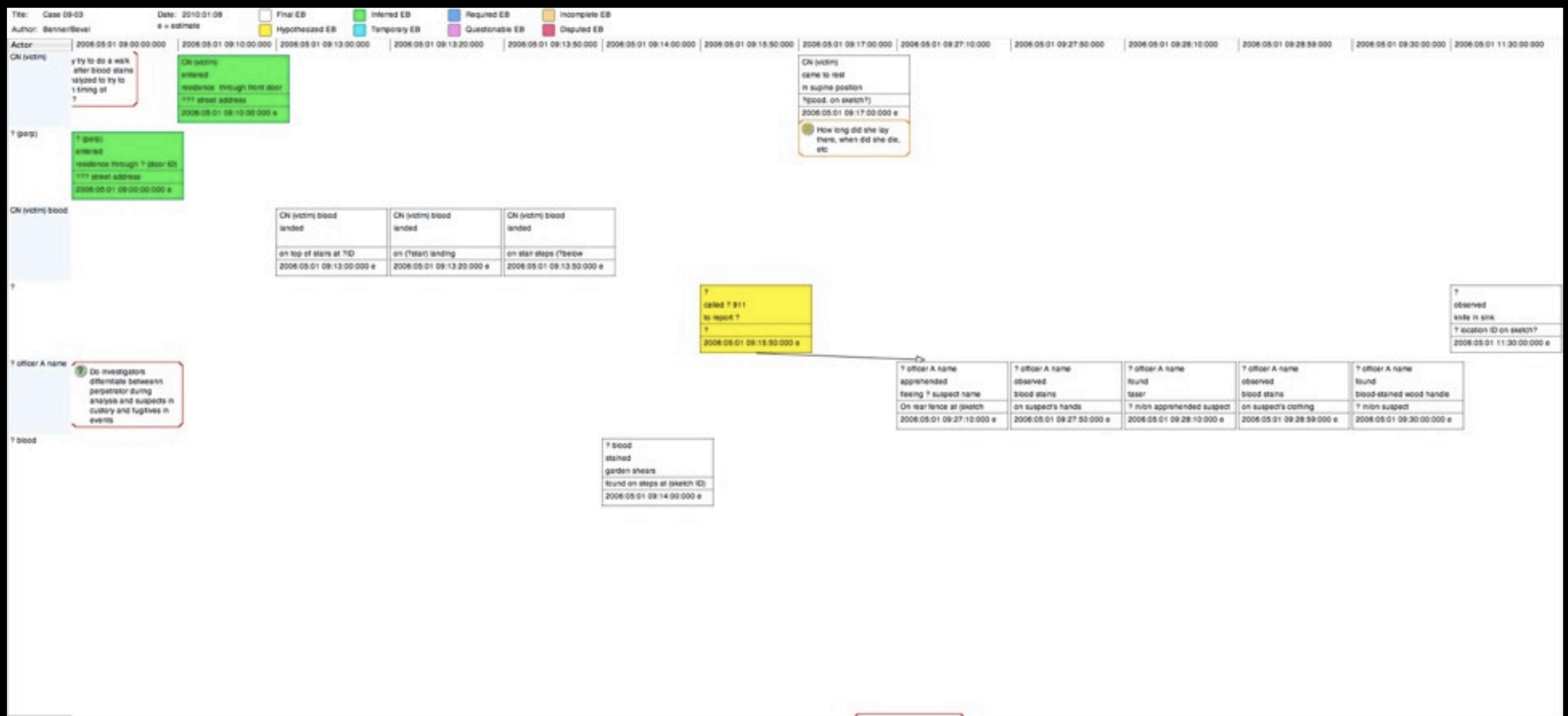
QA SUFFICIENT test for each BB set



1. Were linked input BBs SUFFICIENT to produce next action?
2. If not, add BBs and links until you can answer “yes.”

This one is a little more difficult: are the inputs you have sufficient to REPRODUCE the subsequent actions the way they happened?
Mark any remaining gaps, uncertainties with ? so they don’t escape notice, and your acknowledgement.
I’m not clear how vital it is for CSRs to worry about the sufficiency tests – let’s talk about that when we do the demos.
Question is how much is enough evidence to satisfy your purposes?

QA FINAL MATRIX GAP CHECK



IF OK, PRINT BBs FOR REPORT

Here is what a worksheet might look like.

This is when you do your QA final check of your analysis. If it is OK, you can print the worksheet or export a list of the BBs in the order they occurred, and use that to outline your report.

As you follow the BBs from left to right, your “finished” worksheet should give you a clear picture of what happened, in the who what when where format. It may also offer sufficient detail to explain why it happened if that’s your target.

A Heads Up about potential application of MES to criminal investigations and crime scene reconstruction

- Role of evidence development
- Data structure challenges
- Simplification needs
- Computer support

The previous slide shows part of a worksheet I set up as part of my preparations for this Conference, using information from one of the criminal case studies we will be using for our demos.

As I prepared it from the material I was given, I learned that there are some noteworthy differences in how accident and criminal cases would be processed with MES worksheets –
We'll see those as we do the demos, but I want to give you a heads up about what to watch for during the demos.

1. Evidence development is more rule-bound in criminal cases than accident investigations, and thus could play a role in criminal case worksheet development – during early part of analysis, for example, observations by responding police officers might be created and entered on worksheets to establish presence of suspect at a scene; if other evidence of suspect's presence is found those BBs might be deleted later.

2. The structure of the MES building blocks may pose a significant but I think beneficial challenge to CSIs and CSAs; you really need to adjust your mindset to look for actors as the first data to document...

3. The simplification of the end product is more significant in criminal than accident cases. With the prevention goal,
interest in the smallest details of what happened must be satisfied, whereas in criminal cases, the evidence required for a jury or judge to weigh so they can reach a decision should probably be less detailed. But the exclusions should be made at or near the end of the project. With software, you will see how easy it is to change the outputs.

4. Adaptation of computerized implementation of MES support for criminal investigations starts slowly but accelerates over time.

Now you know the essentials.

MES becomes intuitive with practice. Investigation Catalyst software helps that happen.

For additional information visit Starline Software's web site at

http://www.starlinesw.com or see Technical Notes at

http://www.investigationcatalyst.com/TN/technotes.html

Where are we?

I have told you and shown you what MES is,

Now let’s do MES using a real case

MES DEMONSTRATION

CASE 1: a homicide

ANALYST: you, the audience.

TASK: use evidence to document what happened.

OUTPUT: a flow chart describing what happened.

EVIDENCE CLERK: As available...

To get us started, I'll ask Tom a couple of questions, and enter data as Tom gives it to me, so you can get a feel for how it's done. It'll start slowly at first, then pick up speed as we proceed. I'll act as your data entry clerk, making comments about what I am doing, or responding to you to make teaching points for you

After a couple of entries, I hope you will start to ask him the questions about what I'm doing or why I'm doing it, or about the case.

I'll use investigation support software to speed up preparation of the MES analysis. Could be done by hand.

Let's see what happens.

MES DEMONSTRATION

Remember, we're doing this to help you….

- Recognize some ways MES AI tools might be adapted to your tasks,
- Know how to put the tools to work for you, and
- Recognize challenges the tools pose for CSIs and CSRs if you use them

MES DEMONSTRATION

Stand by for a moment...

I'll switch over to the support software so we can start the demo

INVESTIGATION CATALYST

MES DEMONSTRATION

CASE 2: suicide or homicide?

ANALYST: you, the audience.

TASK: use evidence to document what happened, and arguments for or against homicide.

OUTPUT: a flow chart describing what happened.

EVIDENCE CLERK: As available…

To get us started, I'll ask Tom a couple of questions, and enter data that as Tom gives me, so you can get a feel for how it's done. It'll start slowly at first, then pick up speed as we proceed.

I'll use investigation support software to speed up preparation of the MES analysis. Could be done by hand.

After a couple of entries, I hope you will start to ask him the questions, and I'll act as your data entry clerk, making comments on your dialogue to make teaching points for you

MES DEMONSTRATION

CASE 3: Whom to believe ?

ANALYST: you, the audience.

TASK: use evidence to document what happened, and arguments for or against favoring one witness' assertions over another

OUTPUT: a flow chart describing what each reported

EVIDENCE CLERK: As available…

Potential MES Benefits

- ☑ enables orderly handling of data sources
- ☑ helps guide data acquisition
- ☑ enables continuous quality checks
- ☑ easier to dispose of unjustified hypotheses
- ☑ expedites written report preparation
- ☑ quick ID and retrieval of sources used

MES Challenges

may be hard to...

- get used to transforming info into the actor/action format, especially with the times needed
- get used to breaking down actions and knowing when to stop
- find exactly the right words to describe actions
- avoid poison words, passive voice in reports
- persuade yourself and others that time spent on MES saves time and pays off in the long run

What's next?

Individual CSRs explore applicability of MES

Possibility of grants for ACSR to study…

- Contemporary CSR constraints and impediments
- AI technology transfer opportunities
- Supporting software development including
  - remote input data entry, distribution
  - open source exploitation
  - cross-platform processing

Here are some thoughts about what's next

individuals take action

ACSR takes action

We're done!

Thank you for participating.

Let's adjourn.

luben@mac.com

For additional information visit Starline Software's web site at

ww.starlinesw.com or see Technical Notes at

www.investigationcatalyst.com/TN/technotes.html

BREAKING DOWN ACTIONS

① *ORIGINAL EVENT*

air

Warm air goes to cooling tower

② *SAME ACTOR, NEW ACTION*

air

Warm air goes to cooling tower

Cooled air enters HVAC ducts

BREAKING DOWN ACTORS