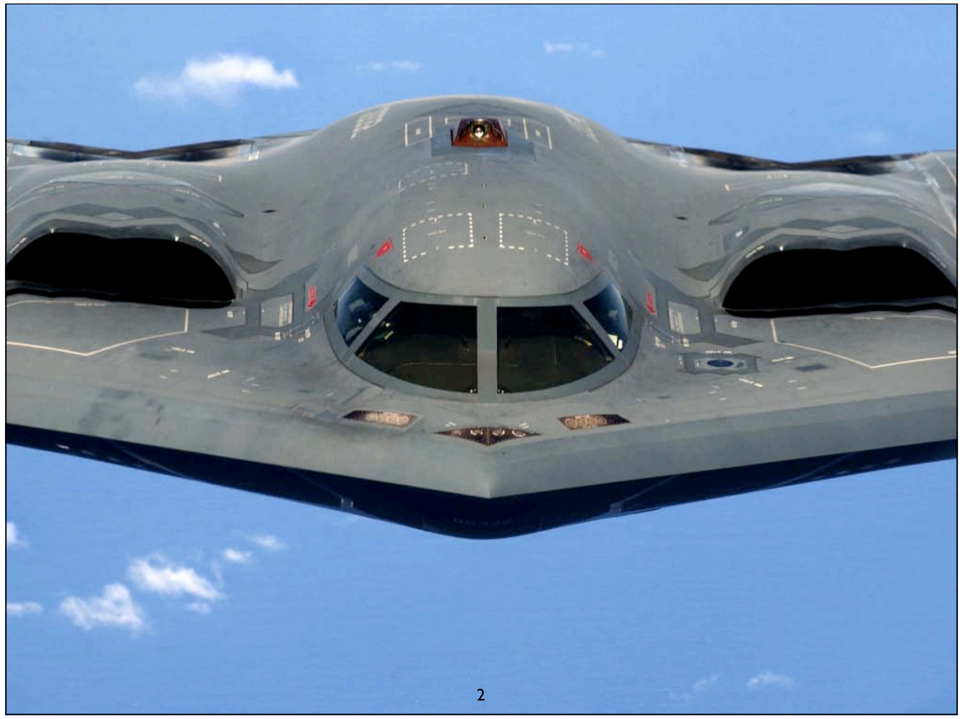
Tutorial:
LESSONS LEARNING SYSTEMS ANALYSIS AND ASSESSMENT

LUDWIG BENNER AND WILLIAM D. CAREY



This is a B2 Spirit Bomber – cost estimates range from 1.4 – 2.2 billion depending on who you talk to. Most technologically fantastic ever &c. Flies from Missouri, can hit targets anywhere. We had 21 of them.

May have seen it on the news. Pilots eject in frame 3. Plane go boom.

Now we have 20 bombers.

"This technique was **never formalized** in a technical order change or captured in **'lessons learned' reports**. Hence, only some pilots and some maintenance technicians knew of the suggestion," according to Carpenter's executive summary of the accident.

The report said, "The human factor of **communicating critical information** was a contributing factor to this mishap."

From Maj. Gen. Floyd L. Carpenter, who headed an accident investigation board. (AP News)

A lesson was not learned.

The Cost: well over $1 billion + diminished capability

"This technique was **never formalized** in a technical order change or captured in **'lessons learned' reports**. Hence, only some pilots and some maintenance technicians knew of the suggestion," according to Carpenter's executive summary of the accident.

The report said, "The human factor of **communicating critical information** was a contributing factor to this mishap."

From Maj. Gen. Floyd L. Carpenter, who headed an accident investigation board. (AP News)

A lesson was not learned.

The Cost: well over $1 billion + diminished capability

Who's Here?

- Who here works with lessons learned?
- What's your involvement with lessons learned processes?
- Is anyone involved with safety management systems?

Poll class 1 Q at a time

What we're going to talk about today:

- What do we mean by "lessons learned?"
- What are lessons learning systems?
- How do we analyze and evaluate them?
- How can we make them better?
- Your questions and suggestions.

What do we mean by LL
What systems produce them
How do you evaluate yours?
How you can make them better

We'll lead, but **your willingness to share** will pay dividends for everyone.
Scope of tutorial includes everything from the development of a lesson to the ultimate verification by an end user that a change inspired by the lesson has been learned and produced the desired results.

Do you work with LL of any kind in your jobs?

Let’s define some terms:

What do we mean by “lessons learned?”

Hey, this is not just theoretical – it affects LL system design decisions – strategy and attributes, and resultant lessons learned system performance. **(STOP)**

Ask participants to write by No. 1 on our handout (blank paper) and jot down what they think lessons learned are,

Later, then ask them to read them back as time and participation dictates

"Lessons Learned"

"Lessons learned" are new knowledge gained from investigations to enable improved future performance.

CALL defines lessons learned as validated knowledge and experience derived from observations and the historical study of military training, exercises, and combat operations <u>that lead to a change in behavior</u>..." *(emphasis added)*

From CALL Handbook 09-22 Chapter 4 CALL: Collection Principles

What do we mean by Lessons Learned?
Actually, on the surface there's pretty general agreement about **meaning** of term – but abstraction masks differences in the actual lessons developed in practice, as we'll see.

Focus of tutorial is on lessons learned during mishap investigations – both **before and after they happen,** so think hazard and risk analyses which are "pre-mishap" investigations, as well as post-mishap investigations.

Both provide "new" knowledge from experience.
Pretty ambiguous, although with CALL, a little less. We like the part of call that says "change in behavior" but what follows is ambiguous –
What's doctrine, training or education behavior change? Aren't we aiming for design and operational behavior changes in people, objects or energies? Doesn't leadership behavior determine organization behavior? We can guess, but should we have to.….

What's a "lesson"…

- to investigators?
- to system safety analysts?
- to you?
- to your customers?

Shows different views of lessons.

- Investigators report causes, cause factors, root causes, issues, errors, failures, and recommendations, etc. as lessons learned, but don't report as lists "lessons" or "what was learned"
- Hazard analysts report hazards found, but no "lessons learned" per se
- for you personally – ?
- knowledge they can act on –

Who is expected to "learn"?

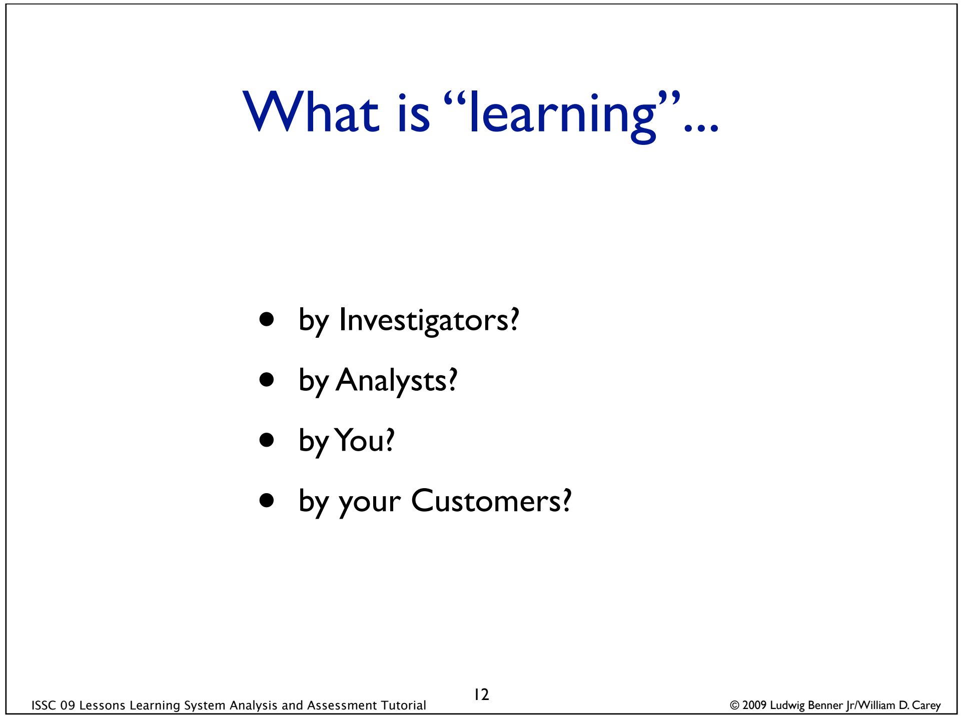
- Investigators?
- Analysts?
- You?
- Customers?

- Investigators learn what happened and produce recommendations that if implemented are presumed to fix the reported causes, factors, issues or whatever

- Hazard analysts learn about past hazards and mishaps from ?

- You? What are you expected to learn?

- CALL (as a customer) wants "change in behavior...of doctrine, organization, training, material, leadership and education, personnel and facilities domains "



use to bring out different views of learning
2 kinds of learning - 1= lessons from accidents, 2= changes from lessons.

AI - learn new knowledge about what happened

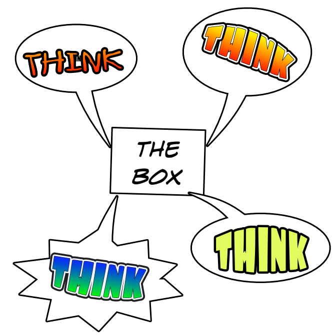
Analysts - learn new knowledge about what might happen

by you - how things can go bad

by your customers - changes made due to lessons made available to them

Let's think outside the box…

- The lesson is an understanding of how unwanted outcomes came about or might come about.
- The learning is the changed behavior of people, objects, or energies that results from the lesson.



For this tutorial, let's adopt a couple of meanings that help us achieve our tutorial objectives

LESSON

how unwanted outcome came about = investigation output

how unwanted outcome might come about = analysis output

LEARNING

Changed some behavior (s)

What are "lesson learned systems"?

They are the systems – the interacting components – that produce the the changed behaviors learned from lessons derived from mishaps.

They are the systems

– the interacting components –

that produce changed behaviors learned from lessons generated during mishaps.

Some examples:

- FAA – ASIAS
- NASA – ASRS
- DOD – CELL
- NIOSH (Medical Devices)
- USGS (Earthquakes)
- Wildland Fire Lessons Learned Center
- Army – CALL
- DoE – SELLS
- NASA LLIS
- DHS - LLIS
- OSHA – Safe Tank Alliance
- DoT - RITA

Here are just a few examples of governmental Lessons Learned systems, all of which strive to improve safety performance, based on mishap experience, through the acquisition and processing of Lessons Learned. Most private organizations have LL systems with widely varying degrees of sophistication.

ASIAS = Aviation Safety Information, Analysis and Sharing Center
NASA – ASRS = Aviation Safety Reporting System
DOD – CELL Center for Engineering Lessons Learned
Army – CALL – Center for Army Lessons Learned
DoE – SELLS = Society for Effective Lessons Learned Sharing
NASA LLIS =Lesson Learning Information system
OSHA –Safe Tank Alliance
DoT – RITA Research and Innovative Technologies Lessons Learned reports for programs
And they are all different, but with some common components.

What are the main components of contemporary **mishap investigation** lessons learned systems?

- Identification
- Documentation
- Dissemination
- Implementation
- Feedback

Lets take a look at some practices that constitute the system within your organizations.

What are the components or elements that make up an **investigation** lessons learned System that you can discuss - your own, preferably, but anybody else's you care to mention.

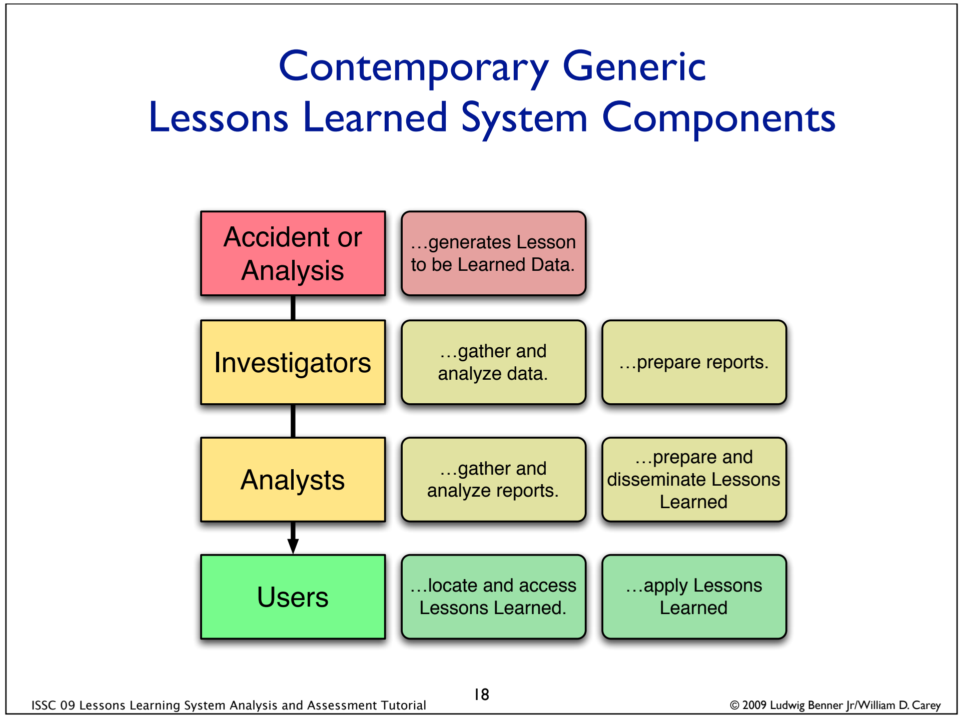
First, lets try to walk through the system, starting with the occurrence of a mishap
After that, we'll do the same for a hazard or risk analysis system - how are lessons learned developed and handled there?

What are the boundaries for mishap investigation lessons learned system?

- Mishap or investigation report of "experience"
- Recommendation for action
- Closed recommendation

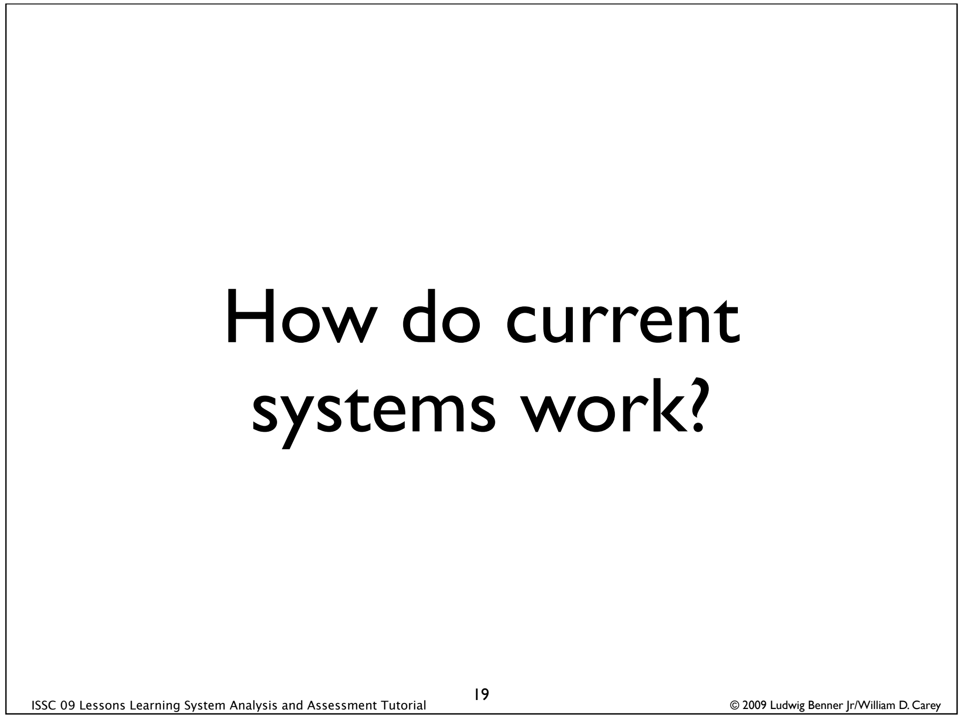
What do we mean by system boundaries?

how components of a constituting a system are limited by definition.



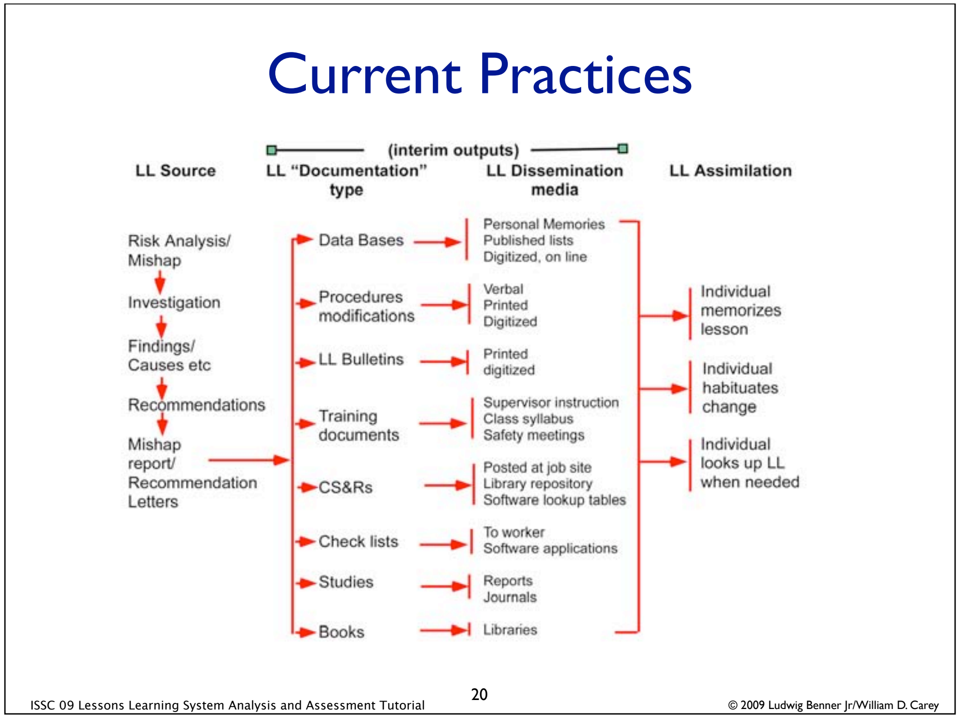
If you think of the components and functions that produce LL from mishaps as a system, here is a flow chart showing a generic system we synthesized from 7 selected accident investigation related LL processes. The role of analysts in the system operation is especially noteworthy, and reflects a strategic system design decision, as you will see later

We also found it useful to think of the data generated by an accident or incident as raw “lessons-to-be-learned” data from which lessons must be developed.



Poll class...

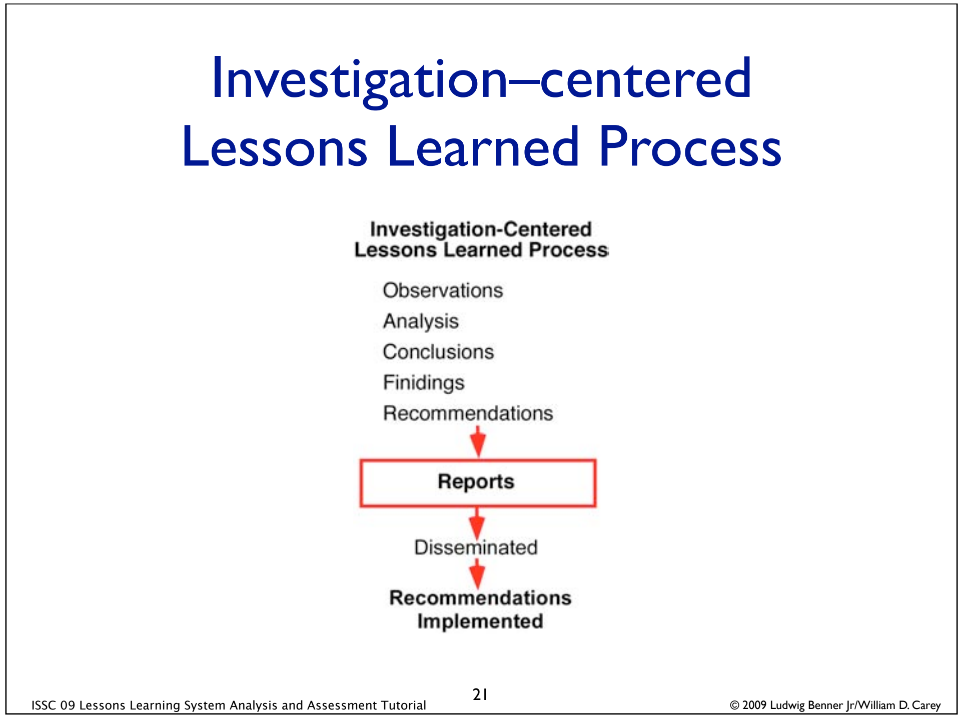
Well, lets take a look at current systems, and see how we found they work.



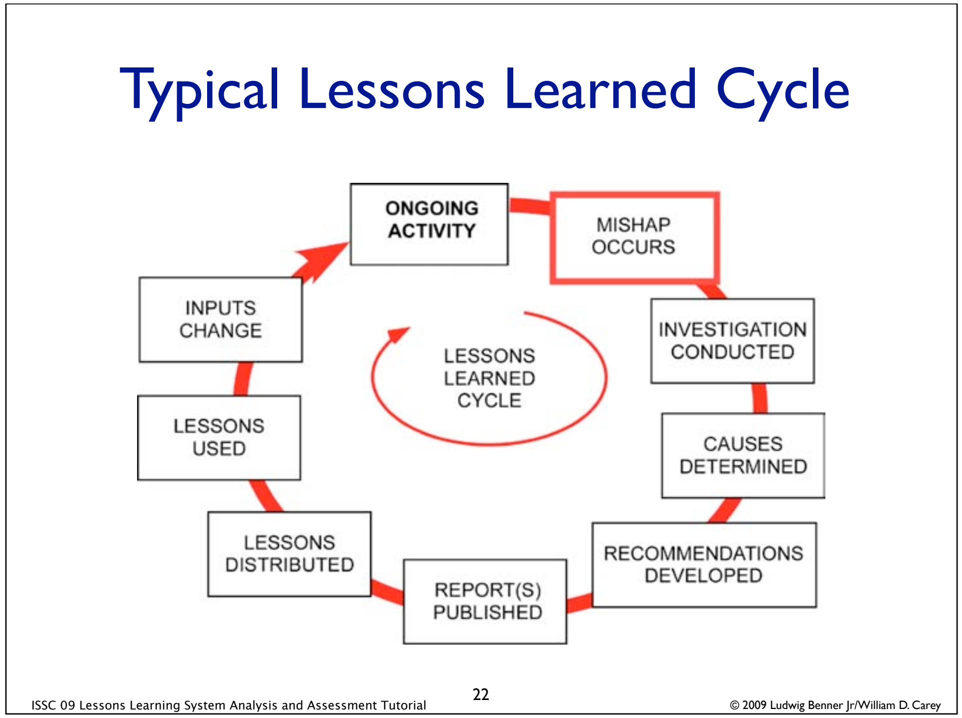
Here's a general representation of current mishap lessons learned system practices we put together before today, and how they fit together.

Note that there's a lot of action between the occurrence of the incident and the final assimilation of lessons learned.

(LL Process flow.png)



Here is how we thought to represent the way investigations lead to changes. This follows present ideas about investigations



Now, if we look at an ongoing activity, the lessons learned system needs to be continuous if the organization is to be a “learning organization” of the kind envisioned by Senge in his book, The Fifth Discipline: The Art and Practice of the Learning Organization. That’s an organization that joins adaptive learning with “generative” learning to enhance its capacity to create its future.

The mishap lessons learning system must be a continuous “loop” where experience changes inputs to the ongoing activity as it becomes available.

This graphic illustrates the nature of present mishap lessons learned cycles.

Observed Lessons Learned System Attributes

1. Divergent views of Lessons Learned
2. No listing of Lessons Learned by that name in reports
3. “Undisciplined” natural language inputs
4. Recommendations are proposed responses to Lessons Learned
5. Causes, factors, issues etc affect taxonomies
6. Analysts select recommendations to promote
7. Recommendations assume favorable change
8. Key words may be assigned to help retrieval
9. Context buried in verbiage
10. Recommendations “pushed” to addressees
11. Assimilation by others “pulled” haphazardly
12. If used, results metrics are unstructured

Here’s a quick summary of the attributes we found during research of lessons learned systems. It’s worth spending a moment highlighting some of them like 1, 2, 3, 5, 8, 9, 10

Observed Lessons Learned System Attributes

1. Divergent views of Lessons Learned
2. No listing of Lessons Learned by that name in reports
3. "Undisciplined" natural language inputs
4. Recommendations are proposed responses to Lessons Learned
5. Causes, factors, issues etc affect taxonomies
6. Analysts select recommendations to promote
7. Recommendations assume favorable change
8. Key words may be assigned to help retrieval
9. Context buried in verbiage
10. Recommendations "pushed" to addressees
11. Assimilation by others "pulled" haphazardly
12. If used, results metrics are unstructured

Here's a quick summary of the attributes we found during research of lessons learned from investigations. This is just how things are, not intended to be good or bad.

It's worth spending a moment highlighting some of them

Where do System Safety Analysts fit now?

let's talk about this a moment now – to introduce you to our way of looking at analysts role they might have, now or later

System safety analysts are end users of lessons from accident investigations during their analyses.

This is main thrust of tutorial. LL should be available to help you with your work.

System safety analysts may also be producers of lessons from their pre–investigation of accidents during hazard and risk analyses.

Might this apply to analysts? Anybody want to comment on this notion

As tutorial progresses, we'd like to keep this possibility in mind as we get into criteria.

What are the "lessons" aspects of current **hazard and risk analysis** processes and practices?

- Identification
- Documentation
- Reporting
- Dissemination
- Updating

Aren't hazard analyses in reality mishap investigations before they happen?

Analysts just hypothesize what <u>might</u> happen rather than reconstructing what <u>did</u> happened.

We could walk through each step of hazard and risk analysis lessons learned practices like we just did post-mishap investigations.

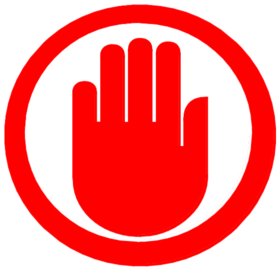
Introduces an approach for defining safety analyst's predictive Lessons Learned "system"

Could spend a lot of time looking into this little hummer - but we won't
(later, Tutorial offers approach and questions you can take home)

How well do current systems work?

Talk with people here.

Break time.
Back in the saddle in 5 minutes.



Identification of lessons learning system components was derived in part from personal experiences with functions and actions required to bring about successful behavioral changes in people, objects and energies through accident investigations at the national level.

This accident killed a firefighter training officer. Our finding out what happened, and subsequent tasks, eventually led to major behavioral changes in the US fire services' responses.

Oh, there were some observations during unsuccessful efforts, too.

Have we left you out in the cold so far?

Well lets start poking into the details to see if that helps.

Review

- Defined lessons and learned
- Modeled contemporary lesson learned processes
- Talked about how well they perform
- Identified system safety analysts roles as lesson learned process users and producers

Here's where we are.

How do we evaluate the effectiveness of lesson learning systems?

Talk with people here.

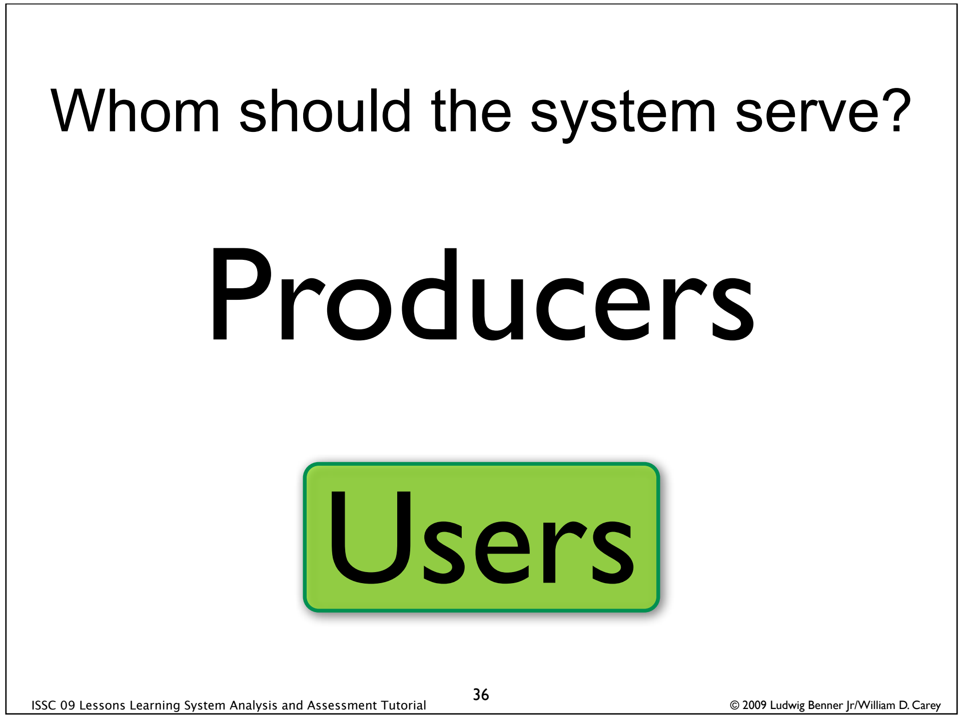
Lessons Learning System attributes

- Why should we care?
- How determined?
- From whose perspective
- What are they?

Why care? You need to know what is desirable to determine if what you have is OK, and to
distinguish relative quality of alternative strategies and systems

To determine them, we called on experiences in bringing about changes in the past, applied systems analysis tools to track the progression of lesson data through the system, and we looked at how contemporary processes worked and what problems they seemed to pose

(Possibly digression about Karl Popper)



The system must help lessons producers and users.

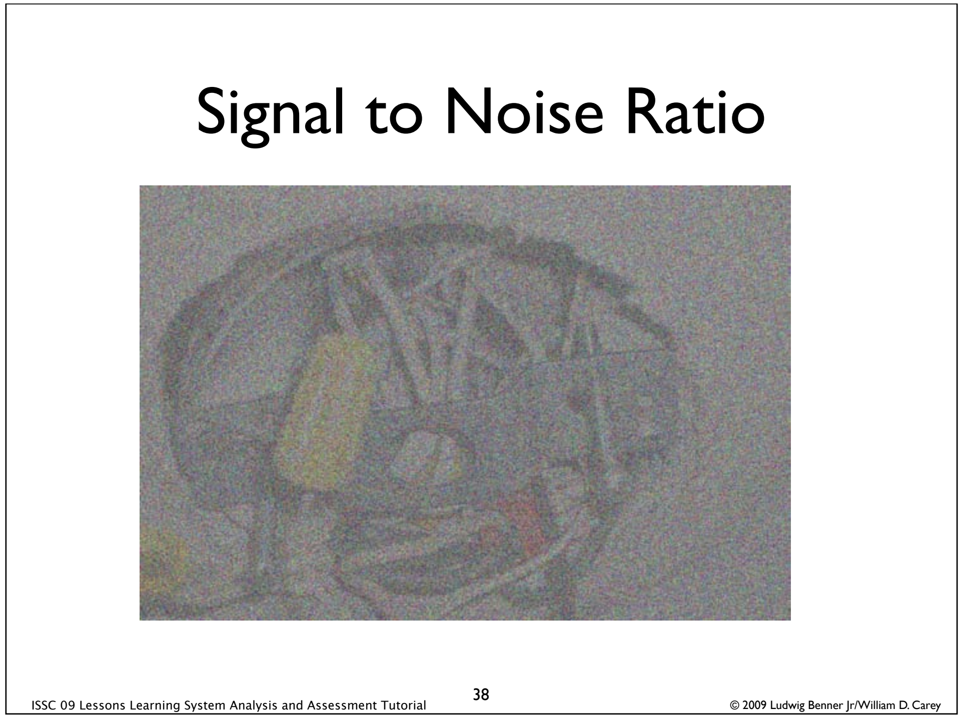
As we analyzed the necessary system operation, it soon became apparent to us that by differentiating between the learning and the lesson creation functions, the main “driver” for a well-performing lessons learning system design must be the users’ perspective and resultant needs, rather that the investigators’ or analysts perspectives of their own needs and outputs.

However both must be accommodated. So we divided the system into two parts- one part for user functions and the other part for developer functions.

- must be designed and optimized to provide lessons to users who can bring about better behaviors in people, objects or energies.
- design should NOT be driven by investigators’ or analysts’ perceptions of prevention

First, what do we want from the lessons themselves.

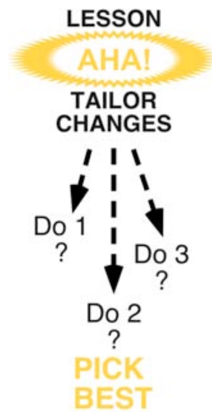
Let's take a what we expect from the lessons themselves. What attributes are important to users?



A frequent user complaint is the quantity of data that must be searched to find the morsel of interest to a potential LL user. It is difficult to acquire good messages from “noisy” data. This is mostly due to use of unstructured narrative form and vocabularies of LL. Lessons learning system design must address this signal-to-nose maximization challenge.

Another way to look at it is to think of “data density” of the documentation within which the LL are contained.

Multiple Change Options



Recommendations by analysts rarely offer options for fixing “lessons learned” by investigations, so they can be tailored to the specific activities of users. There are exceptions, particularly in some engineering lessons learned processes. Ambiguously worded recommendations requiring interpretations, it might be argued, offer tailoring opportunities, but that poses other problems.

Context Identification

2. Analysis

2.1 Handling of the incident by the flight crew

The flight crew were made aware of a vapour trail emanating from their aircraft at an early stage of the flight. Its diagnosis was not straightforward; there were no abnormalities displayed on the flight deck instrumentation and the fuel flow to the engines also appeared normal. The fuel synoptic page of the EICAS showed no imbalance between the wing tanks and this, combined with the lack of a visible leak from the engine pylons, led to the flight crew correctly diagnosing that the leak must be from the CWT. Continued visual reports of the leak from other aircraft indicated that the leak was not transitory so the crew rejected the option of continuing to their intended destination. A decision was then required between landing as soon as possible, with the aircraft still about 65 tonnes above its maximum landing weight, or remaining airborne and reducing the fuel load in order to land at maximum landing weight. The crew decided that the additional fire hazard associated with the increased brake temperatures generated during an overweight landing outweighed the hazards associated with remaining airborne and jettisoning fuel. Although they were not aware at the time, the nature of the fuel leak was such that this extra time airborne meant that fuel was no longer leaking when they landed, further reducing the risk of fire. Jettisoning fuel for 24 minutes also allowed for a considered and well-planned approach and landing with sufficient time to brief cabin crew, passengers, ATC and the operating company. In view of their limited knowledge of the nature of the fuel leak, landing with minimum braking from an automatic approach was well reasoned and well executed.

Information gathering to assist the commander with decision making was considerably helped by the presence of the third flight deck member. He was particularly useful in visually checking the exterior of the aircraft from the passenger cabin, liaising with the cabin crew, checking documentation for relevant information and communicating with the company's maintenance control. However, given the time available to the crew, these tasks could have been delivered in the same manner by the normal crew complement.

2.2 Cause of the fuel leak and its potential consequences

The fuel leak on G-YMME was caused by fuel escaping from the CWT through the open purge door. Prior to departure the CWT on G-YMME was more than half full with 43,400 kg of fuel, which would have reached a level in the tank just below the purge door opening. Therefore, despite the open purge door, no fuel would have leaked from the CWT during the refuelling period at the aircra-

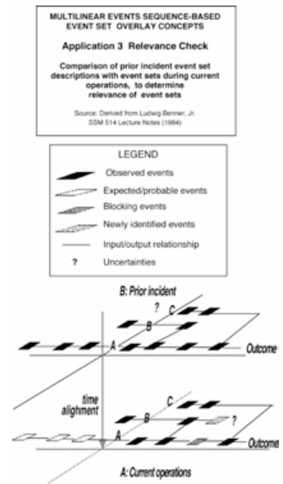
Page 65

Documented lessons learned need to provide some form of context data for each lesson, to help users understand what happened, with the context in which it happened. Formal accident reports often contain the context, somewhere in the narrative if one has the time and skill to find it. Context identification should be directly discernible, not a treasure hunt.

Freshness

Overtaken by events?

Relevance



Determining relevance of an accessed lesson is a subjective decision by a user. Users need to be able to “overlay” the lesson onto their activities. The longer this decision takes, the greater the disincentive for the user to use the system, so this is a significant design consideration.

Measurability

Assimilability

- Can users relate the lessons to what they do?
- Will lessons prompt user to make changes
- Can users use lessons to design actual behavior changes?

Assimilation is the absorption or integration and use of lessons for one's benefit. The spotty record of assimilation and achievement of new behaviors, for contemporary processes, raises the question: what is the best way to ensure maximized assimilability of a lesson by a potential user?
Little research of lessons learned assimilability has been done to our knowledge, so the choice presently seems to depend on episodic observations or logic. But intuitively, simplicity and clarity seem to be essential.

When a user finds lessons, how does a user know they're relevant to what he or she is doing now? (Relevance)

Is the context readily discernible?

Will the lessons data actually prompt user to change what they are doing

Is lesson an actionable item for them – something they can change in how or what they do in their own tasks or activities?

Will they be there in the future if users want to refresh their memories until the desired behavior is a habituated?

Sociability

What will
Lessons convey?

- Encourage or obstruct changes?
- Does vocabulary inspire or inflame?

Sociability is a subtle system attribute to consider. Sociability of lessons, or how lessons fare in the social milieu after they are "published," poses at least two kinds of challenges - creating a climate to encourage the behavior changes, and avoiding a climate for obstructing changes. Restricted sharing of the lessons, for example, can obstruct changes. The vocabulary used to document lessons can inflame or inspire reactions to their documentation and dissemination, and also needs to be considered in system design decisions.

Dynamic process compatibility

- Static data inputs
- Dynamic data inputs

ASRS Reporting Form defines static attributes

ASRS Format for description of occurrence dynamics

Another attribute is dynamic process compatibility. Relatively good data dictionaries and definitions of static data, such as that required by the FAA's and NASA's ASRS aviation reporting system now exist, but when describing the dynamics of an accident, we present blanks for writing unstructured narratives. Should it surprise anyone that you need an army of analysts to try to glean useful lessons learned out of such inputs?

No wonder it is so difficult to develop lessons learned from such data, or to use those that are reported.

War story:

Formal reports are not much better: the Commercial Aviation and Helicopter Safety Teams had to glean and recast data from formal reports to get the information they needed to propose safety improvement actions. - volunteers spend 1/5 of their working hours doing that.

Bottom Line: Can you use it?

Now, let's look at the system criteria

Next let's take a look at expectations for the lessons learning system...

Capturing lessons

- What is system trying to capture?
- How many of the available lessons is system capturing?
- How does system capture and document them?

How and from what perspective has what the system is trying to capture been identified and defined?

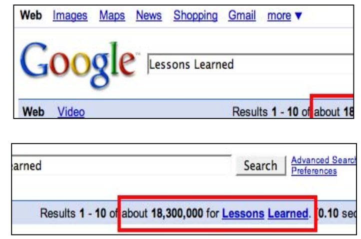
Have the perspectives and goals been documented?

Is the system capturing all lessons generated by a mishap? Does system provide a way to determine that? (If this isn’t possible, is there some benchmarking of how many?)

How concretely does system document lessons it has captured?
Are lessons documented persuasively?
Are the lessons actionable?

Accessibility

- How is a system publishing them?
- How fast can an end user locate them?
- How easy is it to sort wheat from chaff?
- Can actual human beings read them quickly?



You might think accessibility is about making what you capture available. It’s not. That’s producers’ perspective.

It’s much more, from an individual user’s perspective.

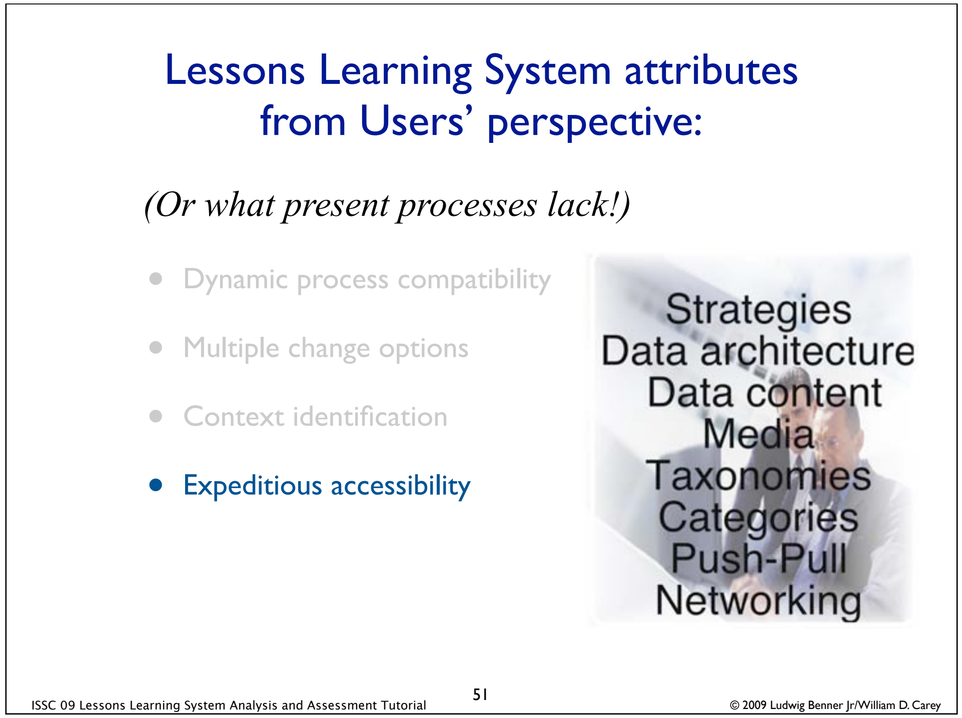
Users must be able to locate a source of relevant lessons quickly and easily. Are they being published so users can do that?

It can’t take them forever to do that.

When users find a source, they’ve got to be able to filter lessons quickly to find those that will help them.

All this should require minimal read time for user – they have other things to do, too.

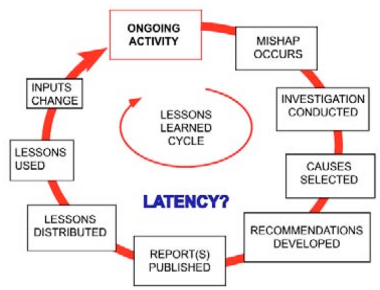
Demands high data density lessons learned data



A major obstacle to use of LL in present processes is potential users' difficulty in accessing the lessons.
Locating and accessing LL is a challenge due to strategies chosen, data architecture, media, taxonomies, and other choices.
Data obsolescence and backward compatibility are additional concerns that must be taken into account while designing access to a lessons learning system.

Latency

- What's the actual system latency?
- How rapidly are the lessons disseminated
- How rapidly can the lessons be implemented?



How much time elapses between the generation of the lessons when the mishap occurs, and the changes they are intended to achieve? An important attribute of present

That's the latency.

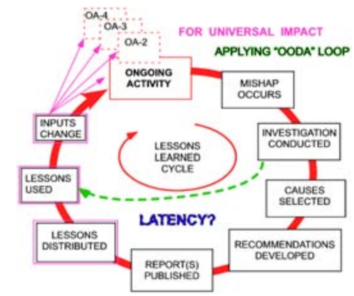
Once identified, how rapidly are the lessons launched on their way to users?

Once accessed, how rapidly can the lessons be implemented by changing what people or objects do?

How quickly can operations be restarted with lessons implemented?

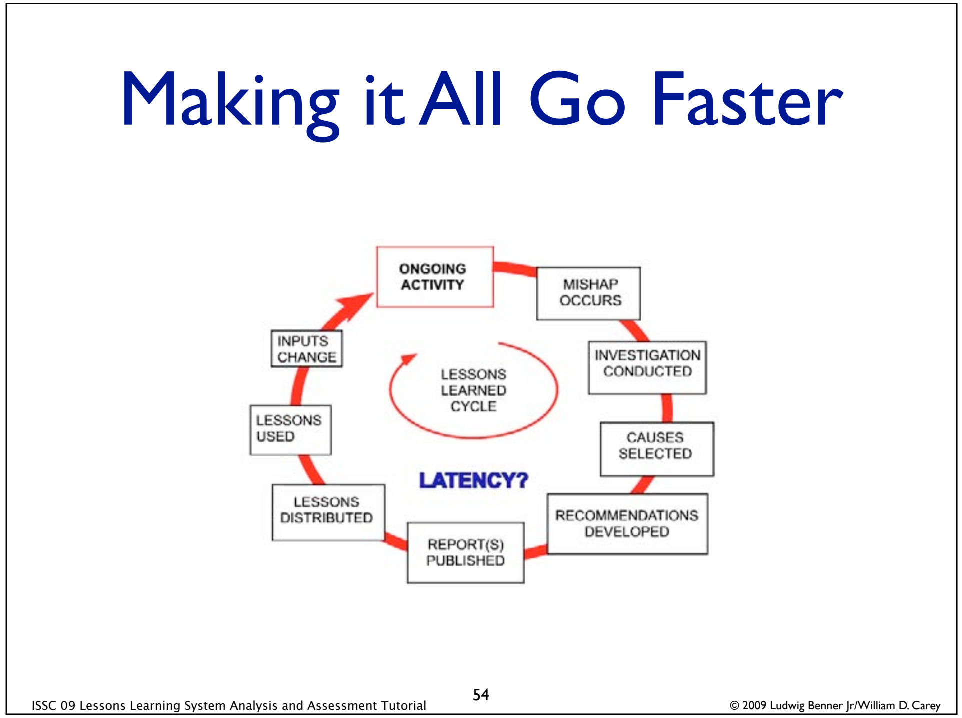
Totally quantifiable.

680



One sample in 2008 of 20 reports from a major investigation organization had a 680 day average latency period. A recent descriptive preliminary incident report by another organization had a 41 day latency period. Could even that be improved?

Learning system design could benefit from application of Boyd's OODA loop concepts. We had some thoughts, like bypassing analysts' functions by changing investigation and reporting of LL could dramatically reduce latency periods. This sounds like heresy, but we think its potential makes the possibility worth pursuing.



An important attribute of present Lessons Learned systems is the latency of the Lessons Learned from mishaps.
Latency is the term used to describe the period between the moment something is initiated and the moment its effects begin or become discernible.

In mishaps, Lessons Learned are generated by the mishap. When a mishap occurs, it generates the data needed for Lessons Learned to be derived from the mishap. However, the **elapsed time** between the mishap and the time actual changes, indicated by the Lessons Learned, are accomplished can range from an almost instantaneous reaction, like pulling one's hand back from a hot stovetop, to years! In a sample of the 20 most recent reports published by the NTSB, for example, the latency period until the Lessons Learned were distributed (not implemented) averaged 689 days.

Dissemination or Distribution or Something

- Who are the right people?
- What media are used to deliver them?
- Are they pushed or pulled?

We’ve said that accessibility isn’t about getting the data out there. Anyone can publish anything. 6 million kitten blogs.

Databases, Procedure Modifications, Lesson Learned Bulletins, Training Documents, Internet Repositories, CS&Rs, Checklists, Books, Studies & Research, Memories.

Everyone know what we mean when we talk about pushed or pulled?

Feedback

- Does system identify if user has learned the lesson?
- Did the changed behaviors produce the desired results?
- Does the system provide feedback on the "lesson learned" itself?

Does system provide feedback about what happened to lessons that were reported??

We're talking about validation, here – of both the assimilation of the lesson, and the efficacy of the lesson

- Part of benefits identification challenge
- Data for measuring "success" of lessons learning system operation
- Intra-system "learning organization" element
- Scope of changes achieved

Getting Useful Feedback

- Part of benefits identification challenge
- Data for measuring "success" of lessons learning system operation
- Intra-system "learning organization" element
- Scope of changes achieved

Systemic Loop
Measure data access
User investment in system
Transition from a just-publish to a more interactive system.

Timely Repository Updating

Repositories must be kept trustworthy, by purging lessons learned that didn’t work or were misdefined otherwise unsuccessful, so users can sleep well after they use them.

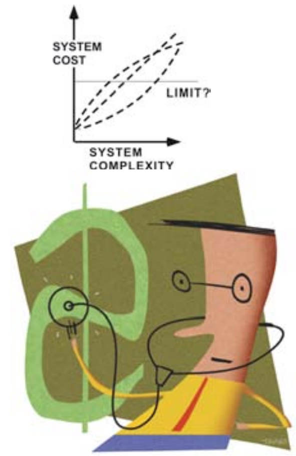
Scalability

- System scalability

As system content grows, that growth should not sacrifice quality. Scalability needs to be designed into a lessons learning system so its growth does not discourage users from using it.
Retrieval problems with taxonomies, key words and categories suggest an alternative approach could be useful.

Economics

- System cost
- Price sensitivity
- Efficiency



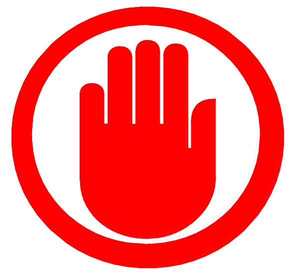
Lessons learning systems cost money. Resources devoted to lessons learning systems are not without limits. The sensitivity of price to performance of such systems must be a consideration in system design, which means maximum <u>efficiency</u> of the lesson development, dissemination and use functions is an attribute to seek in their design.

Example: NTSB cost per recommendation was almost 600K in 2008!

Other criteria that we missed?

Any suggestions for us??

Snack time! See y'all in 30.



Lessons learned processes do not produce changed behaviors very well. Widely acknowledged underperformance of present processes, reflects deeply ingrained process attributes and design decisions. Therefore, we are going to suggest system attributes for what would be a better system for you.

Lessons Learned $\neq$ Changed Behavior

Why are Lessons Learning systems hard to optimize?

- Inherited vision
- Sunk investment
- Momentum
- Skepticism

Basic practices have been in place a long time

Recent attempts have tinkered with existing systems, but little changed in underlying vision, assumptions, strategies, principles, design or data

WHY? Present systems conform to **inherited vision** of accidents, incidents, investigations, causes and lessons learned---a vision for a system that's better has been lacking

a lot of people and organizations have a large sunk investment in present practices that change would put at risk

status quo has a lot of momentum - comfortable doing what we know, in the groove, why bother looking for trouble

Skepticism that need exists - we're getting by ok

Why are Lessons Learning systems hard to optimize?

- Technical challenges
- Murky, incremental benefits
- Lack of metrics
- Fear of change

Optimizing implies something better is available.
Technical challenges are not trivial. It's hard work to figure out what's better

Hesitancy is normal reaction when benefits of a change are ambiguous, viewed as incremental

Then there's a lack of sound metrics that would reveal the poor performance of present processes

Then there is plain emotion-based fear - fear or losing job, fear or failing, fearing lack of competence, etc

What are some other constraints might you add?

To modify or supplant legacy systems, something better must be offered.

- Technical challenges
- Murky, incremental benefits
- Getting by.
- Fear of change

Optimizing systems is a difficult challenge.

- B-2 Crash on Guam
- Studies like Werner and Perry
- NASA shuttle accident investigation reports

We've talked a bit about the B-2.

In their study, Werner and Perry cited a bunch of reasons why lessons learned are underutilized in the aviation community.

"NASA stated that it must do a better job of communicating the various lessons learned sources to employees, improving mechanisms to link these sources, and ensuring appropriate training for employees in order to maximize lessons learning." (United States General Accounting Office (2002) Report to the Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives, NASA: *Better Mechanisms Needed for Sharing Lessons Learned*, GAO-02-195,)

Personal use of public lessons learned data is unknown, quantitatively, but interest in and use to generate new behaviors by individuals seems very limited. For example, one widely respected and emulated public incident lessons learned database with over 700,000 records (ASRS) had 88 search requests by individuals during a recent six year period.

How many individuals would buy a 334 page, $80 book to find lessons learned that might apply to their tasks and then internalize all of them to change their behaviors? How frequently do individuals change their behaviors due to desired interpretations of generalized training, procedures, standards or regulations? We don't know. However, few would argue that present practices maximize investigation lessons learned dissemination and their use by all who might benefit from the data.

Natural Language Difficulties

- Ambiguity
- Abstractions
- Subjectivity
- The Passive Voice

Natural language is a blessing and a curse. It can be very expressive and communicate meaning without being concrete. It can also frustrate the description of people, objects and energies and their actions because of its propensity to use and tolerate **ambiguity**, the great variety of ways it is possible to express something, **value-laden** vocabulary, and flexibility of grammar and syntax, for example.

Know about Hayakawa's ladder of **abstraction**, and the ambiguity introduced as objects rise on the ladder; abstractions can be "cover up" words chosen to cover up lack of specificity of understanding, and thus pose barriers to **objective** understanding of phenomena, **objectively** describing and explaining them, identifying lessons learned, and communicating that understanding and the lessons learned.
Descriptions can be enhanced by the definitive vocabulary, grammar, and structure.

The challenge is to work abstraction, ambiguity and subjectivity out of Lessons Learned systems.

And never use the passive voice. Ever. Weasel wording.

It’s not impossible.

It may be hard, but not impossible.
Our research has disclosed promising ideas.

Lessons Learned Processes
vs
Lesson Learning Systems

- Most people think in terms of lessons learned processes.
- A process is a series of actions or steps (tasks) taken to produce a particular end.
- A system is a set of components working together as parts of an interconnected network, for some purpose.

We' re system safety people here – let's start by talking about a lessons learning system.

Think Lessons Learning System in a Learning Organization

Shifts focus from

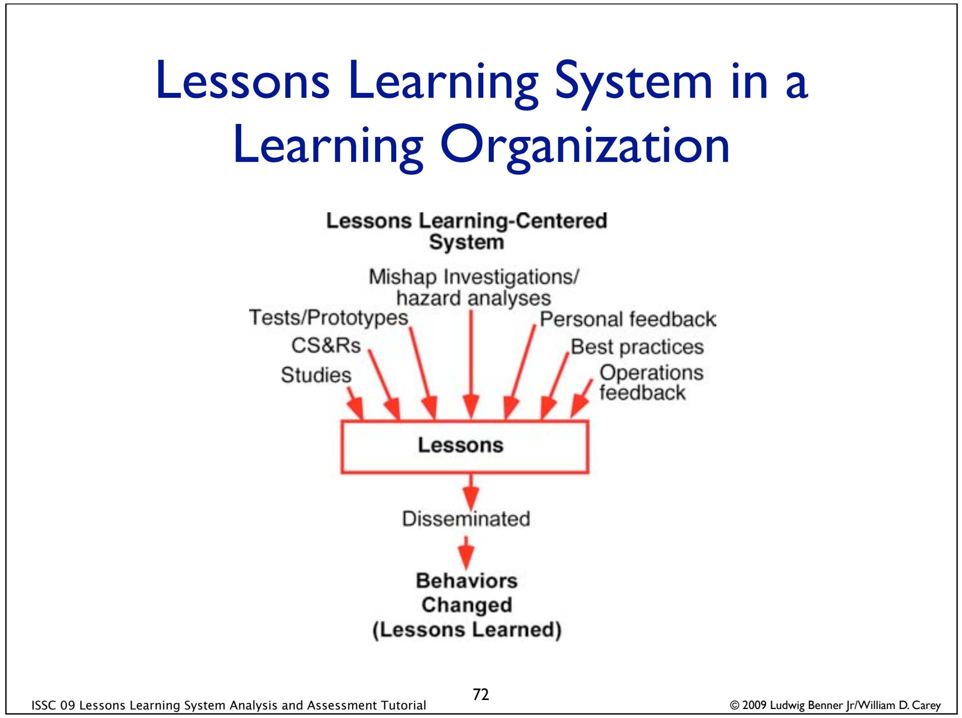
Lessons Learned

during investigations or analyses

to

Learning from such lessons

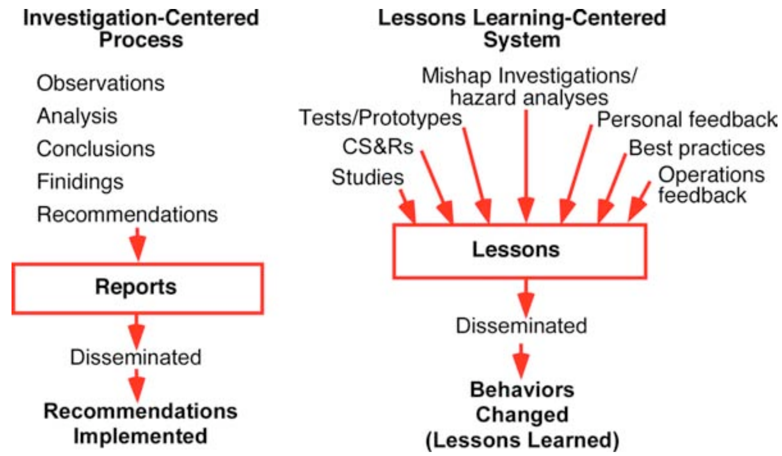
First lets shift the arena for discussion.



Viewed this way, focus of investigation is to provide the new knowledge that will enable a learning organization to bring about changed behaviors, rather than determination of causes, root causes, probable causes, proximate causes, remote causes, or cause factors, or hazards or recommendations.

Lessons learned from each source must be compatible to support a true Learning Organization's needs

How do they differ?



	Old School	New School
Where's the focus of the system?	causes	description of behavior
Whose needs come first?	investigators	users
Who defines the lessons?	analysts	investigators
What do you report?	recommendations	lessons
How accessible are the lessons?	limited	universal

Strategic Choices!

Focus on determining causes or on descriptions of behavioral interactions of people, objects, or energies that users can change to achieve improved performance.

Limited accessibility or universally accessible lessons for all who could benefit from their assimilation.

Focus on causes or descriptions of behavioral interactions?

Design to investigator or user needs?

Analysts or investigators define lessons?

Report recommendations or lessons?

Limited or universal accessibility?

Lessons **Learning** System Components

- Derived from functions and tasks needed to document and use lessons to bring about *changed behaviors* and safer performance
- Differentiated between user (learning) and developer (lessons) functions
- New system boundaries

We analyzed the functions and tasks needed to covert data generated by an accident or mishap into outputs that would produced changed behaviors AND safer performance.

That led us to new system boundaries.

We also found it imperative to separate the functions of users who were the “learners” in the system from the “developers” who produced the lessons to be learned by the users.

Boundaries

OLD

- Mishap or investigation report of "experience"
- Recommendation for action
- Closed recommendation

NEW

- Mishap data generation
- Updated repository of successful lessons

What do we mean by boundaries?
What components does system include?

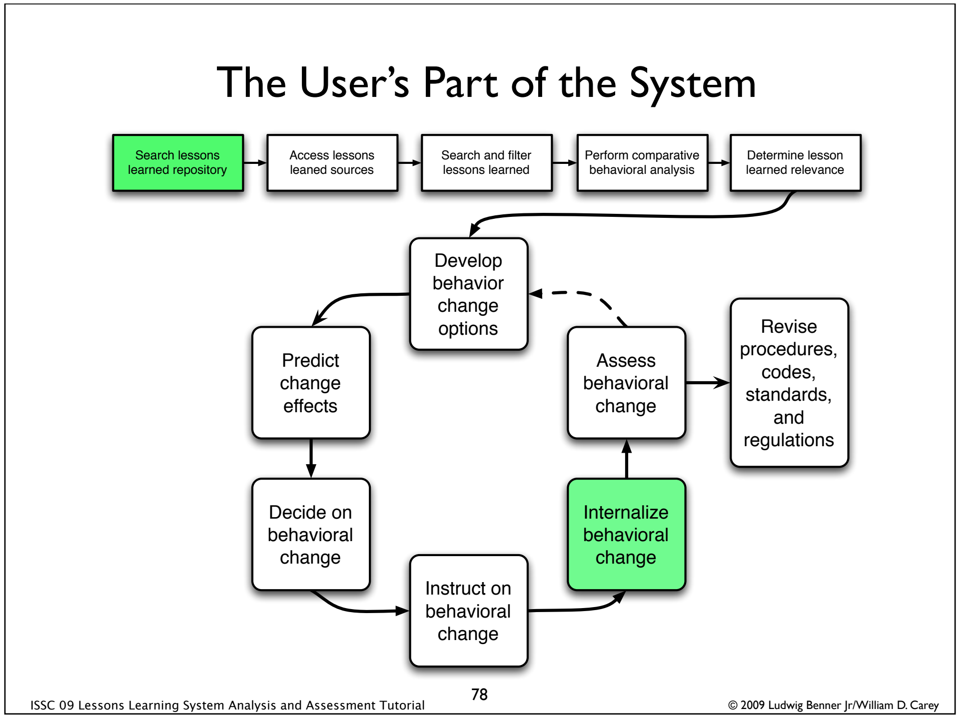
Old boundaries

We suggest new boundaries –
one – accident or mishap that generates new data from which lessons are extracted
two – updated repository of successful lessons
lessons learning learning system is everything in between.

What functions do users have?

- ✦ Access relevant lessons.
- ✦ Interpret lessons data.
- ✦ Select relevant data.
- ✦ Change behaviors.

Users must access lessons, interpret them for relevance and applicability, select relevant lessons, figure out what changes are needed to respond to lessons, and then produce the changed behavior needed



Let's look at user or learning part of system

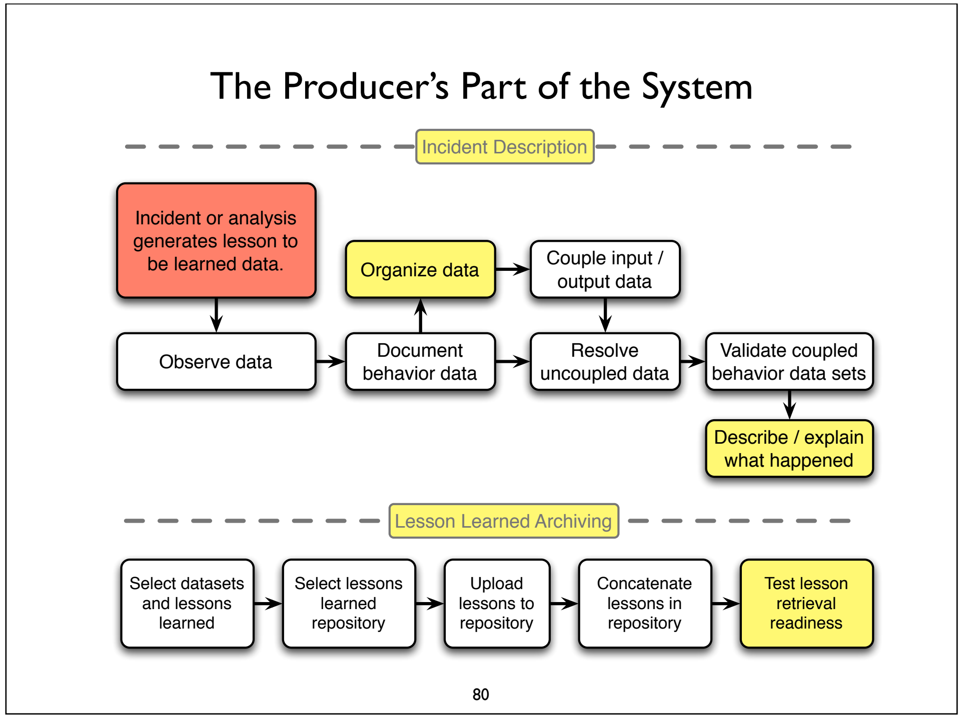
What functions do producers have?

- Find lessons in data generated by accidents.
- Document those lessons.
- Archive those lessons to provide access to users.

We found it helpful to distinguish between the finding and documentation the lessons and the subsequent “archiving” functions involved in making the documented lessons accessible and assimilable for users.

Investigation functions are needed to develop LTBL data and document all lessons

Archiving functions are needed to make LL easily accessible and assimilable for users



Lesson developers also have a lot to do. This developer part of the investigation learning system model reflects several strategic choices by us, based on previously reported work. For this model, we chose to

define the "lesson learned" as a description of what happened during the accident process,

document the lessons as coupled behavior sets in order to do that

So: What do we want?

- Lessons Learning System
- Right strategy choices
- All needed components
- Desired attributes
- Performance metrics

Some Specifics

Structured Process Data

ASRS Reporting Form defines static attributes

CERTIFICATES/RATINGS

☐ student ☐ private
☐ commercial ☐ ATP
☐ instrument ☐ CFI
☐ multiengine ☐ F/E
☐ ____________________

ATC EXPERIENCE

☐ FPL ☐ Developmental
radar _____________ yrs.
non-radar ___________ yrs.
supervisory _________ yrs.
military _____________ yrs.

WEATHER

☐ VMC ☐ ice
☐ IMC ☐ snow
☐ mixed ☐ turbulence
☐ marginal ☐ tstorm
☐ rain ☐ windshear
☐ fog ☐ _______

LIGHT/VISIBILITY

☐ daylight ☐ night
☐ dawn ☐ dusk
ceiling ________ feet
visibility______ miles
RVR _________ feet

ATC/ADVISORY SERV.

☐ local ☐ center
☐ ground ☐ FSS
☐ apch ☐ UNICOM
☐ dep ☐ CTAF
Name of ATC Facility:
____

AIRCRAFT 2

__ ☐ EFIS
☐ FMS/FMC
orporate
ther _________

(Other Aircraft) _________________ ☐ EFIS
☐ FMS/FMC
☐ air carrier ☐ military ☐ corporate
☐ commuter ☐ private ☐ other _________

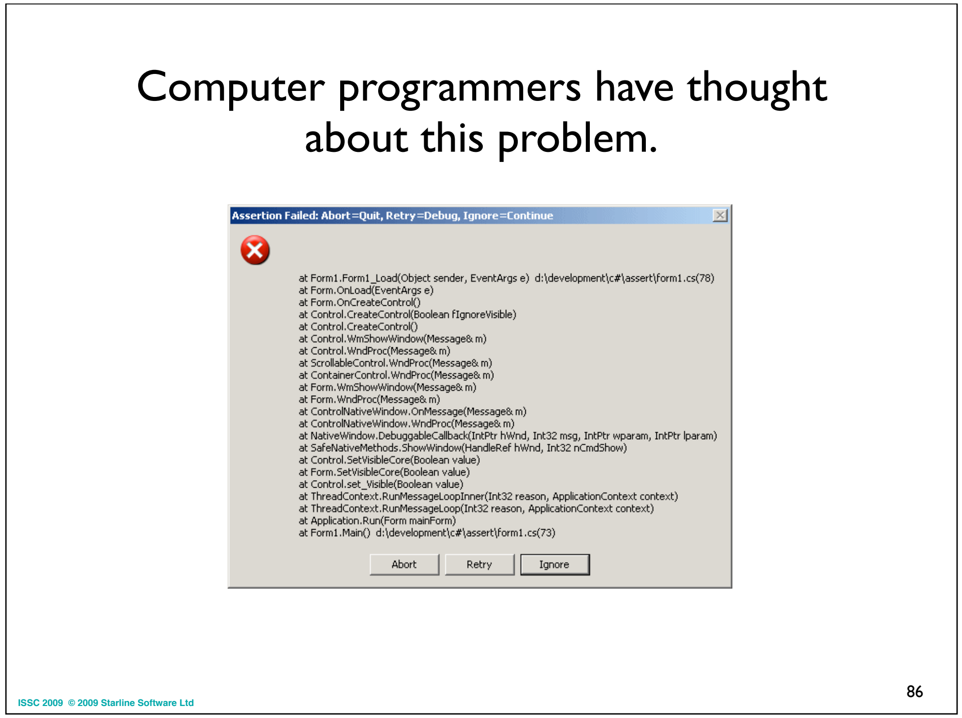
Not how well the static data requested by the form is defined for the user.

ASRS Format for description of occurrence dynamics

Mishaps are dynamic processes.

This is the guidance for describing dynamic occurrence.

So what? Ambiguous, abstract, subjective, weasel wording.



Programmers don't want a narrative explanation of what went wrong. They want a stack trace.

Programmers have developed language (and code) to capture and record "mishaps".

What data? Why? Formats and structure?

Define, Identify, Document, Validate?

Structural language vs dictionary approach – dictionary fine for objects and their description

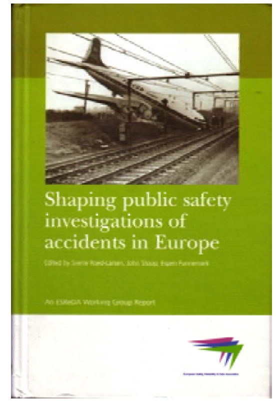
Static data relatively easy to define, and being done.

Process data a little trickier.

Emphasis on Behavior in a Lesson Learning System

"…a decomposition of the dynamic behavior of systems and their actors benefits from a behavioral approach, decomposing the system into events, actions, decisions, errors and scenarios."

From ESReDA Working Group Report (2005) "Shaping public safety investigations of accidents in Europe" p 35



People bring about change.

Focus on behaviors - who does what, when, where?

Note the third line -
The focus on behaviors reported in our paper is not particularly original - the ESReDA working group recognized the benefits of the behavioral approach to decomposing the system in 2005.
Our experiences support the benefits envisioned.

More emphasis on behavior

CALL defines lessons learned as validated knowledge and experience derived from observations and the historical study of military training, exercises, and combat operations <u>that lead to a change in behavior</u>…"
(emphasis added)

From CALL Handbook 09-22 Chapter 4 CALL: Collection Principles

People must bring about change

Focus on behaviors - who does what, when, where?
Army CALL says behavior change is goal.

Consistency

To recap,

- We described the components of a lessons learning system
- We provided attributes users and providers would like
- We modeled user and provider parts of the system

Break time.
Back in the saddle in 5 minutes.

Next: Analysis and Assessment

Now we're going look at

- How can we analyze present LL processes.
- How can we assess LL processes
- How to get or produce better lessons if we want better performance.

How do you analyze a lesson learning system?

As Users
As producers

We need to analyze system as users or producers of lessons learned from investigations and analyses. How can you tell if your system is satisfactory. Let’s start with criteria for an optimal Lessons Learned System, from User’s or Customer’s perspective

What attributes are worth measuring and monitoring to help you decide?

As an end user

- If producers provide you with the right stuff, you'll do fine
- We discussed what you should be able to expect from producers earlier.
- Let's focus on producers so you get the right stuff

Let's keep user's analysis short.

As a Producer

We need to look at

- lessons we produce.
- the changes they should support
- if and how they are used.
- whether changes worked.

Producer screening questions

- ☑ Is producing lessons one of our goals?
- ☑ Are we documenting lessons explicitly?
- ☑ Are our lesson outputs accessible to everyone who might benefit from this new knowledge ?
- ☑ Are our lesson outputs producing changed behaviors?
- ☑ Are those behaviors improving performance?

here's a quick check list we offer to get an overview of how things are going

Producer process criteria

- ☑ Purpose includes LL
- ☑ Input-output framework
- ☑ Focus on behavior data
- ☑ Specifications for building blocks
- ☑ Interoperability for data sets
- ☑ Objective quality assurance
- ☑ Tools for behavior sets
- ☑ Behavioral output specs
- ☑ Machine interoperability
- ☑ Internet repository capabilities
- ☑ Rapid repository access
- ☑ Objective quality assurance
- ☑ Repository updating capability

Here's a quick check list of desired process attributes we would offer to anyone who wants to review an investigation-based lessons learning system

Use user attributes as a check list:

- Dynamic process compatibility
- Multiple change options
- Context identification
- Expeditious accessibility
- Minimal latency
- Maximized signal-to-noise ratio
- Expeditious relevance determination
- Maximized assimilability
- System scalability
- Price sensitivity
- Controlled socialization
- LL Performance metrics
- Timely repository updating

If you are a user, here’s a quick check list we developed to help determine if lessons learned process is providing useful new knowledge...

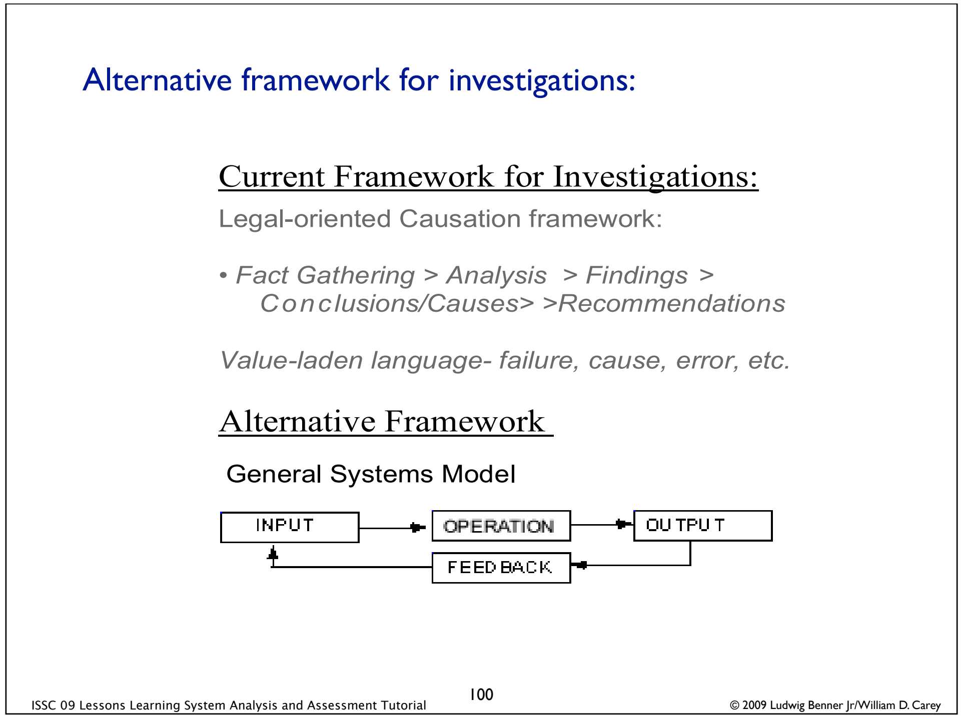
If screening raises concerns

- What would be better?
- Why?

We've looked at this challenge...

Here are some ideas we think might work better...

We tried to Re-think how things were being done, and how that might be improved, and we're going to share what we came up with next.



What might be an alternative to the current **inherited** investigation framework of accident causation models?

We tried the General Systems Model

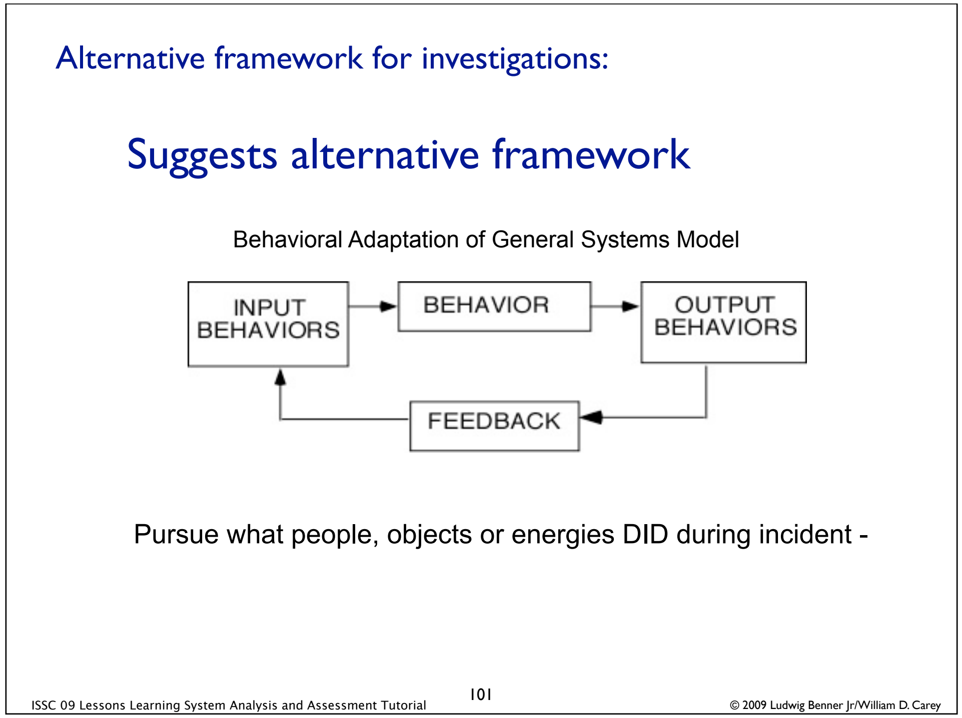
Could we use it for a new framework for thinking about investigations - by adapting it as an investigation process framework?

What would it do?

•Well, it seemed to fit a learning organization better

•it can change how we think about investigations - to I/O framework

•it could potentially minimize value-laden language,



But if we want to focus on behaviors, how might we describe our framework?

Well, here's what we came up with.

How would that change investigations? Changes what investigators look for –

Look for dynamics of incident, e.g., BEHAVIORAL INTERACTIONS or COUPLED BEHAVIOR SETS

Alternative framework for investigations:

Focus on behaviors during investigations

- Pursue what people, objects or energies DID during incident - e.g., their behaviors
- Look for *dynamics* of incident, e.g., BEHAVIORAL INTERACTIONS
- A way to address dynamics of mishaps

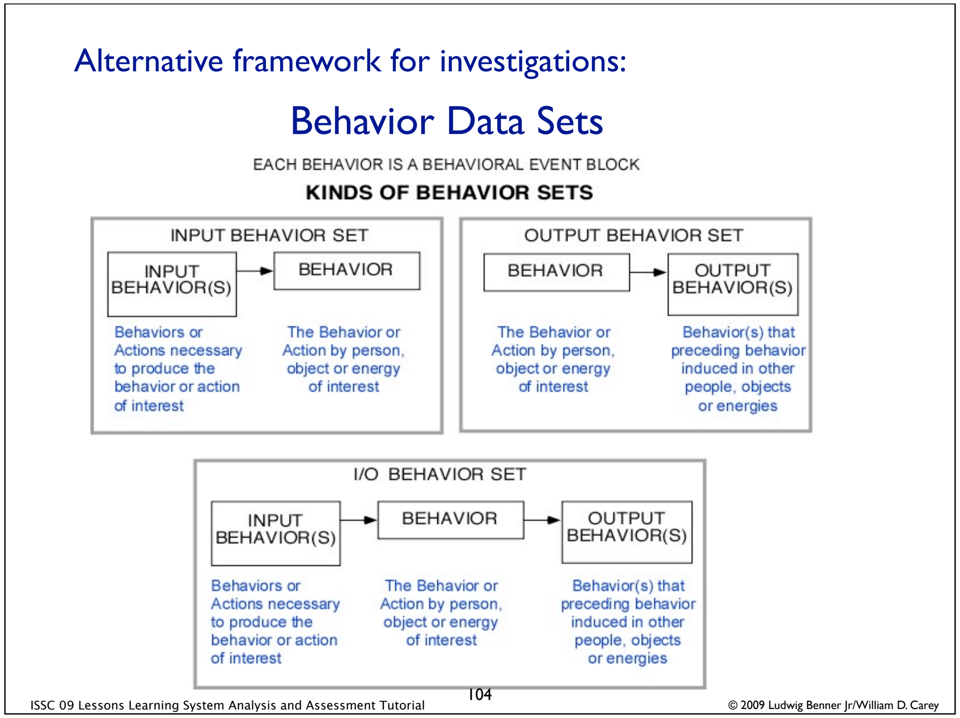
With the modified general systems model, we have a way to address the DYNAMICS of accident during investigations.

Alternative framework for investigations:

Coupling Behaviors led to

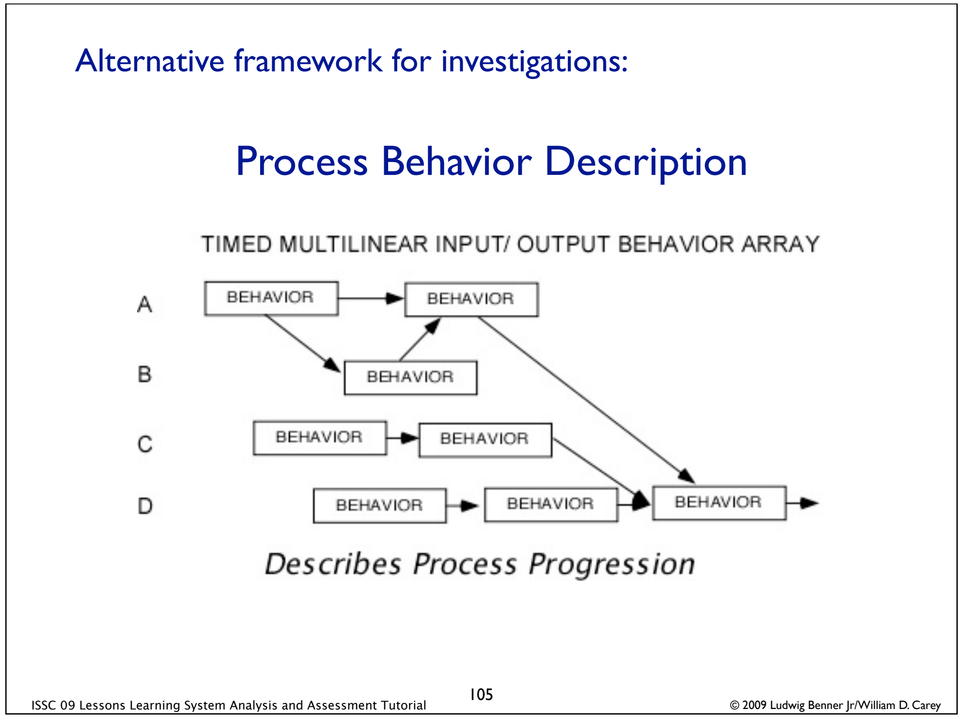
- identification of different kinds of behavior interactions

When we started coupling behaviors we discovered we could get different kinds of behavior interactions or sets



Here’s a look at some of the different kinds of behavioral interactions this approach might provide for us. Don’t have to study – but this is what we went through

(Step thru sections)



How do we organize these behaviors after we capture them?

Well, one way is to set up data on a matrix so you can follow who did what,
But also what behaviors they influenced, by showing arrows to represent interactions. This is the behavior coupling step – establishing interactions among everyone and every thing involved in producing the eventual outcome.

Alternative framework for investigations:

Each I/O data set can lead to

- a structured "problem" definition
- a specific intervention opportunity
- context of problem and opportunity
- maximized lessons capture from incident

now, if we do it this way, look at what it could do for us.

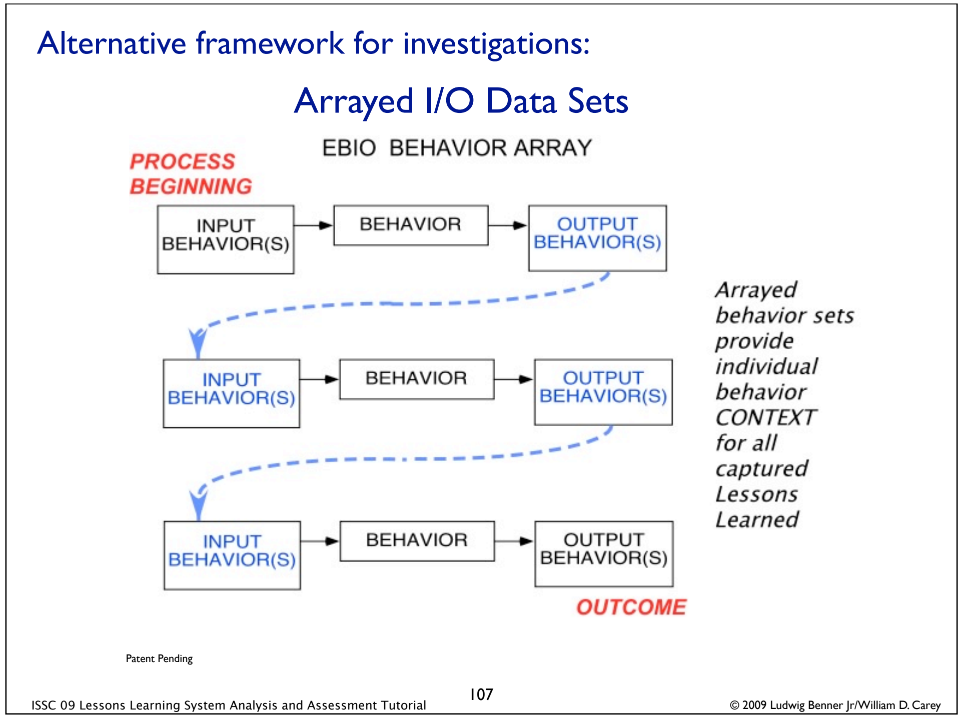
Each I/O data set constitutes a "problem definition" Think of this way.
if the interactions had not existed, the accident would not have progressed the way it did. So if you eliminate a set, there would have been a different outcome.

But gee, the accident happened. How about if you eliminate that behavior interaction from future operations?
That would reduce likelihood of similar accidents where that set would have to be present.

And when you couple behaviors before and after the set you are working with, you have indications of the context of the problem behavior set, and of the opportunity changing it might present.

And lastly, you capture ALL the behavioral lessons from the accident.

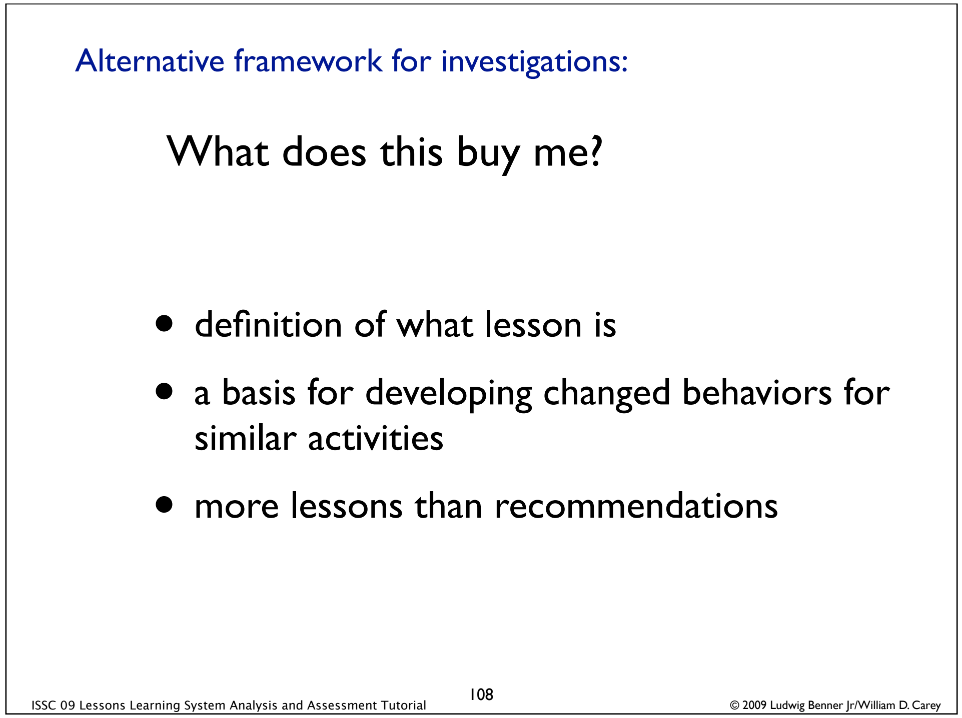
Not too shabby.



How investigators organize their investigation data affects the story they tell. Often it's put into logic trees, or EC&F charts. Not bad, as far as it goes, but because they use unstructured data, couplings are not very compelling.

Here's what we came up with to show the dynamics of the behavioral interactions, as part of a continuous series of changes that led to the outcome.

Can you see how this "flows" the behavioral inputs, actions and outputs??



- New knowledge is understanding of behavioral interactions in form of coupled input/output behavior sets
- Behavioral interaction sets provide basis for developing changed behaviors for similar activities
- Enables broader use than recommendations

WYLFIWYF

- WYLFIWYF +
- natural unstructured language = ?

We have observed that what investigators look for during investigations depends heavily on their perspective of what an accident is. That's called WYLFIWYF (Wilfi wif) And then findings are reported in natural language.

results: today's performance.

how about hazard analyses…? Simiilar problems???

- View accidents as processes generating lessons-to-be-learned data for investigators
- Investigate to gain understanding of behaviors that produced the outcomes
- Structure inputs and outputs to guide investigations?
- Here are some ideas we think will help overcome that for

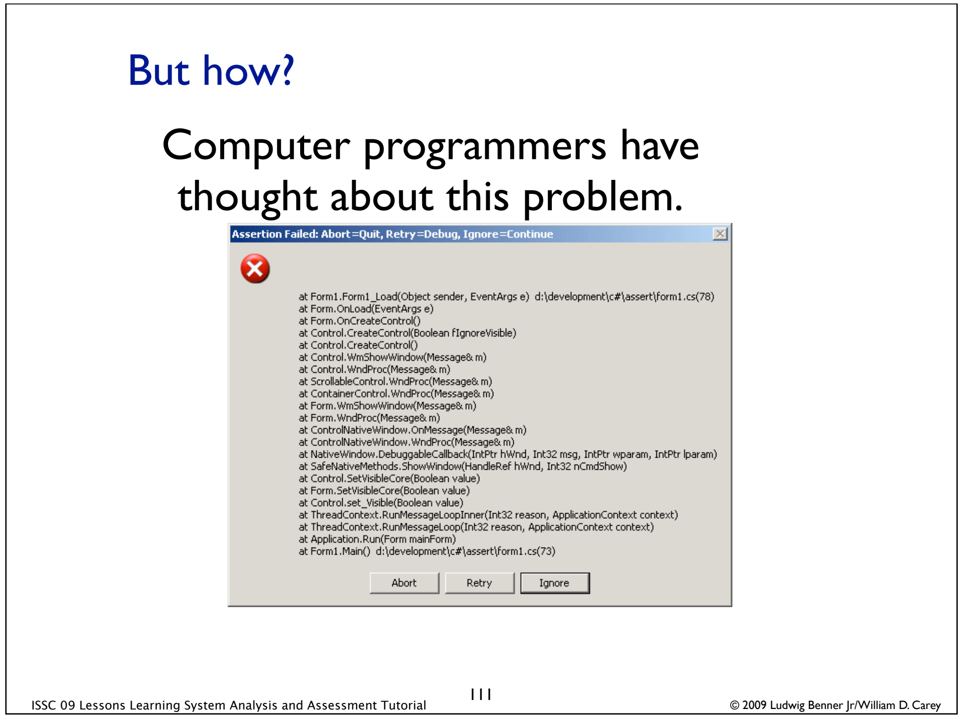
investigations

Structured Data
=
More Accessibility

But only for the static data. ASRS does this well.

For dynamic data? Harder? Ham–fisted right now

How do you solve that problem?



As we mentioned,
Programmers don't want a narrative explanation of what went wrong. They want a stack trace.

Programmers have developed language (and code) to capture and record "mishaps".

So we tried to learn from them...

Investigation data structuring:

Investigation Building Blocks

- Investigators use “building blocks” to reconstruct mishap scenarios
- Analysts use “building blocks” in the hazard and risk analysis methods
- Building blocks need common structure

we started with the investigation input data, which leads to building blocks.
So, we structured the building blocks to require structured input data,
to provide guidance for investigators and analysts
to facilitate machine interoperability for data
to enhance search and retrieval of lessons
to optimize assimilation of lessons

Offer data structure:

Example of Structured Behavioral Building Block

Figure 3. Investigation Building Block Elements in XML Document *

```
<?xml version="1.0"?>
<mesblock unique_id=""> (9)
    <actor></actor>  (1)
    <action></action> (2)
    <object></object> (3)
    <location></location> (4)
    <start_time type=""> (6)**
        <year></year>
        <month></month>
        <day></day>
        <hour></hour>
        <minute></minute>
        <second></second>
        <millisecond></millisecond>
    </start_time>
    <end_time type="">  (7)
        <year></year>
        <month></month>
        <day></day>
        <hour></hour>
        <minute></minute>
        <second></second>
        <millisecond></millisecond>
    </end_time>
    <source></source>  (5)
    <remarks></remarks> (8)
    <nstest> </nstest>***
    <link></link>****
</mesblock>
```


Here’s an example of a well defined structure for a behavioral building block using data tags (This is in use)

Times permit machine ordering of behaviors

Enables investigators to couple behavioral inputs and outputs

Structure helps reduce natural language problems of ambiguity, abstraction and inconsistency

Readily expandable to accommodate addition data elements if needed

enhances machine interoperability

What’s needed?

Data structure requires

- a whole system and structure of language
  - ✦ grammar rules
  - ✦ syntax specifications
  - ✦ word forms
  - ✦ value-free vocabulary

to optimize consistency
to optimize machine interoperability
to reduce conflict following investigations

We think we really need to change investigation vocabulary to value-free, non-judgmental, words - eliminate accusatory or pejorative words, like cause, fault, failed to, error, failure,

Judgments about what happened are the province of different societal entities, not SS or AI

How might we do that?

Develop Input/Output Relationships

- During investigations, pursue behaviors
- Identify and define necessary and sufficient behavioral inputs into each behavior
- Identify subsequent behaviors induced by each behavior during mishap
- Couple inputs and outputs to each behavior to produce dynamic description

* The coupling of the inputs, behaviors and outputs produces behavioral sets which can be manipulated by machine. Those sets can provide context for lessons learned.

This lets you do a more readily defined search.

Capture the static attributes related to the incident, as in the ASRS system, for statistical analyses and potential search keys.

Capture the dynamics with coupled structured behavior data elements.

What could structured data do for me?

Exploit machine readability

Structured Behavioral Building Blocks could

- improve data entry consistency.
- enhance machine parsing capability.
- enhance data aggregation, archiving and retrieval.

About the lessons themselves...

- How are they reported now?
- Are "lessons" recommendations?
- Do recommendations satisfy end user needs?

Remember our earlier discussion?
We realized that recommendations which are common investigation outputs are not lessons but FIXES for problems defined by the investigators.

So we thought it would be a good idea to call lessons lessons, not recommendations, factors, causes, failures, etc

we wondered why we don't see lessons listed as lessons

That's when we started thinking old school vs new school again

About lessons dissemination:

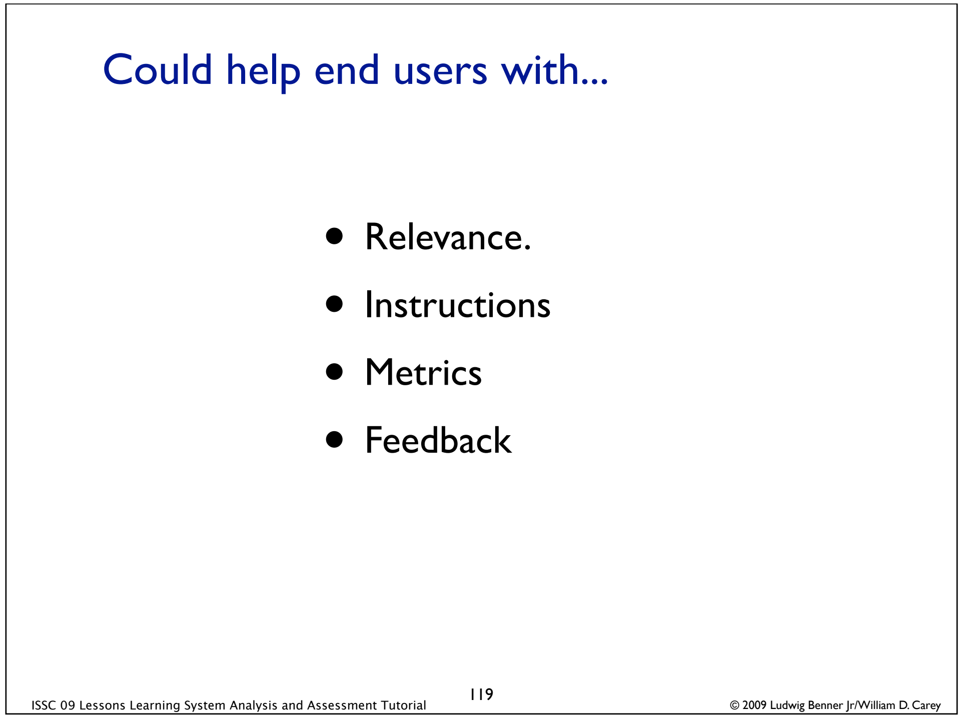
- Archive investigation or analytical "lessons" formatted as behavioral data sets
- Use behavior data sets for search and retrieval activities: not taxonomies.
- Archive in media that maximizes access
- Find metrics to lesson retrieval, uses and success

The answers weren't obvious to us at first, but gradually some ideas took hold.

If we used behavior sets as the lessons, that's what we could archive, and it could improve search and find capabilities because of their machine interoperability characteristics – no taxonomies to second guess.

New media exist to maximize unfiltered, uninterpreted access –the internet,

Behavior sets could be observed, and thus monitored before and after they are changed.

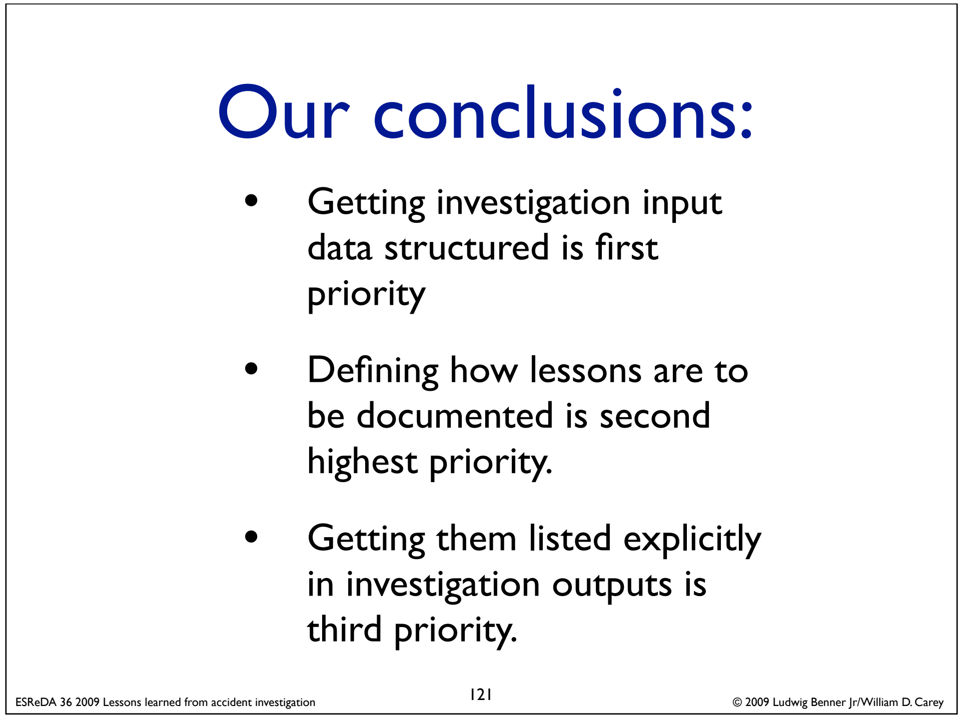


We think I/0 behavior sets could definitely help users with certain tasks they are faced with when an incident reveals sets they have in their operations. Those tasks include lessons relevance determination, converting those lessons into task changes in their organizations, developing metrics to assess lessons and changes made, and a format for offering feedback to lesson suppliers.

Review

- We proposed that Lessons Learning Systems should provide useful lessons to anyone who can beneficially change behaviors of people objects or energies
- We showed reasons why creating optimized Lesson Learning Systems is difficult.
- We suggested some examples of ideas that might help us get to optimized lessons learning systems.

SS practitioners can demonstrate a way to go with their own outputs. Start by cleaning up fault trees we create by using structured input behavioral data. Do parallel outputs if necessary to test ideas, and provide basis for comparison of results.



Here are the priorities we think are in order to develop optimized lessons learning system performance.

To that end,

Open Source (LGPL) Library:

http://code.google.com/p/meslib/

Complete OS X sample app in Objective C, early alpha development library in platform independent C++. Some sample PHP for online stuff too.

Contribute your ideas!

Contact: luben@starlinesw.com
billcarey@mac.com

We believe very strongly in our approach, and the potential for evolutionary development of improved systems. So strongly that we are making publicly available on line an Open Source Library of software we developed, to launch the first steps toward needed changes. The Software Library includes a royalty-free license for use by anyone who wants to redesign their investigation data inputs and lessons documentation to support lessons learning system improvements.

Complete OS X sample app in Objective C, early development library in platform independent C++. Some sample PHP for online stuff too.

(Library GPL is the license)
(work in progress)
(C++, Objective C)

Let's Discuss Experience

Free discussion for about 10 minutes, plus more after session if desired.

We're done!

Thank you for participating.

Lunch time!

Open Source (LGPL) Library:

http://code.google.com/p/meslib/

Complete OS X sample app in Objective C, early alpha development library in platform independent C++. Some sample PHP for online stuff too.

Contribute your ideas!

(See handout for details)

Contact: luben@starlinesw.com
billcarey@mac.com

We believe very strongly in our findings, and the potential for evolutionary development of improved systems. So strongly that we are making publicly available on line an Open Source Library of software we developed, to launch the first steps toward needed changes. The Software Library includes a royalty-free license for use by anyone who wants to redesign their investigation data inputs and lessons documentation to support lessons learning system improvements.

Complete OS X sample app in Objective C, early development library in platform independent C++. Some sample PHP for online stuff too.

(Library GPL is the license)
(work in progress)
(C++, Objective C)