Systems Engineering Approach to Operations and Maintenance

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Safe Systems through Systems Engineering

Systems Engineering: A Successful Approach

Systems Engineering is a successful discipline because it brings myriad design elements under a single umbrella.

Can this approach be applied in other areas, such as transit operations & maintenance?

Can such an application be coordinated with “traditional” systems engineering?





Systems Engineering Defined

International Council on Systems Engineering (INCOSE) defines Systems Engineering as:

An interdisciplinary approach and means to enable the realization of successful systems. It focuses on:

- defining customer needs and required functionality early in the development cycle,
- documenting requirements,
- then proceeding with design synthesis and system validation while considering the complete problem.





Systems Engineering Defined

According to INCOSE, Systems Engineering integrates:

- Operations
- Performance
- Testing
- Cost & Schedule
- Manufacturing
- Cost & Schedule
- Training & Support
- Disposal

Systems Engineering then :

- forms a structured development process that proceeds from concept to production to operation.
- considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs.





Does Systems Engineering Fall Short in the Long Run?

Systems engineering attempts to identify all of the "working parts" of a specific system, such as:

- a railcar
- an entire fixed guideway signal system

But what happens when this complex system is integrated into the even more complex workings of a complete transit operating and maintenance environment?

What happens over time as the operating and maintenance environments evolve?





Could Systems Engineering be the Solution to this Shortfall?

When does Systems Engineering end?

- End of the project? Handover of the system? Beyond?

With traditional Systems Engineering, what do we get?

- A realistic process for the specific product/system?
- A realistic process for the needs of the transit agency?
- A realistic process that must be integrated into the agency?

Expanding the concept of Systems Engineering to agency-wide O&M is the solution.





Examples of the Systems Engineering Shortfall

Major bus transit provider upgrades its radio system to best CAD/AVL product out there

- Training provided by contractor, not incorporated by agency into SOPs
- Five years out, new dispatchers are not trained
- Agency relies on train the trainer
- Simple, automated functions like on-time performance measurement not used; other data still recorded on paper forms





Examples of the Systems Engineering Shortfall

Light rail operator installs new cab signal system on vehicles

- Contractor provides operating manual, agency does not update rulebook
- Agency trains future operators on old rulebook and says “ignore this” without formally deleting old information, *or*
- Recommended cab signal inspection cycle does not coincide with vehicle inspection cycle
- Inspection forms are not updated and all inspections are now off-cycle





Systems Engineering is Still the Solution

The transit agency must realize that Systems Engineering in the project design and roll-out must continue through life-cycle.

The Systems Engineering approach must be ingrained in the way we do business to ensure that systems function:

- when they are new,
- as the agency evolves, and
- as the various parts of the agency change.

Without a formally engineered “system” for all parts of agency O&M, problems will continue.





Systems Engineering: How We Normally View It

…as an interdisciplinary field of engineering that focuses on how to design and manage complex projects over their life cycles.

Systems engineering is organized to maximize performance.

This works at the transit agency level too…





Systems Engineering: How We Normally View It

Core Systems Engineering Principles:	For Complex Projects/Systems:	For Transit Agency O&M:
1. Reliability	1. Will it function?	1. Is our service reliable?
2. Logistics	2. Do the parts talk to each other?	2. Are our modes connected?
3. Coordination of Teams	3. Are engineers working together?	3. Do departments share information?
4. Evaluation Measurements	4. Does it work as we designed it?	4. Do we act on shared information?





Systems Engineering: How We Normally View It

Core Systems Engineering Principles:	For Complex Projects/Systems:	For Transit Agency O&M:
1. Defined Work Processes	1. Networks & coding are well defined.	1. Do we have accurate/ current rules & SOPs?
2. Optimization Methods	2. Data is designed to flow quickly/correctly.	2. Are we working with real time data?
3. Risk Management	3. Fail-safe systems are designed.	3. What rule compliance/ audit programs exist?





Systems Engineering: The Big Picture

Design + Construction + Operations/Maintenance

Transit systems can guarantee success with an integrated approach to design ***and*** operations/maintenance.

Design/construction and operations/maintenance functions should not be viewed as separate activities, but activities in both parallel and in series.





Without Systems Engineering: The Design and O&M Functions Race

Design specifications →

Rules and Procedures →

Training →

Operations/systems monitoring →

Re-evaluation of Programs →

System Modification or Rule / Procedure Update →

These functions sometimes occur in their own separate lanes without the appropriate handoff of vital information.





Systems Engineering: A Relay, Not an Individual Race

We know it is important that the handoff is executed perfectly.

What happens before the handoff is just as important.

The person handing off has an end goal focused on the next person.

The person handing off knows what the receiver expects from him and why it is important.





Systems Engineering: A Relay, Not an Individual Race

The receiver knows what, when, where, how, and who from whom he is receiving the baton.

Both parties are briefly in motion together at the same time.

The handoff is predicated on both parties knowing what they have to provide.





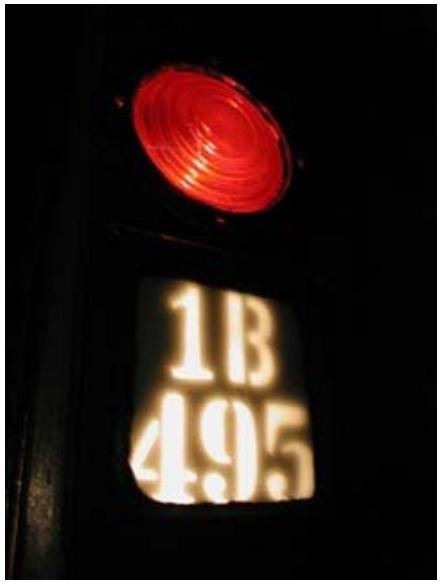
Our Relay: Design and O&M

System engineers have operational expectations in mind when designing systems.

These designs must have a close nexus to actual operations.

The design should drive the rules and procedures.

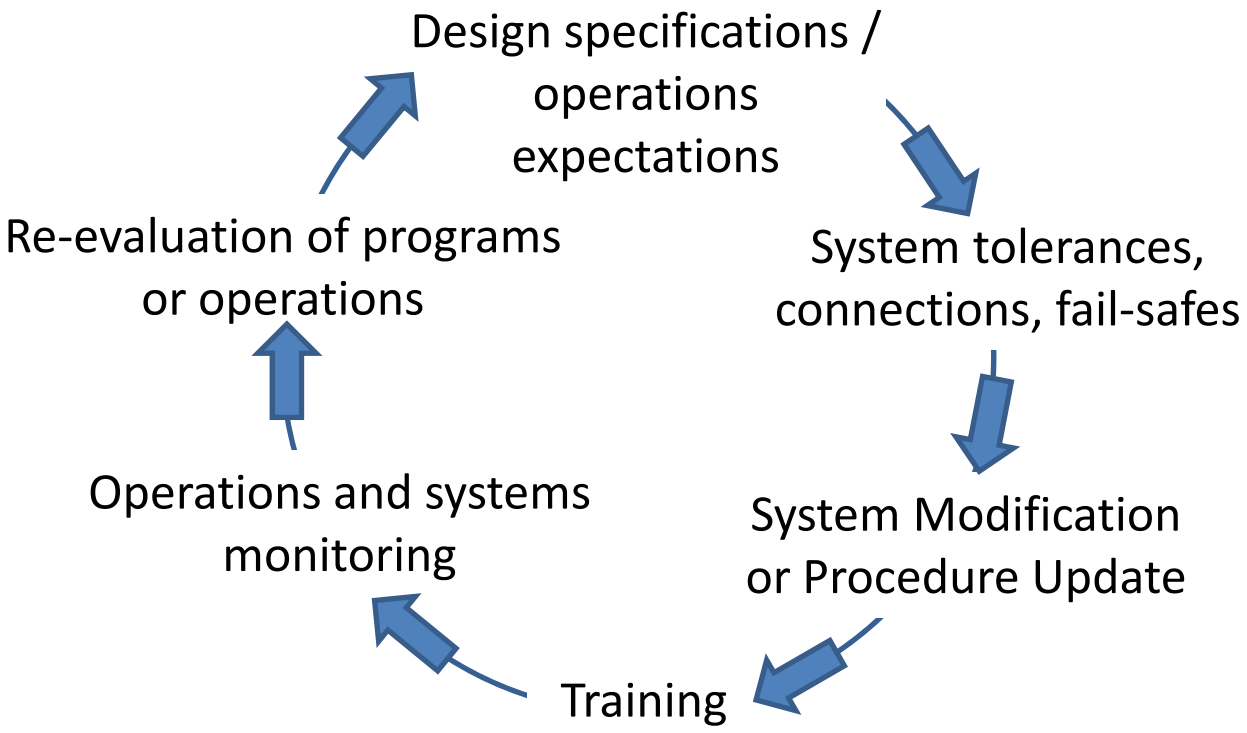
Changes by O&M staff to operations, procedures, or systems may not be in accordance with the design expectations.







Our Relay: Design and O&M



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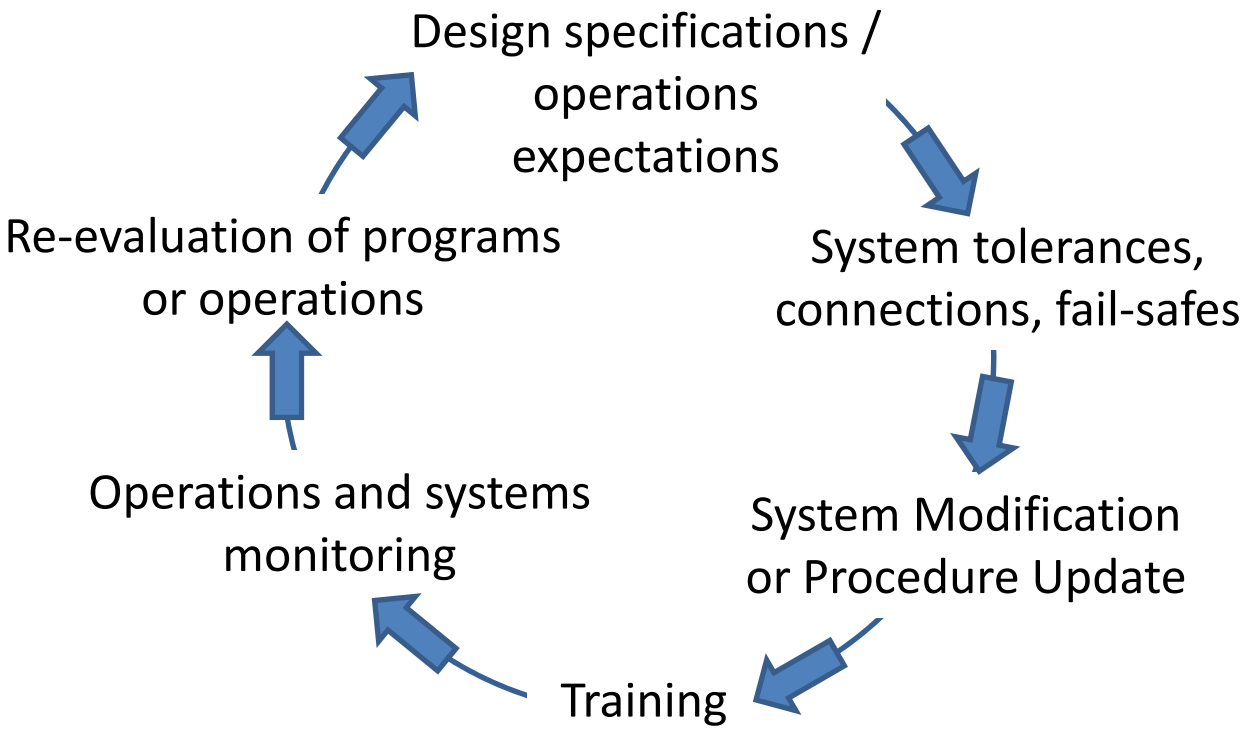
Our Relay: Design and O&M



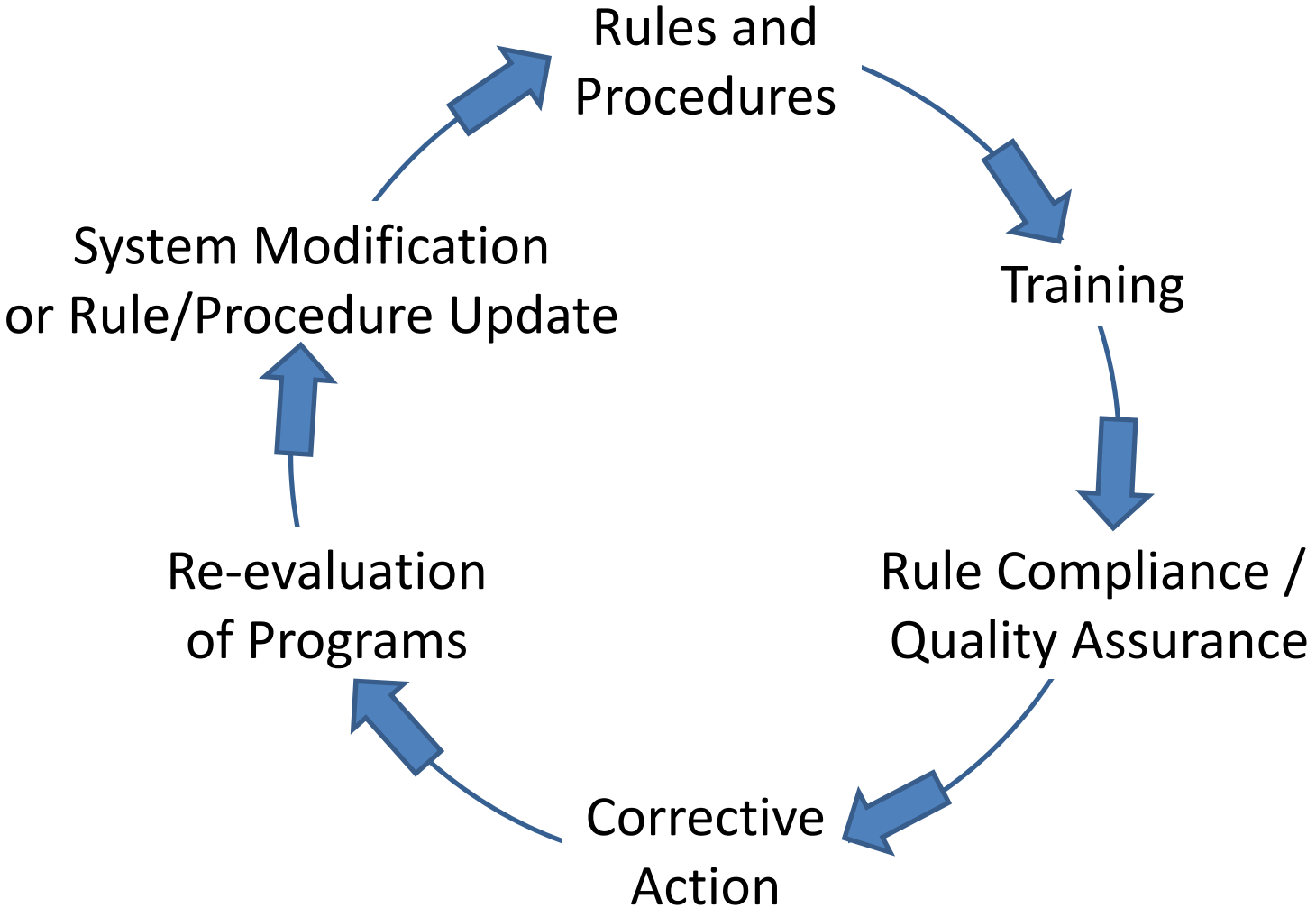
The receiver knows what, when, where, how, and who from whom he is receiving the information.

The handoff is predicated on both parties knowing what they have to provide.





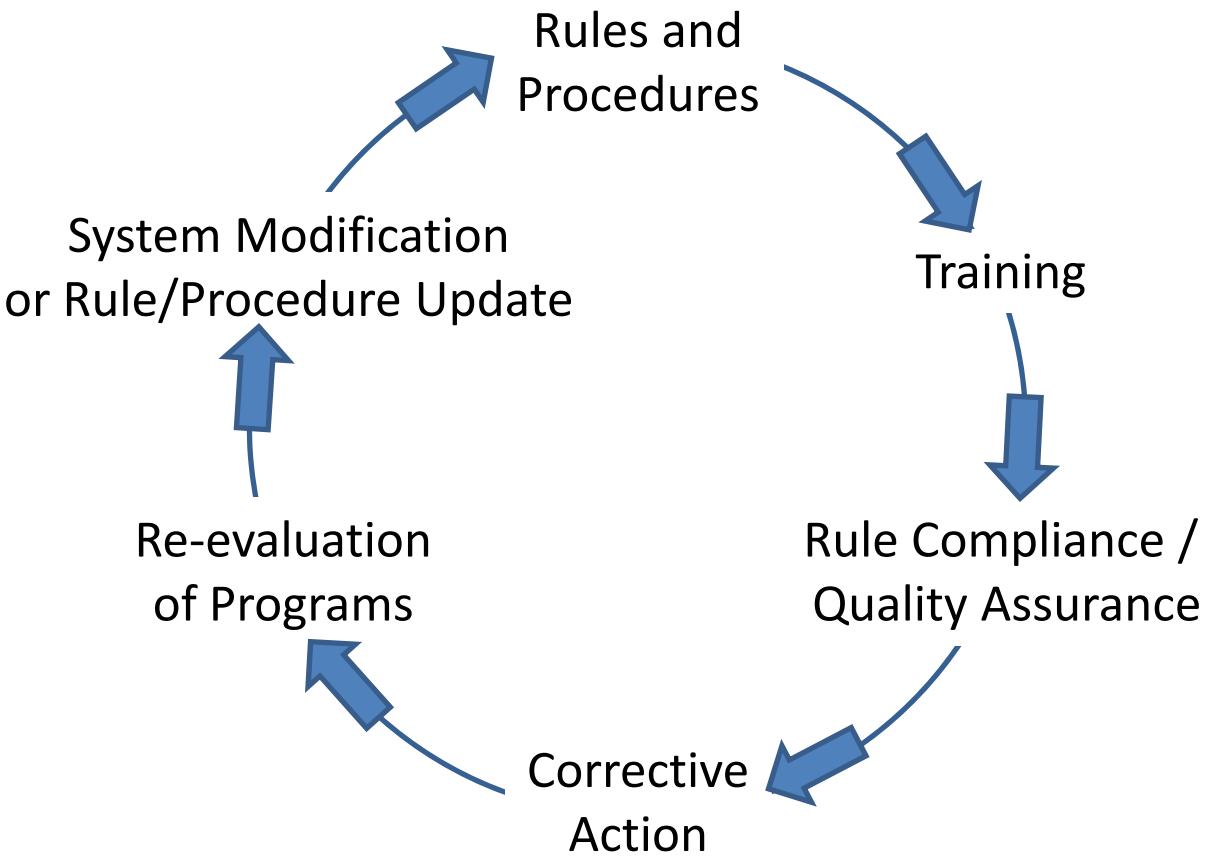
Our Relay: O&M Functions







Systems Engineering for O&M



Other Examples:

Pre-trip vehicle inspections

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Coordination with mechanics

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Identification of trends

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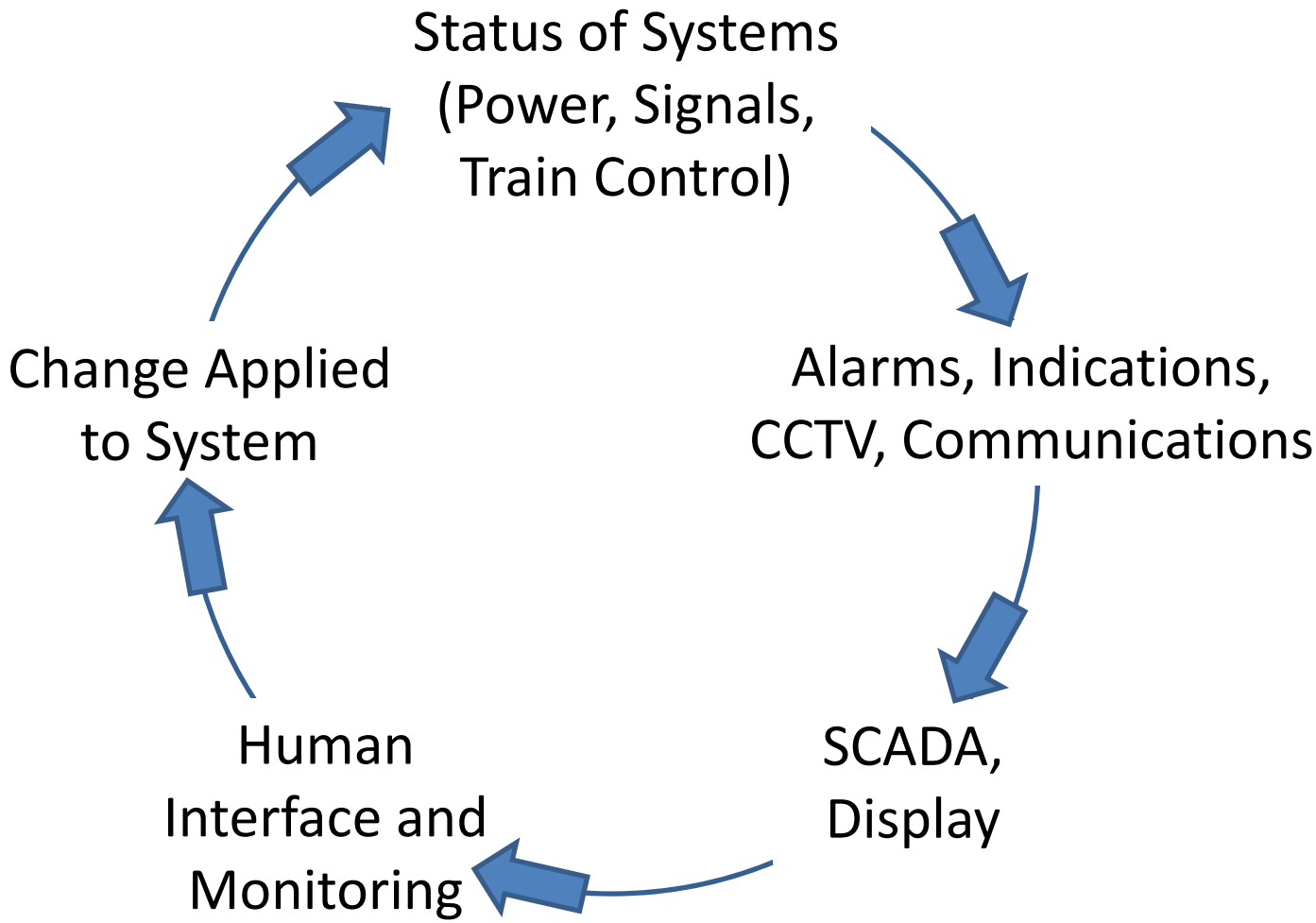
Hazard management





"Traditional" Systems Engineering







Information Needed to Successfully Integrate Systems Engineering into O&M

Do I know what information I need from the O&M personnel to improve systems during testing?

Do the O&M personnel know what information they need to provide to me during testing and before making changes?

Do I know what information I need to provide to O&M personnel and why it is important?

At what points do I work together with O&M personnel?





Information Needed to Successfully Integrate Systems Engineering into O&M

Does every party know explicitly what information it needs to receive and from whom?

Does every party know explicitly what information it needs to provide and to whom?

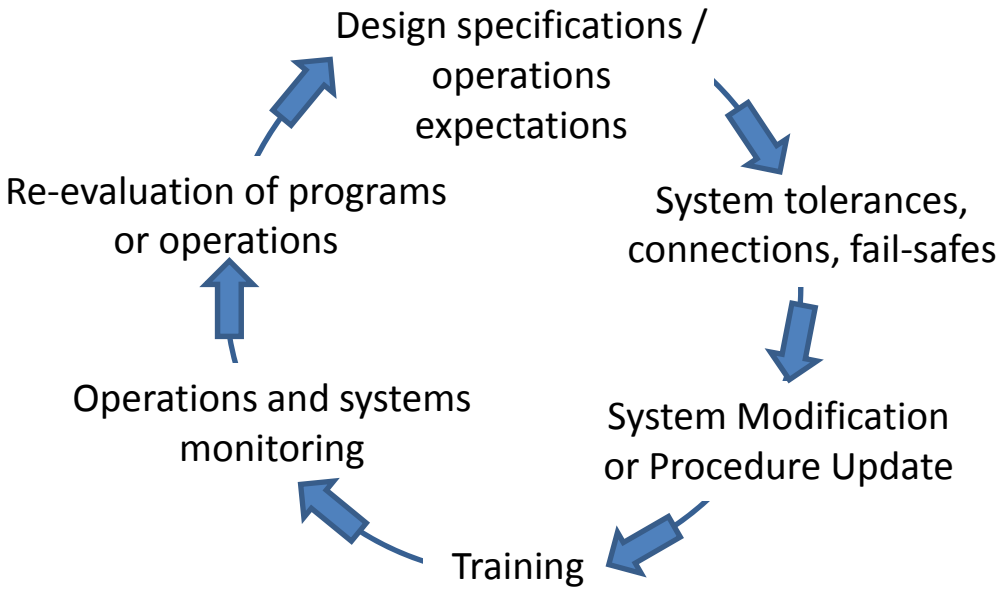
Are these lines of communication/coordination formalized?

Can every piece of data be carried through the “relay race” to ensure that all impacts are considered *on the system?*





Systems Engineering Approaches to O&M formalize a constant feedback loop in a cohesive system where everyone knows what they can contribute.



Questions?