Systems Engineering Pathology: Comprehensive Characterization of Systems Engineering Dysfunction

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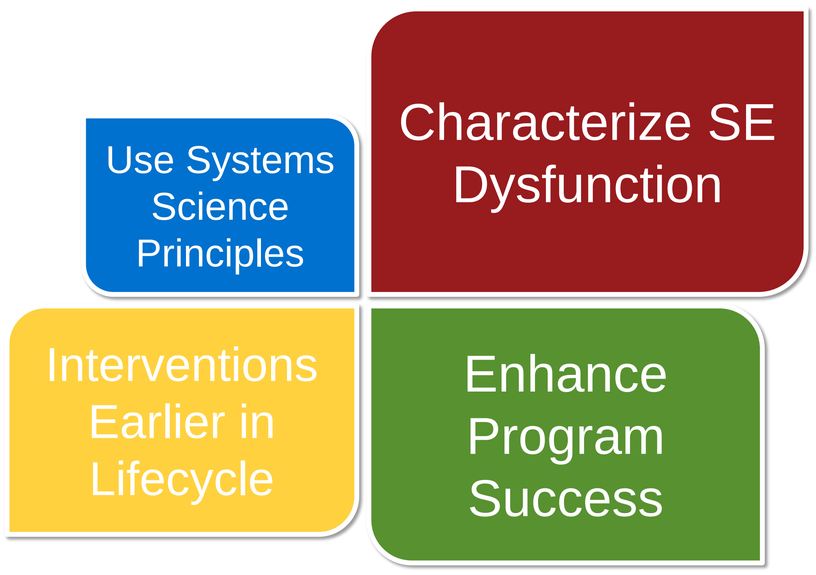
PURPOSE

- Systems Science concept of Systems Pathology extended to Systems Engineering (SE) Pathology to characterize SE execution dysfunction in a more methodical and systematic way
- As medicine accumulates understanding of causes, detection, treatment of diseased states, SE can accumulate understanding of causes, detection, treatment of dysfunctional SE execution
- The objective is to better achieve affordable, healthy SE functions enabled to positively influence program outcomes



LITERATURE REVIEW

- Definitions: **pathology** refers to study of disease; **etiology** is the manner of causation; **diagnosis** is identification of nature of illness by examination of symptoms; **prognosis** is likely course of ailment; **symptom** is subjective indication of disorder
- INCOSE Systems Science Working Group (SSWG) "Systems Processes and Pathologies" project identifying generalized systems processes and corresponding failure modes
- Examples include Cyberpathologies (dysfunctions of feedbacks); Rheopathologies (dysfunctions of systems flows); Cyclopathologies (dysfunctions of cycling, oscillations); etc.
- Extend concept to SE for "SE Pathology"
- Existing SE Pathology literature described in paper
- Thomas [2007] described system failures that resulted from deficiencies in SE process implementation and Gariepy [2017] mapped these to the Troncale [2013] systems pathologies

CASE STUDY SUMMARY

	CYBER-PATHOLOGY	CYCLO-PATHOLOGY	NEXO-PATHOLOGY	RHEO-PATHOLOGY	HETERO-PATHOLOGY	TERATO-PATHOLOGY	ALLOMETRIC PATHOLOGY
ARIANE 5	X					X	
HUBBLE		X			X		X
MARS OBSERVER			X	X			
WIRE	X	X					
GENESIS				X			X
LEWIS						X	
DART	X	X					
ORBITAL						x	
SPACEX	x						
MARS CLIMATE ORBITER	x					x	
HELIOS		x					
ORBITING CARBON	x					x	

Table 1: Summary of "Systems Architecture Disease" Experienced in System Failure Case Studies [Gariepy, 2017, reprinted with permission]

ANALYSIS

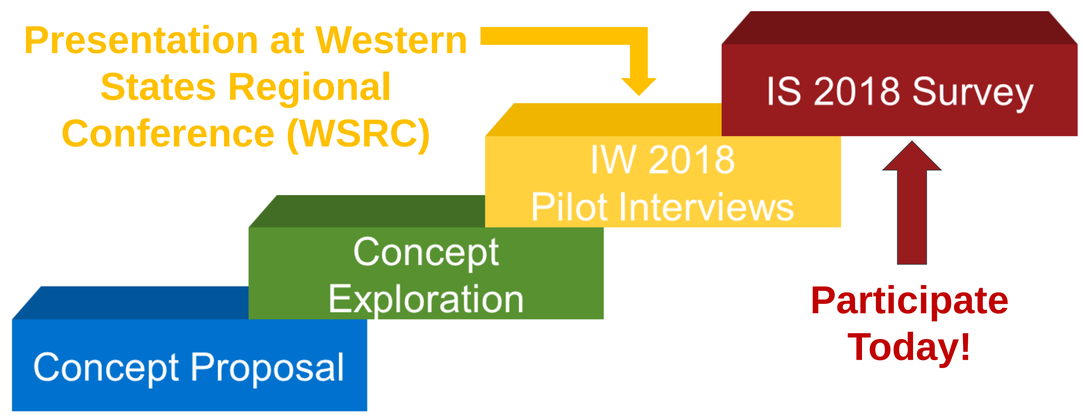
- Aggregation of literature provides four general categories of SE dysfunctions: (1) Knowledge, Understanding, and Experience; (2) Organization; (3) Resources; (4) Implementation Errors
- Example dysfunctions: Unskilled SE (those performing SE have inadequate SE knowledge, skills, abilities); Pace (program pace too quick, not enough time for adequate SE); Management (managers or executives have inadequate understanding of SE)
- Being able to characterize SE dysfunction in a more methodical and systematic manner enables more strategic intervention
- Using medical analogy, unfortunate if disease only revealed when patient is doomed. Post-mortem investigations inadequate.
- Finding symptoms early enough is the whole reason for a more rigorous approach to understanding SE dysfunction. Intervene before system development doomed.

CONCLUSIONS

- SE lacks fundamental scientific principles. There are no Ohm's Law, Bernoulli's Principle, and Newton's Laws for SE.
- Building on the growing work in Systems Science and Systems Pathology, SE Pathology is a way to characterize SE dysfunction
- Scientifically-developed theoretical integration would enable more strategic intervention
- SE Pathology is a new field of study in development, not a singular exercise, and empirical data gathering is needed

NEXT STEPS

- Empirical data gathering to collect SE dysfunctions and corresponding causes, symptoms, prognosis, treatments
- Transfer to practice – develop resources to systematically guide SEs and programs in navigating SE dysfunction



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