SACADA Data for HEP Estimates

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U.S.NRC
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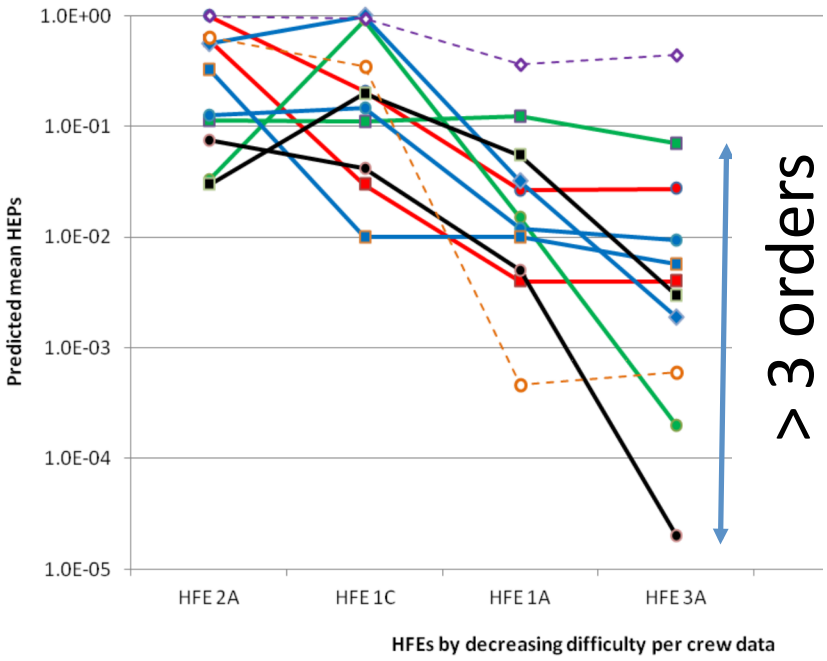
Protecting People and the Environment

Issue – Lack Data



HEPs by HFE (All Methods)

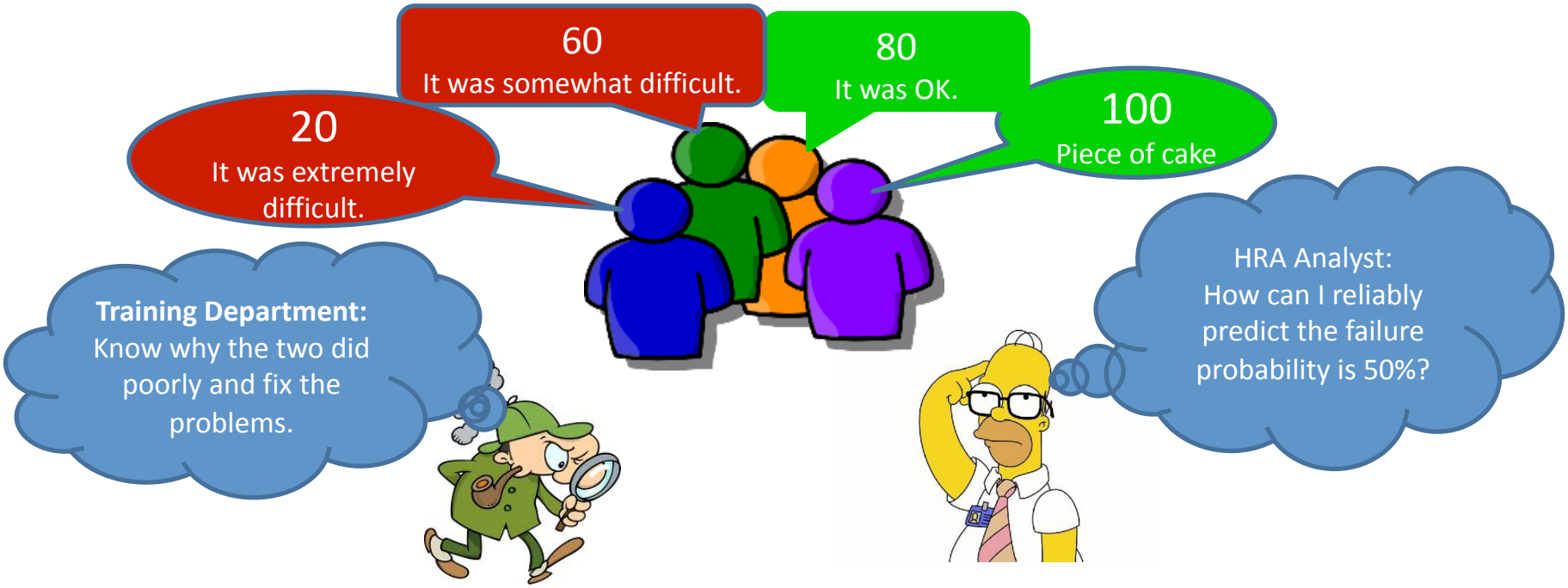
Solution – Collect Data

Brief SACADA History

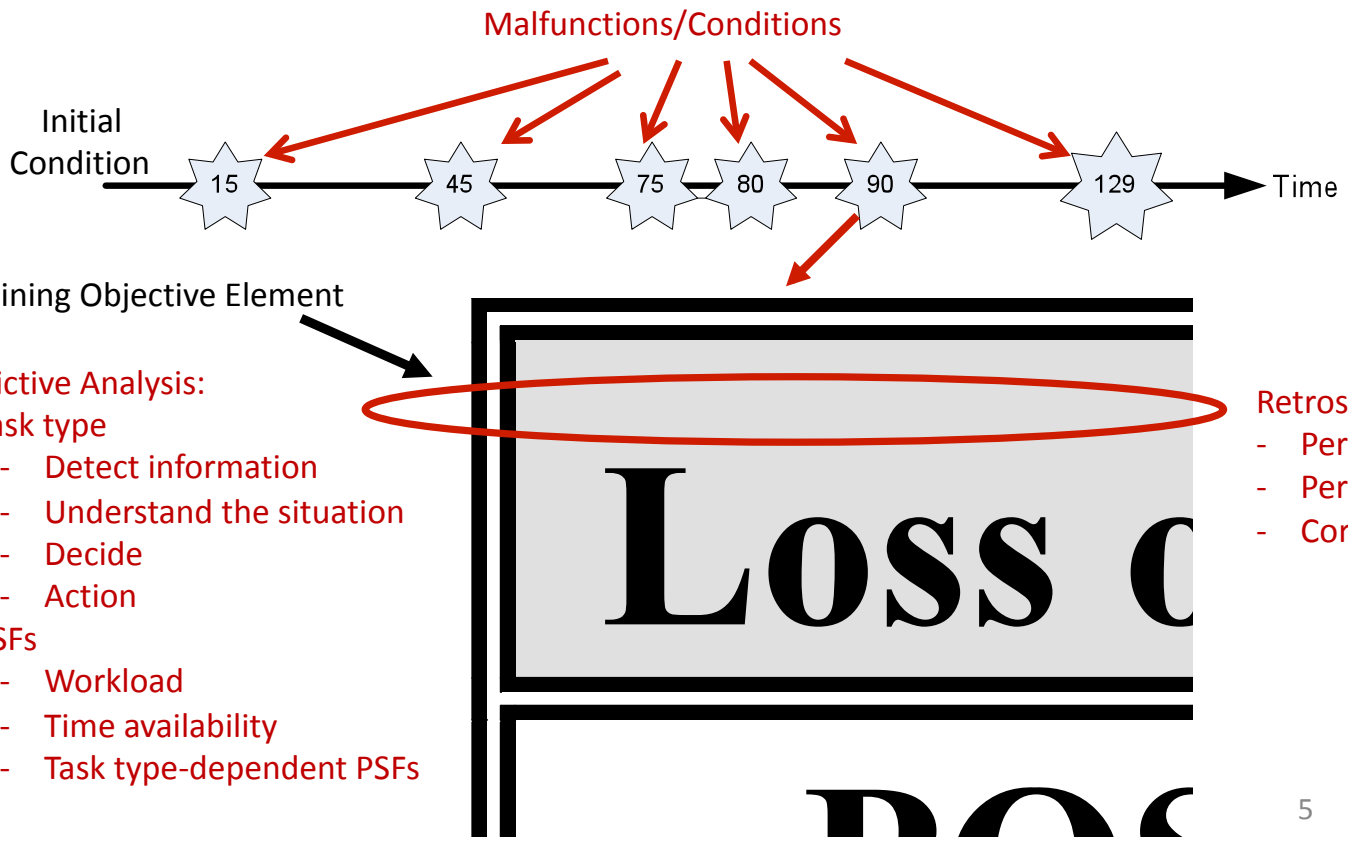
- 3/2011 the NRC signed a memorandum of understanding (MOU) with STPNOC to develop a tool to collect operator simulator training information for human reliability analysis (HRA) and operator training
  - SACADA aims to provide empirical data with statistical significance to inform human error probability (HEP) estimates
- 5/2012 piloted SACADA software at STPNOC
- Late 2012 to present: outreach for collaboration – signed multiple MOUs
- Hosted two international HRA data workshops to present SACADA data for HRA in 4/2015 and 3/2018.

Different Focuses Between Training Department and HRA Analysts

Four students took the same exam. The results are:



Toward a Context-Similarity Based Data Analysis to Inform HEP Estimates

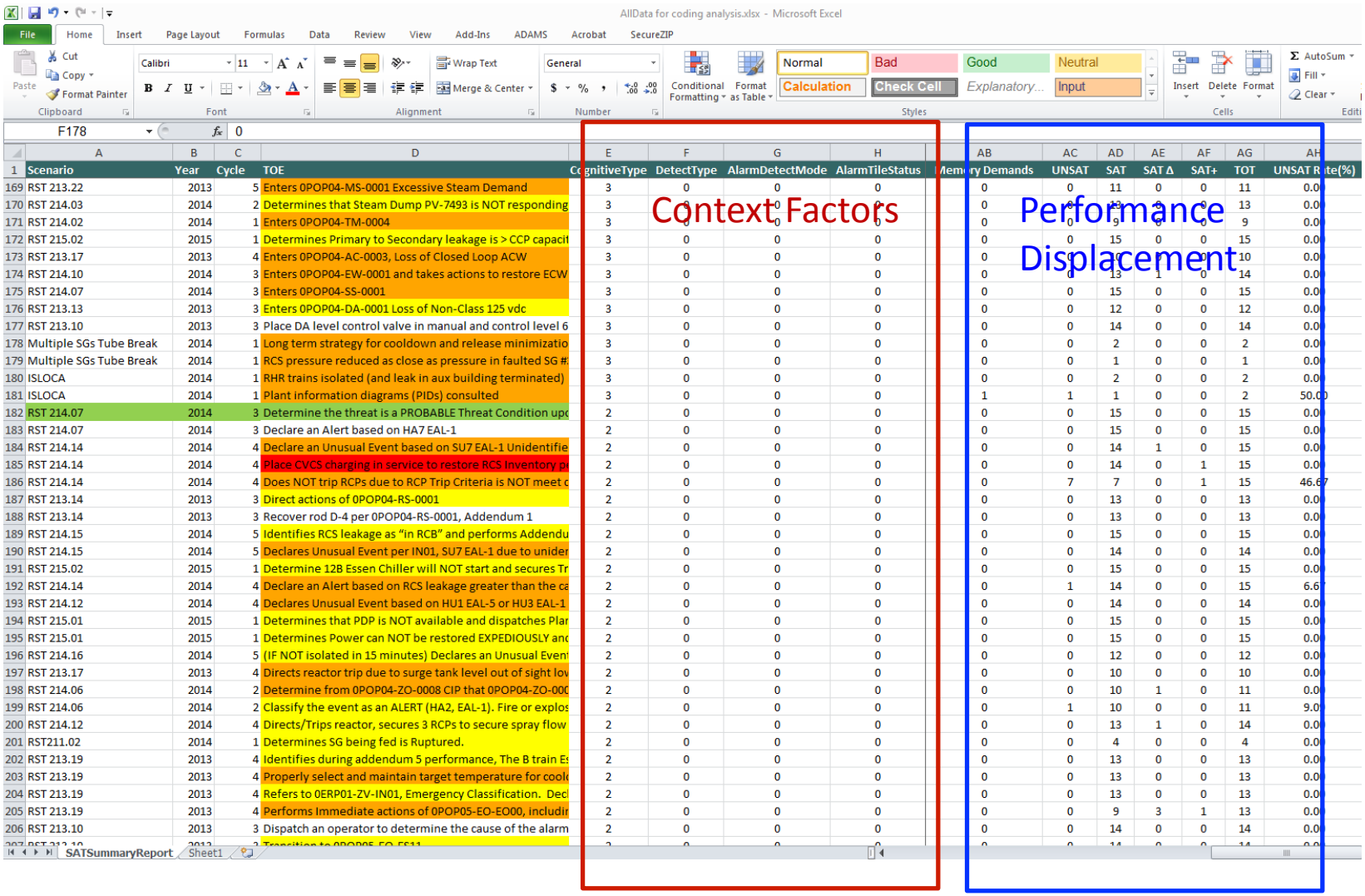


Predictive Analysis:
- Task type
  - Detect information
  - Understand the situation
  - Decide
  - Action
- PSFs
  - Workload
  - Time availability
  - Task type-dependent PSFs

Retrospective Analysis:
- Performance rating
- Performance analysis
- Corrective action

A SACADA Output for Data Analysis (Partial)

- Context, Performance Placement, and # of Data Points



	A	B	C	D	E	F	G	H	AB	AC	AD	AE	AF	AG	AH
1	Scenario	Year	Cycle	TOE	CognitiveType	DetectType	AlarmDetectMode	AlarmTileStatus	Memory Demands	UNSAT	SAT	SAT Δ	SAT+	TOT	UNSAT Rate(%)
169	RST 213.22	2013	5	Enters 0POP04-MS-0001 Excessive Steam Demand	3	0	0	0	0	0	11	0	0	11	0.0
170	RST 214.03	2014	2	Determines that Steam Dump PV-7493 is NOT responding	3	0	0	0	0	0	13	0	0	13	0.0
171	RST 214.02	2014	1	Enters 0POP04-TM-0004	3	0	0	0	0	0	9	0	0	9	0.0
172	RST 215.02	2015	1	Determines Primary to Secondary leakage is > CCP capacit	3	0	0	0	0	0	15	0	0	15	0.0
173	RST 213.17	2013	4	Enters 0POP04-AC-0003, Loss of Closed Loop ACW	3	0	0	0	0	0	10	0	0	10	0.0
174	RST 214.10	2014	3	Enters 0POP04-EW-0001 and takes actions to restore ECW	3	0	0	0	0	0	13	1	0	14	0.0
175	RST 214.07	2014	3	Enters 0POP04-SS-0001	3	0	0	0	0	0	15	0	0	15	0.0
176	RST 213.13	2013	3	Enters 0POP04-DA-0001 Loss of Non-Class 125 vdc	3	0	0	0	0	0	12	0	0	12	0.0
177	RST 213.10	2013	3	Place DA level control valve in manual and control level 6	3	0	0	0	0	0	14	0	0	14	0.0
178	Multiple SGs Tube Break	2014	1	Long term strategy for cooldown and release minimizatio	3	0	0	0	0	0	2	0	0	2	0.0
179	Multiple SGs Tube Break	2014	1	RCS pressure reduced as close as pressure in faulted SG #	3	0	0	0	0	0	1	0	0	1	0.0
180	ISLOCA	2014	1	RHR trains isolated (and leak in aux building terminated)	3	0	0	0	0	0	2	0	0	2	0.0
181	ISLOCA	2014	1	Plant information diagrams (PIDs) consulted	3	0	0	0	1	1	1	0	0	2	50.0
182	RST 214.07	2014	3	Determine the threat is a PROBABLE Threat Condition upc	2	0	0	0	0	0	15	0	0	15	0.0
183	RST 214.07	2014	3	Declare an Alert based on HA7 EAL-1	2	0	0	0	0	0	15	0	0	15	0.0
184	RST 214.14	2014	4	Declare an Unusual Event based on SU7 EAL-1 Unidentifie	2	0	0	0	0	0	14	1	0	15	0.0
185	RST 214.14	2014	4	Place CVCS charging in service to restore RCS Inventory pe	2	0	0	0	0	0	14	0	1	15	0.0
186	RST 214.14	2014	4	Does NOT trip RCPs due to RCP Trip Criteria is NOT meet c	2	0	0	0	0	7	7	0	1	15	46.6
187	RST 213.14	2013	3	Direct actions of 0POP04-RS-0001	2	0	0	0	0	0	13	0	0	13	0.0
188	RST 213.14	2013	3	Recover rod D-4 per 0POP04-RS-0001, Addendum 1	2	0	0	0	0	0	13	0	0	13	0.0
189	RST 214.15	2014	5	Identifies RCS leakage as "in RCB" and performs Addendu	2	0	0	0	0	0	15	0	0	15	0.0
190	RST 214.15	2014	5	Declares Unusual Event per IN01, SU7 EAL-1 due to unider	2	0	0	0	0	0	14	0	0	14	0.0
191	RST 215.02	2015	1	Determine 12B Essen Chiller will NOT start and secures Tr	2	0	0	0	0	0	15	0	0	15	0.0
192	RST 214.14	2014	4	Declare an Alert based on RCS leakage greater than the ca	2	0	0	0	0	1	14	0	0	15	6.6
193	RST 214.12	2014	4	Declares Unusual Event based on HU1 EAL-5 or HU3 EAL-1	2	0	0	0	0	0	14	0	0	14	0.0
194	RST 215.01	2015	1	Determines that PDP is NOT available and dispatches Plar	2	0	0	0	0	0	15	0	0	15	0.0
195	RST 215.01	2015	1	Determines Power can NOT be restored EXPEDIOUSLY and	2	0	0	0	0	0	15	0	0	15	0.0
196	RST 214.16	2014	5	(IF NOT isolated in 15 minutes) Declares an Unusual Event	2	0	0	0	0	0	12	0	0	12	0.0
197	RST 213.17	2013	4	Directs reactor trip due to surge tank level out of sight lov	2	0	0	0	0	0	10	0	0	10	0.0
198	RST 214.06	2014	2	Determine from 0POP04-ZO-0008 CIP that 0POP04-ZO-000	2	0	0	0	0	0	10	1	0	11	0.0
199	RST 214.06	2014	2	Classify the event as an ALERT (HA2, EAL-1). Fire or explos	2	0	0	0	0	1	10	0	0	11	9.0
200	RST 214.12	2014	4	Directs/Trips reactor, secures 3 RCPs to secure spray flow	2	0	0	0	0	0	13	1	0	14	0.0
201	RST211.02	2014	1	Determines SG being fed is Ruptured.	2	0	0	0	0	0	4	0	0	4	0.0
202	RST 213.19	2013	4	Identifies during addendum 5 performance, The B train Es	2	0	0	0	0	0	13	0	0	13	0.0
203	RST 213.19	2013	4	Properly select and maintain target temperature for cool	2	0	0	0	0	0	13	0	0	13	0.0
204	RST 213.19	2013	4	Refers to 0ERP01-ZV-IN01, Emergency Classification. Decl	2	0	0	0	0	0	13	0	0	13	0.0
205	RST 213.19	2013	4	Performs Immediate actions of 0POP05-EO-EO00, includir	2	0	0	0	0	0	9	3	1	13	0.0
206	RST 213.10	2013	3	Dispatch an operator to determine the cause of the alarm	2	0	0	0	0	0	14	0	0	14	0.0

An Example of Context-Similarity Analysis (Start with 7042 Data Points)

PIF	Status 1	Status 2	Status 3	Status 4	Data Points
Cognitive Type	Response Planning (R.P.)				1990
R.P. Basis	Skill	Procedure	Knowledge		1282
R.P. Familiarity	Standard	Adaptation Required	Anomaly		959
R.P. Uncertainty	Clear	Uncertain	Competing Priority	Conflicting Guidance	861
Workload	Normal	Concurrent demand	Multiple concurrent demand		523
Time Criticality	Expensive	Normal	Barely adequate		408
Communication Required	Normal	Extensive Within MCR	Extensive Onsite		226
Miscellaneous	Non-Standard	Noisy Background	Coordination	Communicator Unavailable	201
	Memory Demand				

16 Elements of 9 Scenarios Have the Same Context

Elements	UNSAT #	Data Points
Announces transition to 0POP05-EO-ES01	0	9
Enter POP05-EO-EC00 Loss of All AC Power and perform immediate actions	0	15
Enters 0POP05-EO-EC00	0	15
Directs/Sets up/Commences Main Turbine load reduction @ < 5%/min	0	11
Verifies the Reactor and Turbine are Tripped	0	15
Transitions to 0POP05-EO-ES13 at 75,000 gallons in RWST	0	10
Initiates RCS cooldown to Cold Shutdown at < 100 degrees per hour	0	13
Directs/Performs EO immediate actions	0	15
Perform load reduction to <50% per 0POP04-CD-0001, Addendum 3	0	13
Continue through POP04-RC-0003 in an attempt to identify and isolate the source of the leakage.	0	14
Direct a transition to POP05-EO-ES12, Post LOCA Cooldown and Depressurization.	0	14
Stops SDG 13	0	1
Determine and report that RCS leakage has exceeded charging capacity to maintain pressurizer level.	0	14
Transition to POP05-EO-EO10 based on RCS leakage to containment.	0	14
Directs/performs actions of 0POP05-EO-ES01 Reactor Trip Response	0	14
Transition to POP05-EO-EO10, Loss of Primary or Secondary Coolant.	0	15
TOTAL	**0**	**201**

Change the Response Planning Basis from Procedure-Based to Knowledge-Based

PIF	Status 1	Status 2	Status 3	Status 4	Data Points
Cognitive Type	Response Planning (R.P.)				1990
R.P. Basis	Skill	Procedure	Knowledge		626
R.P. Familiarity	Standard	Adaptation Required	Anomaly		459
R.P. Uncertainty	Clear	Uncertain	Competing Priority	Conflicting Guidance	373
Workload	Normal	Concurrent demand	Multiple concurrent demand		245
Time Criticality	Expensive	Normal	Barely adequate		189
Communication Required	Normal	Extensive Within MCR	Extensive Onsite		124
Miscellaneous	Non-Standard	Noisy Background	Coordination	Communicator Unavailable	115
	Memory Demand				

8 Elements of 5 Scenarios have the Same Context

Elements	UNSAT #	Data Points
Enter POP04-ZO-0004, Personnel Emergencies	0	15
Perform EO00 immediate actions from memory; close E1C1 and E1C2 LC supply breakers if SI actuated	1	14
Enters 0POP04-CD-0001	0	14
Enters 0POP04-RC-0003, Excessive RCS Leakage	0	14
Enter POP05-EO-EO00, Reactor Trip or Safety Injection	0	14
Directs/Performs 0POP04-ZO-0003, Secondary Plant Stabilization	0	14
Enters 0POP04-TM-0004, Failure of Turbine Impulse Pressure Transmitter (PT-505/506)	0	15
Enter POP04-RC-0003, Excessive RCS Leakage and transition to Addendum 3.	0	15
TOTAL	1	115

Context Similarity

- Increase data usability
  - Data points of different elements in different scenarios can be pooled together to provide statistical indications
- Inform HEP estimates more reliably than task-based analysis
- Provide more granularity on performance shaping factor (PSF) effects than existing HRA methods
  - Context specific PSF effects on human performance
  - E.g., Change UNSAT ratio from 0/201 to 1/115 due to change from procedure-driven to knowledge-driven in the specific context. Potential to significantly improve HEP accuracy.

Context Similarity Presented in 3/2018 HRA Data Workshop

- 3TKS (Stanley Fitch et al.,) and UMD (Katrina Groth) employed Bayesian Belief Net tool to use SACADA data to estimate HEPs
- IESS (Ali Azarm, et al.,) presented a formal quantitative method to identify and group critical PSFs

3TKS: Trinitek Services, Inc
UMD: University of Maryland, College Park
IESS: Innovative Engineering & Safety Solution, LLC

Current Status

- Continue outreach for data collection collaboration
- Developing SACADA 2
  - Collect simulator training, job performance measures, written exams, and actual event information in a single database
  - Beta version expected to be available in 11/2018
- Explore to have a BBN-based tool that incorporates human performance data of various sources to inform HEP estimates
- Looking for an organization to manage and promote the use of SACADA