Rolling the Dice

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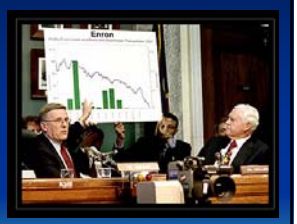
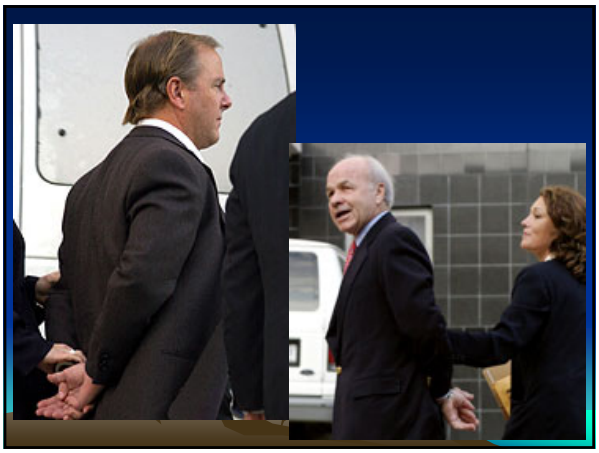




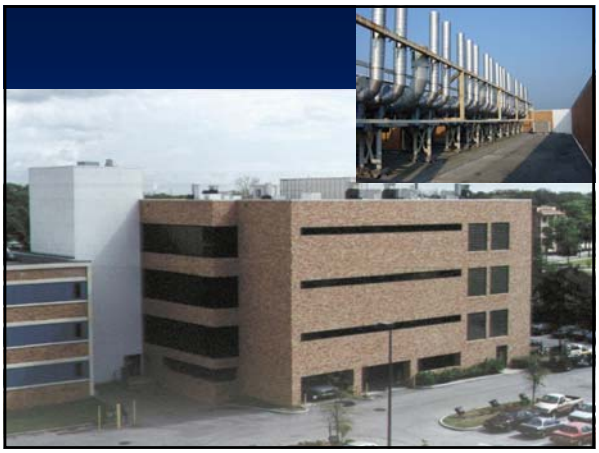
What are We Going For?

What is performance?

Risk Management

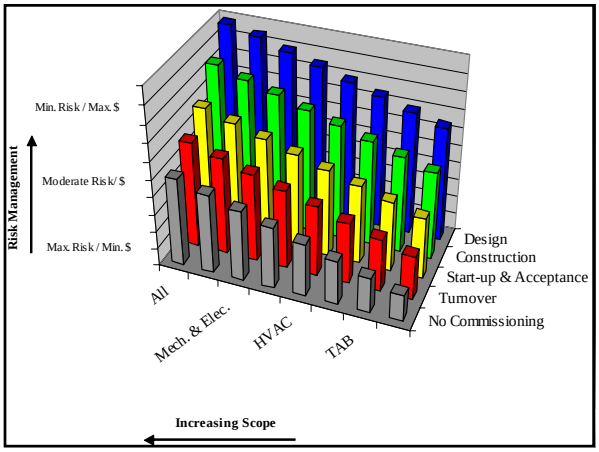
- What is the value of reliability to an owner?
- The answer is in risk tolerance.

Project Type	Occupant	Failure Effects	Reliability of Performance
Office Building	Office Worker	Reduced Productivity, Health Problems	Desired
Laboratories	Bio-hazardous Organism (Virus)	Failed Research, Illness	Essential
Rocket Launch Facility	Satellite	Failed Launch, Explosions	Critical



Objective

- Our goals:
  - Examine risk analytically.
  - Demonstrate the relationship between commissioning scope and reduced risk.
- Purpose:
  - Create a risk management model.
    - Scope can be determined analytically.
    - Knowledge is shared with the stakeholders.
  - Empower owners to value risk management.



Pricing Commissioning in 7 Steps

- Step 1: Identify Risks - What are you afraid of?
- Step 2: Cost Failures - How much can this hurt?
- Step 3: Establish Tolerance - How much do you care?
- Step 4: Build Risk Matrix – Where do you focus?
- Step 5: Assign Costs – What are the price tags?
- Step 6: Evaluate – Does the benefit justify the cost?
- Step 7: Set Scope & Contingency – Are you prepared?

Step 1- Identify Risks

- Parameters
  - Establish reliability goals
  - Determine failure potential
- Methods
  - Use industry data or experience (guess)
  - Conduct risk analysis (E.g. FMECA)

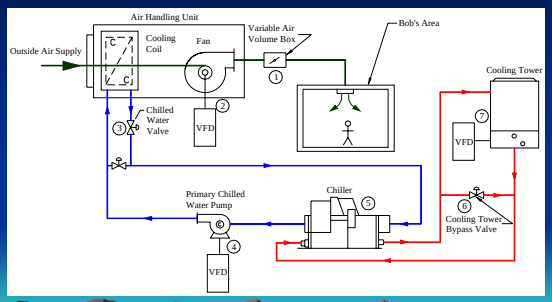
Reliability

- Reliability has been defined as an attribute of any system that:
  - produces the same results
  - meets or exceeds specifications
  - endures or lasts while continuing to perform
- Trust

Failure

- Catastrophic
  - System or system element causes shutdown.
  - Component erodes performance below minimums.
  - Unseen deterioration (mold, scale, oil)
  - Cost is in both repair and impact (trust).
- Efficiency
  - Facility performance is below expectations.
  - Reflected in consumptions costs (utility, replacement)
  - Cost reflected in reduced life cycle performance.

Examine Environment



Analyze Systems

VFD Fan	Bypass Valve	Compressor Vanes	VFD Pump	CW Valve	VFD Fan	VAV Valve
7	6	5	4	3	2	1

- In order for that cool air to reach B.O.B.'s room, a number of independent actions must occur:
  ….successfully.
- In fact, at least seven closed loop control sequences must work correctly to ensure performance.

Classify System or Component

(Critical-single point or process, Efficiency-utility or life span)

Classify Criticality Levels

- Level 1 – Failure results in loss of service or reduced performance to non-critical areas. (1 point)
- Level 2 – Failure results in system damage and loss of service to non-critical areas. (2 points)
- Level 3 – Failure results in loss of service to critical areas. (5 points)

Failure Modes, Effects and Criticality Analysis (FMECA)

System Name	Function	Time Period/ Time to Effect	Failure Mode	Effect of Failure:	Alternative:	Criticality Level	Criticality Points
Condenser Water System	Provide condenser water for cooling system	Continuous Flow	System Failure	Damage to system and loss of cooling to all areas.	Redundant condenser components start up (If applicable)	3	5
Chilled Water System	Provide chilled water for cooling system	Continuous Flow	System Failure	Damage to system and loss of cooling to all areas	Redundant chiller components start up (If applicable)	3	5
Wing 1 Air Handling Unit	Provide conditioned air & pressurization to lab areas	Continuous Flow	System Failure	Loss of conditioning & containment ability in lab areas	Redundant AHU components start up (If applicable)	3	5
Wing 2 Air Handling Unit	Provide conditioned air to admin & security areas	Scheduled & Continuous Flow	System Failure	Loss of conditioning to admin and security areas	Controlled shut down of equipment	1	1
Lighting Control System	Controls lighting in facility	Scheduled Operation	System Failure	Lighting remains on continuously.	Controlled shut down of equipment	1	1
Control System	Controls infrastructure systems	Continuous Operation	Sensor Failure	Damage to systems and loss of control to area	Controlled shut down of equipment	3	5
			Sensor not calibrated	Inefficient operation of equipment	Controlled shut down of equipment	2	2

Step 2 - Cost Failures

Cost Components by Failure Type	
Reliability Failure (Catastrophic)	**Efficiency Failure (Partial)**
• Repair and replacement costs o Materials o Equipment o Labor • Impact on human health or life (labs, hospitals, pharmaceutical)	• Higher Life Cycle Costs o Lower efficiency – Increased operation costs (fuel costs) o Higher maintenance costs o Premature replacement costs o Reduced salvage value
Either Type of Failure	
• System clean up costs (Premature filter replacement, clean room cleaning) • Reduced productivity (processes or human performance)	

Classify Cost Levels

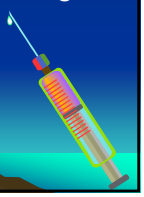
- Level 1 – Failure results in cost to the owner between $0 - $25,000. (1 point)
- Level 2 – Failure results in cost to the owner between $25,000 - $200,000. (2 points)
- Level 3 – Failure results in cost to the owner over $200,000. (5 points)

Estimate Failure Costs

System – Failure	Failure Type	Cost Items to Correct Failure	Cost Items Resulting from Failure	Cost	Cost Level	Cost Points
Condenser Water – System Failure	Reliability	New equipment/ materials, labor	Facility down time, ruined lab experiments	>$500,000	3	5
Chilled Water – System Failure	Reliability	New equipment/ materials, labor	Facility down time, ruined lab experiments	>$500,000	3	5
Wing 1 Air Handling Unit – System Failure	Reliability	New equipment/ materials, labor	Wing down time, ruined lab experiments, containment breach	>$1M	3	5
Wing 2 Air Handling Unit – System Failure	Reliability	New equipment/ materials, labor	Wing down time, loss in worker productivity	$10,000	1	1
Lighting Control – System Failure	Efficiency	New equipment/ materials, labor	Increased life cycle costs. (Cost given is over system life)	$100,000	2	2
Control – Sensor Failure	Reliability	New equipment/ materials, labor	Facility down time, ruined lab experiments	>$200,000	3	5
Control – Sensor not calibrated	Efficiency	Possibly new sensor, labor	Increased life cycle costs. (Cost given is over system life)	$20,000	1	1

Step 3 – Establish Tolerance

- Criticality of risk point value: 1
- Cost of failure cost point value: 2
- Risk Factor Rating **3**



Risk Factor Categories

- DESIRABLE: Risk Factor (1-2)
  - Activities related to components and systems which have a ***limited*** impact on operational program, the life safety and O&M requirements for the defined areas.
- ESSENTIAL: Risk Factor (3-5)
  - Activities related to components and systems which have a ***moderate*** impact on the operational program, life safety and O&M requirements.
- CRITICAL: Risk Factor (6-10)Typically
  - Activities related to components and systems which have a ***significant*** impact on the operational program, life safety and O&M requirements.

Step 4 - Build Risk Matrix

SYSTEM NAME	COMPONENT NAME	TAG NO.	LOCATION	AREA SERVED	CRITICALITY POINTS	COST POINTS	TOTAL POINTS	RISK FACTOR RATING		
								DES.	ESS.	CRIT.
Condenser Water	Pre-Cool Coil	PCC-01	Wing 1	Lab 01	5	5	10			X
Condenser Water	Pre-Cool Coil	PCC-02	Wing 1	Lab 02	5	5	10			X
Condenser Water	Cooling Tower	CT-01	HVAC Building Roof	All Areas	5	5	10			X
Condenser Water	Cooling Tower	CT-02	HVAC Building Roof	All Areas	5	5	10			X
Condenser Water	Cond Wtr Pump	CWP-01	HVAC Building	Chiller - 01	5	5	10			X
Condenser Water	Cond Wtr Pump	CWP-02	HVAC Building	Chiller - 02	5	5	10			X
Condenser Water	Cond Wtr Pump	CWP-03	HVAC Building	Pre-Cool Coil 01 & 02	5	5	10			X
Condenser Water	Cond Wtr Pump	CWP-04	HVAC Building	Pre-Cool Coil 01 & 02	5	5	10			X
Wing 2 AHU	Fan	FAN-02	Wing 2 Roof	Wing 2	1	1	2	X		
Wing 2 AHU	VFD	VFD-02	Wing 2 Roof	Wing 2	1	1	2	X		
Wing 2 AHU	Cooling Coil	CC-02	Wing 2 Roof	Wing 2	1	1	2	X		
Wing 2 AHU	Coil Control Valve	VLV-02	Wing 2 Roof	Wing 2	1	1	2	X		

Step 5 - Assign Commissioning Costs

SAMPLE TASKS INCLUDED IN COMMISSIONING SCOPE	TIME PER TASK	COST PER HOUR	DESIRED SYSTEM	ESSENTIAL SYSTEM	CRITICAL SYSTEM
	(Hrs)	($125)	(25%)	(50%)	(100%)
Planning Phase					
Design Intent	3	$375	$94	$188	$375
Design Phase					
Design Review	1	$125	$31	$63	$125
Commissioning Specifications	1	$125	$31	$63	$125
Construction Phase					
Contractor Document Review	0.5	$63	$16	$31	$63
Pre-Functional Checklist Development	1	$125	$31	$63	$125
Functional Test Development	4	$500	$125	$250	$500
Site Visit	0.5	$63	$16	$31	$63
Pre-Functional Checkout	1	$125	$31	$63	$125
Acceptance Phase					
Equipment Start-Up Assistance	2	$250	$63	$125	$250
Balancing Review	1	$125	$31	$63	$125
System Performance Testing	8	$1,000	$250	$500	$1,000
Turnover Phase					
Training Coordination	0.5	$63	$16	$31	$63
O&M Manual Review/ Develop Systems Manual	4.5	$563	$141	$281	$563
Warranty Visit	1	$125	$31	$63	$125
TOTAL COST PER SYSTEM			**$906**	**$1,813**	**$3,625**

Step 6 - Evaluate

- This industry lacks actuarial data
- Compare commissioning cost to failure risk and performance gain (established in steps 1-5).
- E.g. Condenser Water System
  - Costs $40,000 to Cx
  - Efficiency Gain is a 7 year payback
  - Reliability reward is $500,000
- Process involves judgment

Step 7 – Set Scope & Contingency

- Base scope on evaluation & matrix
- Recognize process limitations:
  - Update scope when appropriate to clarify value.
  - Establish and manage a scope contingency
- Adjust focus during project phases
  - concept: disciplines
  - design development: systems
  - contract documents: components/ specs.
  - construction: value analysis
  - turnover: use contingency (or not)

Update Evaluation

- Initiate or repeat this process at any phase either in its entirety or to focus on one area.
- Iterations or repetition of scope evaluation has two benefits:
  - Each iteration allows the quality assurance budget to be fine tuned or re-visited.
  - Risk tolerance is subjective; periodically reexamining risk confirms owner endorsement.

Set Scope Contingency

- Establish Budget
- Clarify Budget over project life
- Set aside contingency to allow
  - Retesting
  - Performance Enhancements
    - Additional fine tuning
    - Enhanced turnover

Conclusion

- Commissioning scope is tied to Risk Tolerance
- Commissioning scope, with contingency, can be structured to focus on specific areas of concern.
- Multi-step value specific process yields benefits and identifies limitations:
  - Benefits: scope valued according to owner's priorities.
  - Limitations: risks are mitigated not eliminated.
- Actuarial data will reduce reliance on judgment.


Fault Tolerance