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Session 6C-2114: How Much Is Another Measurement Worth?

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Speaker

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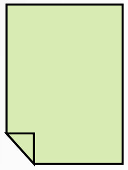
Background: Many years experience designing, justifying, installing and commissioning advanced real time computer/ automation applications in the process industries.

Value of Information on Your Checking Account Balance

Yesterday – Monthly Report; Manual Updates



Today – Real Time Access

What is the economic value?

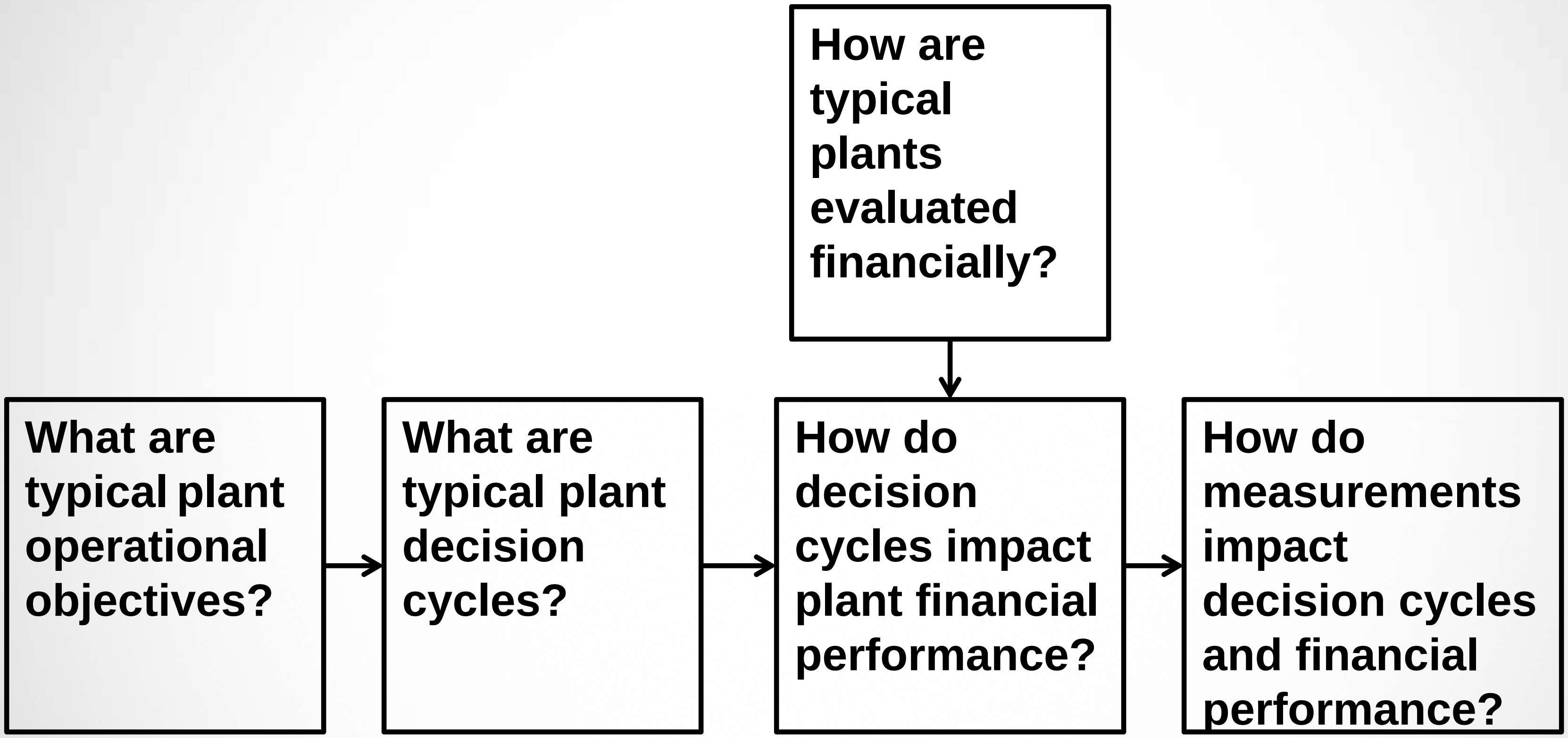
1. **Cost Saving – Reduction in overdraft fees, etc**
2. **Revenue Increase – Move "reserve" money from low interest checking to higher interest account; Reduced time required allows reallocation to value creation activities**
3. **However – more information enables a change but doesn't require it**

Typical Process Plant Measurement Upgrade Questions

How to economically justify:

- **A new flow measurement that has a higher accuracy than the existing one or an additional one where none currently exists**
- **A new measurement that might identify equipment problems earlier**
- **A new online analyzer that replaces less frequent lab measurements**
- **A more accurate temperature measurement in cases where precise temperature control is important**

Outline of Paper



Study Basis

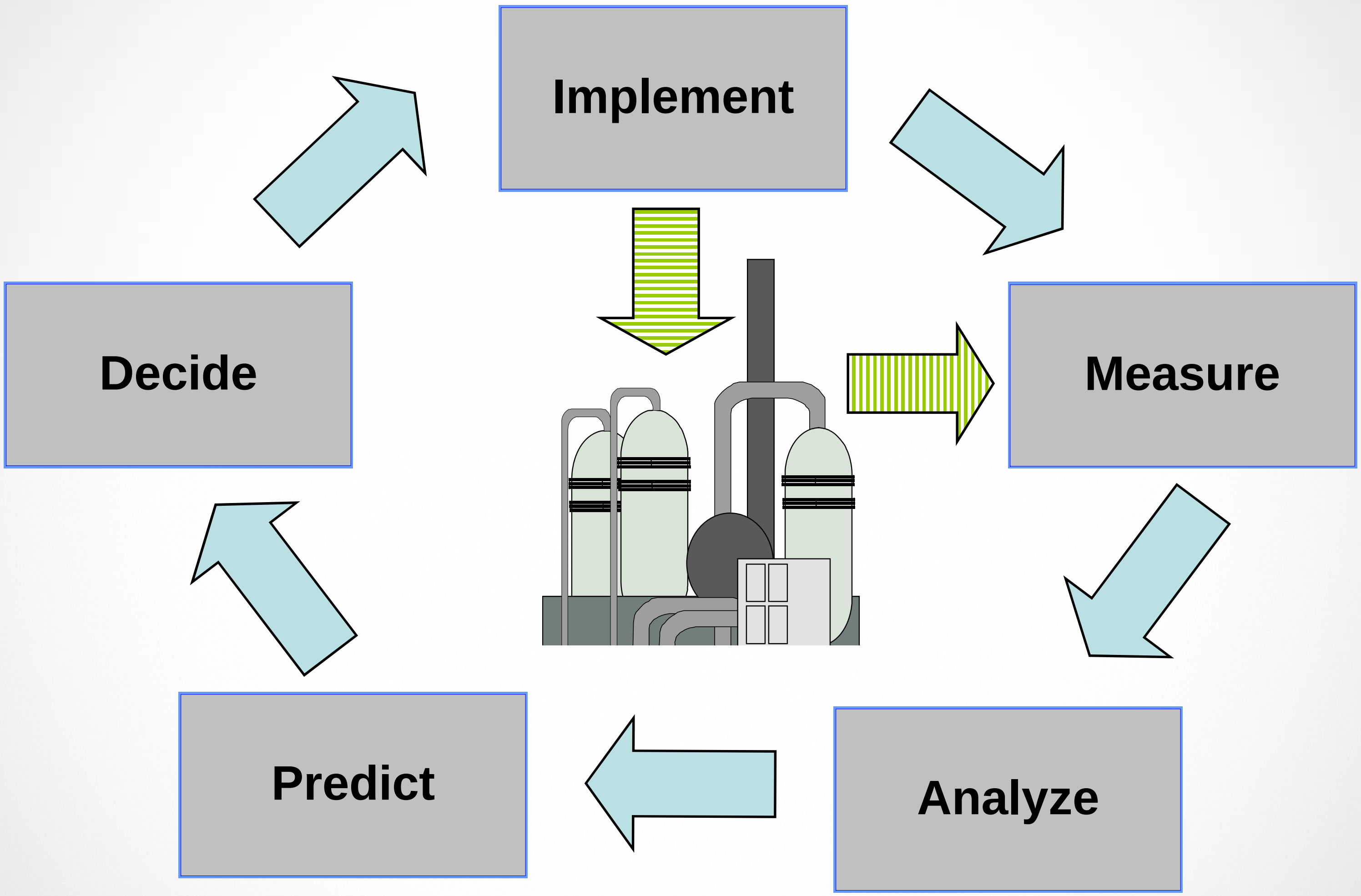
- **In this work it is assumed that there already exists in the plant or proposed plant a minimally sufficient set of measurements to insure safe and stable operation of the plant and to meet all regulatory and fiscal requirements. The focus here is on additional measurements that will increase the plant's financial value.**

What Are Typical Process Plant Operating Objectives - The Four Zero's

- ***Safety*** **– the goal is <u>zero serious safety incidents</u>**
- ***Sustainability*** **– the goal is <u>zero significant environmental incidents, excess energy use and excess waste</u>**
- ***Reliability*** **– the goal is <u>zero unscheduled downtime</u>**
- ***Optimization*** **- the goal is <u>zero lost profit opportunities</u>**

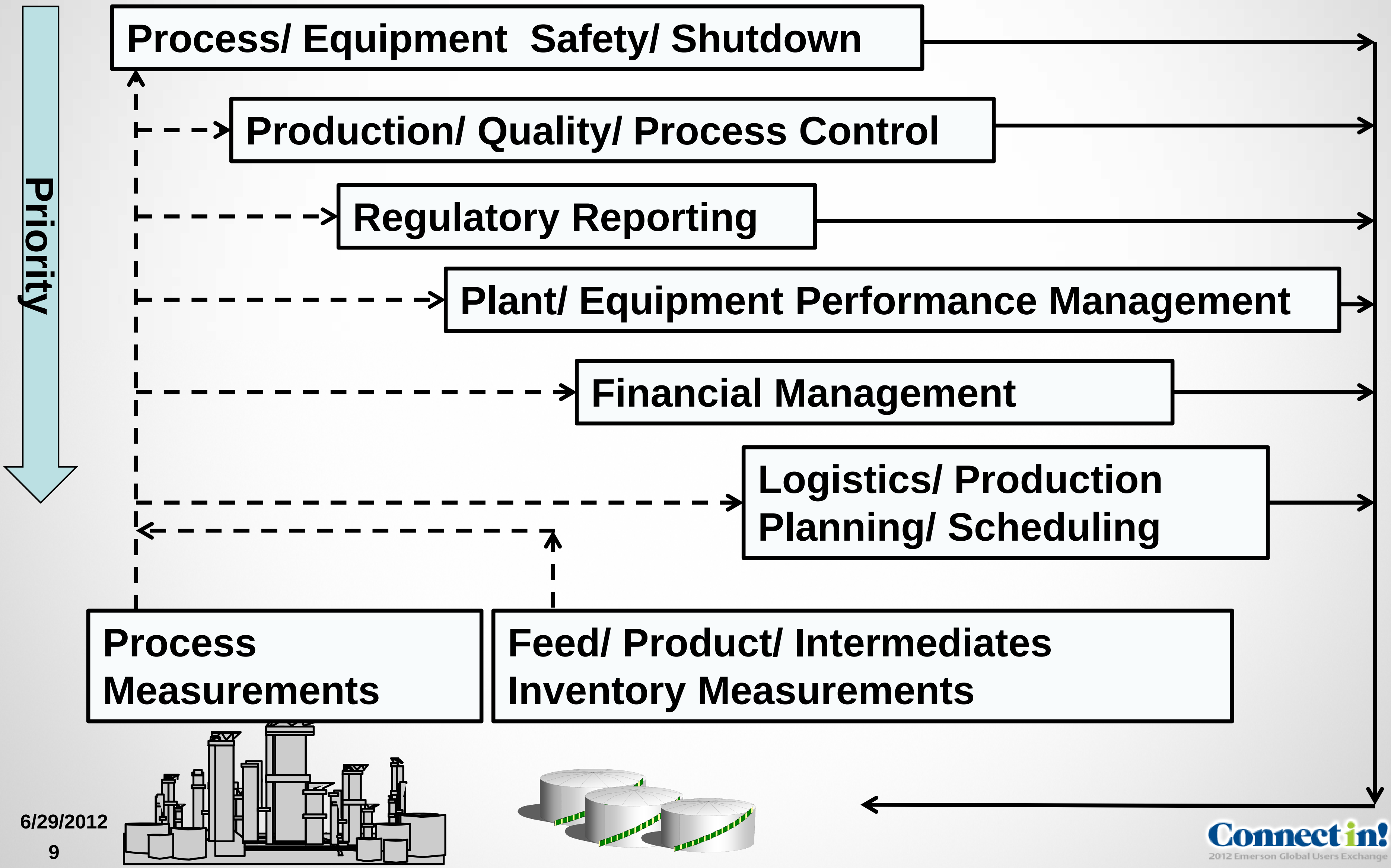
How Can New Measurements Support These Goals?

What is a Plant Decision Cycle?



This is the mechanism by which most plant operational decisions are made – either implicitly or explicitly

What are the decision cycles in the plant with a major influence on financial performance?

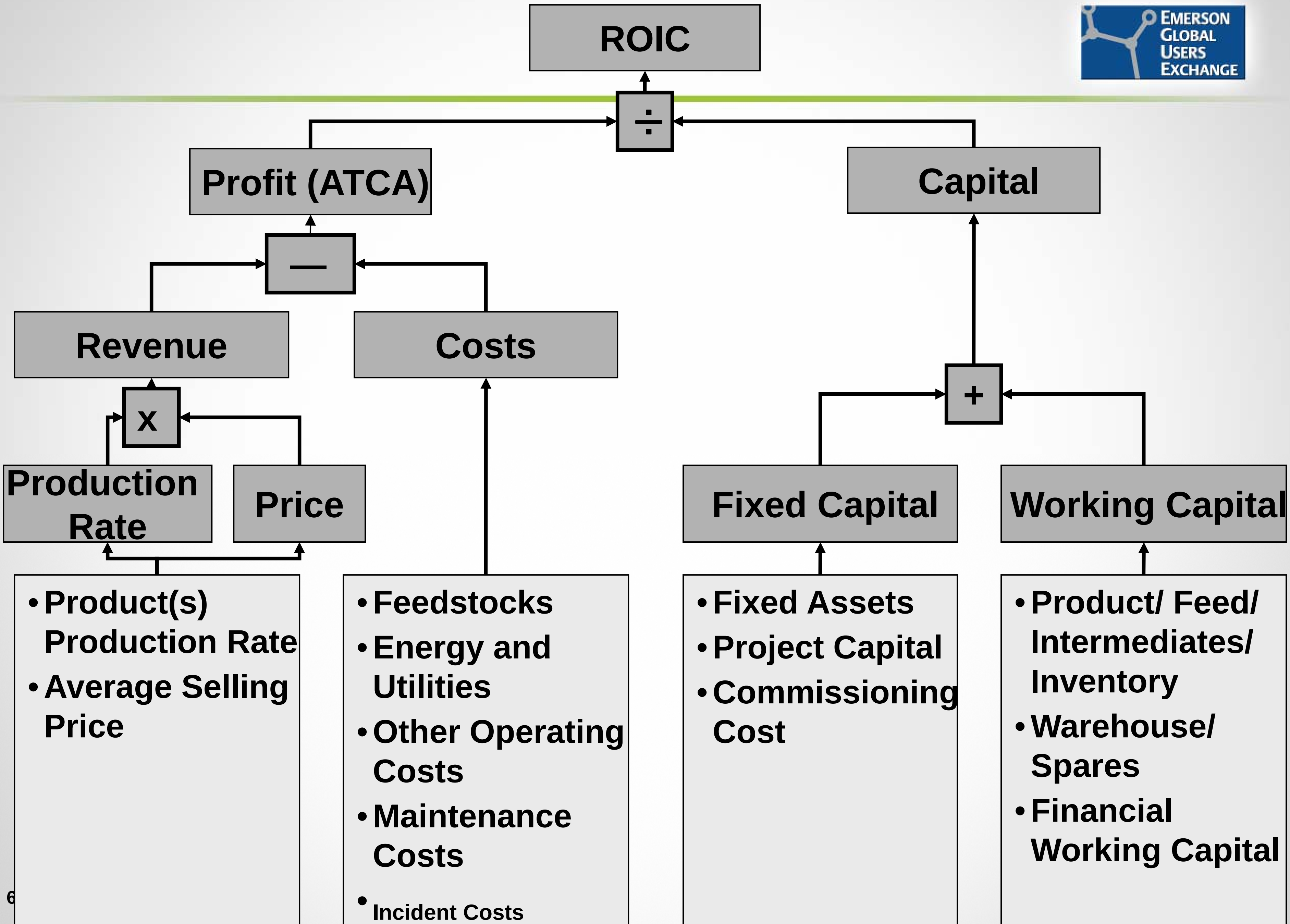


Decision Cycles and Measurements

- ***Process/ Equipment Safety/ Shutdown*** **– The highest priority is always assuring the safe operation of equipment and the process itself. Safety shutdown systems often have independent, sometimes redundant, measurements that are intended to detect when plant materials or equipment are in imminent danger of failure and take automatic action to bring the plant to a stable shutdown state.**
- ***Production/ Quality/ Process Control*** **– There are multiple measurements and control loops in the plant which are designed to regulate the plant equipment to meet product production rate targets and insure the products are within quality limits in the presence of external and internal disturbances and changing market demands. Additional controls may be in place to optimize energy usage or reactor conditions while meeting these goals.**
- ***Regulatory Reporting*** **– there are many regulatory requirements requiring plant measurements and reporting, often including emissions. Failure to provide these values can result in fines or, in the extreme, loss of the plant's operating license.**
- ***Plant/ Equipment Performance Management*** **– Production and quality targets cannot be met if required equipment is not available and operating at an acceptable performance level. There are many measurements that are intended to monitor the performance of the equipment to allow early detection of performance deterioration or possible failure and facilitate decisions on when to take maintenance action to correct the deterioration and avoid the failure.**
- ***Financial Management*** **– For the plant to maintain profitable operation it is necessary to accurately measure how much was produced (so customers can be properly invoiced) and how much was consumed (raw materials, energy, catalysts, etc.) so appropriate financial performance indicators can be monitored.**
- ***Production Planning/ Scheduling*** **– Decisions on the type, quantities and timing of raw materials to purchase and products to produce that optimize profitability depend on accurate measurement of current inventories and current plant/ equipment production limits as well as projected future performance.**

How do we measure plant economic valuation?

- **ROIC = Return on Invested Capital**
- **ROIC = ATCA / Invested Capital (Start of Year)**
  - **ATCA = Yearly After Tax Net Income (Tax Adjusted)**

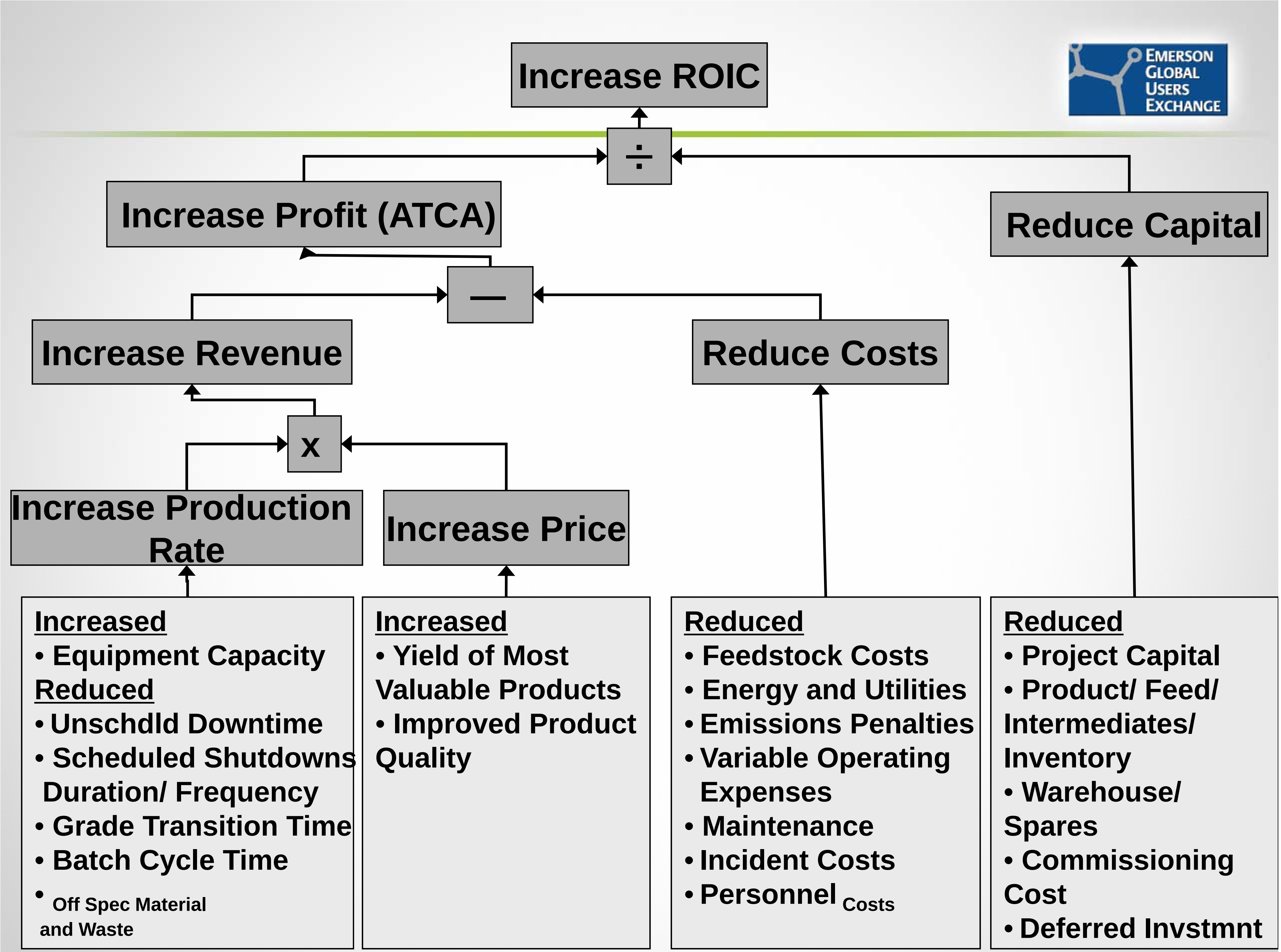

ROIC
÷
Profit (ATCA)
Capital
—
Revenue
Costs
+
x
Production Rate
Price
Fixed Capital
Working Capital
• Product(s) Production Rate
• Average Selling Price
• Feedstocks
• Energy and Utilities
• Other Operating Costs
• Maintenance Costs
• Incident Costs
• Fixed Assets
• Project Capital
• Commissioning Cost
• Product/ Feed/ Intermediates/ Inventory
• Warehouse/ Spares
• Financial Working Capital

How Do Measurements Impact Plant Financials?

Improved Measurement → Improved Decision Process → Improved Plant Financial Performance

How Can Measurement Improvements Impact Plant ROIC

- **Knowing better what the plant is doing now – this implies more accurate measurements with less delay and more frequent measurements of previously difficult to measure conditions.**
- **Comparing better what the plant is doing against what it is expected to do and understanding the differences – this leads to model based analysis and techniques to better comprehend the information**
- **Predicting better the effect of alternate decisions in the future**



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Increase ROIC
÷
Increase Profit (ATCA)
Reduce Capital
—
Increase Revenue
Reduce Costs
x
Increase Production Rate
Increase Price
Increased
• Equipment Capacity
Reduced
• Unschdld Downtime
• Scheduled Shutdowns Duration/ Frequency
• Grade Transition Time
• Batch Cycle Time
• Off Spec Material and Waste
Increased
• Yield of Most Valuable Products
• Improved Product Quality
Reduced
• Feedstock Costs
• Energy and Utilities
• Emissions Penalties
• Variable Operating Expenses
• Maintenance
• Incident Costs
• Personnel Costs
Reduced
• Project Capital
• Product/ Feed/ Intermediates/ Inventory
• Warehouse/ Spares
• Commissioning Cost
• Deferred Invstmnt

Methodology For Estimating Measurement ROIC

The recommended methodology for quantifying the financial impact of improved measurements is then to:

1. Identify the decision cycles that would be affected by the measurement
2. Identify the plant financial variables that are functions of the decision cycles identified
3. Estimate the potential increase in profit or reduction in capital that would be obtained through the improved measurement
4. Calculate the increased margin and/ or the return on investment

Measurements Provide Options For Improvement

- **Improved measurement provides the <u>option</u> to improve decisions but does not guarantee implementation – it is a necessary but not a sufficient condition**
- **Need to calculate a probability that the information will be used to actually improve the decision cycle based on its mechanics and use this probability to calculate an expected value of the improvement**

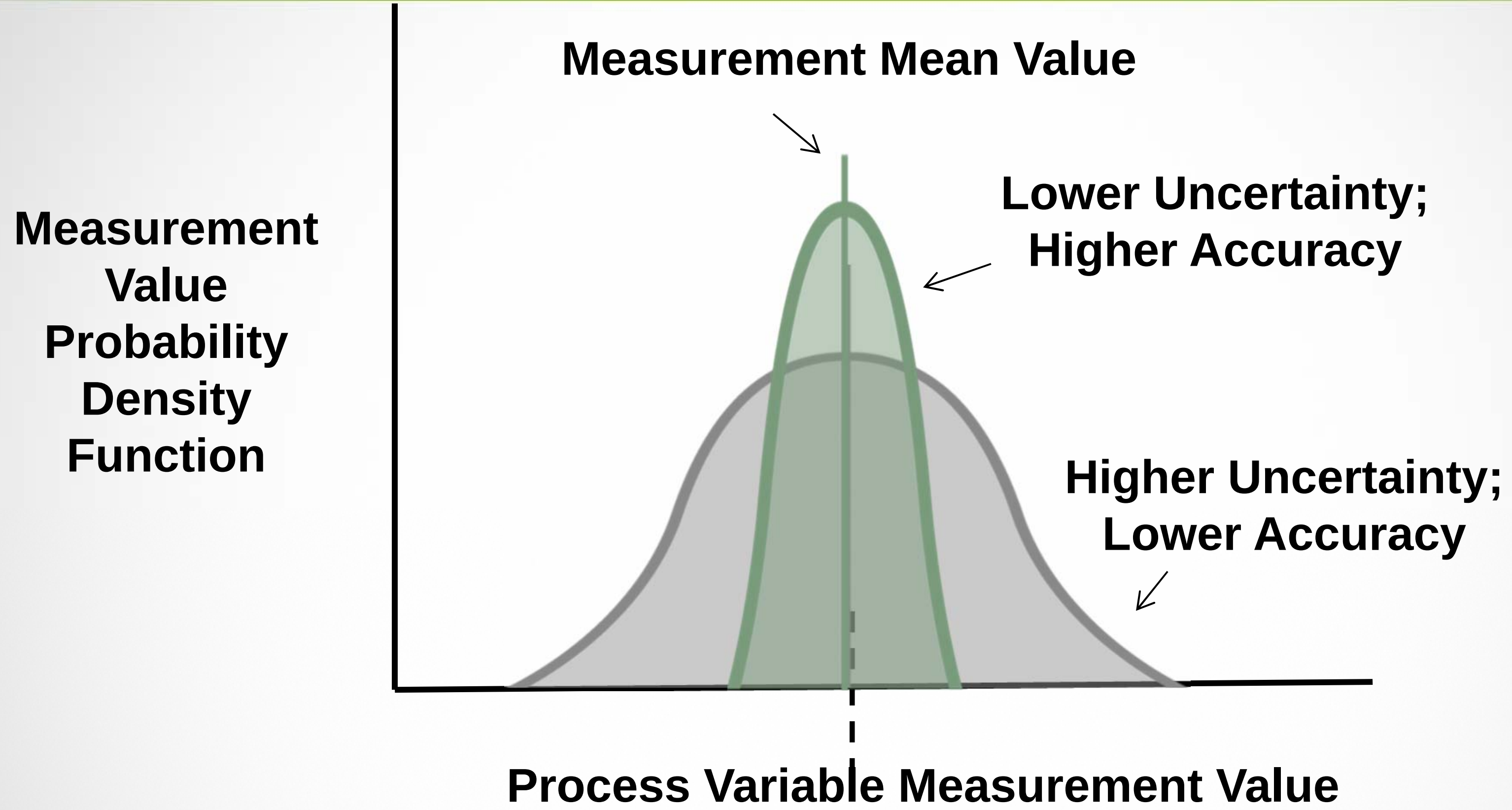
This consideration seems often to be missed in other references on this subject

Case Study 1

How To Justify Improved Flow Measurements

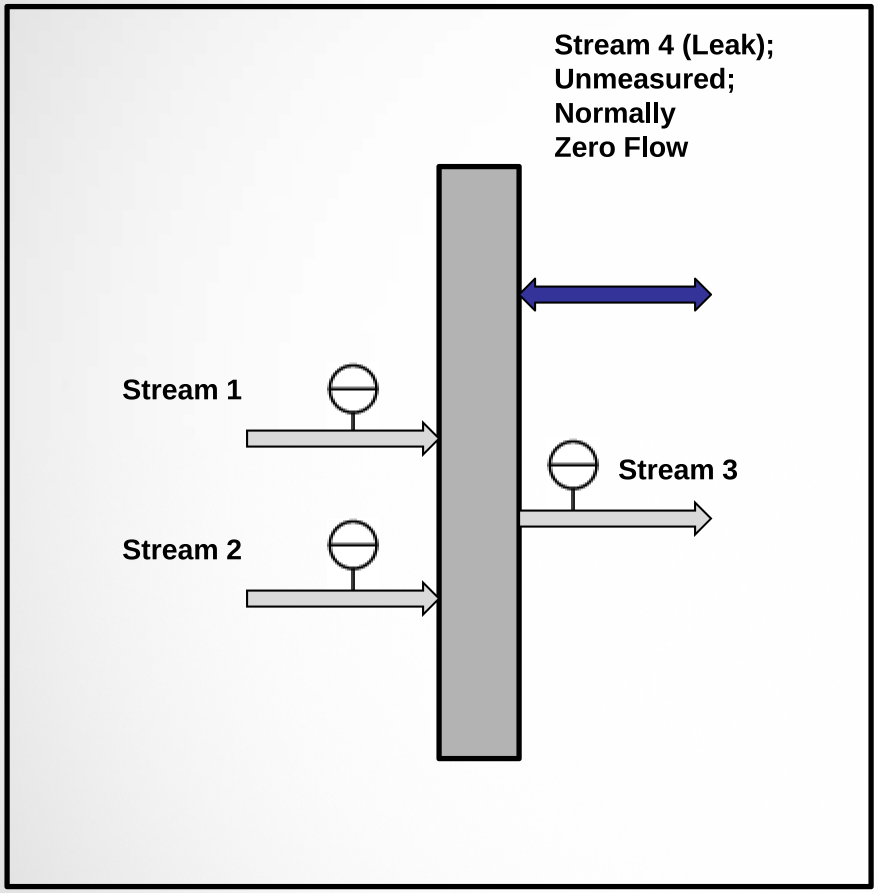
Example: Leak Detection

Value of Reducing Uncertainty



What is the value of reduced uncertainty?

Case Study – Improved Measurement Accuracy



Reducing "Value at Risk"; Minimum Unmeasured Flow Value That Is Statistically Indeterminate

Decision Cycle Impact: Plant Performance Monitoring – could be others as well

Measurement Terminology

- **Repeatability – The ability of a measuring device to give the same result at the same process conditions**
  - **Usually taken at two times the sample standard deviation observed (95% confidence level)**
- **Accuracy – The closeness of agreement between the result of the measurement and the true value**
  - **Errors can be random or biased**
  - **Often expressed over a range of process conditions**
  - **Can be measured only under test conditions**
  - **Usually taken at two times the standard deviation calculated or observed (95% confidence level)**
- **Uncertainty – An expression that represents the dispersion of values that could reasonably be expected under the conditions of measurement**
  - **Usually expressed as standard deviation**

Value of Improved Accuracy

Possible Leak Investigation					
	Original Flow Readings	Flow, Mass Balanced Converged	Absolute Difference	Flow Measurement Uncertainty, 3% Accuracy	Flow Measurement Uncertainty, 1% Accuracy
				0.03	0.01
Stream 1	45	44.43	0.57	1.35	0.45
Stream 2	55	54.15	0.85	1.65	0.55
Stream 3	96	98.58	2.58	2.88	0.96
Conclusion				**No Result**	**Leak Likely**

Increasing Flow Accuracy Permits Identification of Possible Leak

Leak Estimate

Plausible Leak Estimate				
	Original Flow Readings	Flow, Mass Balanced Converged	Absolute Difference	Flow Measurement Uncertainty, 1% Accuracy
Stream 1	45	44.81	0.19	0.45
Stream 2	55	54.71	0.29	0.55
Stream 3	96	96.88	0.88	0.96
Stream 4 (Leak)	0	2.64	2.64	

Value At Risk = 2.64 x value per production unit x time scale of interest

Case Study 2

How To Justify New Measurements to Identify Potential Reliability Issues

Example: Improving Pump Performance

Decision Cycle

Decision Cycle Impact:

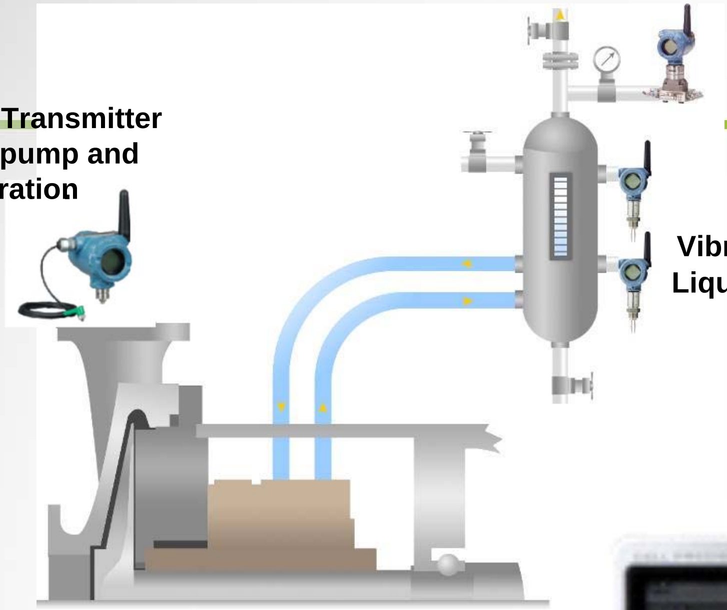
Plant/ Equipment Performance Management – could be others as well

Wireless Pressure Transmitter

Wireless Vibration Transmitter monitors pump and motor vibration

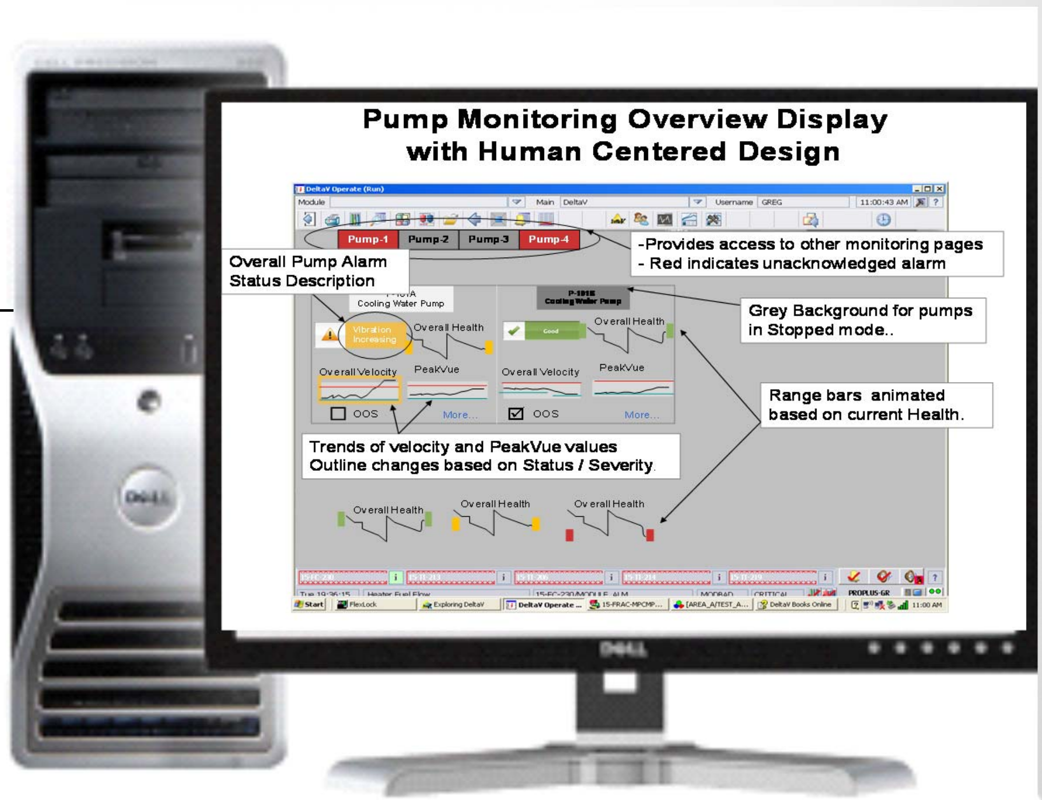
Vibrating Fork Liquid Level Switches

Case Study : Improved Pump Performance Monitoring



Pump

Wireless Gateway



Financial Impact Areas For Improved Equipment Performance Measurements

Reductions in:

- Unscheduled Shutdowns
  - Lost Unit Production Value (when production limited)
  - Direct Cost Unscheduled Shutdown (non serious incident related)
    - Off spec (slop) product reprocessing, flared material loss, catalyst loss/ deterioration, critical equipment damage, unscheduled maintenance labor (fully burdened)/ unscheduled cranes/ heavy equipment, equipment replacement, cleanup, operating staff overtime
  - Serious incident cost (fire, major/ reportable environmental release, shelter in place, injury/ death)
    - External compensatory and cleanup payments
    - Reporting Costs
    - Fines
- Unit Upset
  - Lost Unit Production Value (when production limited)
  - Direct Cost Unit Upset
    - Off spec (slop) product reprocessing, flared material loss, catalyst loss/ deterioration, critical equipment damage, unscheduled maintenance labor (fully burdened), equipment replacement, cleanup, operating staff overtime
- Unscheduled Slowdowns
  - Lost Unit Production Value (when production limited)
- Routine Maintenance
  - Ongoing Maintenance
  - Turnaround Maintenance
- Manual Equipment Readings (Reduced Personnel Exposure)

Pump Breakdown Modes – Incident Rate

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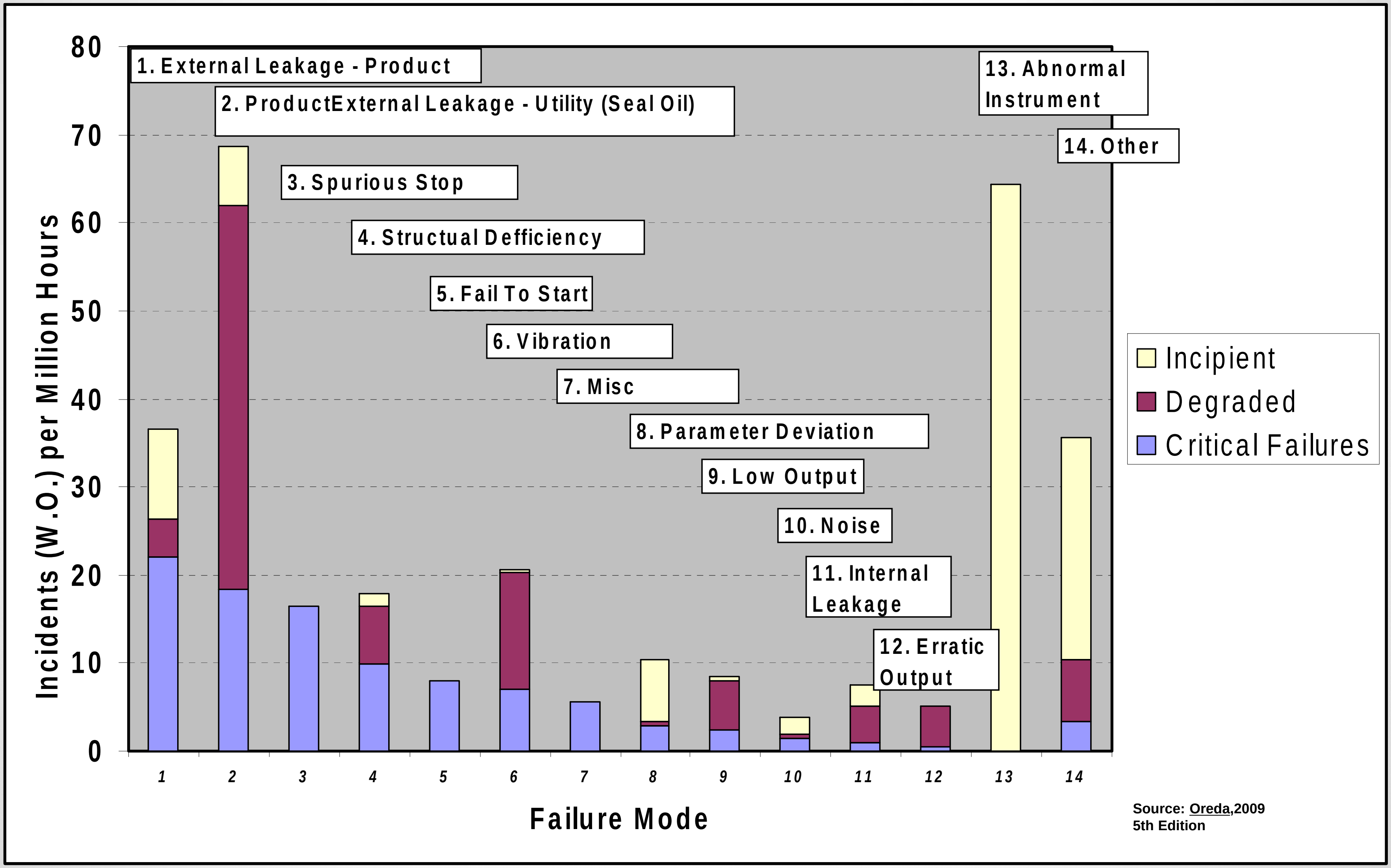

Source: Oreda,2009
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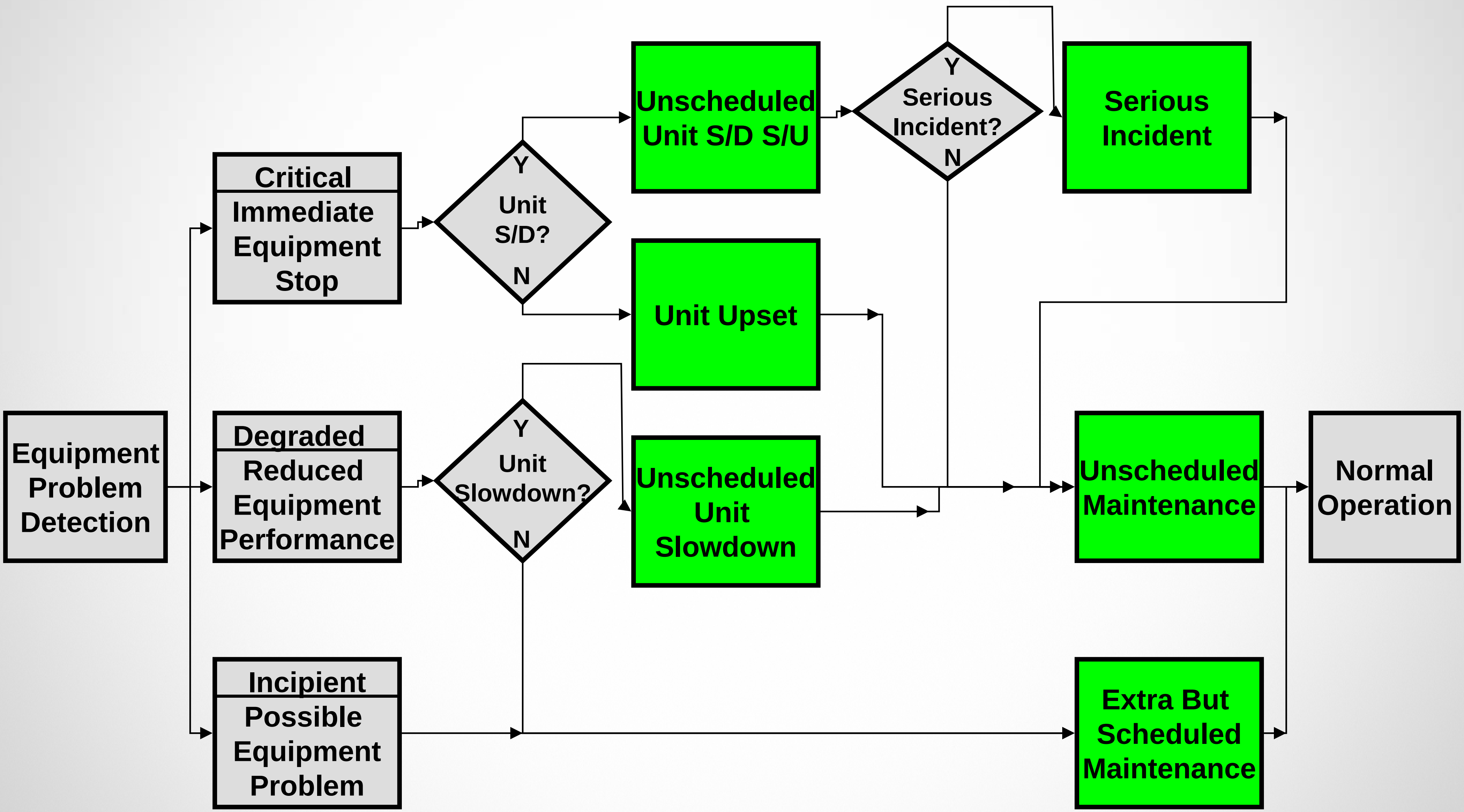
How To Quantify Financial Impact Areas: Use Incident Rate Data



Calculating The Plant Financial Impact

Availability Impact, Unscheduled Shutdowns and Slowdowns										
Process Units	Operating Margin, $/ Bbl	Comment	Process Capacity, BPD	Comment	Pumps, Lost unit availability, %	EHM Impact, Reduction in Lost Availability, %	Unit Operation at Maximum, % Time	Single Unit, Value Reduction, Lost Availability, $/ Yr		Closely Linked Units
Crude	$2.00		250000		0.2%	30%	25%	$26,625		Vacuum
Vacuum	$1.00		125000		0.2%	30%	25%	$6,656		
Saturated Gas Plant	$0.25		12500		0.2%	30%	25%	$166		Crude
FCC	$5.00		87500		0.2%	30%	25%	$23,297		Alkylation
Alkylation	$2.00		17500		0.2%	30%	25%	$1,864		FCC
Unsaturated Gas Plant	$0.25		6250		0.2%	30%	25%	$83		FCC
Hydrotreaters	$0.50		175000		0.2%	30%	25%	$4,659		
Reformers	$2.00		50000		0.2%	30%	25%	$5,325		Hydrotreaters
Hydrogen Plant_PSA	$0.50	$/ kscf	50	mscfd	0.2%	30%	25%	$1,331		Hydrocracker
Hydrocrackers	$6.00		25000		0.2%	30%	25%	$7,988		Hydrogen Plant
Coker	$8.00		37500		0.2%	30%	25%	$15,975		
Sour Gas Treating_Sulfur Plant	$1.00	$/ LT Sulfur	425	LT/ D	0.2%	30%	25%	$23		Most Units
Utilities		Purchased Power Cost			0.2%	30%	25%			
Offsites					0.2%	30%	25%			
Total								$93,992		

Unscheduled Shutdowns, Direct Cost					Unscheduled Shutdowns, Serious Incidents					
Process Units	Direct Cost - Unscheduled Shutdown, No Serious Incidents, $	Frequency Unscheduled Shutdown due to pump, incidents per year	EHM Impact, Reduction in Incidents, %	Value, $/ Yr	% Serious Incidents	Total Per Unit, $/ Yr	% From Pumps	EHM Impact, Reduction in Incidents, %	Value, $/ Yr	Closely Linked Units
Crude	75000	0.4	30%	$9,000	18%	$180,900	20%	30%	$10,854	Vacuum
Vacuum	25000	0.4	30%	$3,000	14%	$140,700	20%	30%	$8,442	
Saturated Gas Plant	15000	0.4	30%	$1,800	2%	$20,100	20%	30%	$1,206	Crude
FCC	750000	0.4	30%	$90,000	14%	$140,700	20%	30%	$8,442	Alkylation
Alkylation	25000	0.4	30%	$3,000	5%	$50,250	20%	30%	$3,015	FCC
Unsaturated Gas Plant	15000	0.4	30%	$1,800	2%	$20,100	20%	30%	$1,206	FCC
Hydrotreaters	15000	0.4	30%	$1,800	3%	$30,150	20%	30%	$1,809	
Reformers	25000	0.4	30%	$3,000	5%	$50,250	20%	30%	$3,015	Hydrotreaters
Hydrogen Plant_PSA	10000	0.4	30%	$1,200	3%	$30,150	20%	30%	$1,809	Hydrocracker
Hydrocrackers	250000	0.4	30%	$30,000	14%	$140,700	20%	30%	$8,442	Hydrogen Plant
Coker	25000	0.4	30%	$3,000	5%	$50,250	20%	30%	$3,015	
Sour Gas Treating_Sulfur Plant	15000	0.4	30%	$1,800	9%	$90,450	20%	30%	$5,427	Most Units
Utilities					3%	$30,150	20%	30%	$1,809	
Offsites					3%	$30,150	20%	30%	$1,809	
Total				$149,400	100%	$1,005,000			$60,300	

Return on Investment Summary – Monitoring on 10 Pumps

Benefit Summary - 10 Pumps	
	$/ year
Reduced Unscheduled Shutdowns/ Slowdowns	
Increased Availability (Crude + Vacuum)	33000
Reduced Direct Cost, Unscheduled Shutdown	9000
Reduced Serious Incidents Cost, Unscheduled Shutdowns	18000
Reduced Routine Maintenance	30000
Reduced Turnaround Mintenance	6000
Total	96000
Investment 10 Pumps	155000
Simple Payback, Years	1.6

Summary

- Determining the financial justification for additional measurements in existing or new proposed process plants is a common issue.
- Measurements have to improve decisions (including control loop decisions) to have value
- Typical plant decision cycles and plant economic valuation models can be used to calculate the expected return on investment

References

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  - Design of process sensor networks under a variety of scenarios with minimization of the instrumentation capital cost as the normal objective function under different sets of constraints such as precision, gross error detection, and availability.
- Madron, František (1992). *Process Plant Performance*, Ellis Horwood, NY, NY
- Narasimhan, Shankar and Cornelius Jordache (2000). *Data Reconciliation & Gross Error Detection,* Gulf Publishing Company, Houston, Texas
  - Measurement theory in process plants with a particular emphasis on data reconciliation and gross error detection
- Many other references

Questions? Comments? Other References

1. Questions? Comments – contact doug.white@emerson.com

2. More material on subject:

http://www2.emersonprocess.com/en-US/brands/processautomation/consultingservices/Pages/ConsultingServices.aspx