



# What Should Chemical Engineers Know About Reliability and Maintenance?

Presented to

South Texas Section of AIChE

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**2012 President AIChE**

**Reliability Delivery and Asset Management  
Manager**

**Jacobs Engineering Group, Houston**

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# Safety Moment

- Safety and Reliability
  - A reliable plant is a safe plant.
  - Reacting to equipment failures does not provide an opportunity to plan exposing responders to increased environmental, health and safety risks.
  - The same principles and behaviors that drive improvements in safety also drive improvements reliability performance
  - Safety and Reliability are everyone's responsibility.



# Agenda

- Introduction and Safety Moment
- Myths and Facts
- Major Concepts
  - Definition of Function
  - Hidden Plant
  - Randomness of Failure
  - Failure Curve
- Chemical Engineer's Role – Maintenance Function
- AIChE – Moving Forward with our Strategic Plan – This Year's Performance
- My Report Card
- Closing



# David A. Rosenthal, PE, CMRP

*“Reliability and Maintenance leader with over 30 years of Chemical and Process Industry experience”*

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- Reliability Delivery and Asset Management Manager, Jacobs Engineering Group
- Reliability Manager, Southern Region, Marsulex Refinery Services, Texas City
  - Coke cutting, handling, and transport assets
- Maintenance Director, MEMC Electronic Materials, Pasadena
  - Polysilicon manufacturing for solar cells and electronic components
- Reliability Consultant, Celerant Consulting, Lexington, MA
  - LANXESS, Butyl Rubber Manufacture, Sarnia, ON
  - Kellogg's, Snack Foods Division, Battle Creek, MI
- Maintenance and Reliability Manager, Rohm and Haas Company, Deer Park, Texas
  - Acrylic Acid, Ethyl Acrylate, Butyl Acrylate, Sulfuric Acid manufacturing
- Manager of Manufacturing Excellence, Rohm and Haas Company, Bristol, PA
- Reliability Engineer, Rohm and Haas Company, Bristol, PA
- Technical Manager, Rohm and Haas Company, Bristol, PA
  - Acrylic Emulsions manufacturing
    - MS in Chemical Engineering, University of Texas, 1981
    - BS in Chemical Engineering, Drexel University, 1979
    - President American Institute of Chemical Engineers, 2012
    - Member of Society of Maintenance and Reliability Professionals
    - Certified Maintenance and Reliability Professional, PE in Pennsylvania



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# Myths and Facts

- True or False - Correlation to maintenance costs, maintenance labor hours or mechanical availability?
  - Plant age
    - False
  - Number of employees
    - False
  - Geographic size
    - False
  - Plant Replacement Value
    - False
  - Organizational levels
    - False
  - Central versus Distributed
    - False
  - % Planned work, % Scheduled work
    - False
  - Spared equipment levels
    - False

Al Poling, Solomon Associates, Presentation to Maintenance and Reliability Symposium, South Texas SMRP, August 23, 2012

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# Myths and Facts

- Poorer Performers
  - More emergencies per US \$ Plant Replacement Value

Al Poling, Solomon Associates, Presentation to Maintenance and Reliability Symposium,  
South Texas SMRP, August 23, 2012

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# Myths and Facts

- Best Performers
  - Have a strategic plan
  - Measure and report performance on an on-going basis
  - Identify and focus on critical equipment
  - Lower craft – supervisor ratio
  - Lower craft – planner ratio
  - Lower craft – engineer ratio
  - Defined maintenance and T/A workflow
  - Single point of accountability for Reliability / Maintenance
  - More WO's per US \$M PRV
  - More PdM (Predictive) per US \$M PRV
  - Greater schedule compliance and planned, ready backlog



Failure to perform practices by  
best performers limits your  
ability to perform at higher levels



# Major Concepts

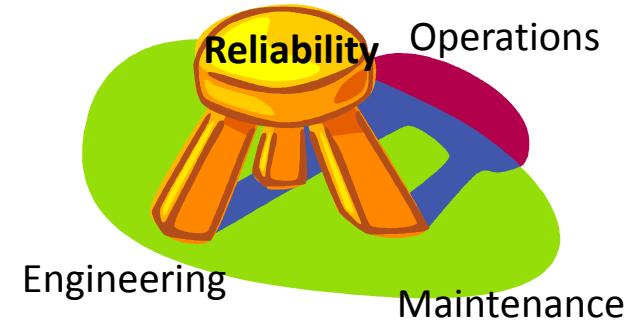
Partnership

Definition of Function

Hidden Plant

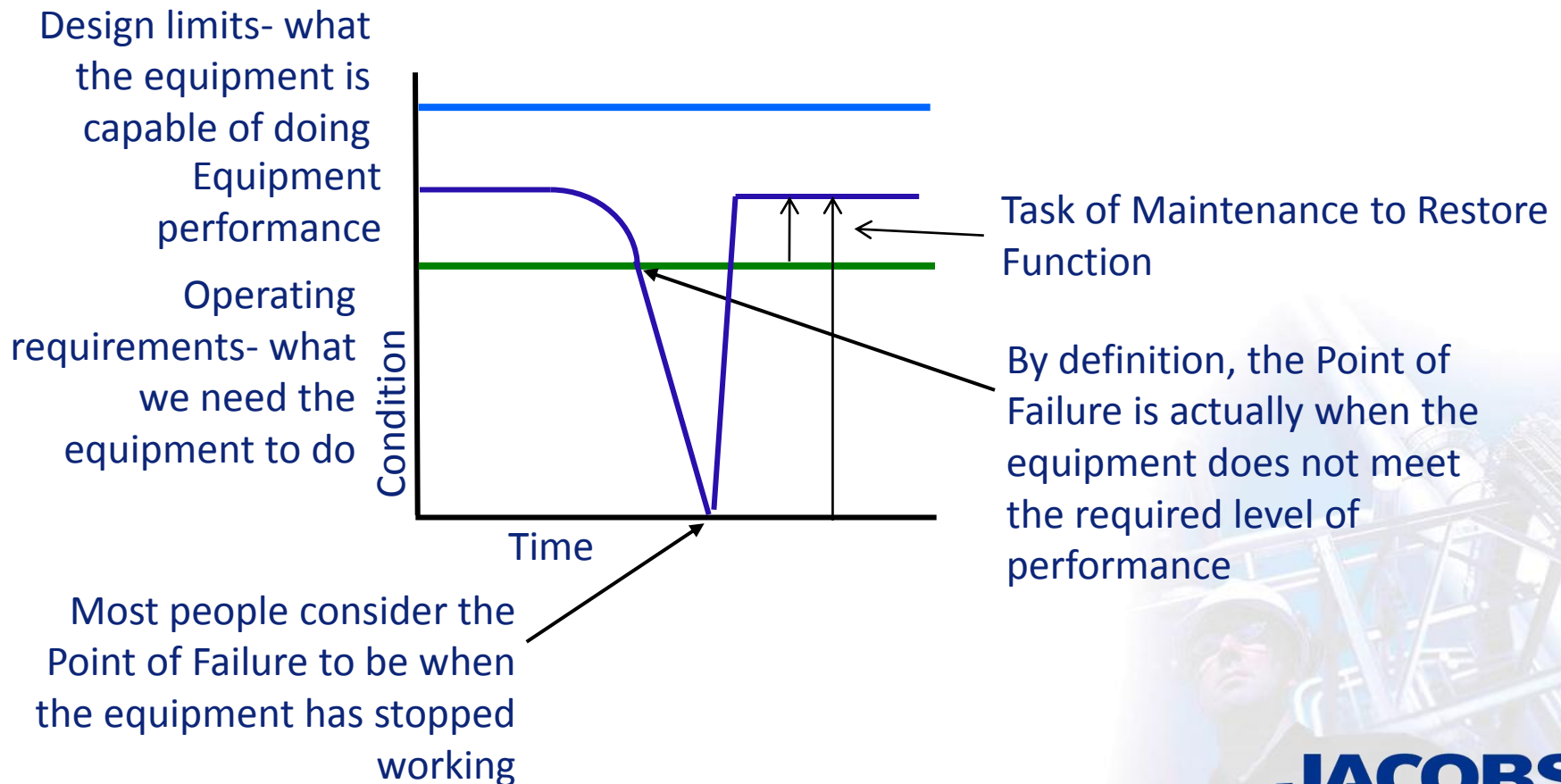
Randomness of Failure

Failure Curve



# Definition of Function – Maintenance Restores Function

- Equipment or a system can be considered to have failed if it no longer achieves a desired level or standard of performance.



# Types of Maintenance Care

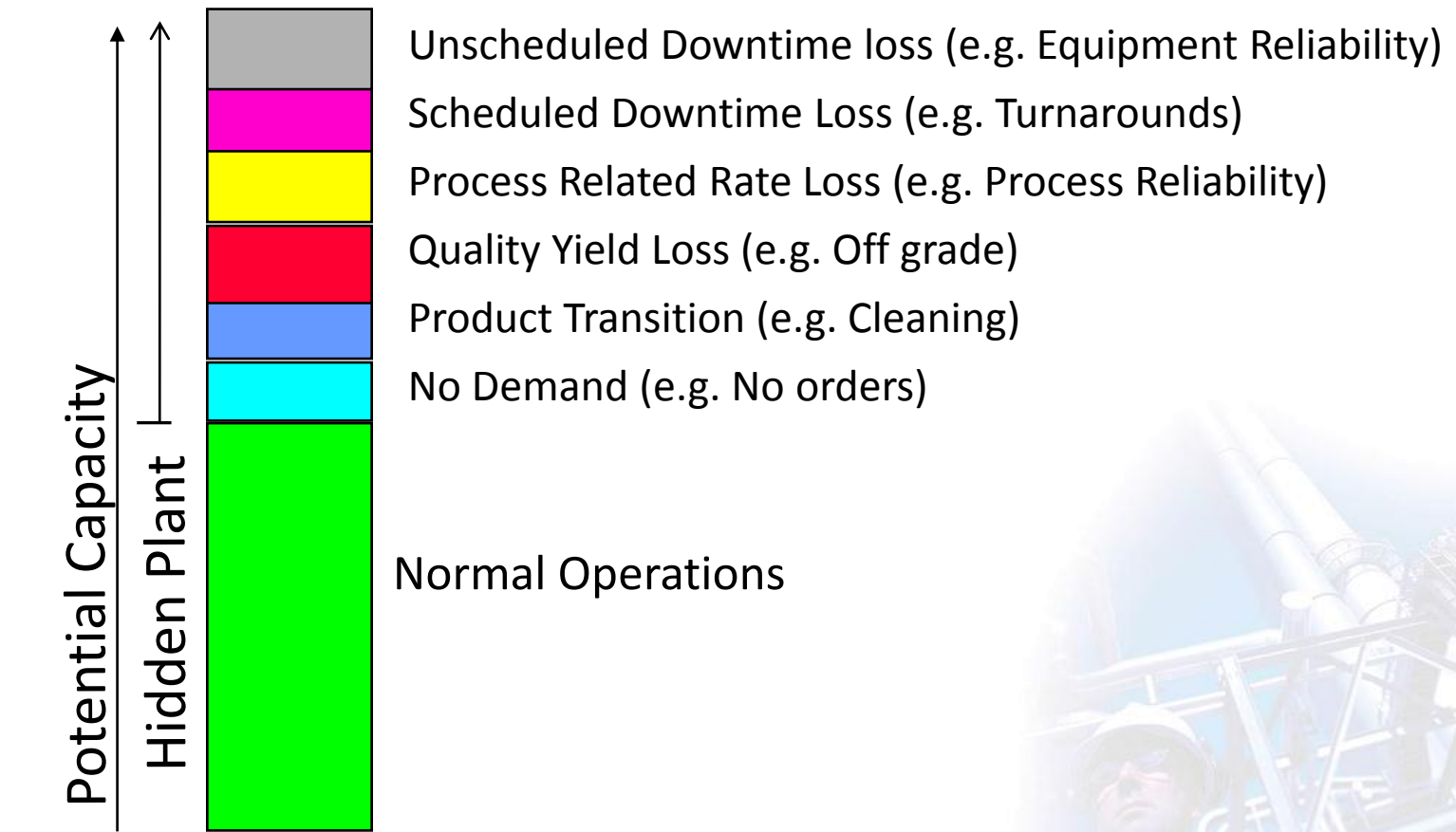
Category	Definition	Example	Conditions for Usage
Run to Failure	Involves making a conscious decision to run certain equipment to failure	Light bulb burning out	Any equipment in this category must be non-critical and cost implications of failure should be very low
Planned Component Replacement	Components are replaced at fixed intervals prior to failure	Replace oil in car every 3,000 miles	Used for wear components that have very consistent degradation rates
Preventive Maintenance	Equipment is periodically taken off-line (if necessary), inspected, and necessary repairs are made (if any) before the equipment is put back on-line	Inspect air filter on a car during oil change	Failure rates are consistent. There is a dominant failure mode. Some preventive maintenance is mandated by state laws

# Types of Maintenance Care

Category	Definition	Example	Conditions for Usage
Failure Finding	Testing equipment to ensure it is working properly	Lighting a match under a smoke detector	Equipment that does not run constantly. Protective devices that can have hidden failures
Condition Directed	Predictive maintenance tasks that inspect the condition of equipment and alert crews when it is time to perform required repairs	Vibration monitoring of bearings	Failure modes are well understood. P-F intervals are somewhat consistent. Accurate data is available
Precision Maintenance	The concept of completing jobs with a mastery level of precision, then the only failures would be wear-out failures	Alignment of rotating equipment	Skilled craftsmen, well developed job procedures, basics (cleaning and correct operation) must be done well

# “The Hidden Plant” – The Plant That Does Not Produce Product

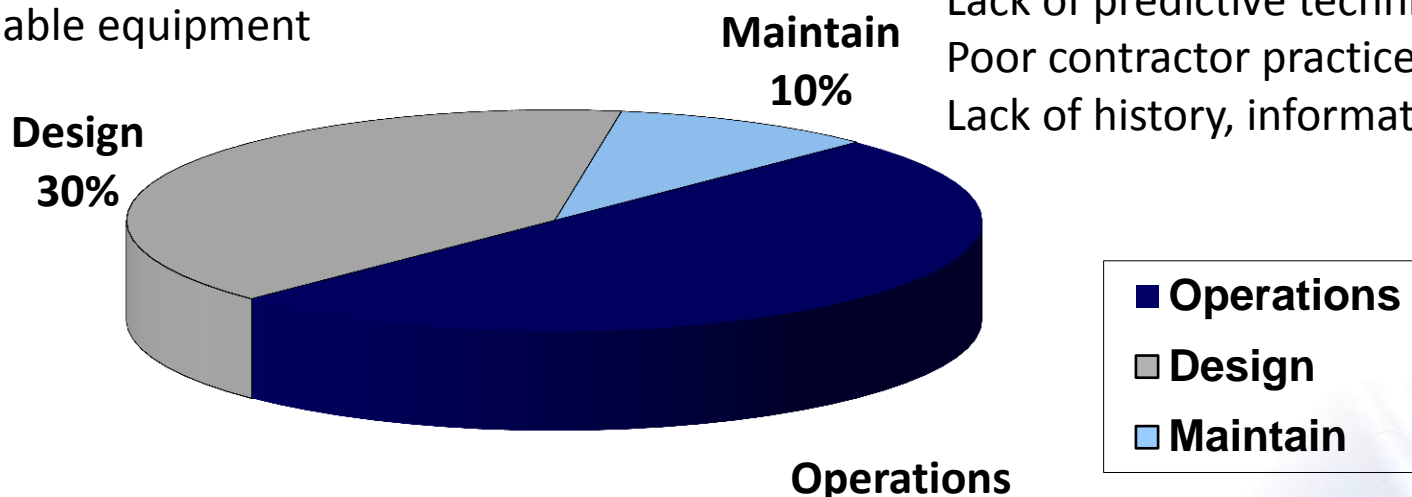
The hidden plant impacts what is important to the chemical engineer in a manufacturing environment.



# Loss of Function: Causes of the “Hidden Plant” (Partial List)

Poor installation standards  
Equipment layout issues  
Purchasing practices  
Unreliable equipment

Lack of Preventative maintenance  
Poor quality parts  
No work order execution process  
Lack of predictive techniques  
Poor contractor practices  
Lack of history, information



The majority of sources of failure develop from the operation of the equipment!

**Operations 60%**

Procedures not reflecting current operation  
Miscommunication between shifts  
Incorrect equipment operations  
Lack of teamwork  
No root cause investigations  
Operating outside of accepted ranges

# Machines Fail Randomly : Bathtub Curves

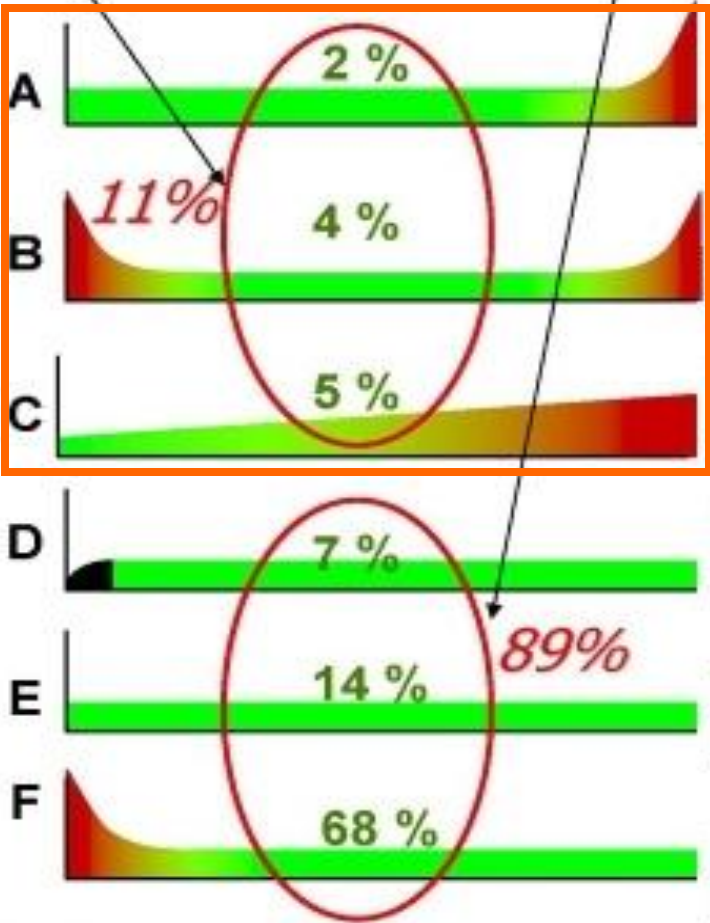
Time-based PM

Condition-based PdM

Some Age  
Related Failure

No Age  
Related Failure

## The Reality of Failure



"Traditional View"

Random Failure then a wear out zone

"Bathtub Curve" - High infant mortality, then a low level of random failure, then a wear out zone

"Slow Aging" - Steady increase in the probability of failure

"Best New" - Sharp increase in the probability of failure then random failure

"Constant Random Failure"

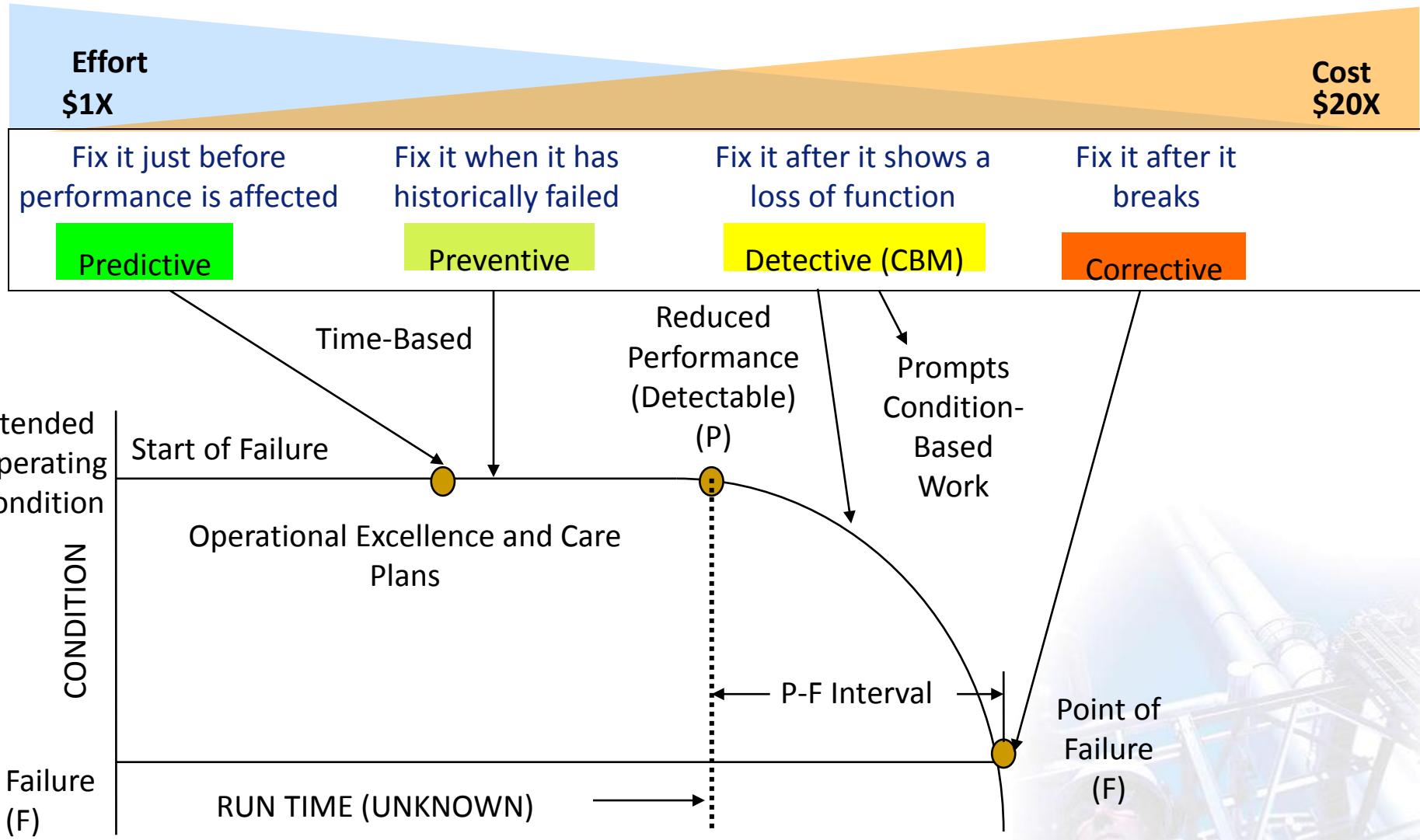
Random - No age related failure pattern

"Worst New"

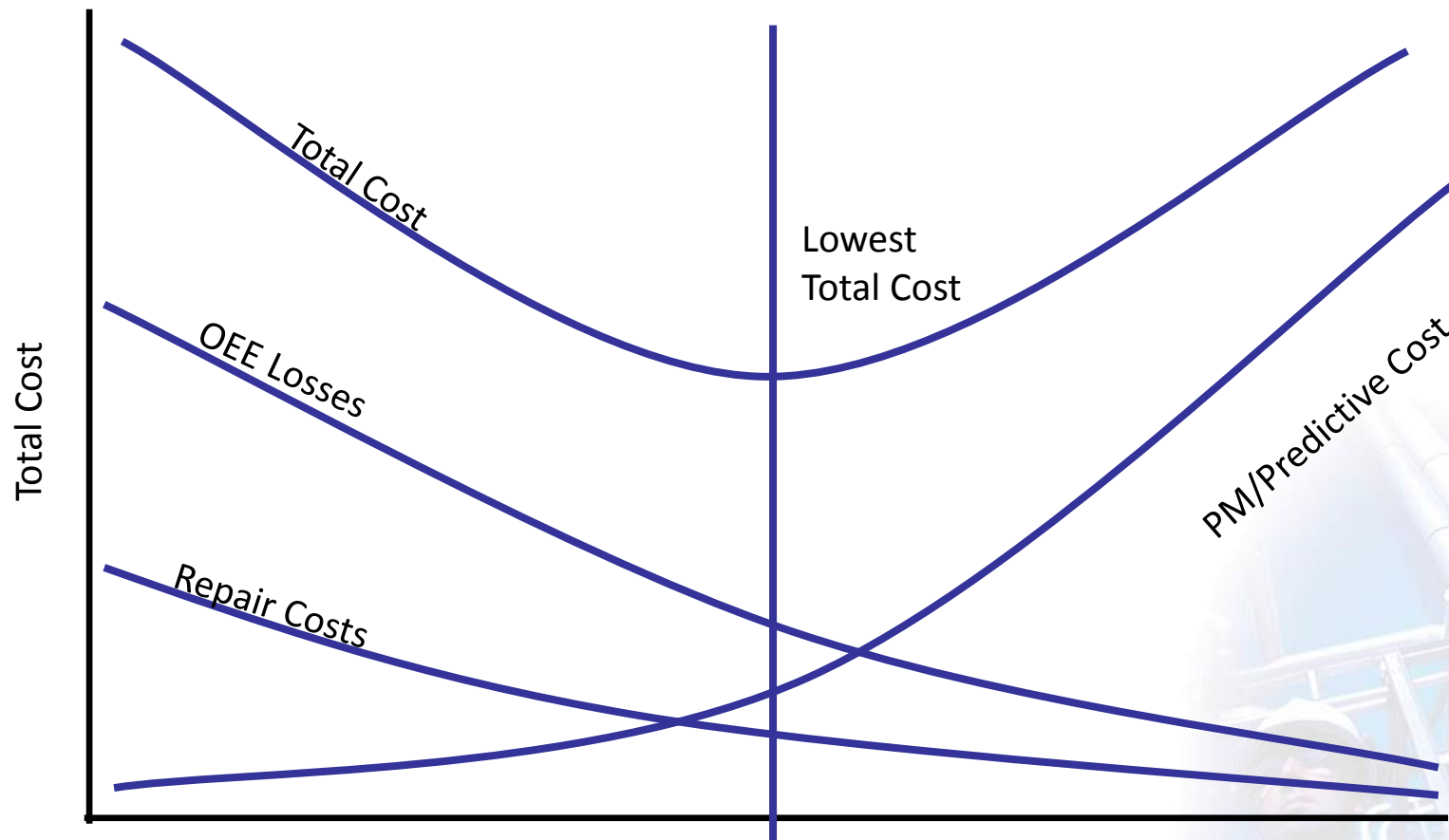
High infant mortality then random failure



# Failure Curve



# Optimal Application of Maintenance Care



# Your Car's Care Plan

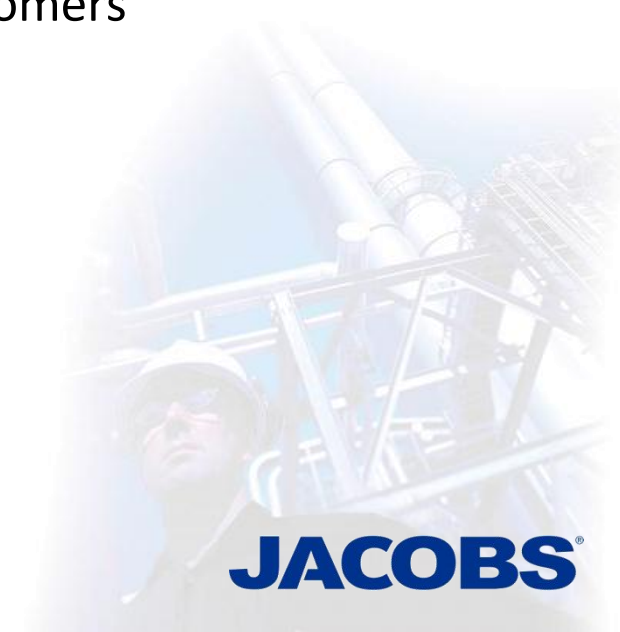
Plan Activity Type	Activity	Failure Modes
Preventative	Change oil every 3000 miles	Engine failure
	Maintenance checks	Component failures
Predictive	Brake pad thickness	Brake failure
	Monitor temperature	Cooling failure
	Monitor oil pressure	Oil pump failure
Normal Care	Wash exterior	Paint failure
	Fill with proper gas grade	Fuel system failure
	Avoid rough roads / obstacles	Suspension / Tire failure
Protective	Apply wax	Paint failure
Operational	Drive safely	Accidents
	Excessive speed	Exceed design
Repair / Installation	Use of expert shops	Premature failure

# Care Plan : Fans, Blowers, Pumps, Motors, Compressors, Agitators, and Mixers (Partial)

Preventative	CBM: Predictive	Normal Care	Operational	Installation and Repair	Protective	Spare Parts
Oil changes	ODR Routes : Four senses	Oiling	Monitor process conditions	Pump repair sheets	Swapping	Critical spares
Belt Changes	Current flux analysis	Greasing	Startup procedures	Alignment procedures	Interlocks	Risk-based stocking
	Vibration checks	Adjust belts	Shutdown procedures	Base plate installation		SOMI
	Oil Analysis	Alignment	Normal operation	Use of special shops		
	Infrared Analysis			Clean room usage		
	Temperature			PMI – Materials of Construction		

# What is Important to the Chemical Engineer in a Manufacturing Environment?

- Safety – Minimizing EHS risks
  - Minimizing risks to personnel
  - Minimizing risks to the community
- Productivity – Meeting design production rates
  - Reaction chemistry performance
  - Separations / Finishing performance
- Quality – First pass quality meeting specifications
  - Minimizing product that can't be sold to customers
  - Minimizing unwanted by-products
  - Minimizing waste
- Costs - Operating
  - Meeting budgets
  - Yield performance



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# Chemical Engineer - Importance of Process Reliability

- Overall reliability depends on both process and mechanical reliability
- Equipment operation generally has a “sweet spot” established from its design
- Reliability (mechanical and process) is impacted mostly in design.
  - Operating consistency targeting
    - Process parameter controls to identify variations
  - Using of technology and automation
    - Trending and data analysis to understand variation (DCS Indicators)
  - Maintaining Operating Windows
    - Pressure and Temperature affects Corrosion Rates
  - Procedures and Instructions
    - Operating Instructions that reflect “reality”
    - Startup, Shutdown, Troubleshooting procedures are important

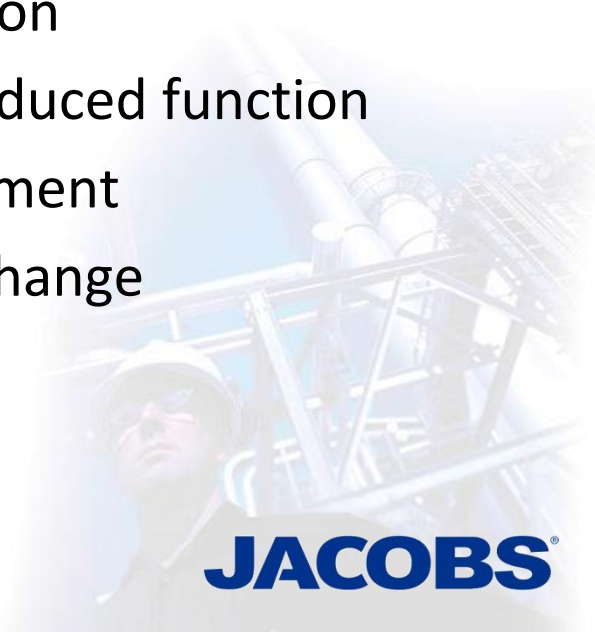
# Chemical Engineer's Role - Developing Operator Ownership

- The randomness of failure requires the continual monitoring of the process and the assets
- Operator ownership and understanding of the equipment is unclear at most sites
- Teamwork between the Operator, Supervision, and the Chemical Engineer is required to reduce the majority of equipment failures from operations
  - Operator understanding of the process and equipment is critical
  - Checklists and Inspections must be managed for each task
    - Operator Rounds and Checklists – Process conditions
    - Operator Performed Inspections (OPI) – Mechanical conditions
    - Operator Performed Maintenance (OPM, TPM)



# Chemical Engineer's Role - Maintenance Function

- The chemical engineer requires the assets to perform to meet production demands. The chemical engineer can assist Maintenance by;
  - Maintaining design operating conditions
  - Informing Maintenance of process excursions
  - Ensuring operating instructions reflect what occurs in the field
  - Setting up monitoring schemes on Control systems which inform maintenance of variations in function
  - Reporting failure at the earliest signs of reduced function
  - Understand the “mechanics” of key equipment
  - Involve Maintenance in Management of Change



# Closing

1. A reliable plant is a safe plant
2. The “hidden plant” impacts what is important to the Chemical Engineer
3. Operations has the most significant impact on equipment failure.
4. Equipment fails randomly
5. Maintenance only restores function
6. Process reliability also contributes to the overall equipment reliability
7. Operator lack of ownership through understanding of their role and their lack of knowledge of the equipment at most sites contributes to failures.
8. The Chemical Engineer should understand the role of maintenance and how they can assist them.

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# Balanced Scorecard

Global

ITG's

Via web

Education

Society

## Membership

- Increase member benefits
- Grow globally
- Grow YPs
- Develop ITGs
- Impact Society

## Finances

- Achieve financial targets
- Strengthen financial position
- Office relocation

Vision  
Strategy  
Objectives

## Business Processes

- Upgrade database
- Update & document processes
- Develop new business models

## Staff & Org Development

- Improve teamwork
- Improve organizational efficiency
- Develop staff

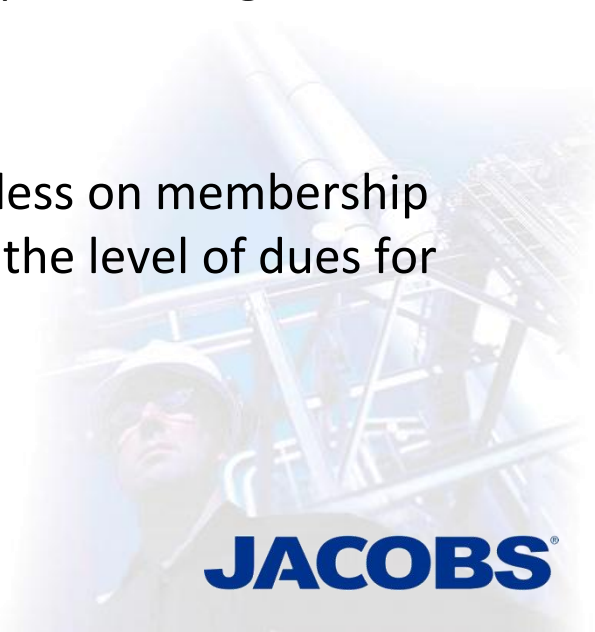
# Moving Forward – Strategic Plan

## Strategic Goals

- Become a global organization of chemical engineering practitioners.
- Strengthen industry and technology groups and create new groups where needed to support the diverse interests of members.
- Aggressively develop innovative new products and services for members based on web-based technologies.
- Engage with others to improve the undergraduate curriculum in chemical engineering and promote life-long learning.
- Impact societal issues by informing and educating the public and government in complex technical areas.

## Enabling Goals

- Identification of alternative business models that rely less on membership dues. The plan commits the Institute to no increase in the level of dues for the next five years.
- Make membership in AIChE more inclusive.
- Improve the operational effectiveness of AIChE.



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# Highlights – Year's Performance

- Since 2009, 18% revenue growth and over a 30% revenue growth projected into 2013
- Improved net assets to \$11MM
- Reversal of our professional membership loss trend
- Highest or the second highest total meeting attendance of any year
- Growth of member value – expanded training courses, meeting content, online content, webinars, Virtual Local Section with 270 members from 38 countries
- A new website
- Addition of new member homes – Upstream Engineering & Flow Assurance Forum, International Society of Water Solutions, International Society of Metabolic Engineering
- Greater alignment from the BOD, through to the OC's, to our volunteers implementing our strategic plan serving our members, profession, and society

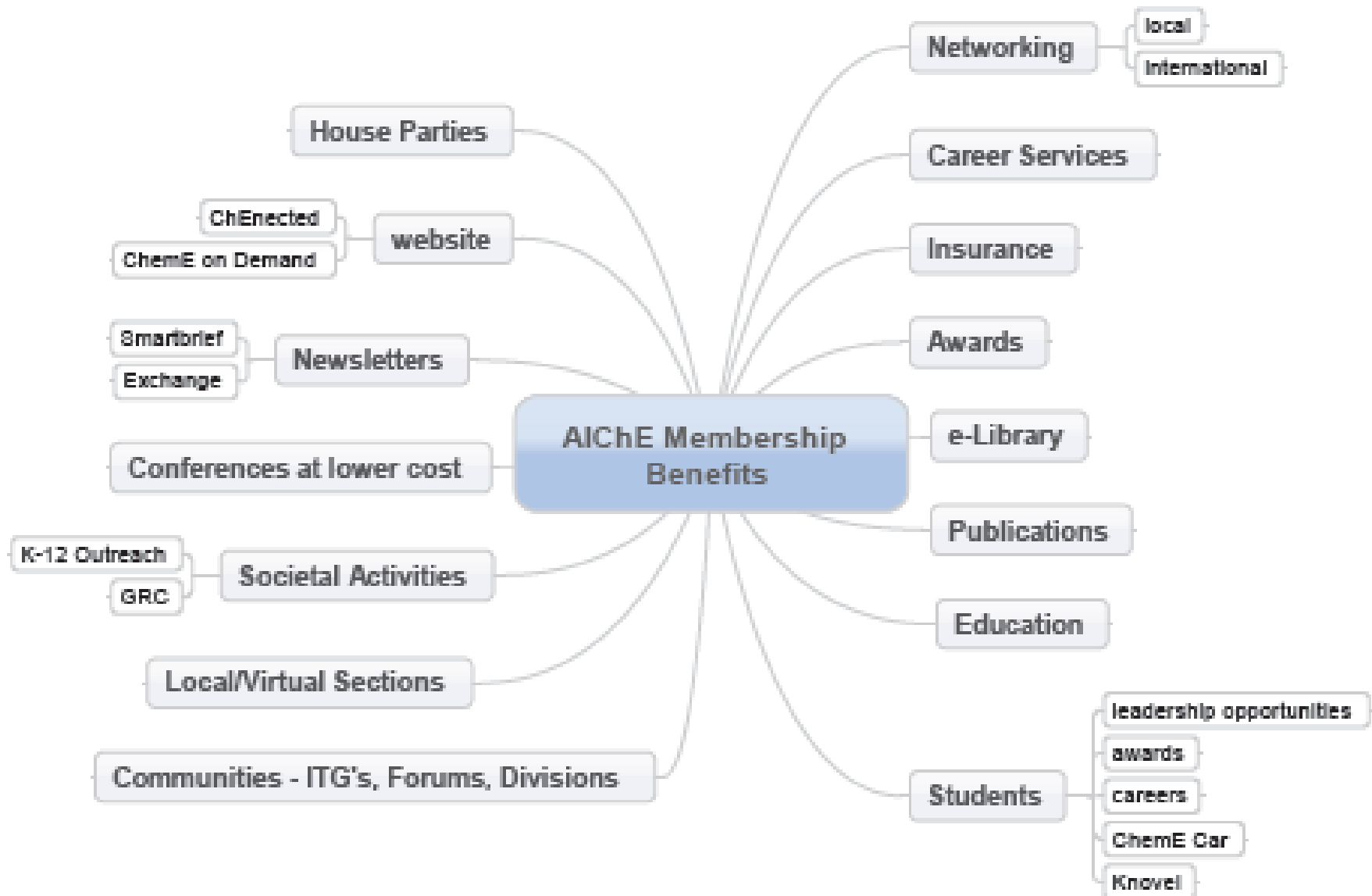


# My Deliverables : President

- Adding New Member Homes – UE&FA, International Society of Water Solutions and the International Society of Metabolic Engineering
- Driving Member Value –Expert Networks - IdeaConnection, Centers of Excellence – Water Initiatives, Undergraduate Safety Education
- Gaining organizational alignment with our Strategic Plan
  - Two-Three Year Roadmap
  - Improved Operating Council alignment with BOD direction
- Building a Stronger Team – BOD, Executive Director, Leadership team
  - Establishing Roles and Responsibilities for BOD
    - Growing BOD ownership for our Strategic Plan
    - Third-Party BOD training at our mid-year meeting
  - Creating an Environment for Change
    - BOD agenda modifications, third-Party BOD self-evaluation
    - Executive Sessions
- Guarding the budget – Operational “surplus” over \$700M projected for 2012
- Managing the lease expiration of our NY Headquarters – search continues



# Members, Members, Members





## Questions and Thank You

David Rosenthal, PE.

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