INCOSE Healthcare Working Group

5th Annual Systems Engineering in Healthcare Conference

May 1-2, 2019
Minneapolis, MN

So You Wanna Be a Rock 'n Roll Star

Maximizing Your Impact as a System Engineer

Gary Strong

CT and PET Engineering GM at General Electric, Retired

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Disclosures:

Speaker is a former, long-time GE employee.

The views of the speaker do not necessarily represent the views of GE.

Complex topics are simplified to convey a message or concept… just go with it. ☺

Goals:

Share some ideas to help you be a "Rock Star" Systems Engineer…
Impactful, Influential, Respected

Keep everyone awake

Agenda:

- Context and Background
- “The True Value of Systems” … What our business needs from Systems Engineering.
- What makes a Systems Engineering Organization great, and how you be a “Rock Star” in that organization
- Q & A

Elevator Speech:

The World Needs *Rock Star Systems Engineers,* and also *Astute Systems Thinking Across the Entire Organization*

Rock Star Systems Engineers are Servant Leaders who Influence, Motivate, and Enable Others to Contribute to a Wildly Successful System Design

Servant Leadership Behaviors = $\mathcal{F}$(Skills * Values)

Influence = $\mathcal{F}$(Something to Say * (How You Say It or Credibility))

The Very Best Systems Thinkers are Influential and Respected Servant Leaders Who Have a Significant Impact on the Product and the Business

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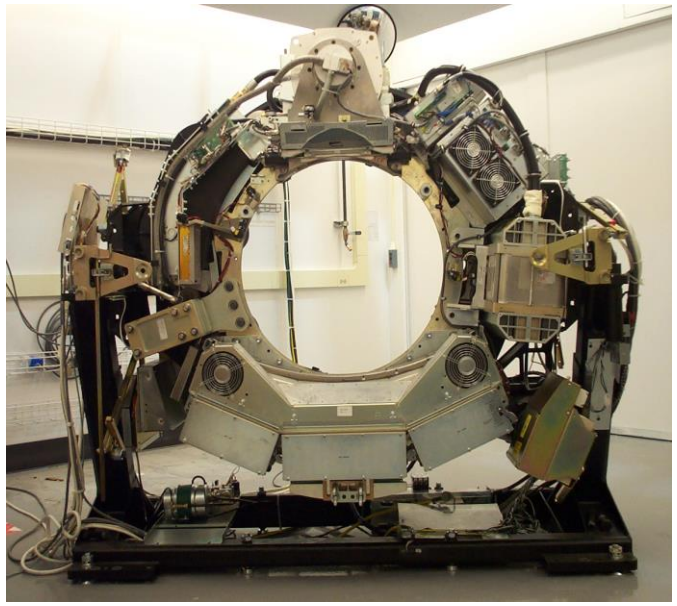
What is a CT Scanner?



A High-Precision Imaging Device

Uses X-rays, Detectors and Algorithms to Create 2D & 3D Images of Internal Organs

Images Interpreted by Radiologists

Introduced in 1970's

Complex System and Sub-Systems

SW (UIF, Control, ImageGen), ME, EE (Digital, Analog, Power), Materials, Algorithms

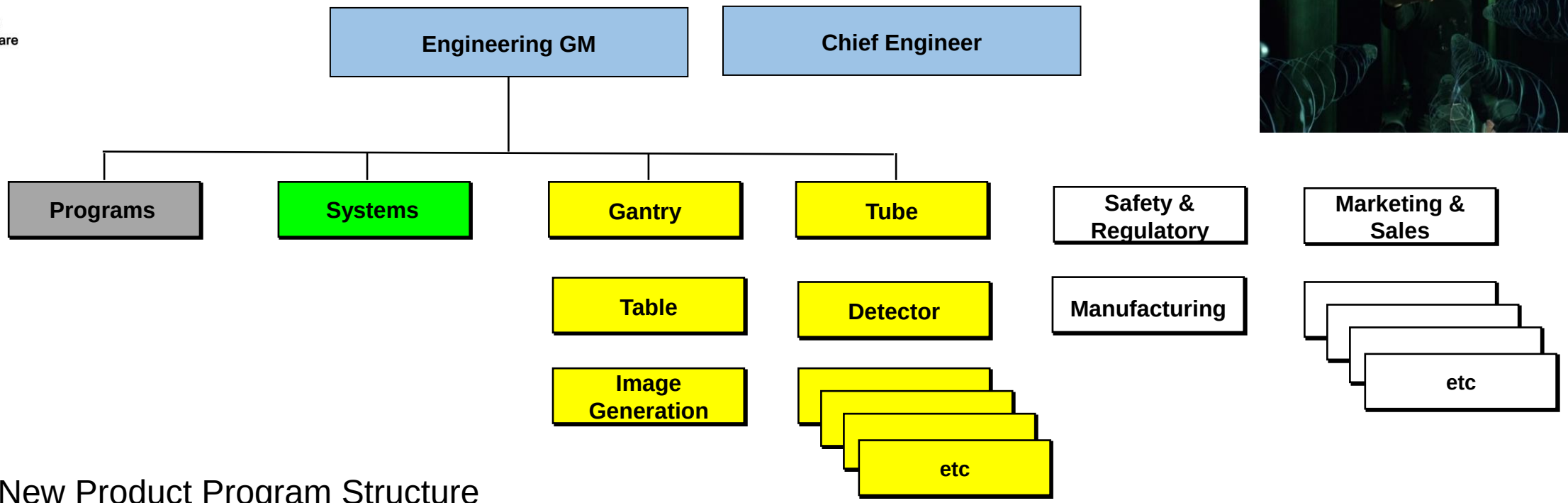
Dramatic Advances in Capabilities

Many New Applications Past 20 Years

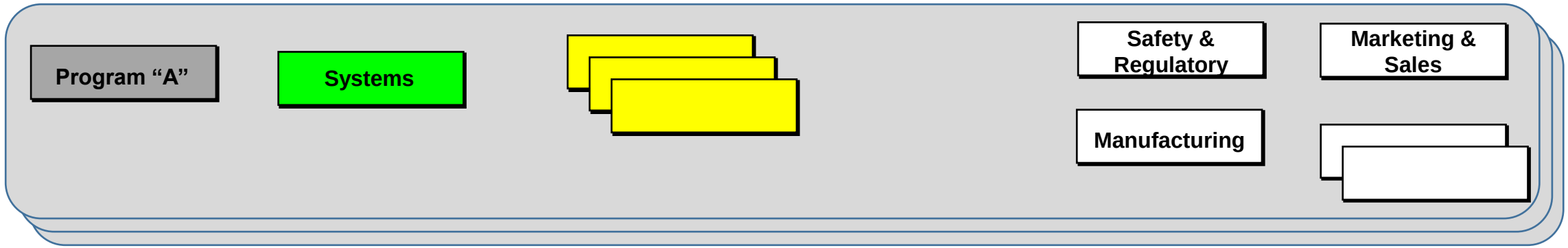
New Product Engr Teams of 10 - 300

CT Virtually Eliminated Exploratory Surgery

the Matrix



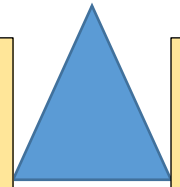
New Product Program Structure



The Program Engineering Leadership Triad

Program Manager (PM)
Features/Quality/Timing/Budget
Program Team Effectiveness
Operating Mechanisms, Budget
Supply chain and service readiness
Owns everything "internal"

Marketing Product Manager (MPM)
Customer Interface
User Needs and Requirements
Marketing and Sales
Applications Support
Owns everything "external"



Lead System Designer (LSD)
System Architecture
Detailed Design
Risk Retirement
Product Quality & Compliance
Leads the System Design Activities & Team

Lead Program Integrator (LPI)
Program Planning and Execution
Integration Strategy
Resource Management

Lead System Designer is an Influential Leadership Position.

This Presentation Focuses on LSD, but Applies to All Systems Engineers. Only Difference is Breadth and Scope of Responsibilities.

Back in the Day….

Experiences

7 Years	Sub-Systems
9 Years	Systems
17 Years	Management

1985-1989	Cruise Missile Guidance Research Project Leader
1990-1991	CT Systems: Performance Simulation Lead
1992-1993	CT Systems: Image Quality Engineer
1994-1995	CT Image Generation Project Leader
1996-1998	Lead System Designer: LightSpeed (4-slice CT)
1999-2002	Program Manager: LightSpeed Ultra (8-slice CT)
2003-2006	Program Manager: LightSpeed VCT (64-slice CT)
2007	Program Manager: Engineering Compliance
2008-2009	Program Manager: Revolution CT (256-slice CT)
2010-2012	GE Global Research Technology Leader (GM)
2013-2014	DGS Chief Engineer
2015-2017	CT and PET Engineering GM

Sub-System & System Roles were a Solid Foundation for My Later Roles

Agenda:

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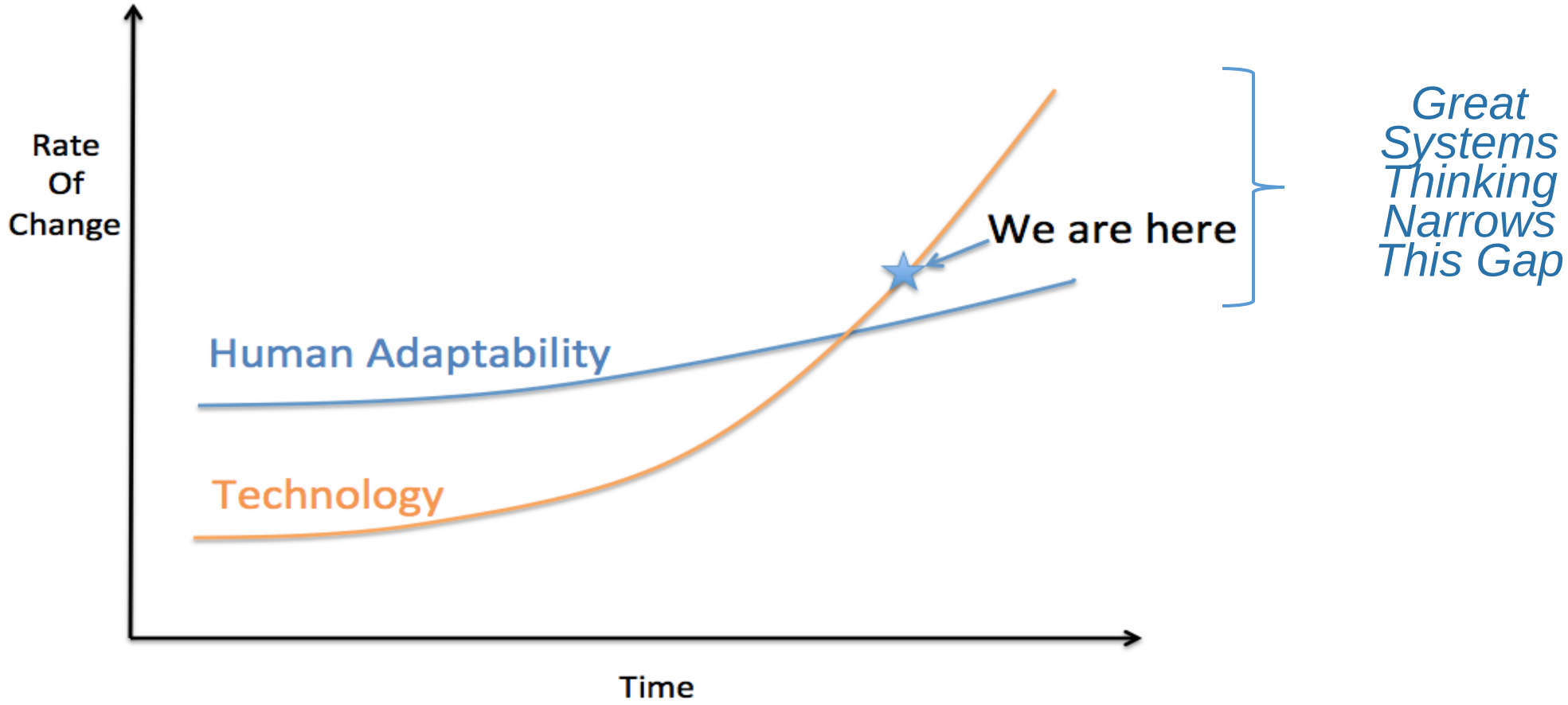
- Q & A

The World Needs *Rock Star Systems Thinkers*



Systems Thinking Brings Clarity to Ambiguity and Chaos

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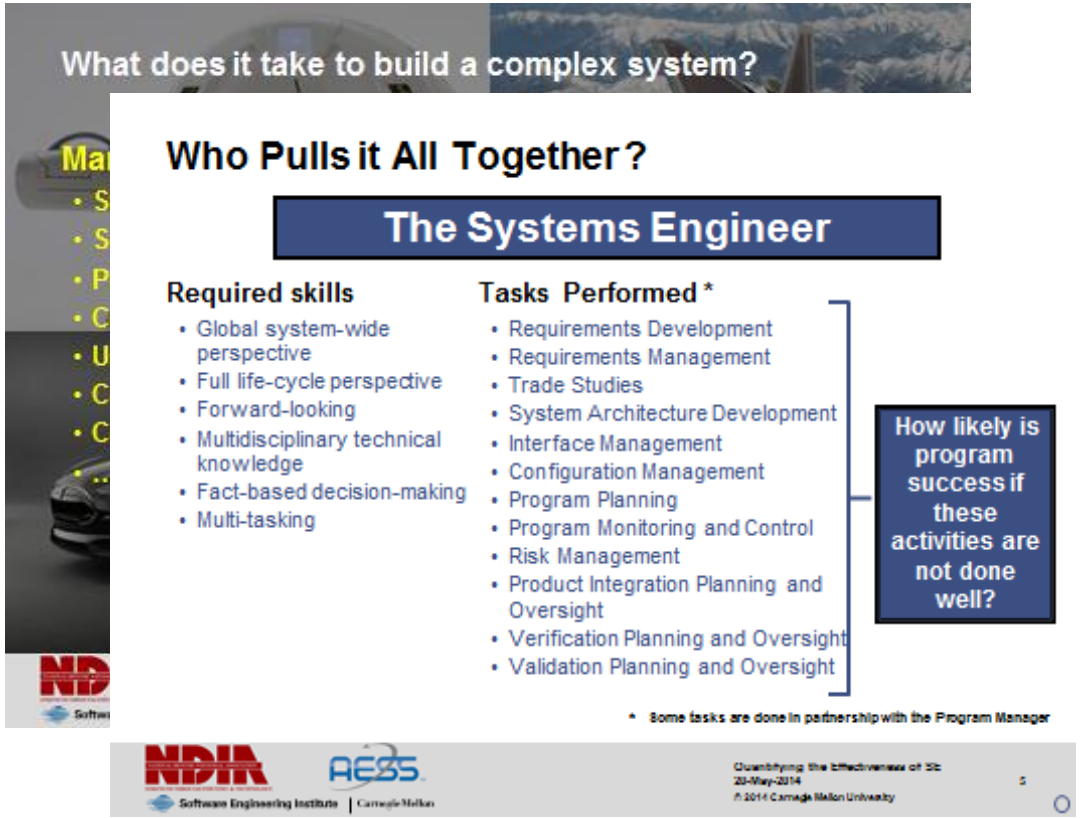


More Sub-Systems
More Interfaces
More Functional Disciplines
More Complex Use Cases

Optimize the Design

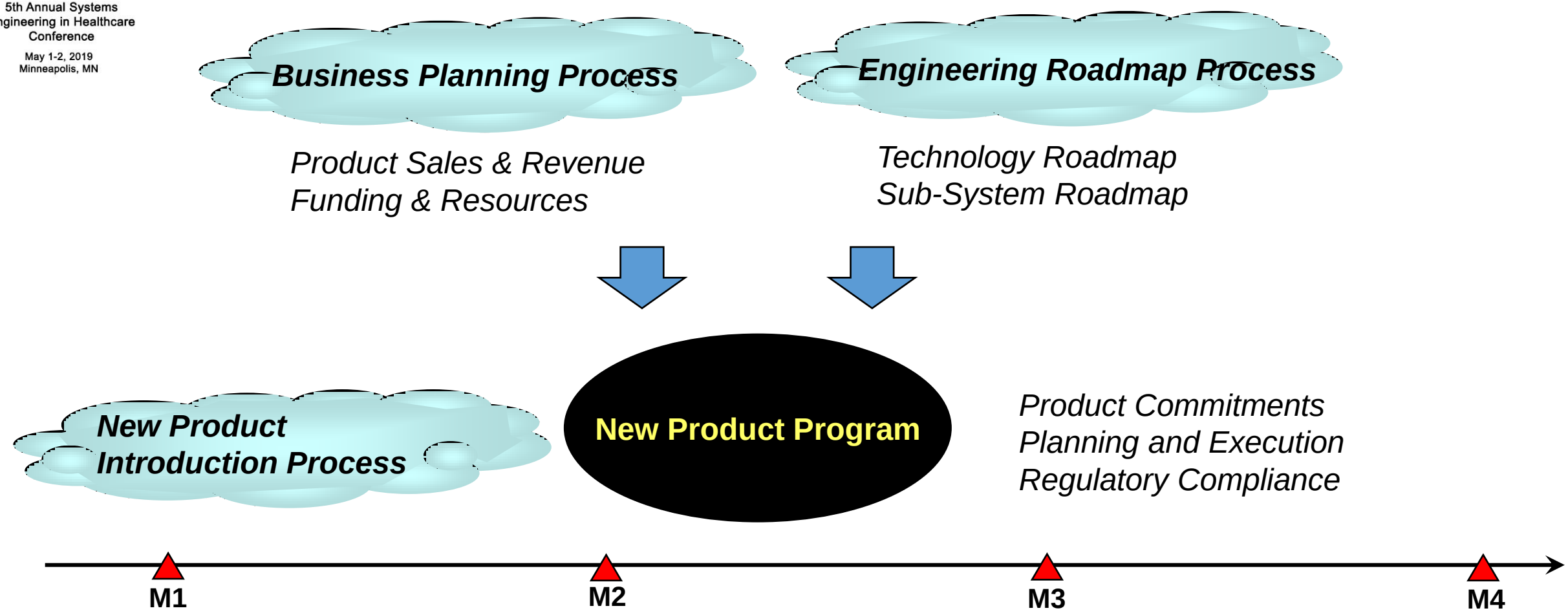
More Complex Competitive Landscape
More Complex Business Environment
More Complex Regulatory Environment

Optimize the Business Impact

All Drive the Need for More & Better ***Systems Thinking!!***

The Broader Your FOV, the Bigger Your Business Impact

Business, Technology & Program Relationship

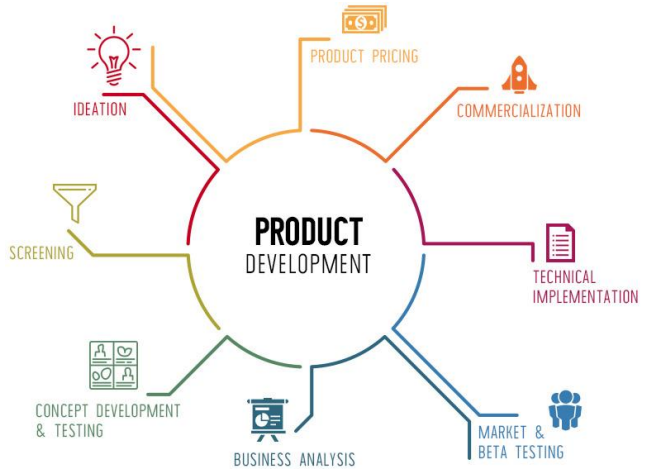


Business Plans and Engineering Roadmaps Sets the Context for the New Product Program

Optimizing Business Results

Customer Needs
Current Products
Current Platforms/Architecture
Competitive Products
Technology Roadmap
Sub-System Roadmap
New Technology Innovations
Funding & Resources
Etc. Etc.

$ ➡



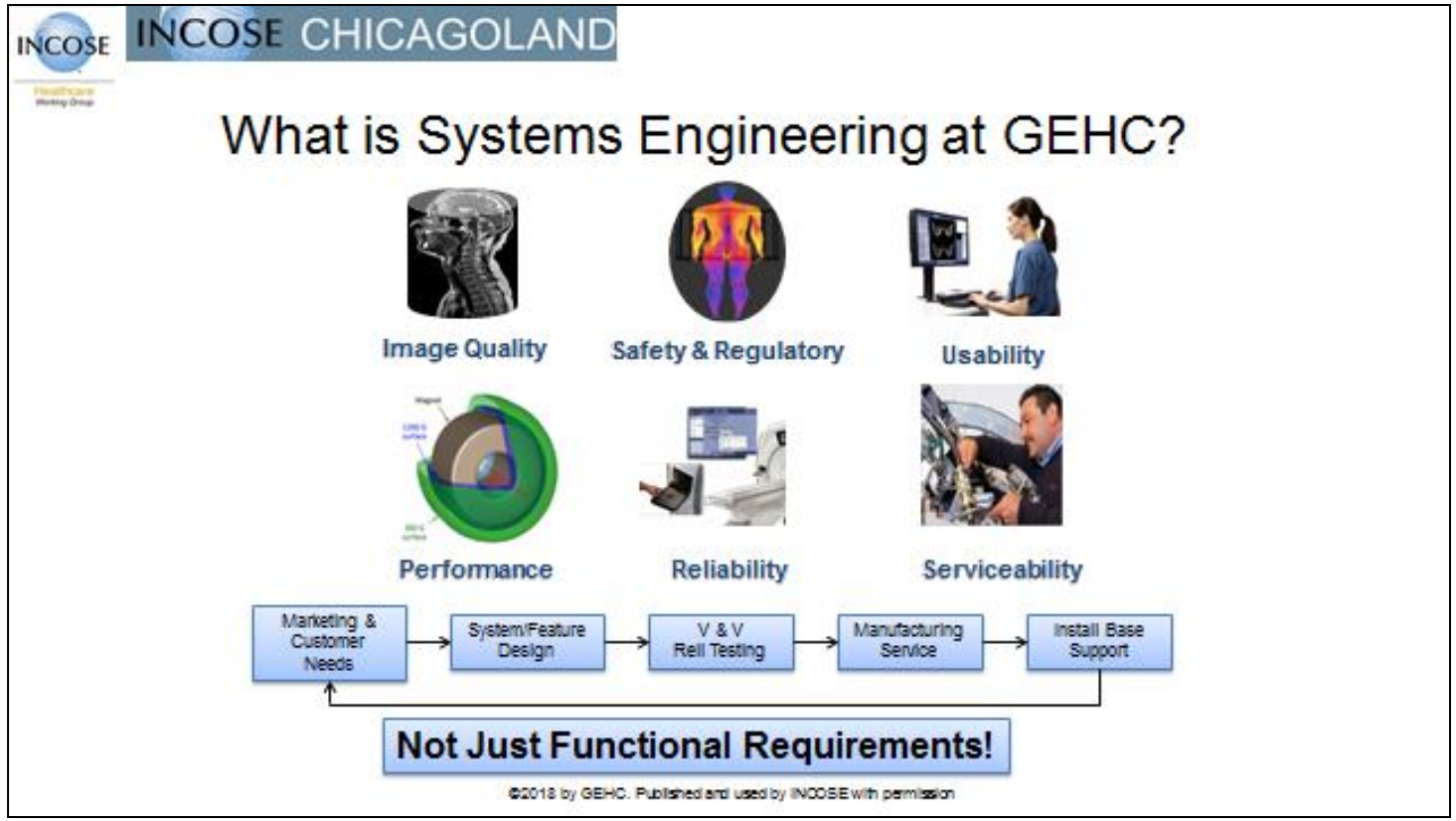
➡ $$$$

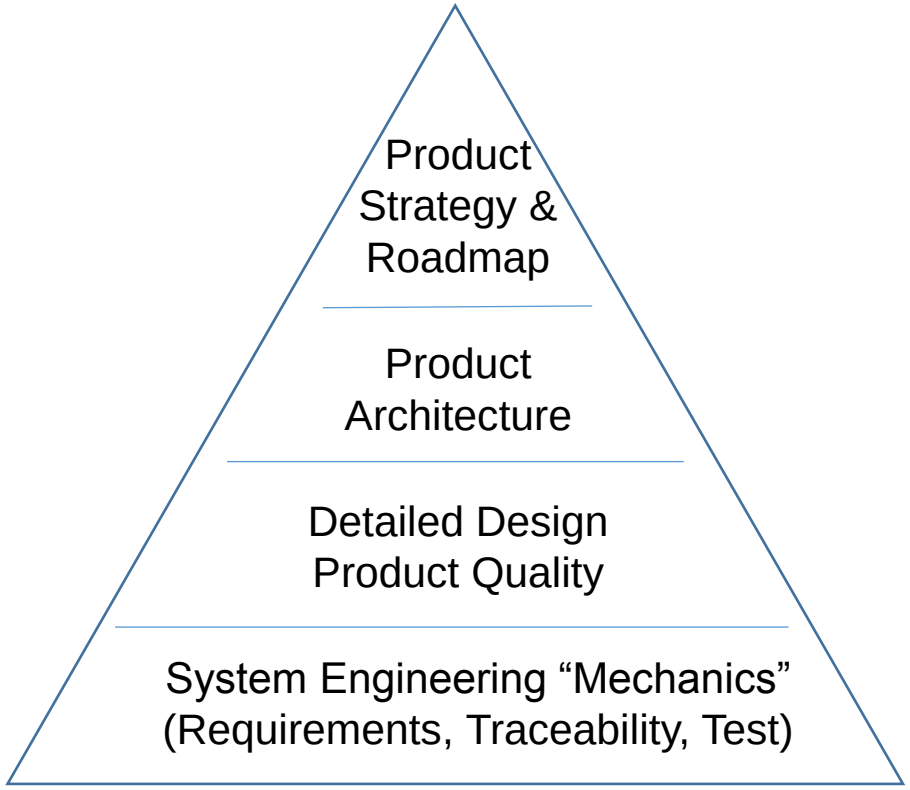
Systems Thinking Drives:

- Customer & Patient Impact
- Features & Capabilities
- Reliability
- Cost of Product
- Cost of Development
- Time to Market
- Business Vision & Roadmap

A Great System Design Effort Maximizes Return on Investment….
For One Product, and for a Roadmap of Products

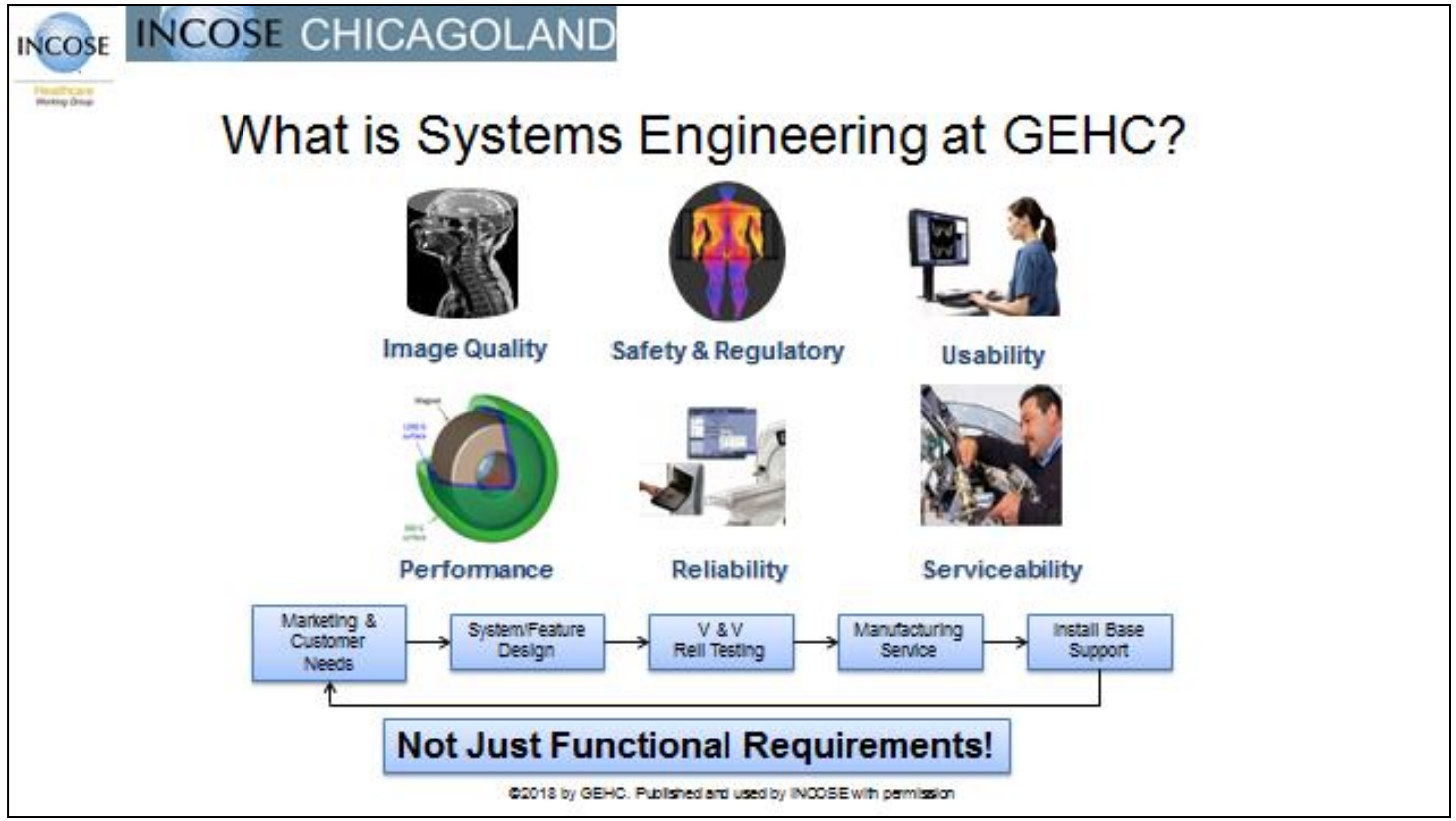
System Design Program/Product Impact

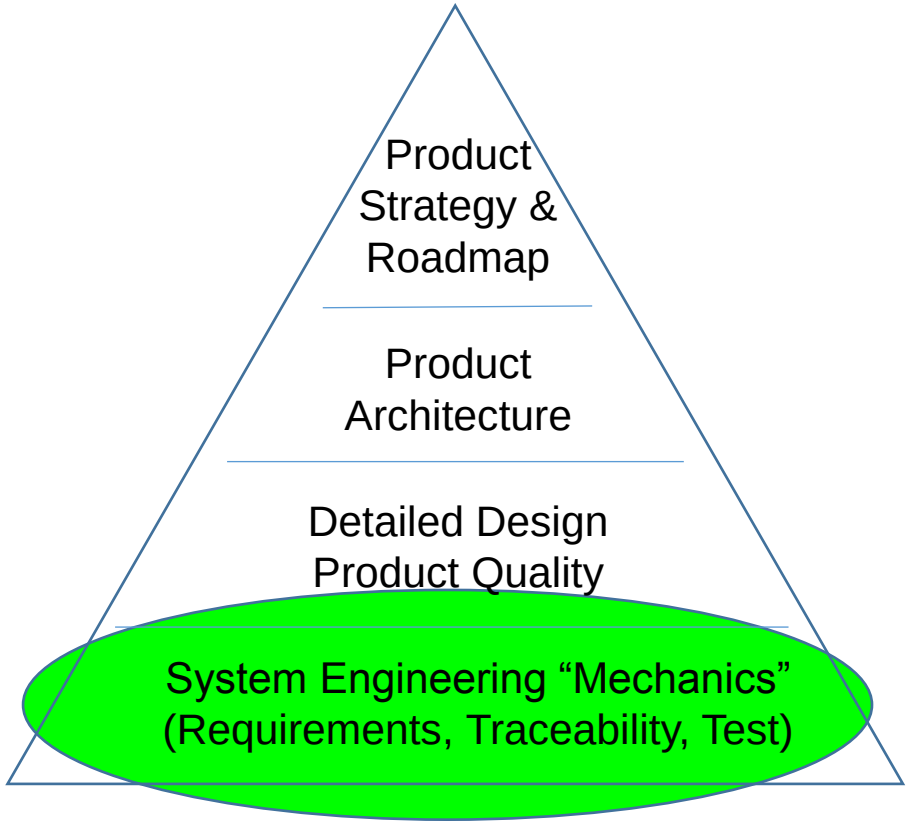




Where Do You Want to Play? Where Do You Have the Skills, Experience, Credibility, and Influence to Play?

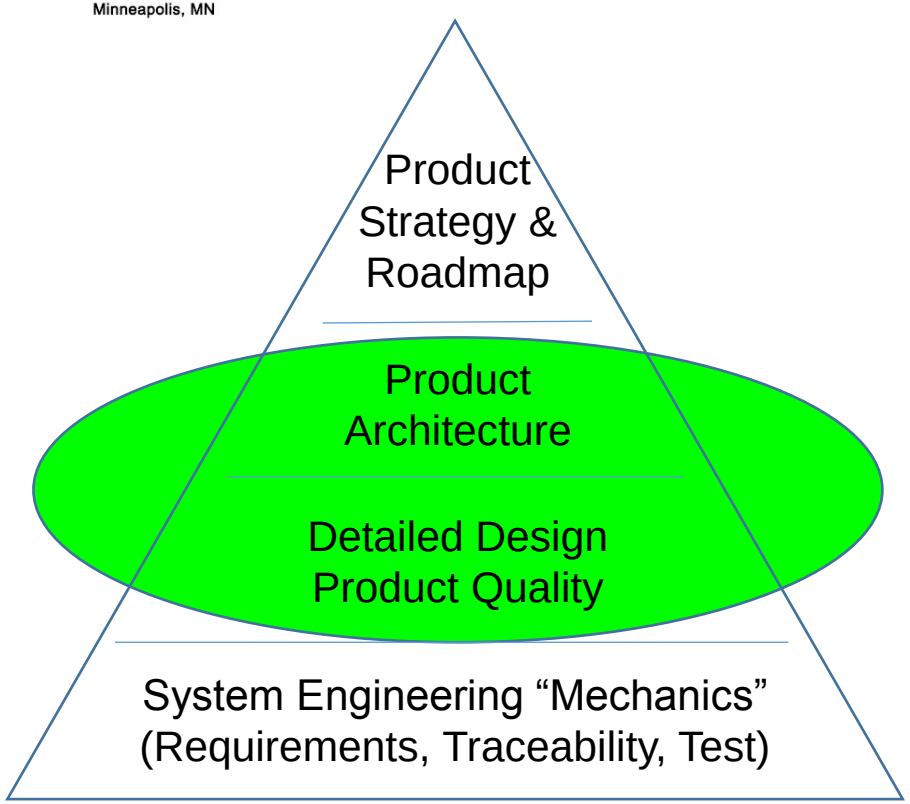
System Design Program/Product Impact





The Mechanics are Our Ticket to Play….
An Absolute Requirement. How to Do This Efficiently?

Good Design Balances Multiple Factors



Benefit

- ✓ Functionality and Performance
- ✓ Quality and Reliability
- ✓ Usability
- ✓ Serviceability
- ✓ IP Landscape

Product Cost

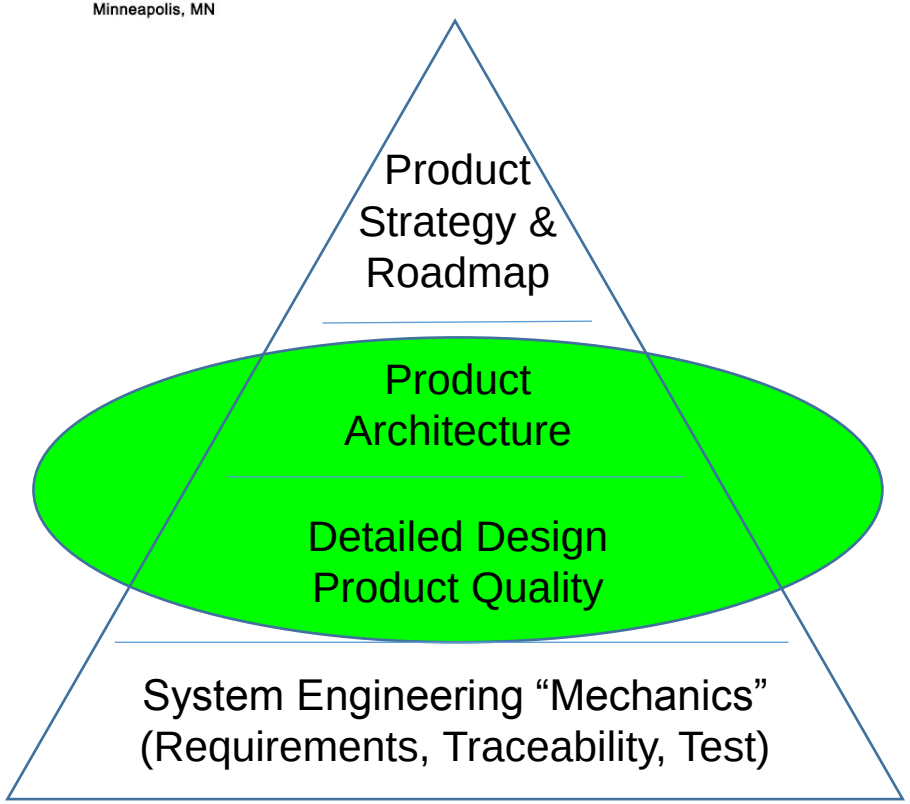
- ✓ Parks and Labor to Build
- ✓ Parts and Labor to Service

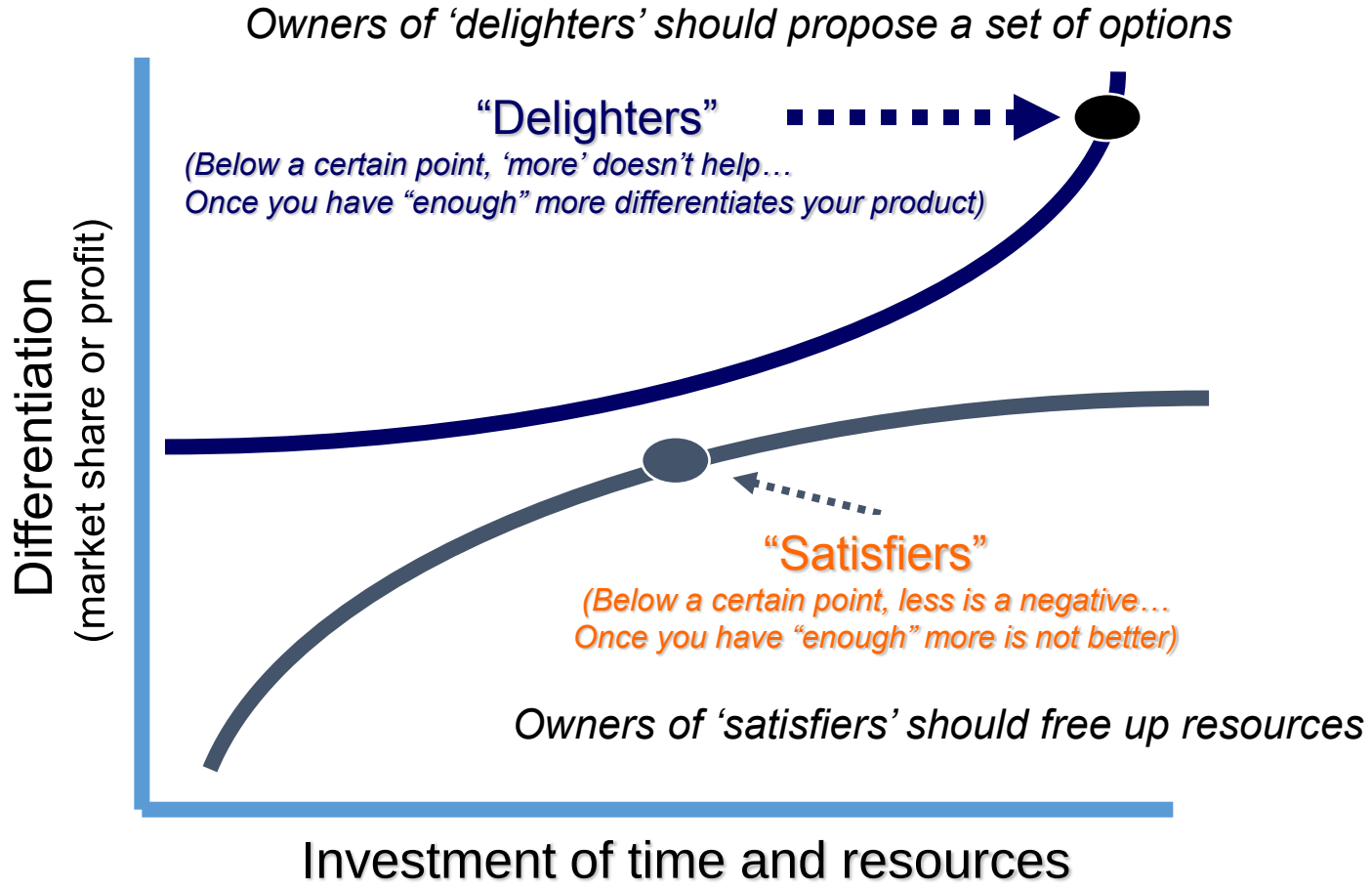
Effort

- ✓ Technical Risk
- ✓ System/Algorithms/SW/HW Architecture
- ✓ Regulation, Registration, Datasheet, Labeling
- ✓ Supply Chain

Not Simply Optimizing the Design, but Optimizing Business ROI

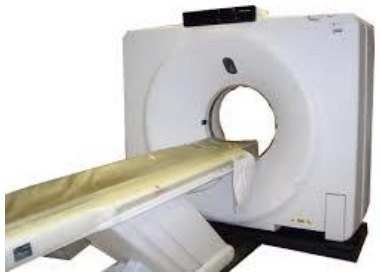
Good Design Balances Multiple Factors





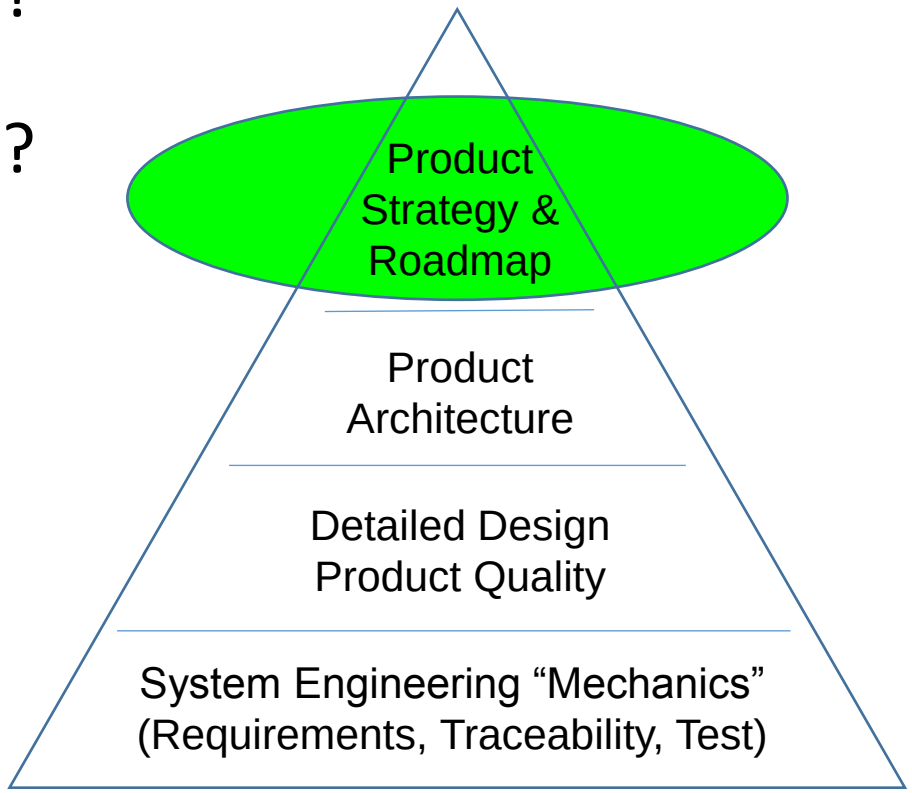
Not Simply Optimizing the Design, but Optimizing Business ROI

Chief Engineer, the Ultimate Systems Engineer



Single Slice CT
1992

?
?
?
?



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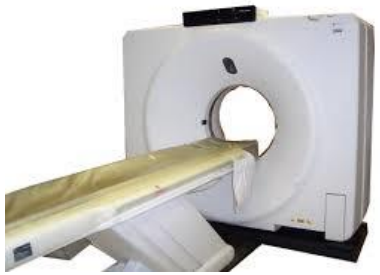


Single Slice CT
1992

1998 4-Slice CT

2001 8-Slice CT

2002 16-Slice CT

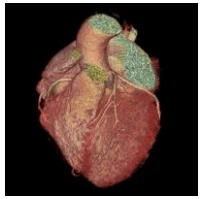
+ Other HW & SW Releases

2004 64-Slice CT

2005 32-Slice CT

+ Other HW & SW Releases

"Ultra-Wide Coverage CT"
Scan the Head & Heart in a Single Scan



2013 256-Slice CT

2016 128-Slice CT

+ Other HW & SW Releases

Defining and Continually Shepherding a Winning Long-Term Strategy Has a Huge Business Impact!!

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Right-Size Your Systems Engineering Team

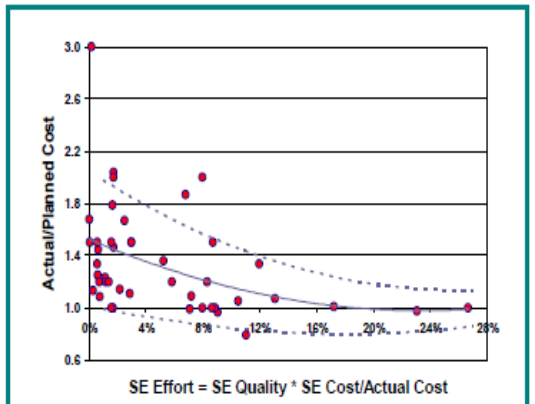


Figure 14. Cost performance as a function of SE effort

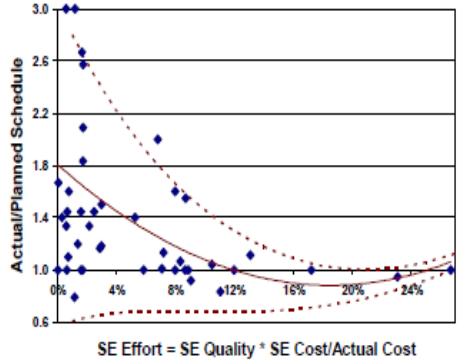
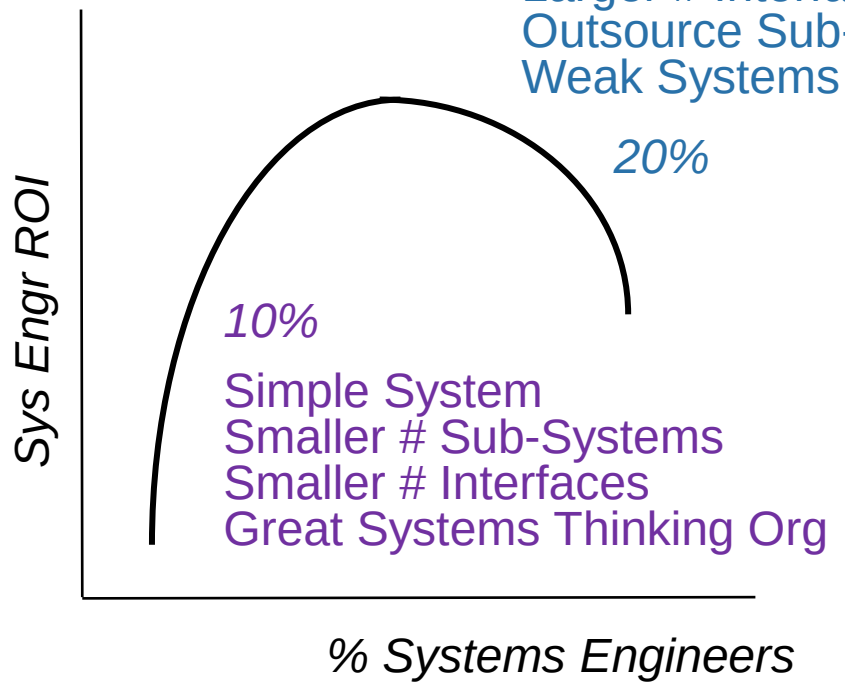


Figure 15. Schedule performance as a function of SE effort.

Eric Honour, "Understanding the Value of Systems Engineering" INCOSE 2004

Broad Maximum in ROI at 15% Systems Effort

Complex System
Larger # Sub-Systems
Larger # Interfaces
Outsource Sub-Systems
Weak Systems Thinking Org



How Big Should Your Systems Engineering Team Be? It Depends!

Optimizing Systems Thinking of the Entire Org
Specialized Systems Engineers

Lead System Designer

- Product System Engineers
- Verification and Validation Sys Engrs
- *Image Quality System Engineers*
- *Customer Applications Sys Engrs*
- *Service Design System Engineers*
- *Manufacturing Design Sys Engineers*
- *Reliability System Engineers*

Drivers:

- Complex Use Cases
- Challenging Technology
- Critical to the Business
- Drives Competitive Advantage
- Required for Each New Product

Specialized Systems Engineers…
A Bit of an Oxymoron, But It Works!!!

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So you Wanna Be a Rock n Roll Star…

Servant Leadership Behaviors = $\mathcal{F}$ [Values (Who You Are) & Skills (What You Can Do)]

Exceptional Values and "Mad" Skills are the Foundation of Outstanding Servant Leadership Behaviors

So you Wanna Be a Rock n Roll Star…

Values

- Accountability: Takes Full and Personal Ownership
- Confidence: Well-Founded Self-Belief, Appropriately Humble, not Cocky nor Arrogant
- Discernment: Great Judgement and Wisdom, Knows Who to Trust, Can Spot “BS”
- Inclusiveness: Values, Welcomes, Integrates and Leverages Diverse Employees

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Skills

- Ability to Empower: Works With and Through Others to Successfully Carry Out Specific Activities
- Ability to Synthesize: Frames Complex Problems, Provides Context, Brings Clarity
- Ability to Communicate: Conveying Information in a Clear, Motivational and Energizing Manner

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- Ability to Communicate: Conveying Information in a Clear, Motivational and Energizing Manner

- Credibility: Trusted Across the Organization Based on a Distinguished Track Record

A Servant Leader You Can Trust to Make Things Happen

Behaviors of an Impactful Systems Organization

1. Effectively Make Decisions
2. Close Decisions and Keep them Closed
3. Influence at All Levels Organization
4. Optimize Systems Thinking of the Entire Org

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Effective Decision Making

- **The critical decisions are listed**...
  - Any decision gating team productivity is listed...the team agrees to the list and prioritization
  - The **decisions listed are truly decisions**, not just topics (there are options to choose between with decision criteria which guide the downselection)
- The proper level of attention is applied to each decision
  - **Complex, important decisions** have a decision plan which includes **stakeholder analysis and pre-briefings** to ensure consensus and decision buyin
  - Simple tracker (excel) to ensure **focus and execution** and **publicly record decisions**

How Systems Engineering Can Reduce Cost & Improve Quality | 1-2 May, 2018 Twin Cities, Minnesota #hwgsec

Decision Making Models:

- Executive *(Top-Down from Outside the Team)*
- Program Leadership *(Top-Down Inside Team)*
- Expert (this includes the LSD) *(Top-Down)*
- Expert-led Near-Consensus *(Bottom-Up)*

Teams Should Use a Mix of Decision-Making Models

Effective Decision Making

"Expert-Led Near-Consensus" Decision Making

- Led by an expert who is also a systems thinker and strong leader
- Utilizes the expertise of entire team
- Will make better decisions & trade-offs
- Teams truly understands the decisions
- Gets team's conviction and buy-in (not simply compliance)

Top-Down Decision Making

- Faster
- When near-consensus is not possible or not reached… especially when decision crosses multiple teams, multiple products, or multiple business units

Teams Should Use Expert-Led Near-Consensus Decision Making as Often as Possible. So What is the LSD's Role???

"Expert-Led Near-Consensus Decision Making"

1. Frame and state the decision to be made
2. Identify the decision team and expert team leader
3. Identify decision criteria and underlying assumptions
4. Developing options
5. Rate options vs decision criteria
6. Reach consensus/near-consensus on decision
7. Design Review
8. Review with Program Team (and other stakeholders)
9. Review with Leadership/Management (if needed)
10. Communicate Broadly

Iteration

Use This For As Many Big Decisions As Possible.
There Will Be Times When Top-Down Decision Making Is Appropriate.

"Expert-Led Near-Consensus Decision Making"

LSD Defines a Design Decision Plan that Supports the Program, with Sufficient Time for Analysis and Iteration.

LSD Charters the Team

1. Frame and state the decision to be made
2. Identify the team and expert team leader
3. Identify decision criteria and underlying assumptions

Iteration

4. Developing options
5. Rate options vs decision criteria
6. Reach consensus on decision

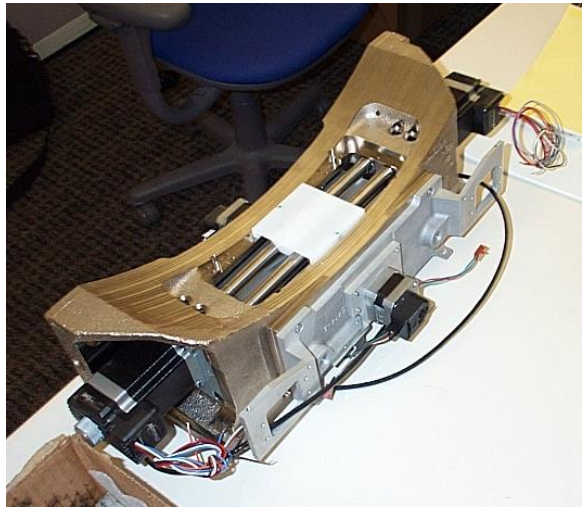
LSD Closes, Communicates, Rallies Team

7. Design Review
8. Review with the Program Team (& other stakeholders)
9. Review with Leadership/Management
10. Communicate Broadly

"A Genuine Leader is Not a Searcher for Consensus but a Molder of Consensus." Dr. Martin Luther King, Jr.

Accountability
Confidence
Discernment
Inclusiveness
Empowerment
Synthesizer
Communication
Credibility

Effective Decision Making Example



Priority	Decision Factor	Option 1	Option 2	Option 3
High	Real-Time Risk			
Medium	Cost of Product			
Medium	Interface Complexity			
Medium	Sub-System Simplity			

Team Used Expert-Led Near-Consensus Decision Making to Recommended Option 3… But….

Accountability
Confidence
Discernment
Inclusiveness
Empowerment
Synthesizer
Communication
Credibility

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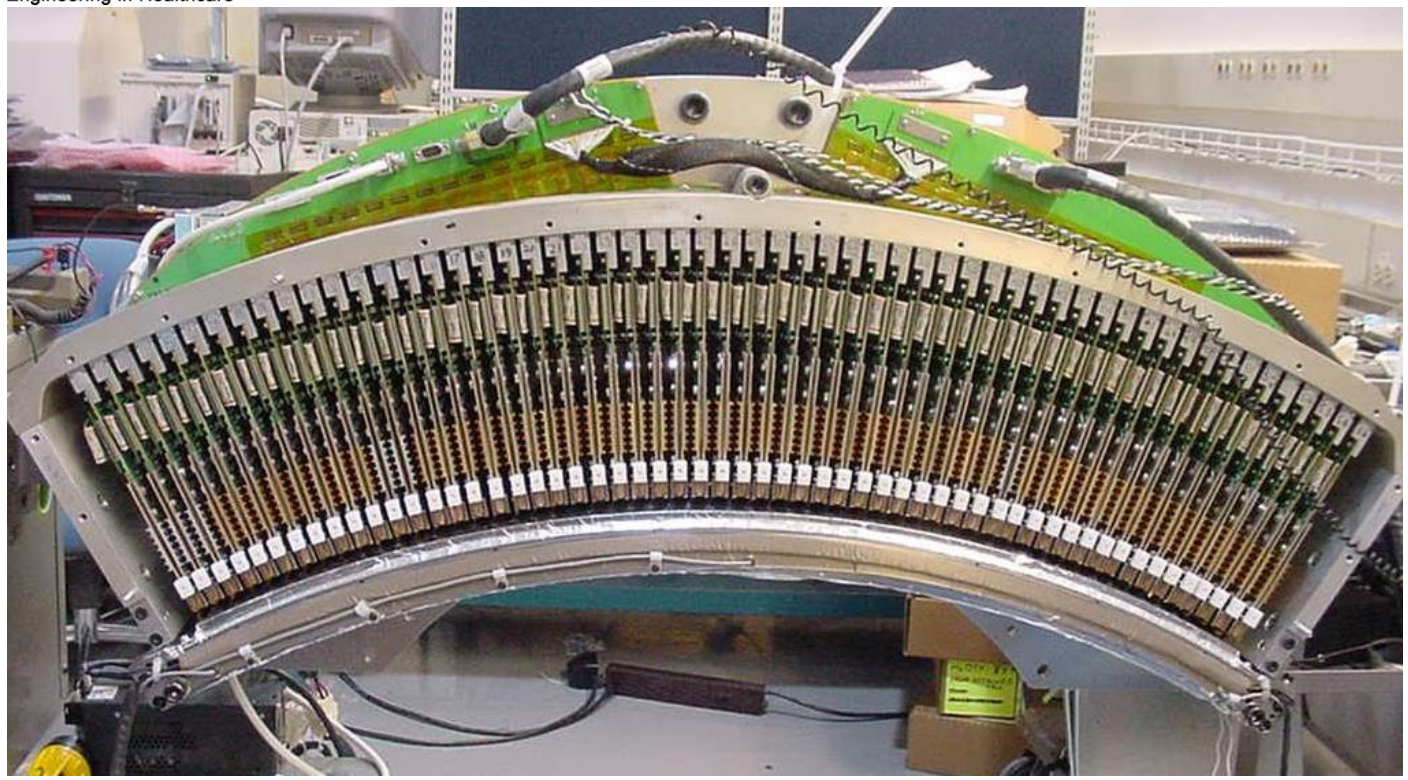
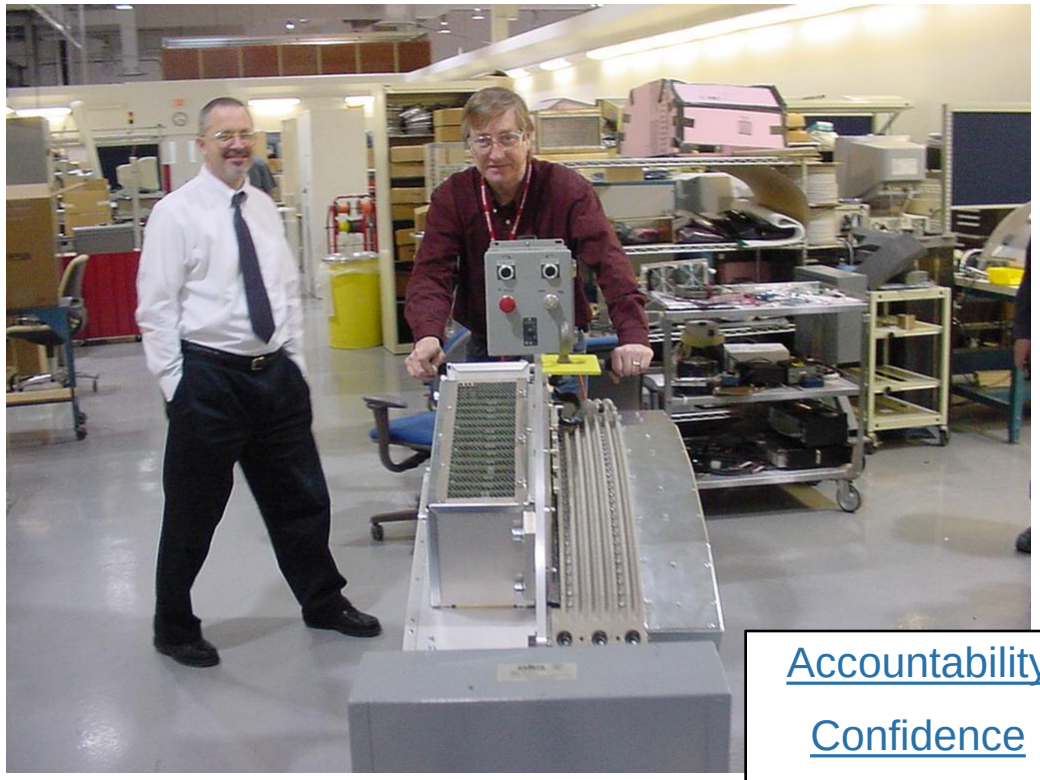
Effective Decision Making, Part 2





"Leaders Have the Courage to Make Unpopular Decisions"
Jack Welch

Once in a While, a Top-Down Leadership Call Is Best

Accountability
Confidence
Discernment
Inclusiveness
Empowerment
Synthesizer
Communication
Credibility

Behaviors of an Impactful Systems Organization

1. Effectively Make Decisions
2. Close Decisions and Keep them Closed
3. Influence at All Levels Organization
4. Optimize Systems Thinking of the Entire Org

Effective Decision Making…
Closing Decisions and Keeping Them Closed

Decision Factor	Option 1	Option 2
Factor A		
Factor B		
Factor C		
Factor D		
Factor E		

Some Reasons Decisions Get Changed:

1. Poor understanding/analysis of technical details

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Effective Decision Making…
Closing Decisions and Keeping Them Closed

Priority	Decision Factor	Option 1	Option 2
Medium	Factor A		
High	Factor B		
Medium	Factor C		
Medium	Factor D		
High	Factor E		
High	Factor F		
Medium	Factor G		

Some Reasons Decisions Get Changed:

1. Poor understanding/analysis of technical details
2. Team missed some of the key decision factors
3. New information adds new decision factors
4. Team did not understand the priority/weight of the decision factors
5. The decision pros and cons were not well communicated to leadership who may have different or additional information.
6. New leadership changes the decision factors or priority/weight of the decision factors

Nothings Delays a Program Like Changing Decisions Late in the Game

Effective Decision Making… Closing Decisions and Keeping Them Closed

Frequency	Some Reasons Decisions Get Changed:
Seldom	Poor understanding/analysis of technical details
More Often	Team missed some of the key decision factors
Seldom	New information adds new decision factors or score
More Often	Team did not understand the priority/weight of the decision factors
More Often	The decision pros and cons were not well communicated to leadership who may have different or additional information.
Seldom	New leadership changes the decision factors or priority/weight of the decision factors

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Effective Decision Making…
Closing Decisions and Keeping Them Closed

Frequency	Some Reasons Decisions Get Changed:	Team Control	LSD / Systems Role
Seldom	Poor understanding/analysis of technical details	Yes	Know who to trust. Challenge the team to think broad and deep. Stop the decision if insufficient analysis.
More Often	Team missed some of the key decision factors	Yes	Set the context. Ensure key stakehold and customer input. Challenge the team to think broad and deep.
Seldom	New information adds new decision factors or score	No	
More Often	Team did not understand the priority/weight of the decision factors	Yes	Set the context. Ensure key stakehold and customer input. Challenge the team to think broad and deep.
More Often	The decision pros and cons were not well communicated to leadership who may have different or additional information.	Yes	Ensure clear communication to leadership. Espcially ensure that the Cons are well understood by key stakeholers.
Seldom	New leadership changes the decision factors or priority/weight of the decision factors	No	

Accountability
Confidence
Discernment
Inclusiveness
Empowerment
Synthesizer
Communication
Credibility

LSD's Leadership Critical in Decision Closure and Communication

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May 1-2, 2019
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Effective Decision Making…Example
Closing Decisions and Keeping Them Closed

A Major Innovation in one Sub-System Improves Image Resolution 45%. This would be a major delighter for our customers and a big competitive advantage.

Team Set System and Sub-System Architecture.
Team Designed, Built and Tested Prototype.
Team Demonstrated the 45% Benefit with Images.

But…the change was not accepted into the next product release because it required major updates to other sub-systems at a high cost. The total implementation cost was not communicated well up front, and the cost/benefit trade-off was not acceptable to business leadership.

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Overall Grade: C- Could We Have Reached This Conclusion During the Architecture Phase???

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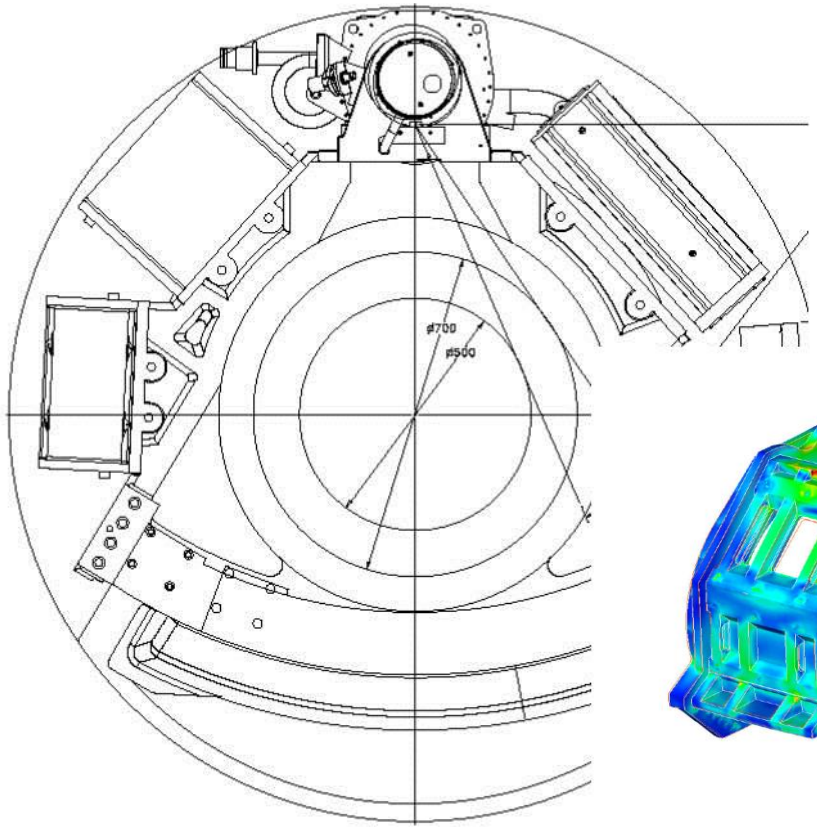
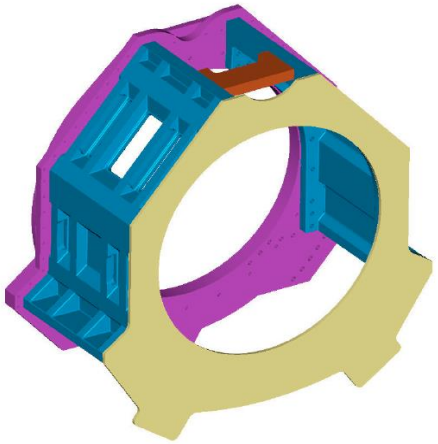
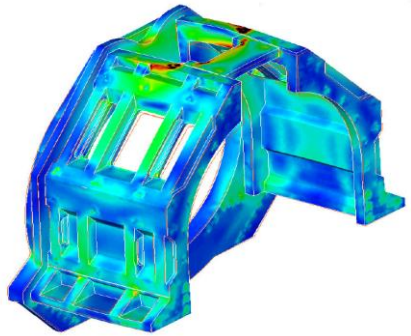
Effective Decision Making…Example
Closing Decisions and Keeping Them Closed

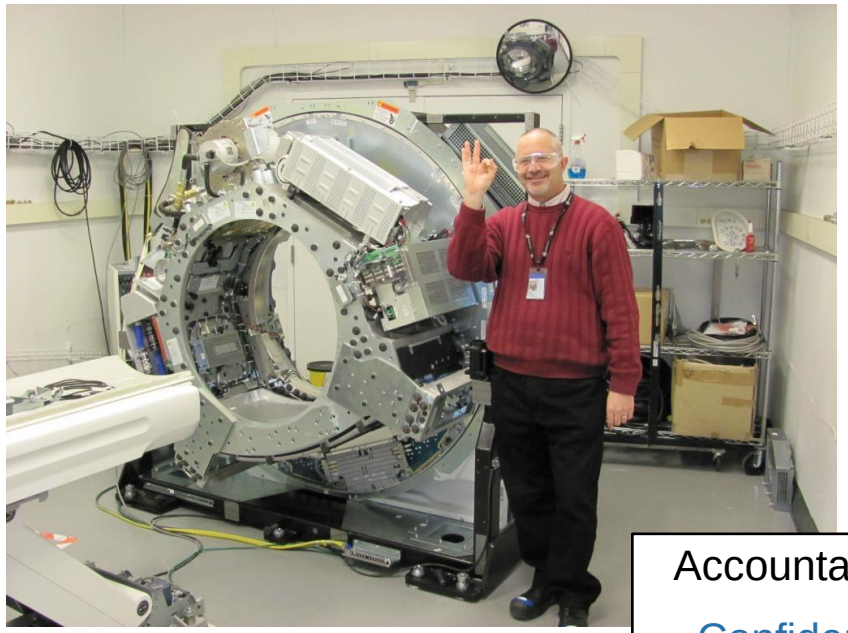
2009







2015



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Decisions Stick When Everyone is On Board

Behaviors of an Impactful Systems Organization

1. Effectively Make Decisions
2. Close Decisions and Keep them Closed
3. Influence at All Levels Organization
4. Optimize Systems Thinking of the Entire Org

Influence at All Levels Organization… Making an Impact

$$\text{Influence} = \mathscr{F}\left[\text{What You Have to Say} \;\&\; \left[\text{How You Say It} \;\&/\text{or}\; \text{Your Credibility}\right]\right]$$

***Credibility**: Trusted Across the Organization Based on a Distinguished Track Record.*

Influence = Convincing People, in Both Their Heads and the Hearts, To Do Something Different Than They Were Doing Before

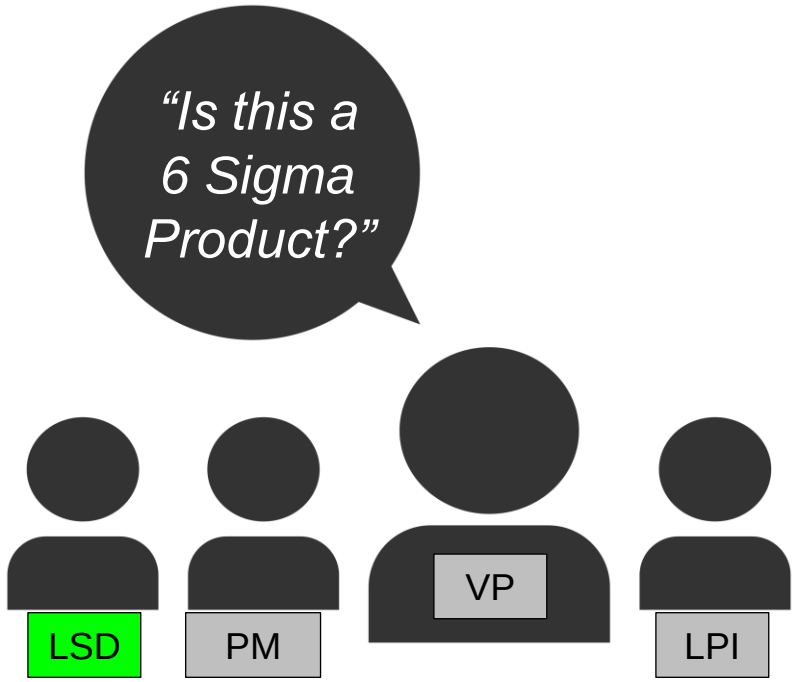
Influence at All Levels Organization
Have something meaningful to say…

1. Always have a firm recommendation that you truly believe in… backed by a thorough analysis after exploring all options. Having the experts on the team behind you will give you confidence.
2. Be proactive. Avoid crises by anticipating needed decisions.
3. Choose your battles wisely and save your "credibility capital" for the things that matter most. Be selective of the problems, arguments, and confrontations that you get involved in.
4. Simply admit it when you don't know something or are not prepared to answer. *"Let me analyze that and get back to you when I am prepared with a recommendation."*
5. When you are wrong (which will happen), simply admit that you made a mistake, and share what you learned from that experience.

Influence at All Levels Organization: *… and be able to communicate it!!*

1. Lead with an "elevator speech" this is no longer than 3 sentences. What the recommendation is, and why you are making it.
2. Shape the communication to fit the audience. Business leaders, program leadership, and the development team all need different levels of information, and will focus on different decision aspects.
3. Sharing your recommendation with confidence and conviction. Practice your delivery with someone who is not technical… your spouse, friend, or even the dog. If they can understand it, a broad group of people will understand it.
4. If you reach a stalemate with a business leader, simple say *"let me analyze this further and get back to you."* Educating a business leader in front of the group is a recipe for career suicide.

Influence at All Levels Organization: *Example:*



"It's All In There"

As the LSD: What Do I Say?

As the LSD: What Do I Do?

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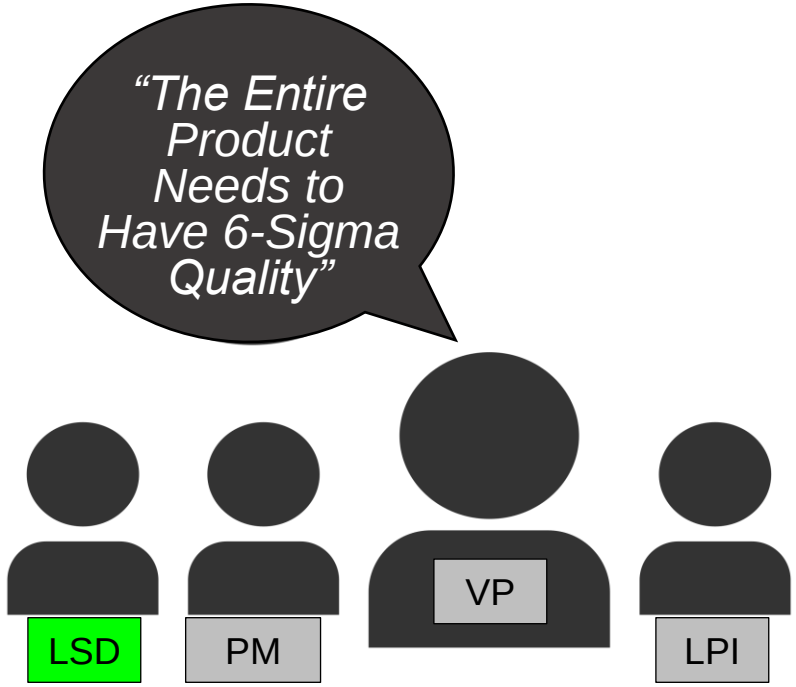
Be Ready to Step Up and Lead at Key Moments

Influence at All Levels Organization: *Example:*



As the LSD: What Do I Say?

As the LSD: What Do I Do?

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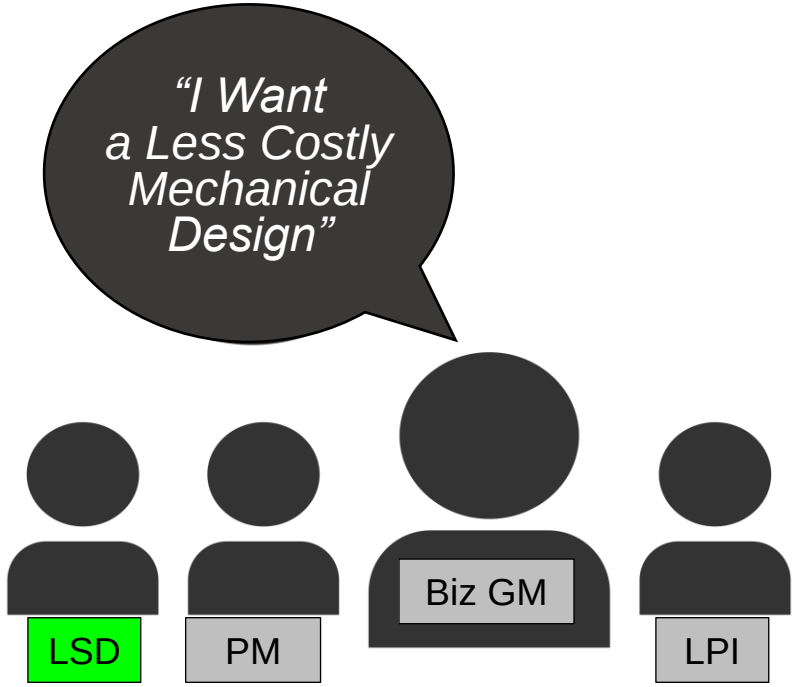
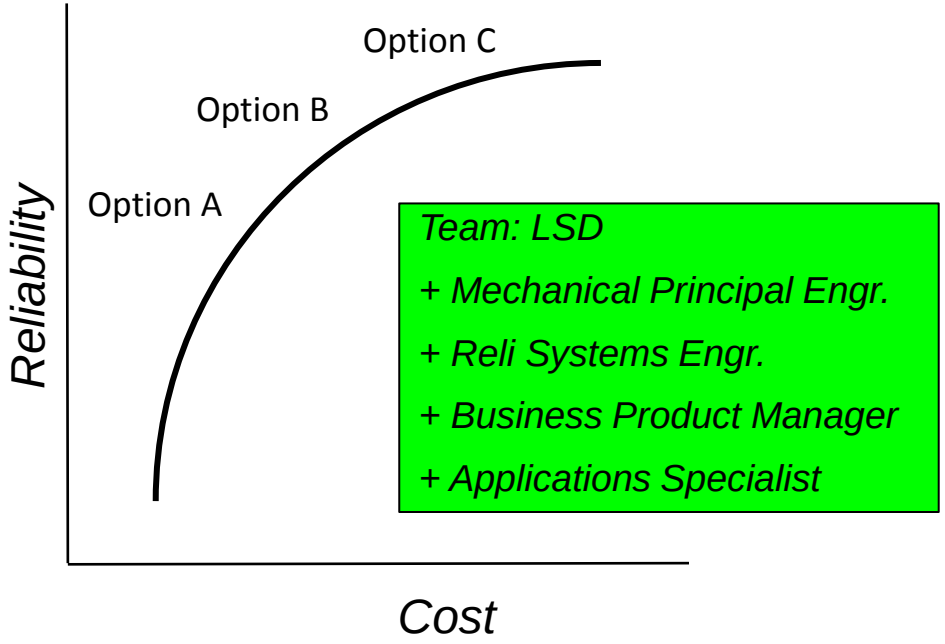
Influence at All Levels Organization: *Example:*

As the LSD: What Do I Say?

As the LSD: What Do I Do?





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Be Ready to Step Up and Lead at Key Moments

Influence at All Levels Organization: *Example: GE's First Six Sigma Product*

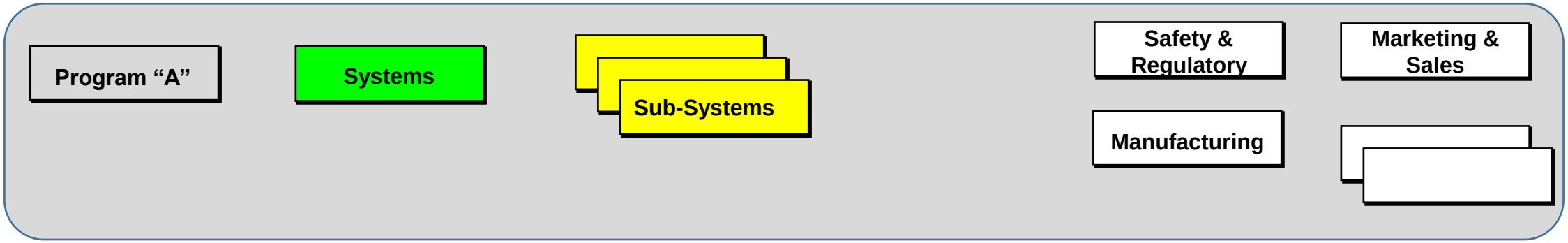
"Normally with new, cutting-edge technology you experience glitches and growing pains. But it did not happen. They installed this new system in 3 days, and the system ran flawlessly and it ran continuously. Before this, I did not understand what 6 Sigma meant. But if this is what 6 Sigma means, then I am sold." Dr. Carl Raven, Duke Medical Center

Behaviors of an Impactful Systems Organization

1. Effectively Make Decisions
2. Close Decisions and Keep them Closed
3. Influence at All Levels Organization
4. Optimize Systems Thinking of the Entire Org

Be a Leader in Optimizing Systems Thinking of the Entire Organization

New Product Program Structure



Model A:

Systems Engineering Does All

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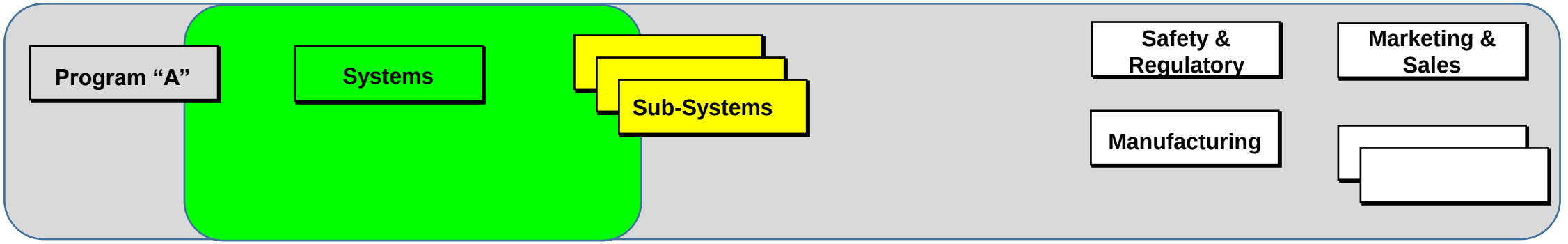
Be a Leader in Optimizing Systems Thinking of the Entire Organization

New Product Program Structure



Model A:

Systems Engineering Does All

Model B:

LSD Leads an Inclusive System Design Process

Sub-System Leadership = ~80% Sub-System + ~20% Systems

- Optimizes Design Decisions
- Can't State Every Requirement in Text… "Fill in the Blanks"
- Gets Team Buy-In to Decisions
- Drive Product Ownership Across Entire Team

"Every Engineer is a Systems Engineer"

Accountability

Confidence

Discernment

Inclusiveness

Empowerment

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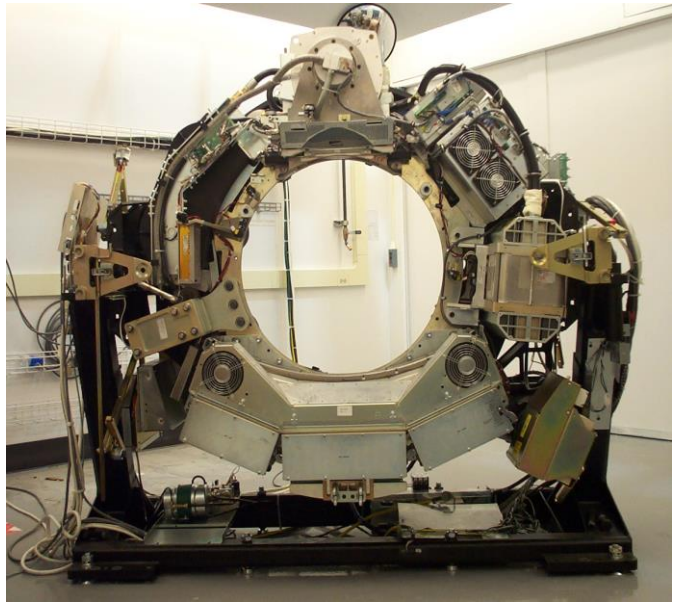
Optimizing Systems Thinking of the Entire Org *Example*



CT Gantry Thermal System Design:
- Complex Interfaces
- Complex Use Cases
- Multiple Sub-Systems

Who do you want to lead the CT Gantry Thermal System Design?

A Systems Engineer who dives into Thermal Controls?

A Thermal Controls Expert who is a Systems Thinker?

- Optimizes Design Decisions
- Can't State Every Requirement in Text… "Fill in the Blanks"
- Gets Team Buy-In to Decisions
- Drive Product Ownership Across Entire Team

LSD/Systems Adds Value by Providing the Context for the Design, and Guiding a Solid System Design Process

Sub-System Leaders Who Own System Designs = Great LSD Candidates!

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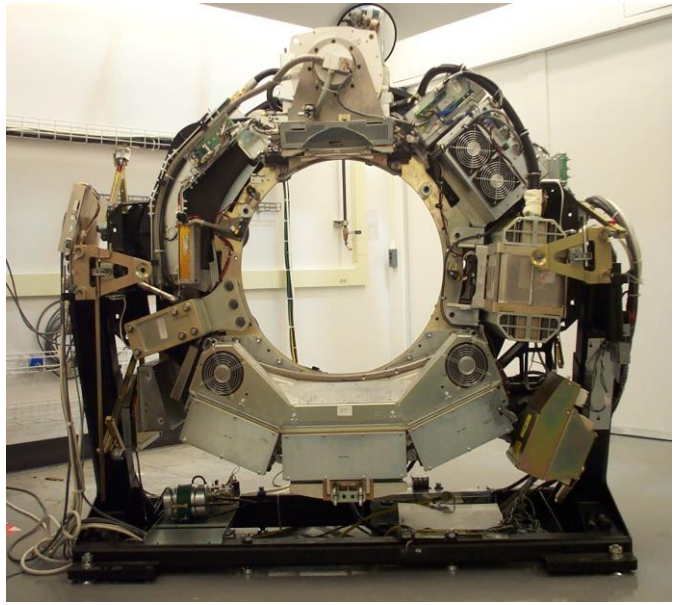
Optimizing Systems Thinking of the Entire Org
How Does the LSD Make This Happen?



CT Gantry Thermal System Design:
- Complex Interfaces
- Complex Use Cases
- Multiple Sub-Systems

- Provide Context. Write and communicate clear statements of Product Purpose, Vision, Concept and Architecture.
- Coach/Mentor the Experts as a Leaders.
- Coach Team in Systems Design Tools and Techniques.
- Ensure Clear Thinking: Challenge & Question. Drive Thorough Design Review.
- Drive Closure with Reviews and Appropriate Communication.

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It is Faster Short-Term to Simply Have 1 Expert Make the Call, But It is Not Better Long-Term

Elevator Speech:

The World Needs *Rock Star Systems Engineers,* and also *Astute Systems Thinking Across the Entire Organization*

Rock Star Systems Engineers are Servant Leaders who Influence, Motivate, and Enable Others to Contribute to a Wildly Successful System Design

Servant Leadership Behaviors = $\mathcal{F}$(Skills * Values)

Influence = $\mathcal{F}$(Something to Say * (How You Say It or Credibility))

The Very Best Systems Thinkers are Influential and Respected Servant Leaders Who Have a Significant Impact on the Product and the Business

So you Wanna Be a Rock n Roll Star…

Values

- Accountability: Takes Full and Personal Ownership
- Confidence: Well-Founded Self-Belief, Appropriately Humble, not Cocky nor Arrogant
- Discernment: Great Judgement and Wisdom, Knows Who to Trust, Can Spot "BS"
- Inclusiveness: Values, Welcomes, Integrates and Leverages Diverse Employees

Skills

- Ability to Empower: Works With and Through Others to Successfully Carry Out Specific Activities
- Ability to Synthesize: Frames Complex Problems, Provides Context, Brings Clarity
- Ability to Communicate: Conveying Information in a Clear, Motivational and Energizing Manner

- Credibility: Trusted Across the Organization Based on a Distinguished Track Record

A Servant Leader You Can Trust to Make Things Happen

Questions??

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Thank you for listening!
Share your experiences at #HWGSEC

Appendix

GE Healthcare Glossary

- General Manager – Responsible for Program and Functional Excellence.
- Program Manager – Responsible for all aspects of a new product
- Lead System Designer (LSD) – Responsible for all aspects of the design
- Sub-System Project Leader – Responsible for all aspects of a new sub-system
- Chief Engineer – Lead Technical person for a product line… #1 Systems Engr
- Principal Engineer – Lead Technical person for a functional or sub-system