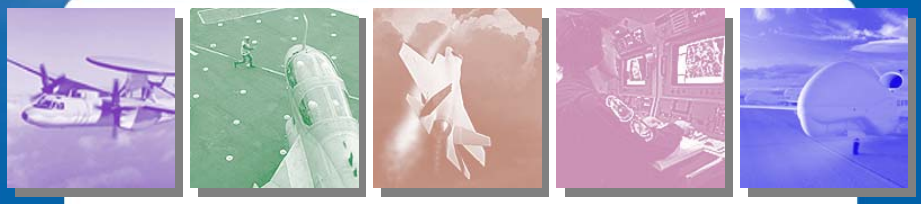
NORTHROP GRUMMAN
Integrated Systems



Lean Case Studies

National Shipbuilding Research Program
Lean Ship Building & Ship Repair Forum
Lexington, Kentucky

Chris Cool
Vice President, Manufacturing, Quality & Lean
Northrop Grumman Integrated Systems

June 5, 2002

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Agenda

- Integrated Systems
- Ship Systems
- Questions

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Sharing the Knowledge

- Applying Lean in Aircraft Fabrication and Assembly Is No Different than Its Application to Erecting and Outfitting a Ship
- An Aircraft Factory Is No Different Than a Ship Factory
  - Aircraft Workers Work Within the Buildings
  - Shipbuilders Work in the Shipyard or Within the Ship
  - Acquisition Processes Are Similar
  - Design and Supply Chain and Infrastructure Are the Same
- Lessons Learned Are Applicable to Both Product Lines
  - Share the Knowledge Both Directions

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Agenda

- Integrated Systems
- Ship Systems
- Questions

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Case Study

- We've Done Lean in Each Element of Our Process Architecture
- These Are Just Examples We Chose in Consideration of Time

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Integrated Systems

- Standard Tool Logistical Supply – F/A-18
- E-2C Subassembly
- Software Estimating

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Standard Tool Logistical Supply

- Tools – There Are a Lot of Them and They Are Cumbersome to Manage
- Tools Are an Expense
- Tools Are an Inventory Concern
- Proper Tool Usage Is Critical
- Tools Get Lost
- People Walk to Get Some Tools
- Some the Tools Worker Owned
- Perishable Tools Get Hoarded
- Tools Must Be Maintained

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We Used To – Before "Lean"

- Multiple Tool Cribs
  - Perishable Tools for Drilling, Routing, Etc
  - Re-Sharpening Centers
  - Large, One-of-a-Kind, Check Them Out of Crib Tools
- Hoarding of Perishable Tools in Workers' Boxes to Be Sure the Tool Was Available to Get the Job Done
- Tools Lost and Shipped With a Product – Not Good!
- Worker-Owned Tools Including the Kitchen Sink Tools
- A Lot of Walking Around to Get Tools

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Costs

- Inefficiencies Abounded
- Worker Travel Costs Were High and Non-Productive Talk Time Around Tool Cribs Was Prevalent
- High Perishable Tool Costs
- High Tool Inventory Costs
- Lack of Standard Tools Made Standard Tasks Not Standard Causing Variability in the Process
- Foreign Object Damage Was Frequent
- Management and Inventory of Personal Tools Was Expensive

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The Challenge

- Reduce Tool Inventories
- Keep the Worker at His Work Station
- Cut the Non-Productive Time
- Make Standard Jobs Standard
- Eliminate Personal Tools
- Reduce Foreign Object Damage (FOD)
- Eliminate Lost Tools
- Reduce Total Tool Costs
- Improve Job Cycle Times
- Be Innovative

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The Tasks

- Air Combat Systems Business Area Initiated
- Do the Value Stream Mapping
- Understand the Processes
- Coordinate With the Customer – the Programs
- Understand the Culture and Its Resistance to Change
- Establish the Schedule
- Develop the Options
- Define the Business Cases
- Make It Happen

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The Program

- Shadow Boxes for Tools
- Company Owned Tools Only
- Standardize the Tools
- Move the Tools to the Worker
- Eliminate the Tool Cribs
- Out Source Perishable Tools
- Develop a Perishable Tool Delivery System
- Tie the Tool Usage to the Job Flow – the Manufacturing Requirements Planning System

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Lean Standard Tool Supply

- Autovending With Computer Controlled Lockers
- Community Workstations
- Tool & Equipment Kits (Tackle Boxes)
- Positionalized Roll-Away Kits
- Portable Power Feed Equipment Kaizan
- Numerical Control Pre-Set Kaizan
- Statistical Process Control Equipment Kaizan

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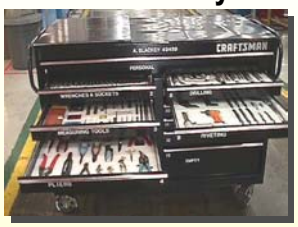
Lean On the Shop Floor

Tool Accountability



Toolbox

Community Toolbox

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Lean On the Shop Floor

Creating Consistency With Standard Tools

Improve Quality through Variability Reduction

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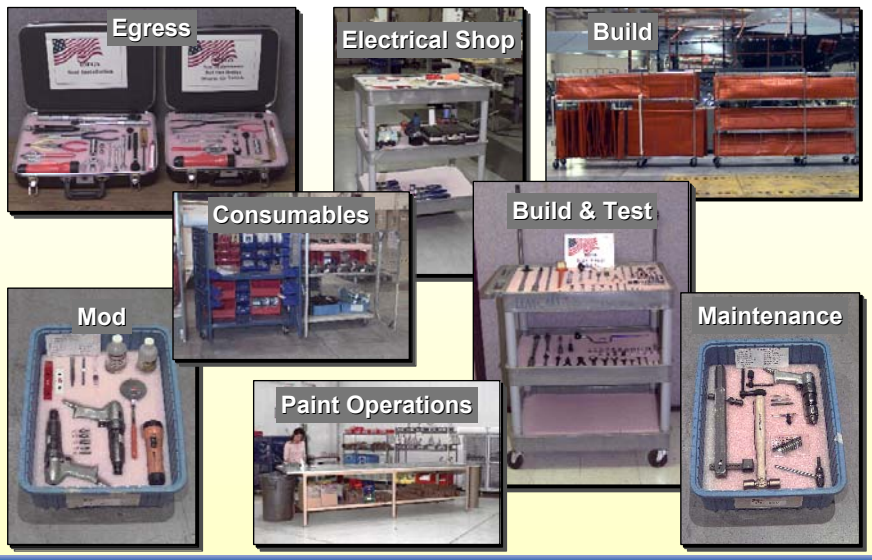
Lean On the Shop Floor



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Automating the Perishable Tools

- Define / Document Requirements
  - Electronic Database (Master Kit List)
  - Historical Usage Rates (Site Specific)
- Define Floor Plan / Vending Locations
  - Projected Requirements / Usage at Each Location
- Signed Contract With Machine Tool Supply (MTS) on August 14, 2000 Via Corporate Procurement
  - Original Statement-of-Work (SOW) in the Contract Is for ACS
  - Contract Is Worded to Provide for "Add On" SOWs for Other Business Areas.
  - Draft a Site Specific SOW to Be Added to the Corporate Contract
- Install Data Cables for Vending Machines
- Provide an On-Site Working Location for MTS

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Automating the Perishable Tools

- Define Reporting Requirements / Formats
- Include MTS in Shop Floor Planning, Production Schedule Changes
  - MTS Treated As If They Were a Northrop Grumman Owned Organizational Element
- Transition Northrop Grumman Work in Progress (WIP) to MTS
- Define Approved Sources
- Establish a Personnel Redeployment Plan
- Transition Reordering Tasks to MTS
- Transition Tool Crib Functions to Autovending
- Transition Reconditioning Task to MTS
- Transition Kitting Functions to MTS

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Machine Tool Supply Tasks

- Install Business Infrastructure at Each Site
  - Become Participant With Shop Floor
- Transition Northrop Grumman WIP Stock to MTS
- Install Autovending Machines & Lockers
- Establish a Site "Requirements Plan"
- Identify Approved Sources
- Establish Report Formats
- Train Mechanics
- Payment to MTS Is 30 – 45 Days AFTER Use of the Tools

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Integrating Suppliers On-Site

Standard Tools Vending Solution

Benefits of Teaming

- Reduce Labor Costs
- Elimination of Work In Process
- Reduce Usage
- Reduce Internal Transportation
- Eliminate Hording
- Reduce Shortages
- Increase Quality

Yesterday

Today

Creating Solutions With On-Site Suppliers

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Vending Machines Situated

F 18 C/D 2520 *915 Paint Shop* *923 Paint Shop*

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Savings for Non-Perishable Tools

- **Labor Savings (17,000 hrs/yr) $1,229K/yr**
  - **Standardized Tool Set and Improved Quality**
  - **Warehouse Personnel**
  - **Acquisition Personnel**
  - **Tool Crib Personnel**
  - **Standard Tool Kitters**
- **Elimination of Northrop Grumman Standard Tool WIP $ 340K/yr**
  - **$4M @ 8.5% Prime**
- **Reduced Standard Tool Usage by 15% $ 1,200K/yr**
- **Reduced Standard Tool Base Cost (12%) $ 816K/yr**
- **Reduced Northrop Grumman Transportation Cost $10K/yr**
  - **2 Vehicles**

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Savings for Perishable Tools

- Total Gross Savings $3,595K/yr
- Integrated Supplier Cost $1,256K/yr
  - 21% of Base Tool Cost
- Total Annual Savings $2,338K/yr

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Lessons Learned

- Historical Usage Rates
  - Poor Usage Rate History, by Cost Center, Made It Difficult to Forecast Requirements for Each Machine
- Data Cable Installation
  - Facilities Cost and Implementation Schedule Impacted Vending Machine Installation Schedules
- On-Site Working Location for MTS
  - Timely Availability of Work Area for MTS Impacted "Start Up"
- Define Approved Sources
  - Approved Manufacturers for Tools Is Critical to Quality Source Selection
- Transition Kitting Functions to MTS
  - Transfer of Tool & Equipment Kits Should Have Been Done "in Parallel" With Existing Kitting Activities in Order to Ensure No Detrimental Impact to Manufacturing Build Schedules

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Best Practice

- Air Combat Systems (ACS) Standard Tool Logistical Supply Declared Best Practice for Sector
- Additional Sites and Locations Added at ACS
- Shadow Boxes, Standard Tools, No Personal Tools Implemented at Other Two Business Areas
- Vending Machine Contract With MTS Extended to St. Augustine, FL in Airborne Early Warning / Early Warning Systems Business Area

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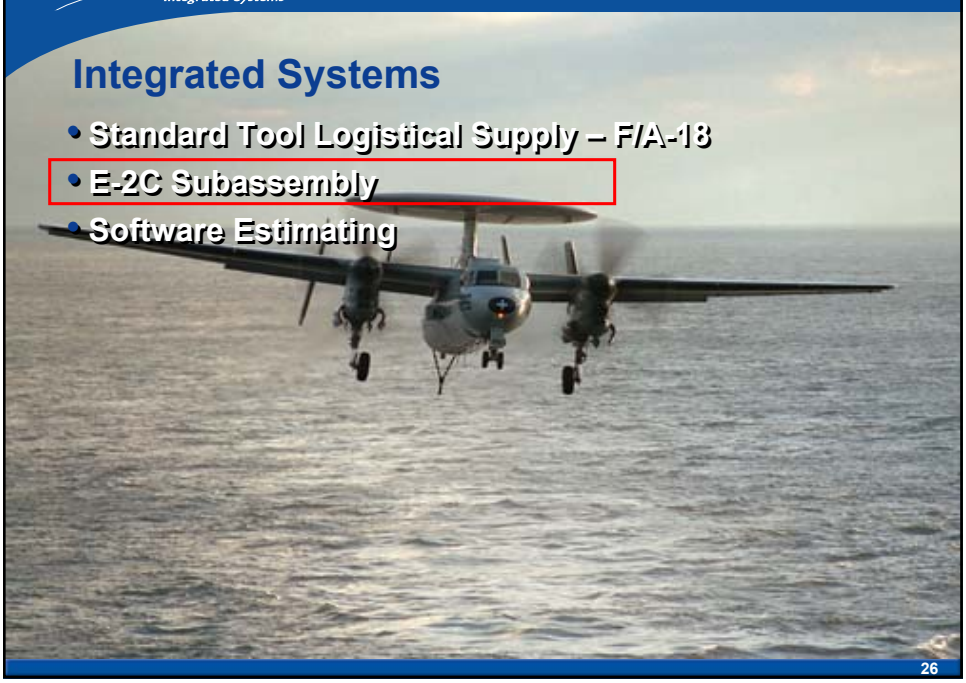
Integrated Systems



- Standard Tool Logistical Supply – F/A-18
- E-2C Subassembly
- Software Estimating

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E-2C Subassembly

- 1960's Era Design
- Many Small Parts
- Many Subassemblies
- Traditional Sheet Metal Aircraft
- Traditional Plant Layout
- Centralized Warehousing
  - Onsite for Immediate Parts
  - Offsite for Main Warehousing and Receiving

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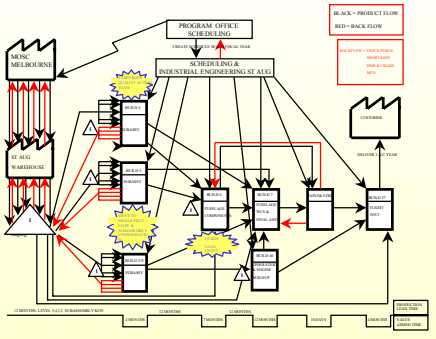
We Used To

- Subassembly Production Was Done in Lots
- Multiple Sub Subassemblies Needed to Be Assembled Prior to Delivery to Final Assembly
- Each Subassembly Lot Was Sent to the Warehouse
- Build Up of Subassemblies Required Multiple Warehouse Requisitions
- Cycle Times Were High
- Dedicated Crews to Subassembly and to Assembly

Current State



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Costs

- Wasted Travel To and From the Onsite Warehouse
- Excessive Shipping and Receiving From Offsite Warehouse
- Rework Cost Associated With Change on Completed Lots
- Disassociated Subassembly From Final Assembly Needs
- Increased Inventory Costs
- More Specialized Workforce
- Occasional Impact on Major Assembly Schedules

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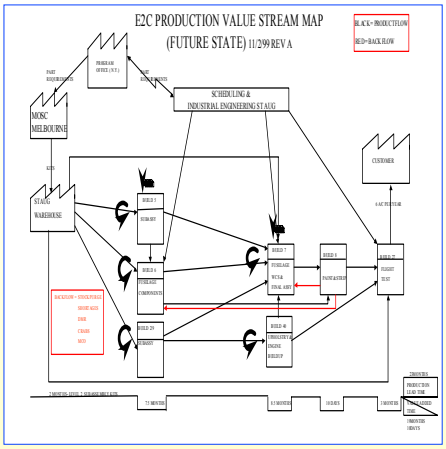
Challenges

- Reduce Costs of Warehousing
- Change From Lot Subassembly Manufacture to Single Unit Manufacture
- Reduce Travel Time on Subassembly to Final Assembly by Relocating Subassembly Areas
- Increase Flexibility of Workforce and Reduce Workforce Size

Tasks

- Go to Single Part Subassembly
- Move Subassembly Fabrication Next to Major Assembly
- Time Subassembly Production to Major Assembly Schedule
- Reduce Warehouse Trips
- Minimize Offsite Warehouse Involvement
- Improve Cycle Times
- Reduce Burden on Support Personnel
- Improve Change Incorporation Capability



Savings

- Operations Sheets Reduced
  - 5,000 for 5 Subassemblies to 2,600 for 1 Subassembly
- Aircraft Production Cycle Time Reduced From 860 Days to 504 Days Within 4 Aircraft (41%) After Implementing Changes
- Distance Subassemblies Transported:
  - 1,305 Miles Reduced to 145 Miles (89%)
- Number of Transports From Offsite Warehouse:
  - 9 Trips Reduced to 1 Trip (89%)
- Packaging / Receiving:
  - 9 Sets Reduced to 1 Set (89%)
- Defects (No. Of MRRs):
  - June = 215, July = 91, Aug = 81 (62%)
- Cost Savings: $4M-$5M
  - Includes Savings From Lower Inventory Costs

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Integrated Systems

- Standard Tool Logistical Supply – F/A-18
- E-2C Subassembly
- Software Estimating

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We Used To

- Have a Significant Number of Internal Process Steps To:
  - Design and Code New Software
  - Conduct Peer Reviews
  - Test Software
- Generate Unnecessary Internal Software Products to Meet Outdated Government Requirements

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Costs

- Throughput Times Were High
- Inefficiencies in Ancillary Tasks to Coding Were Consuming Thousands of Hours

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Challenges

- Reduce Cycle Times
- Improve Throughput Times
- Reduce Basis-of-Estimates for New Coding by a Minimum of 10% in 2001
- Reduce Travel Time Significantly
- Continue to Achieve Higher SEI Certification Levels

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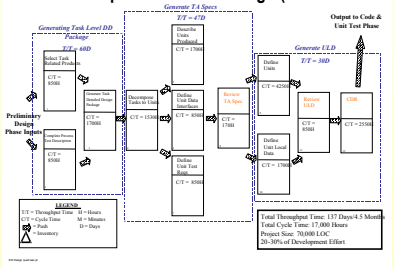
Tasks

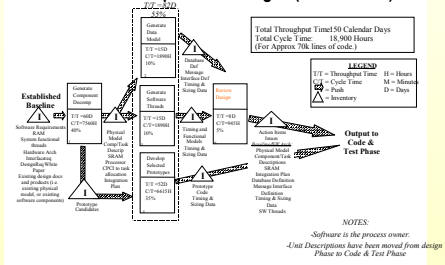
- Value Stream Map
  - Peer Review
  - Software STR / Build
  - Software Design
  - Software Code and Unit Test
- Document in New Procedures Revised Process
- Significantly Reduce the Number of Internal Products

TYPICAL VALUE STREAM MAPS

Value Stream Map for SW Detail Design (Current State 5/14/01



Value Stream Map for SW Design (Future State)



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Savings

- Peer Reviews
  - 40% Reduction in Throughput Times
  - 37% Reduction in Cycle Time
  - 100% Reduction People and Product Travel Time
- Software STR / Build Process
  - 55% Reduction in Throughput Times
  - 84% Reduction in Cycle Time
  - 69% Reduction People Travel Time and 52% Reduction in Product Travel Time
- Software Design Process
  - 42% Reduction in Throughput Times
  - 31% Reduction in Cycle Time
  - 59% Reduction in Internal Software Products
  - Basis of Estimate Reduced 10%
- Software Code and Unit Test
  - 40% Reduction in Throughput Times
  - 32% Reduction in Cycle Time
  - 55% Reduction in Internal Software Products
- 9,700 – 14,900 Labor Hours in Annual Software Cost Avoidance

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Agenda

- Integrated Systems
- Ship Systems
- Questions

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Ship Systems

- Application of Lean to Ships Is Similar to Aircraft
- Goals Are the Same
  - Reduce Cycle Time
  - Apply 5S
  - Standardize Processes
  - Minimize Inventory
  - Deliver High Quality Products
  - Maintain Satisfied Customers
- Integrated Systems Was Asked to Assist Our Sister Ship Systems Sector
  - Lean Education
  - Lean Event Conduct
  - Transference of Lean Tools
  - Guidance for Lean Concepts and Organization

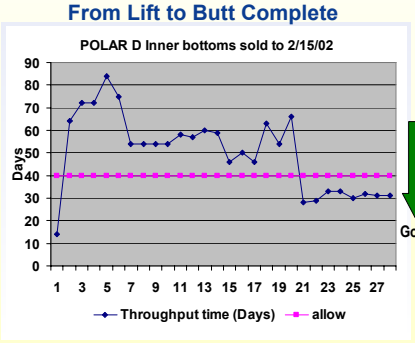
5S Application

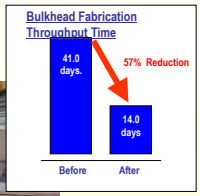
- Applying Sorting, Sifting, Straightening, Shining, and Standardizing Generates Pride As Well As Positive Financial Results
- Assisted in Building Ways 5S
- Assisted in Material Storage 5S

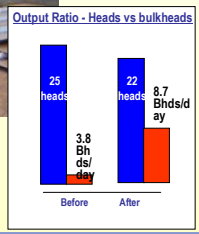
Process Improvements

- Worked With Shipyards to Improve Erection Cycle Times
- Assisted Ship Systems in Sheet Metal Shop Processes

Unit Throughput for Polar D:
From Lift to Butt Complete







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Lean At Newport News

- Newport News Sector Has a Well Established Lean Program
  - Examples of Lean Application at Newport News
    - 57% Improvement in Double Eagle Bow Erection Cycle Time
    - 55% Reduction in Catapult Girder Fabrication
    - 38% Reduction in CVN76 Island Fabrication
    - 50% Reduction in Steel Fabrication Aft Reactor Compartment Bulkhead Cost Performance
- Regular Sharing of Lean Knowledge Between Newport News, Ship Systems, Electronic Systems, and Integrated Systems Has Begun

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Applying the Knowledge

- Tools
  - Shadow Boxing Tools / Company Owned
    - Moves Tools Closer to Welder, Fitter, or Electrician for Increased Productivity
    - Standardizes Tools and Contributes to Consistent Quality
- Perishable Tools
  - Management of Consumables by Integrating As a Teammate the Supplier Right Into the Process and Next to the Worker
  - Improved Productivity, Proper Consumable Usage, Usage Pulled by Jobs
  - Vending Machines Adjacent to Usage Near the Ship or on the Ship
- Evaluation of Value Stream
  - Use of Value Stream Mapping to Understand the Flow, the Constraints of the Statement-of-Work, Relationships of the Teams and Supporting People
  - Improved Product Fabrication and Assembly – Shorter Cycle Times and Improved Quality

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Teaming the Knowledge

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Agenda

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Questions