

Robot Introduction

- Project Management for automated Systems & Machines
 - What to consider
 - Working intelligently with the systems
- The Overriding “Tenets of Automation”
 - Pose Control – Fixed Vs Flexible Automation
 - System Synchronization
 - System Balance
- The Robot as a System – by definition!
 - Manipulator
 - Power System
 - Controller Schemes
 - End of Arm Tooling
 - Sensors (environmental)

- Automation “Defined”:
 - Automation is the technology concerned with the application of complex mechanical, electronic and computer-based (computer-controlled) systems to the operation and control of production

- Automation includes:
 - Automatic Machine Tools, Forges and Sand and Permanent Molding machines for piece processing (CNC & DNC)
 - Material Handling Equipment (ASRS's, AGV's, Reactive Conveyors)
 - Automated Assembly Machines/systems
 - Process Controllers (PLC's)
 - Feedback Control Systems/System Sensors
 - Automated Data Collection Systems (AIDC)
 - Automated Data Reporting Systems (MRP)

- The development of an Automated System is a 4 step process:
 - System problem analysis for overall requirements
 - Determination of the systems special needs
 - Selection of and design of control hierarchy
 - Building/programming of individual components (Robots, Machines, AGV's, etc.)

Working Intelligently with a Production System – Design for Automation

- Does Variety (types) or Piece Count (volume) dominate?
 - Consider Fixed Automation vs. Flexible Automation
- Should we Consider Humans?
 - Typically, making it easier for automation makes it easier for humans (especially true for assembly)
- Cost Justification of the system
 - Consider Production Capabilities & Productivity Gains
 - Leads to Labor Replacement Savings
 - Consider Improved Quality, Repeatability & Reliability
 - Consider Quicker Changeovers/Improved Flexibility in Product development

Project Management for Automated Systems – what to consider

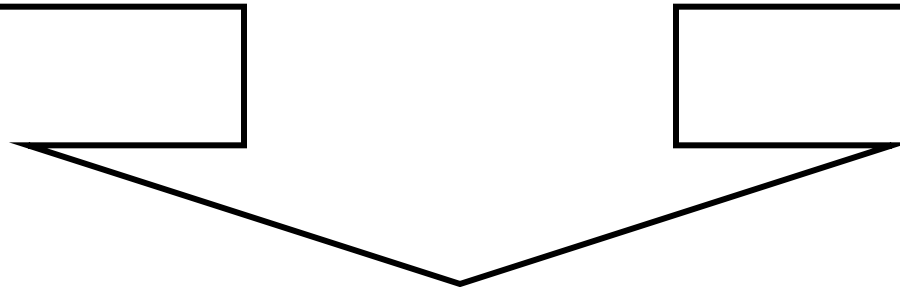
STEP 1

- Quantify Overall System Needs:
 - Number of Parts per hour (Production Rate!)
 - Product Variety and Part Size
 - Part Shape
 - Part Weight, etc

Project Management for Automated Systems – what to consider

STEP 2

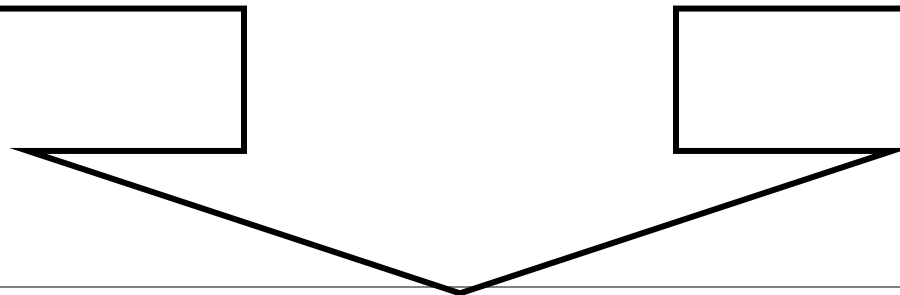
- **Find/Solve Special Needs Issues:**
 - Robot Tooling and Machine Fixturing
 - Sensors for Pose Control or Decision-making
 - Communication Requirements (Machine to Machine)



Project Management for Automated Systems – what to consider

STEP 3

- Determine Control Hierarchy:
 - Isolated Actions
 - Master/Slave(s)
 - Event Driven Response – under higher or parallel control



Project Management for Automated Systems – Final Actions

STEP 4

- Build and/or Program *Individual Units*:
 - Robot Path Control
 - Machine Tool Codes
 - AGV Paths/Controls
 - ASRS Designs/Controls
 - Communication Network
 - Relays/Sensors, etc.

“Tenets of Automation” – Or what must be assured when Machines replace Humans

Pose Control is a principle that states that each degree of freedom of a machine, tool, product or process must be fully known or accounted for at all times for the (high quality) production systems to operate.

- **A Degree of Freedom** in the physical sense is:
 - One of a set of positional bits (X, Y or Z) or
 - One of a set of Rotational bits (Roll, Pitch or Yaw) so
 - **Full POSE Control** requires 6 dof from the machine!

“Tenets of Automation”

- ***System Synchronization*** (timing control) of operations must be maintained:
 - This requires that the sequence and timing of each movement during the process activity must be known and controlled.
 - This includes part counting, machine and product arrivals and departures, completed and closed communication sequences, etc.

- ***System Balance:***
 - Each step in a process must be appropriately sized to complete its tasks within the overall system processing requirements.
 - Thus, no process should be slower/smaller (or faster/larger) than its predecessor or followers without accounting for product accumulation within the system.

Achieving Automation – Fixed vs Flexible

- In Fixed Automation Systems
 - POSE CONTROL is ***imposed*** by stops, cams, rotators, etc
 - SYNCHRONIZATION is controller by in-feed supply, part feeders, hoppers, pallet movers, etc
 - BALANCE is controlled by (Overall System) design

Achieving Automation – Fixed vs Flexible

- In Flexible Automation Systems
 - POSE CONTROL is achieved by sensing and adaptation by the machines to products in the system
 - SYNCHRONIZATION is assured by machine/system level adaptation to the changing needs of the feed stock and throughput demand
 - BALANCE is by designed over an extended time horizon, machines can be reprogrammed (on-line in Real Time) for changing part mix

Achieving Automation – Fixed vs Flexible

- Most Systems currently in use are HYBRIDS with elements of both Fixed and Flexible ideas!
 - Flexible Feed – Fixed POSE
 - Flexible POSE – Fixed Feed
 - Fixed Path-followers and Reprogrammable path-followers intermixed in the station, cell or line

The Robot is a System

– by definition!

- Robots Institute of America: “A Robot is a REPROGRAMMABLE, MULTIFUNCTIONAL manipulator designed to move material, tools and specialized devices through variable programmed motions for the performance of a variety of tasks”
 - Note here: **RE-programmable**, that is an **AGILE**, machine that can be used for many different tasks (without full reconstruction)
- Stanford Research Institute International: “A robot is a general purpose machine SYSTEM that, like a human, can perform a variety of different tasks under conditions (*of time and space*) that may not be known *a priori*.
 - Note here: this implies a manipulator that **May be Mobile** and one that exhibits **Intelligence**.
 - This may be state of the art in the next 10 – 20 years!

The Robot System Contains 5 Major Sub-

systems

- Manipulator
- Power System
- Control
- End-of-Arm Tooling
- Environmental Sensors

- The Manipulator
 - consists of joints (revolute or prismatic), actuators, and kinesthetic (positional) sensors
 - Types:
 - Cartesian
 - Cylindrical
 - Spherical
 - SCARA (selectively compliant assembly robots)
 - Articulating Arms

- The Power Systems
 - Pneumatic for light loads at elevated speed
 - Hydraulic for heavy loads or very high speeds
 - Electric Servo for general applications

- The Controllers
 - *Bang-Bang*: are mechanically programmed (movement to stops) and usually one-axis-at-a-time
 - *Point-to-point servo*: feedback of joints' positions as moves from point A to B are run – no control of the path between A and B (only end points are assured)
 - **G00** and **G11** or **G12** in **RC**
 - **JOINT** in **Karel** (Uses **\$TERMTYPE** to effect rounding)
 - *Servo w/ Path Control*: the motion is controlled completely between point pairs including positions and orientation to follow desired space curves
 - **G01, G02, G03** in **RC**
 - **LINEAR** or **CIRCULAR** in **Karel**
 - *Autonomous Control*: Device control that allows paths to be determined in 'real time' as the devices moves and interprets various sets of sensory inputs to create 'intelligent' paths as it moves

- The End of Arm Tooling -- their complexity of task dictates the type of control scheme that is required
 - Grippers/Hands/spot welders
 - Sensor Arrays (static reading)
 - Sensors (active scanning)
 - Ladle/Hooks
 - Routers/Grinders/Drills
 - Spray Guns/Torches

- Environmental Sensors
 - devices that give higher level information for program control and or path planning
- Repeating, finally, Robots are Systems requiring design choices at 5 levels – mechanically, electronically and with computer integration!