FIND YOURS.

Rapid Deployment Automation

Presented by:
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Overview

• Why companies should invest in automation

• New technologies offer new capabilities

• Risks in automating

• Planning and mitigating these risks
Map 1. Unemployment rates for metropolitan areas, not seasonally adjusted, July 2017

(U.S. rate = 4.6 percent)

NOTE: Map includes data for 388 metropolitan areas based on Office of Management and Budget Bulletin No. 15-01. Areas in the six New England states are Metropolitan and/or Northeastern Planning Areas (NECTAs), while areas in other states are county-based.

1/3rd of 388 areas below 4%
U.S. Labor Turnover Rates

2016 Total Turnover

<table>
<thead>
<tr>
<th>Industry</th>
<th>Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Industries</td>
<td>17.8%</td>
</tr>
<tr>
<td>Banking &amp; Finance</td>
<td>18.1%</td>
</tr>
<tr>
<td>Healthcare</td>
<td>19.9%</td>
</tr>
<tr>
<td>Hospitality</td>
<td>28.6%</td>
</tr>
<tr>
<td>Insurance</td>
<td>12.2%</td>
</tr>
<tr>
<td>Manufacturing &amp; Distribution</td>
<td>16.0%</td>
</tr>
<tr>
<td>Not-For-Profit</td>
<td>15.7%</td>
</tr>
<tr>
<td>Services</td>
<td>16.8%</td>
</tr>
<tr>
<td>Utilities</td>
<td>8.8%</td>
</tr>
</tbody>
</table>

Source: Compensation Force Survey
Robot vs Human Labor Cost

Robot (2 shifts) vs Human Labor Rates

- Large Robot
- Small Robot
- China
- US (BLS)
- Germany

<table>
<thead>
<tr>
<th>Year</th>
<th>Large Robot</th>
<th>Small Robot</th>
<th>China</th>
<th>US (BLS)</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>$20</td>
<td>$10</td>
<td></td>
<td></td>
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<tr>
<td>1970</td>
<td>$30</td>
<td>$20</td>
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<tr>
<td>1980</td>
<td>$40</td>
<td>$30</td>
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<tr>
<td>1990</td>
<td>$50</td>
<td>$50</td>
<td></td>
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<tr>
<td>2000</td>
<td>$60</td>
<td>$60</td>
<td></td>
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<tr>
<td>2010</td>
<td>$70</td>
<td>$70</td>
<td></td>
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<tr>
<td>2020 (est)</td>
<td>$80</td>
<td>$80</td>
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</tbody>
</table>

FIND YOUR WOW
Worldwide Robot Market 2017

Estimated worldwide annual supply of industrial robots at year-end main markets 2015 - 2017

- China: 138, +59%
- Japan: 46, +18%
- Rep. of Korea: 41, -4%
- United States: 31, +6%
- Germany: 21, +7%

Source: IFR World Robotics 2018
Emerging Robot Technology

- Mobile Robots
- 3D Vision
- Collaborative Robots
- More Flexible Grippers
- AI
Mobile Robots (2D LIDAR)

Adept/Precise
Amazon: 60,000
Siasun: China
Kuka: Germany
(Bought by China)
3D Vision: Navigation, Bin Picking

Volumetric Mapping

Bin Picking
Intel Realsense 3D camera
New: Collaborative Robots

Robots that can be installed easily, without safety screens
Lowers time and cost of applying robots
Increases flexibility and reuse of robots
Makes people more comfortable around robots
Robots can be safe

“That was EASY, Daddy!”
New, Versatile Grippers
AI (Supervised AI)

Kindred Robotics

BRETT (Berkeley Robot for the Elimination of Tedious Tasks)

OpenAI (SpaceX, Elon Musk)
“So Let’s Buy Hundreds of Robots”

• What are the risks with automation?

• Strategies for success
Risks in Automation

• Risk: Unrealistic expectations; A robot is not a person
  • Tasks such as picking and assembly requires integration of part feeding, gripping and process
  • Easy for a person, lots of engineering for a robot

• Risk: Install a bunch of unique solutions (shotgun approach: here a robot, there a robot...)
  • Different mechanisms
  • Different GUI
  • Different Data Interface
  • Create a training and support nightmare in factory

• Risk: Scale up before workcells are mature, or staff is trained
  • Scrap hundreds of workcells
  • Destroy support for automation

• Risk: Design “Hard Automation” Stations
  • Process cannot be separated from robotics
  • No reuse of capital beyond product life
Rapid Deployment Automation

- Strategy to Scale up Automation Quickly
- Requires planning
- Requires company training
- Requires product engineering to cooperate
- Will take several years to fully deploy
  - Can start quickly with easy opportunities
RDA: Plan and Roadmap (multi-year)

- Identify Key Processes
- Pilot Line and Evaluation in existing facility
- Product or Package Design Based On Process Module Capability
- Part Packaging For Automation
- Develop Process Modules
- Automation Plan with schedule and metrics
- GUI and Data Interface Spec
- Financial Model
- Training company, suppliers and integrators
- Greenfield Automated Plant
RDA: Pick Key Processes, Prioritize

- Examples
  - Picking Assistant for Human Pickers
  - Final Packaging
  - Palletizing
  - Assembly
  - Test

- Picking Assistant is mostly factory routing software

- Test is mostly machine loading

- Order Picking and Assembly are much more difficult
  - Part feeding and grasping many different parts
  - For assembly, many different processes
    - E.g. screwdriving, dispensing, insertion,
  - May require design changes based on process capability
  - Higher tolerances
  - Higher speeds
  - Complex/custom grippers based on each part
RDA: Company Training

• Once a basic plan is developed start informing employees

• Get employee input to refine plan

• Explain rationale for automation and any impact to employees

• Explain new jobs that will be created to support automation

• Offer to retrain any displaced employees

• Explain timing of rollout; typically several years
RDA: Financial Model

• Keep it real simple

• Financial model for justifying automation
  • Separate robots and stands from product tooling
  • Minimum 3 year depreciation life for robots, product life for tooling
  • Use 1/3 of robot and stand cost and full tooling cost for one year life

• First pass yield improvement analysis
  • Adjust (reduce) automation cost by one year scrap savings
    • (Example: Product connector manual screwdriving damages 1 final assembly every 1 hour X 2 shifts = 16/day X 300 days is 1200 per year X $20 = $240K scrap/repair cost

• Compare adjusted automation cost to
  • 1 to 1.5 year cost of labor 2 shifts (typical) with 15% annual increase
  • Rule of thumb for automation cell in China in 2015 is $30,000 installed
RDA: Process Modules

• Concept of Process Modules
  Factory is a collection of Processes
  Prioritize Key Processes
  Automate these first with standard modules

• Process Module
  • Not only a robot, but complete process
  • Screwdriver Station
  • Dispensing Station
  • Mobile robot with gripper

• Develop Model of Process Module
  • Physical (eg CAD) model
    • Capability model, e.g. screw size, Cpk
  • Throughput model
  • Cost/financial model
  • Data interface model
    • Data necessary to drive process
    • Data desired to control process
  • Operator Interface Model

Process Module; Screwdriving

Process Module; Mobile Robot
Process Modules

- Screwdriver
- Dispensing
- Pick and Place
- Conveyor with Pop-up Pallets
RDA: Material Handling for Assembly Automation

• Consider factories like Intel fab: designed for material handling
  • OEMs should control design of factory and own equipment
  • Consider “copy exactly strategy”
  • Ability to relocate factories

• Start with Material Handling Strategy (Semi uses FOUP)
  • Standard packaging for all components
  • Typical is standard pallet with nests for parts
  • Stack pallets in tray elevators: eliminate all other packaging
  • Recycle pallets to vendors

• Example of poor packaging for automation:
  • Tablet frame stored in carton, in foam sleeve, with Mylar over paint
  • To remove: Cut open carton, remove foam sleeve, remove frame, remove mylar from paint, insert into assembly line
Relatively Easy Process Example (Large Software Content for Routing)

Amazon: 60,000

Fetch Robotics

6 River Robotics
Difficult Process Example: Order Picking

• Financial Justification
• Process Module: Mobile Picker with 3D vision
• Product/Process Redesign:
  • Structured Shelves with product stacked in rows
• Pilot Sites for learning and refinement
• Facility Training and modifications
Order Picking from Shelves

Amazon Picking Challenge ICRA 2015

“It was similar to the DARPA Robotics Challenge. “Like watching paint dry.” As a spectator, I spent most of my time watching robots do nothing. Large amounts of nothing. Occasionally nothing would be enlivened by an attempt to pick up nothing, or perhaps the shelf itself. Once or twice I saw a real pick get dropped.” (Article in The Verge)

In 2016, the winning speed (Delft) increased to 100 per hour, with failure rate of 17%
Humans pick 400 an hour with very few failures
RDA Approach: Structured Picking (IamRobotics)

- Product is stocked in rows
- Bar code under each row
- 3D vision senses depth
- Simple vacuum gripper to pick
Rapid Deployment Automation

GUI and Data Interface

• Data Model and Operator Interface
  • Without a automation plan and framework, vendors will deliver automation stations with completely different GUIs and data structures
  • This will make training and support a disaster
  • It may destroy automation efforts

• Should be thinking about standard GUI for automation stations
  • Keep as simple as possible
    • Build process knowledge into process module
    • GUI should involve
      • Calibrate, Start, Pause, Retry, Service options
    • Data input may be limited to model type to drive process
    • Data collection and analysis should probably be done offline by engineers
RDA: Product Design

• Product Design
  • Product Engineering must work with Manufacturing Engineering
  • This is a culture change
  • This is made easier by Process Module concept
    • Humans are very flexible and place very few constraints on design
    • With models of Process Modules, design engineers can understand factory capability easily
      • Example is machine tool; engineers design for its capabilities

• Example of present practice
  • Present product design of tablet frame
    • Screw access is obstructed by frame
    • Automation Supplier told “Impossible to change!”
    • Result is they spent a year on this project
      • Oblong EDM screwdriver chuck
      • Very expensive
      • Lots of problems and frustration
    • Should have changed design to accommodate screwdriver module
RDA: Flexible In-Line Processing

• Conveyors with “Pop-Up” Pallets
  • Allows flexible timing for operation
  • Other pallets can flow under Elevated Pallet
  • Need tracking of pallets

• Concept of “Clip-On” Robot
  • Attach robot to conveyor
  • All controls inside robot
  • Eliminate control cabinets, automation stands, safety screens, etc.
  • Cut floor space in half
  • Reduce cost to China target
RDA: Integrator Development

• Very few small part assembly automation integrators left
  • World wide capacity wiped out by low cost labor in China
  • Example MMI integration group (Singapore) went from 250 eng to 25

• Automation Strategy needs to include integrator development
  • Need to have a clear plan for what OEM wants from integrator
    • Process development?
    • Make first cell only, then other copy?
    • Make cells, install, and support at OEM or CM?
  • Key integrators need to understand this plan
  • New integrators need to be developed
  • Integrators NEED TO MAKE MONEY
    • Pay more if new process development and debug
    • Pay less to duplicate proven process
    • Help with cash flow
      • If lots of equipment needs to be purchased, make down payments to fund equipment
Rapid Deployment Automation: Summary

- Senior Management Needs to Develop Automation Plan
  - Automation should not be opportunistic and random
- Have a clear justification process for proposals
  - Allows quick decisions
- Strategy for operator interface and data management
  - Avoid chaos on the factory floor
- Part Feeding and Material Handling Strategy
- Develop Process Modules
- Close loop with Design Engineering
- Define a vendor/integrator strategy
  - Pick a few suppliers for long term relationship
  - Treat them well
- Develop Pilot Line for Evaluation and Learning, Then Scale Up
RDA: Roadmap

- Pilot Line and Evaluation in existing facility
- Product or Package Design Based On Process Module Capability

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For more information

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