The Job Shop Lean 2026 Conference

Proven solutions for ***every*** high-mix low-volume (HMLV) manufacturer

August 17, 2026

TIME	TOPIC
7:00 – 8:00 a.m.	• REGISTRATION • BREAKFAST

Welcome to the Conference

8:00 – 8:30 a.m.	(Shahrukh Irani) To Be or Not To Be a Job Shop?

Overview of this presentation: The numerous radical differences between an OEM like Toyota and any job shop are what separate Lean and Job Shop Lean. Each of Toyota's assembly facilities is a **low**-mix **high**-volume manufacturing facility. So, it only needs to be Focused ***and*** Efficient. In contrast, any job shop is a **high**-mix **low**-volume manufacturing facility. So, it needs to be Focused ***and*** Efficient ***and*** Flexible ***and*** Agile. What does any job shop have to do to achieve these four capabilities? This presentation will introduce .Job Shop Lean, a manufacturing strategy based upon the Principles of Lean, which helps any job shop to systematically scope all of its functions (business plans, operational capabilities, workforce skills, production planning and shop scheduling, supplier relationships, etc.) to be Focused ***and*** Efficient ***and*** Flexible ***and*** Agile.

Relevant Information for this Presentation:

1. (**Read_Me**) Principles of Lean
2. (**Listen_To_Me**) Why the Toyota Production System is Unsuitable for Job Shops
3. (**Listen_To_Me**) Overview of Lean Manufacturing
4. (**Listen_To_Me**) Essential Foundation for Job Shop Lean
5. (**Listen_To_Me**) Online Lectures on my YouTube Channel

Implementing Job Shop Lean in a Machine Shop

8:30 – 10:00 a.m.	(Ryan McAuley and Shahrukh Irani) Ongoing Implementation of Job Shop Lean at a US Navy Supplier

Overview of this presentation: This presentation will describe the details of (and lessons learned from) the implementation of Job Shop Lean at ODAT Machine. Being a US Navy supplier, ODAT Machine is easily and obviously a high-mix low-volume manufacturer that needs/wants to improve shop floor management, increase business profitability and eliminate the wastes that cause margin losses!

The implementation of Job Shop Lean at ODAT Machine began on 5/1/2026 with the first steps taken being:

1. Their VP of Operations answered all the questions in the JSLAT (Job Shop Lean Assessment Tool). His answers have helped to pin point (i) a single top-down strategic project (kaikaku) and (ii) many bottom-up improvement projects (kaizen).
2. The PFAST Analysis Report for the machine shop's product mix consisting of approximately 600 different P/Ns (Part Numbers) has been analyzed. The outputs have reinforced the conclusions drawn from the JSLAT.

The first site visit to ODAT Machine has been scheduled for the end of May 2026.

A tentative Plan Of Work for the visit has been submitted to the management of ODAT Machine. Based on insights gained from the JSLAT and outputs in the PFAST Analysis Report, the implementation of Job Shop Lean at ODAT Machine could be similar to a past project done at/for Superior Completion Services (**Read_Me**).

Relevant Information for this Presentation:

1. (**Listen_To_Me**) A Viable Approach to Cellular Manufacturing for High-Mix Low-Volume Manufacturers
2. (**Listen_To_Me**) Job Shop Lean: Lean in High-Mix Low-Volume Production

3. (**Read_Me**) 10 Lean Manufacturing Ideas for Job Shops
4. (**Read_Me**) In a Machine Shop, The Labor of Lean is Data-Driven
5. (**Read_Me**) The Job Shop Lean Guidebook for High-Mix Low-Volume (HMLV) Manufacturers

10:00 – 10:15 a.m.	• BREAK • NETWORKING

X's and O's Interactive Session

10:15 a.m. – Noon	(Shahrukh Irani) Assess the Current State of Your Job Shop Right Now!

Overview of this session: This session will allow each attendee to assess the Current State of their job shop using the Job Shop Lean Assessment Tool (JSLAT). The JSLAT is a questionnaire that consists of several sets of questions to assess the Current State of key aspects of a job shop's operations such as Product Mix, Factory Layout, Production Planning and Scheduling, Management Involvement, Employee Engagement, etc. Each question requires only a Yes/No response. The format of the session will be as follows: (1) A question will be announced, (2) Attendees will check either the Yes or No box for it on their copy of the JSLAT, (3) The ideal/desired answer (Yes or No) for that question will be provided with supporting justification and (4) If any member of the audience seeks further elaboration regarding that question, it will be provided **not just** by the speaker **but also by** knowledgeable members of the audience.

Relevant Information for this Presentation:

Is Job Shop Lean Right For You? (**Read_Me**) All that you need to get started is to download the JSLAT (Job Shop Lean Assessment Tool), complete it and return it to ShahrukhIrani1023@yahoo.com to get back a pro bono no-strings-attached (FREE!) diagnostic report within a week.

Noon – 1:00 p.m.	• LUNCH • NETWORKING

Keys to Successful Management and Growth of a Job Shop

1:00 – 1:30 p.m.	(Todd Chretien) From Mandate to Mindset: Leading a Data-Driven Lean Transformation in a CNC Job Shop

Overview of this presentation: Lean transformations in job shops often stall — not because the tools are wrong, but because leadership treats Lean as a delegated initiative rather than a personal responsibility. This presentation shares a firsthand account of leading a Job Shop Lean transformation in a high-mix CNC machine shop at Superior Completion Services, where success depended less on copying Toyota practices and more on sustained, data-driven leadership on the shop floor. Over an 18-month period, the presenter served as the visible Lean leader, working directly with machinists, supervisors, Industrial Engineering interns, and external advisors to redesign layouts, improve flow, and replace intuition-based decisions with objective labor and throughput data. Rather than pushing change from conference rooms, leadership engagement occurred at the point of work — this involved reviewing cell designs, validating assumptions against reality, and reinforcing why data-driven flow mattered to both employees and the business. Attendees will learn what leaders must *personally* do to make Job Shop Lean stick: how to build trust with experienced machinists, how to use labor data without weaponizing it, and how to sustain improvements in an environment where every job is different. Successful implementation of Job Shop Lean (or even Lean for that matter) in a real CNC job shop is never about the tools used to implement the change — it is about the leadership behaviors required to turn data into disciplined execution.

1:30 – 2:00 p.m.	(Jyot Bawa) Change Management in a Lower Mid-Market Aerospace and Defense Manufacturing Job Shop

Overview of this presentation: L. A. Gauge Company is a family-owned and led aerospace and defense manufacturer specializing in ultra-precision machining of exotic materials and electro-optics. The presenter, who is the President and co-owner of the company, will present a candid case study on how a family-owned and led job shop professionalized its management team. He will discuss leadership decisions, structural changes and cultural resistance encountered during a significant management transition. Additional topics of discussion are executive discipline, accountability and long-term strategic clarity that repositioned the company for scalable growth.

2:00 – 2:30 p.m.	(Ryan McAuley) Enabling Growth in a High-Mix, Low-Volume Precision Machine Shop

Overview of this presentation: This presentation will discuss how Job Shop Lean is enabling the growth of a high-mix, low-volume precision machine shop by having it utilize only one performance metric to drive all management decisions and actions --- THROUGHPUT. Specific examples of practices that we have implemented at ODAT Machine will be presented.

2:30 – 2:45 p.m.	• BREAK • NETWORKING
2:45 – 3:15 p.m.	(Lance Thrailkill) Leveraging AI and Automation to Maximize ROI on Capex Investments in a Custom Fabrication Shop

Overview of this presentation: This presentation will tell the story of All Metals Fabricating, a three-generation company with more than 70 years in business, and its evolution from a small sheet metal shop into a technology-forward custom fabrication operation. Grounded in the realities of a high-mix, low-volume job shop environment, the session will explore how the company has strategically leveraged AI and automation — not as buzzwords, but as practical tools — to drive growth, improve throughput, and maximize ROI on major equipment investments. The speaker, who is their current CEO, will show real-world applications including machine monitoring systems that expose hidden downtime, digital scheduling tools that replace tribal knowledge with data-driven prioritization, automated quoting platforms that compress lead times, and employee performance dashboards that align shop-floor execution with business objectives. Most importantly, the speaker will candidly share what worked, what failed, and what the next phase of digital transformation looks like — a grounded roadmap for job shops seeking to modernize without losing the craftsmanship and culture that built their success.

Relevant Information for this Presentation:

(**Read_Me**) 2026 Outlook: What We Expect for Our Shop and the Manufacturing Industry

3:15 – 3:45 p.m.	(Neville Divecha) Voices from the Shop Floor: A 360° View of a Machine Shop's Successful Partnership between the Top Floor and the Shop Floor

Overview of this presentation: This presentation examines how a machine shop improved manufacturability, reduced setup times, and strengthened on-time delivery by formally integrating shop-floor machinists into quoting, tooling strategy, and fixture design decisions. We will demonstrate how early operator input on tolerances, material behavior, work holding methods, and tool selection prevented costly rework, shortened first-article cycles, and improved real-world cycle times beyond what CAM simulations predicted. The presentation will highlight practical mechanisms — design-for-manufacturability reviews, standardized tooling libraries, modular fixturing, and structured feedback loops between programmers, engineers, and machinists — that turned tribal knowledge into institutional capability. Attendees will gain a repeatable framework for aligning engineering intent with machining reality in high-mix, low-volume environments.

3:45 – 4:15 p.m.	(Dan Oliver) Who Said Company Turnarounds Are Easy?

Overview of this presentation: This presentation will offer a raw and practical look at what it truly takes to restore performance, accountability, and momentum inside a manufacturing organization. Turning around a struggling operation is rarely neat, quick, or comfortable. In this candid presentation, the speaker shares the realities of rebuilding a manufacturing organization after making a difficult leadership change that had been delayed far too long. The journey that followed required cleaning house, hiring dozens of employees in a matter of months, establishing new operating standards across departments, sustaining thousands of hours of overtime, and implementing new software systems — all while keeping production running. The speaker will reflect on the hard lessons of leadership during a turnaround that this experience taught him --- the hidden cost of delaying tough decisions, the discipline required to rebuild a winning culture, the urgency of rebuilding teams quickly, and the necessity of pushing forward with operational improvements even in the middle of chaos.

X's and O's Interactive Session

4:15 – 4:45 p.m.	Should a Job Shop's Employees Be Trained and Developed Differently from an Assembly Line Worker at Toyota?

Overview of this session: This session will discuss an alternative employee training program that is different from all existing training programs such as TWI (Training Within Industry), Toyota Kata, Lean Six Sigma, etc. ***The proposed training program takes into consideration the operational conditions that exist in high-mix low-volume (HMLV) job shop-like manufacturing and service businesses!*** A job shop is not an assembly line. An employee who works in a job shop (naturally) does not work on an assembly line. A press brake operator in a custom fabrication shop who makes one each of 10 different products in a single shift on their machine possesses different skills compared to an assembly line worked who makes 100 pieces of the same product in a single shift at his/her work station. Job Shop Lean accepts the well-known (and undeniable) usefulness of the Lean tools used at/by an automotive OEM like Toyota in any job shop:

1. Some Lean tools like Value Stream Mapping simply do not work for job shops.
2. Some Lean tools like 5S and SMED will need to be adapted for job shops.

3. Some Lean tools like gemba walks, team huddles and company leadership engaging with employees will work for job shops.

So, what training should be imparted to job shop employees (possibly their executives and managers too) so they possess all four capabilities --- Focus, Efficiency, Flexibility ***and*** Agility? Is it realistic to expect that every job shop employee can become cross-trained enough to learn and master the skills, capabilities and tools to implement all four l capabilities --- Focus, Efficiency, Flexibility ***and*** Agility? This presentation will discuss a spectrum of "soft" thinking skills and "hard" problem-solving tools that will help employees do their work in work environments that (1) are complex, (2) routinely experience change and (3) must plan for uncertainty. Some examples of these skills and tools for job shop-type environments that involve high mix in many dimensions (product, tool, setup, work holding, skill requirement, etc.) are (1) Mind Mapping (instead of 5 Why and Fishbone Diagram), (2) Visualization of ***High*** Mix, (3) Flexible Standard Work, (4) Setup Reduction by Setup-dependent Sequencing, etc.

Relevant Information for this Presentation:

Please see Appendix 4 **Education, Training and Development of Job Shop Employees**.

4:45 – 5:00 p.m.	Q&A WITH SESSION SPEAKERS
5:00 p.m.	• ADJOURNMENT • NETWORKING

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Proven solutions for *every* high-mix low-volume (HMLV) manufacturer

August 18, 2026

TIME	TOPIC
7:00 – 8:00 a.m.	• BREAKFAST • NETWORKING
Employee-Centric Management	
8:00 – 8:30 a.m.	(Jyot Bawa) Running on EOS (Entrepreneurial Operating System) in an AS9100-certified Precision Machine Shop
Overview of this presentation: L. A. Gauge Company is a family-owned and led aerospace and defense manufacturing machine shop specializing in ultra-precision machining of exotic materials and electro-optics. The presenter, who is the President and co-owner of the company, will discuss (1) how the company uses EOS to support its AS9100 compliance and (2) how to resolve tensions between the two systems.	
8:30 – 9:00 a.m.	(Neville Divecha) Beyond the Blueprint: How Management and Employees Can ***Together*** Build a Culture of Continuous Improvement
Overview of this presentation: Most scrap, rework, expediting, and customer complaints in a job shop do not begin at the machine — they begin at the blueprint. When machinists repeatedly encounter ambiguous tolerances, missing datums, unstable revision control, and unrealistic surface finish or stack-up requirements, the question is not whether mistakes will occur, but whether the organization has built the trust and structure to surface those risks early. This session challenges CEOs and senior leaders to rethink "employee-centric management" as a competitive manufacturing strategy: empowering machinists to question prints, escalate manufacturability concerns, and participate in disciplined design-for-manufacturability reviews before chips are cut. Drawing on Covey's trust principles and Toyota's Respect for Humans philosophy, we will show how aligning authority with expertise on the shop floor reduces scrap, protects margins, improves first-pass yield, and converts blueprint chaos into institutional learning.	
9:00 – 9:30 a.m.	(Pelumi (Gladys) Alamu, Deepak Jacob, Gowtham Reddy, Naimah Tahmid) No Employee Left Behind: A Case Study on Improving a One-Person Welding Department in a Custom Pipe Fabrication Shop
Overview of this presentation: This presentation will describe (1) the interactions that a team of IE students had with Henry throughout their 1-semester project in INDE6378, (2) the ideas that they recommended to the management team of McWane Plant & Industrial Inc. (Houston, TX) and (3) the justification that they provided for each recommendation.	
9:30 – 10:00 a.m.	(Cory Daniel Parks) Culture Does Not Lead, It Follows: Making Employee-Centric Management Work in Discrete Manufacturing
Overview of this presentation: Employee-centric management works in discrete manufacturing, but only when the standard for performance comes first before culture. Culture follows ***from*** the standard for performance and not the other way around. In discrete manufacturing, there is a pendulum swinging between founder-centric management and employee-centric management. If management spends too much time at either extreme then their business pays for that incorrect over-investment of their time! The real tension is not about which approach to management is right, but how the owner of any SME (Small Manufacturing Enterprise) balances the pressure to produce with the need to retain the people doing the producing. This presentation will draw on the speaker's direct experience across both types of organizations to examine the genuine advantages that employee-centric management can deliver, the dynamics that quietly undermine it, and why company growth is the point where most cultures come apart. This presentation will teach concrete tools to any conference attendee seeking practical advice that they can apply immediately in their place of work.	
10:00 – 10:15 a.m.	• BREAK

	• NETWORKING
10:15 – 10:45 a.m.	(Ryan McAuley) Employee-Centric Management in an ESOP Manufacturing Environment
Overview of this presentation: This presentation will discuss how an ESOP structure can support employee involvement in operational improvements. Topics will include defining roles in workplace changes, incorporating employee input into workstation and layout decisions, and maintaining alignment with overall production flow. Examples from Howell Laboratories, Inc.'s Assembly Department will be referenced.	
10:45 – 11:15 a.m.	(Sultan Ahmed Mohammed) People First, Process Second: Leading Lean in High-Mix Low-Volume (HMLV) Manufacturing
Overview of this presentation: Custom pipe fabrication job shops operate with constant variability that demands that they use many other tools in addition to the standard Lean tools derived from the Toyota Production System. In this presentation, the speaker will share his experience leading the Lean transformation of a custom pipe fabrication facility in Houston, TX, *where with the same 15-person workforce*, they doubled monthly revenue earnings from $600, 000 per month to $1.2 million per month. He will explain how these stellar results were obtained by (1) using Value Network Mapping (an alternative to Value Stream Mapping) to plan the roadmap for improvement projects, (2) implementing technical improvements like re-layout of the factory into two focused factories and (3) people-centered leadership which was key to earning the trust of the 15-person work force. His success *clearly* demonstrates that an Industrial Engineer can drive meaningful operational change in high-mix, low-volume environments by combining technical rigor with the people skills essential to drive a cultural transformation.	
11:15 – 11:45 a.m.	(Pelumi (Gladys) Alamu, Deepak Jacob, Gowtham Reddy, Naimah Tahmid) Teaching the IE Tools for Job Shop Employees to ***Themselves*** Critique and Improve their Daily Work
Overview of this presentation: Whether you are already on the Continuous Improvement journey or you are just beginning to realize the power of implementing Continuous Improvement implementation, the Toast Kaizen training video (Link) is an essential learning tool for providing a simple and effective introduction to Continuous Improvement for the entire work force. This 27-minute video highlights the Seven Forms of Waste aka TIMWOOD (Link) found in the process of making toast and recommends the process of Kaizen (continuously but incrementally making improvements). Unfortunately, the Go See approach of eliminating waste is a whack-a-mole approach that lacks a data-driven, analysis-aided structure. **In stark contrast**, this presentation will describe an alternative to approach to CI using the Kaizen approach. This new approach systematically uses a slew of charts and data analyses utilized by Industrial Engineers to do Operations Analysis aka Methods Engineering. Examples of these charts that were generated ***using only the Toast Kaizen training video as input data*** are Flow Process Chart, Flow Diagram, Bi-Criterion Pareto Analysis, Impact vs. Effort Matrix, Man-Machine Gantt Chart and Project Network will be explained.	
Relevant Information for this Presentation: 1. (**Read Me**) Krafcik, John F. (1988, Fall). *Triumph of the Lean Production System*. Sloan Management Review, Volume 30, Number 1, 41-52. Quoting from this seminal publication "… An anecdote sheds some light on just how remarkable this shift in span of worker control can seem to a manager trained in the Fordist school, NUMMI, the GM-Toyota joint venture, is often used by General Motors to give employees an opportunity to see how the Toyota Production System (TPS) works. One GM IE (Industrial Engineering) manager, intent on discovering the real secret of the plant's superb productivity and quality record, asked a high-ranking NUMMI executive (actually a Toyota executive on loan to the joint venture) how many Industrial Engineers worked at NUMMI. The executive thought for a while and replied. "We have 2,100 team members working on the factory floor, therefore we have 2,100 Industrial Engineers." The GM IE manager could only walk away, shaking his head (because) his entire staff of Industrial Engineers would be largely redundant in a TPS plant …". 2. (**Read Me**) To the absolute contrary, if you are an SME that does high-mix low-volume manufacturing, then this article --- Heston, Tim. (2026, March). *Lean, Flexible, Profitable --- How a Pipe Fabricator Doubled Monthly Revenue*. The Fabricator, 54-56 --- will justify why it is most inadvisable to do what Toyota does. Instead, you ought to hire at least one full-time Industrial Engineer!	
11:45 a.m. – Noon	Q&A WITH SESSION SPEAKERS
Noon – 1:00 p.m.	• LUNCH • NETWORKING

Putting Job Shop Lean to Work at McWane Plant & Industrial Inc.

1:00 – 1:30 p.m.	(Henry Weissenborn) Establishing and Sustaining an Industry-University Partnership
Overview of this presentation: It took just an email from a Director of Operations to establish a thriving partnership between McWane Plant & Industrial Inc., Houston, TX, (MPI-HOUSTON) and the Department of Industrial & Systems Engineering at the University of Houston. The presentation will discuss how a Senior Manufacturing Engineer, IE interns working full-time on-site and student teams doing their industry projects in two courses --- INDE6378 and INDE6377 --- have made this partnership a success, despite the usual hiccups, glitches, doubts and questions.	
1:30 – 2:00 p.m.	(Darin Alley) Common Sense Keys to Effective Leadership
Overview of this presentation: The presentation will discuss core elements of a successful manufacturing strategy that is pursued in this order --- Grow Revenue ⇨Eliminate Waste ⇨ Respect and Reward Your Employees --- with guaranteed results.	
2:00 – 2:30 p.m.	(Sultan Ahmed Mohammed) A Complete Lean Transformation Playbook for Scaling Operations in a Custom Fabrication Shop
Overview of this presentation: This presentation will walk the audience through the speaker's journey of transforming a custom pipe fabrication shop to achieve revenue growth from $600,000 per month to between $ 1 million to $1.2 million per month over 16 months between 2024-2026. The changes implemented range from specific daily actions to the comprehensive re-design of the operational management of the facility. All the operational changes were implemented in a planned sequence, from the scheduling logic to the layout changes to the complete re-structuring of the entire manufacturing floor into two focused factories that each produced a different segment of the product mix. The presenter will share his reflections on (1) what worked as planned and (2) what did not work as planned. It is hoped that this presentation will provide each member of the audience a complete blueprint for sustaining revenue-driven improvements in their own high-mix low-volume (HMLV) manufacturing facility. Finally, it should be noted that all this work was done while navigating real-world obstacles and trade-offs in partnership with students and faculty from two departments at the University of Houston --- (1) Industrial & Systems Engineering and (2) Statistics and Data Science.	
2:30 – 2:45 p.m.	• BREAK • NETWORKING
2:45 – 4:30 p.m.	**[Continuation of Earlier Presentation]** A Complete Lean Transformation Playbook for Scaling Operations in a Custom Fabrication Shop
Overview of this presentation: N/A.	
4:30 – 5:00 p.m.	Q&A WITH SPEAKERS
5:00 p.m.	• ADJOURNMENT • NETWORKING

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August 19, 2026

TIME	TOPIC
7:00 – 8:00 a.m.	• BREAKFAST • NETWORKING
Software to Overcome the Operational Complexity of Job Shops	
8:00 – 8:30 a.m.	(Frederick Gertz) Practical Scheduling of Component Manufacturing and Final Assembly of a Truck Weighing Scale
Overview of this presentation: This presentation will demonstrate a practical approach to production scheduling in a vertically-integrated factory that produces a wide range of Truck Weighing Scales (**Example**). It will demonstrate how a Resource-Constrained Project Scheduling Problem (RCPSP) formulation can be used to model assembly operations, including shared resources and precedence relationships, to generate a feasible initial schedule. The approach uses swarm-based heuristic optimization to produce schedules that are practical to execute, despite incomplete data, real operating conditions on the factory floor and evolving shop floor constraints. The proposed approach has a "sandbox capability" to do what-if analyses to evaluate the impact of schedule changes on throughput, bottlenecks and overall schedule feasibility. This essential capability is achieved through rapid scenario iteration to support decision-making under uncertainty to allow a team to evaluate alternatives before making changes on the shop floor. If time permits, we will briefly discuss how this approach extends to other job shop problems that involve routing changes on the fly, sequencing with sequence-dependent setup changeover times and multi-stage scheduling.	
8:30 – 9:00 a.m.	(Moulydharan Vallal) Real-Time Scheduling of a High-Mix Batch Production Flow Shop
Overview of this presentation: *Part 1 of this presentation* will describe Kairos, a simulation-based scheduling and execution system built internally at Sila Nanotechnologies for a high-mix, constraint-heavy batch-processing flexible flow shop environment. Key topics that will be discussed include (i) why traditional ERP and MRP scheduling failed in this context, (ii) how we designed a heuristic simulation engine that re-optimizes the entire plant every 15 minutes, (iii) how the system integrates directly with plant operations and MES data, (iv) lessons learned from deployment and adoption in a live factory, and (v) a short live demonstration of the system. *Part 2 of this presentation* will focus specifically on how AI tools were used to design, prototype, test, and harden Kairos. The emphasis will not be on AI-driven scheduling logic but on AI as a software development accelerator. Key topics that will be discussed include how AI helped to (i) translate plant constraints into executable simulation code, (ii) generate test scenarios, (iii) validate edge cases and (iv) rapidly iterate on data integration with ERP and MES systems. Key topics that will be discussed include practical examples of moving from whiteboard logic to a production-ready scheduling engine in weeks rather than months, while maintaining deterministic and explainable decision logic. *Part 3 of this presentation* will focus on Kairos as a case study in architecting and implementing a plant-wide scheduling system from first principles. It was not built as an IT project but as an operations system designed by an Industrial Engineer embedded in the factory. The system architecture was shaped by end-to-end ownership of flow, costing, bottlenecks, WIP policies and maintenance constraints. Key topics that will be discussed include (i) how traditional requirements hand-offs often fail in complex manufacturing environments, (ii) how functional system builders bridge the gap between plant reality and software design and (iii) how change management was handled during deployment.	
9:00 – 9:30 a.m.	(Smart Khaewsukkho) Facilitating Shop Floor Management in a High-Variety High-Variability Job Shop
Overview of this presentation: Job shops deal with constant variability caused by rush orders, shared machines, shifting bottlenecks, unpredictable demand, changing product mix, etc. on a weekly, sometimes daily, basis. Traditional Lean tools may help identify to identify waste but, otherwise, they provide a static view (at best,	

snapshots) of a dynamic system. SGETTI is a simulation-powered Lean tool built for high-mix, low-volume manufacturing facilities, in particular, job shops. Using real time data pulled from the ERP, MES, MMS and other IT systems, it allows shops to model their operations and test improvement ideas virtually before making changes on the floor. With SGETTI, any HMLV (high-mix low-volume) manufacturer, including job shops, will be able to (i) Visualize actual production flow that occurred during any period of shop floor operations, (ii) Identify true system constraints, (iii) Compare improvement options and (iv) Estimate impact on lead time, WIP, and throughput. SGETTI has a simple goal --- to improve flow in any job shop with less risk and high predictability based on data that is being gathered continuously and fed to its machine learning algorithms and simulation models.	
9:30 – 10:00 a.m.	(Alexander Klimov) Do What Is Due
Overview of this presentation: Boeing's philosophy for supply chain, from the VP level up, is four words: *Do What Is Due*. Not what is staged in front of a machine, not what is convenient, not what the operator already knows how to run but *what is due*. It sounds simple until a machine goes down at 6 a.m., the material did not arrive at the scheduled start time, two jobs are fighting for the same work center, and the schedule built on Sunday evening is already a fiction by Tuesday morning. This is not the exception in a job shop — it is the daily operating environment! And it is exactly the environment in which most scheduling approaches fail, because they were designed for planning but not for recovery. This presentation proposes treating the schedule not as a plan that gets printed and ignored but as a live commitment that gets fulfilled every day in real time, despite the vagaries of actual shop floor conditions. Using data drawn directly from ERP and MES, this case study will examine how a high-mix low-volume manufacturer can assess whether a production day is recoverable before it collapses, identify where the system is truly constrained, re-prioritize work without creating new disruptions downstream, and align every machine, labor, and material movement decision to one question: Is this what is due? This presentation is a real case study — real weeks, real disruptions, real recovery decisions — from a job shop operating under this discipline for a demanding OEM customer. No theoretical model! No software pitch! Just one shop that decided to take four words seriously --- Do What Is Due --- and did what that actually required them to do on their shop floor.	
10:00 – 10:15 a.m.	• BREAK • NETWORKING
10:15 – 10:45 a.m.	(Amir Ben-Assa) Recovery Plan in Seconds: How AI Scheduling Handles Real-life Disruptions in an HMLV (High-Mix Low-Volume) Injection Molding Shop
Overview of this presentation: Manufacturing schedules rarely unfold exactly as planned. Machine failures, material delays, urgent orders, workforce constraints, and quality issues constantly disrupt production flow. This presentation will provide explore the shift from reactive to proactive production planning using AI-powered scheduling. Through a real-life customer case study of an automotive and industrial component manufacturer, the presentation will demonstrate how planners can quickly test alternative scenarios such as reallocating machines and adjusting priorities, to create a recovery plan that is automatically distributed to the factory floor, ensuring on-time delivery. The presentation will provide a practical view of how AI and simulation-driven planning help manufacturers respond to disruptions and plan for the future with data-driven decisions rather than guesswork.	
10:45 – 11:15 a.m.	(Alex Huckstepp and Abhinav Goyal) CNC Machine Shops Can Win More Work with Short Response Times Achieved by Automating 90% of the Quotation Process
Overview of this presentation: In the case of urgent projects, today's buyers of CNC parts expect same-day quotes and usually go with the first reasonable one they get back. The presentation will feature a live demo of **Uptool** using a previously unseen RFQ package obtained from Dimensional Machine Works, a local machine shop in Houston, TX. Uptool leverages AI to automate 90% of the steps in the quoting process by integrating with the email inboxes of its machine shop clients. It automatically detects new RFQ's or updates existing, RFQ's and extracts data from these files in order to track and estimate each process step. Most shops using this quoting tool have seen the time to quote any part reduce from 15-20 minutes to less than 2 minutes, resulting in a higher win rate from their customers. With this platform, a machine shop gets automated, real-time RFQ creation and tracking right out of the box!	
11:15 a.m. – Noon	(Frederick Gertz, Alex Huckstepp, Shahrukh Irani, Sindhu Kandala, Ryan McAuley, Sultan Ahmed Mohammed and Cathy Poliak) "Digital Gemba Walks" --- Examples of Operational Decisions Driven by Analysis of Data in IT Systems Used by HMLV Manufacturers
Overview of this presentation: A *gemba walk* is a lean management practice where leaders visit the "real place" of work (gemba) to observe processes firsthand, identify inefficiencies and build relationships with frontline employees. Its primary purpose is to understand the reality of operations rather than relying on reports to enable continuous improvement (*kaizen*) and waste reduction (**Read_Me**). However, there is a (physical) gemba which is the factory floor and a (virtual) gemba which is the suite of IT systems such as ERP (Enterprise Resource Planning),	

FCS (Finite Capacity Scheduling System), MMS (Machine Monitoring System), MES (Manufacturing Execution System), QMS (Quality Management System), QES (Quoting & Estimation System), etc. If one remembers Dr. Deming's quote, "In God we trust, all others must bring data"? So, a ***digital gemba walk*** is the application of Data Science, Machine Learning and Operations Research techniques to "mine the data" that is resident in these IT systems that almost every HMLV manufacturer is bound to be using today. Each of these presentations presents an example of data-driven decisions in different HMLV manufacturing facilities. Examples of data-driven decisions (or policies) that are based on detailed analysis of data in one or more IT systems are:

1. It has been known since the early 1960's that a job shop's complexity can be significantly reduced if decisions are made after analyzing its product mix to determine part families, A part family is a group of parts with similar design, manufacturing and other attributes. This presentation will describe how to group the parts in a CNC machine shop's portfolio into part families based on (1) common machines in their routings and (2) similar sequence of machines in the routings.
2. When one custom pipe fabrication facility implemented Job Shop Lean to shorten lead times and increase machine utilization, especially on its bottleneck work centers, it was able to grow revenues by accepting work from ***other*** sister shops owned by McWane Plant & Industrial Inc. However, this shop was selective when it came to accepting or declining orders received from the other shops who were using it as an Outside Vendor. This presentation will describe how orders were selected/rejected using a revenue maximization model that used statistical analysis techniques to analyze past sales (and profit) data.
3. Do Machines Matter More than the Entire Machine Shop? Never! Therefore, instead of OEE (Overall Equipment Effectiveness), anew metric--- OFE (Overall Flow Effectiveness) --- helps to measure the performance of an entire machine shop. OEE measures the productivity of this machine or that machine; in contrast, OFE measures the productivity of the entire machine shop. This presentation will describe (i) how Discounted Cash Flow Analysis, Activity Based Costing, Little's Law and TOC (Theory Of Constraints) have been incorporated in the development of this proposed metric and (ii) lessons learned from its implementation in a machine shop.

Noon – 1:00 p.m.	• LUNCH • NETWORKING

X's and O's Interactive Session

1:00 – 2:30 p.m.	(Shahrukh Irani) Shall We (including Digital Dr. Irani) Crowd Solve Your Job Shop's Challenges?

Overview of this session: This session will have the format of a random lottery. Every member of the audience will write any one challenge that his/her job shop is facing on a Post It note ("chit"), fold it and drop it into a bucket. Once I have collected the chits from interested members of the audience, I will run my hand through the bucket, pick one chit and announce the challenge written on it. That will be the signal for the rest of us to offer helpful ideas, share experiences, give condolences, etc. Hopefully, the individual who submitted that challenge will walk away with an Aha! or two about what he/she could do once they get back to work. Then I will read out the next challenge and the next challenge…. this process will continue until we run out of time.

Relevant Information for this Presentation:

1. Please see Appendix 2 **Challenges Faced by Any Job Shop and Suggestions to Address the Challenges**.
2. Please see Appendix 3 **Debunking Myths about Running a High-Performance Job Shop**.

2:30 – 2:45 p.m.	• BREAK • NETWORKING

X's and O's Interactive Session

2:45 – 4:30 p.m.	(Shahrukh Irani) Do You Seek "Starter Advice" to Implement Job Shop Lean?

Overview of this session: This session will be a Q&A session with an open forum format. If any member of the audience would like to bounce their ideas about implementing Job Shop Lean in their facility when they return to work, this is the moment when they can get free advice from the rest of us. So step right up to the podium and share you plan with us. You are in the company of peers, experts and well-wishers whose only desire is to help you to successfully implement Job Shop Lean --- or whatever practice will benefit both your company's bottom line and top line.

4:30 - 5:00 p.m.	• CONFERENCE EVALUATIONS • TEARFUL FAREWELLS • ADJOURNMENT

Appendix 1

Will You Benefit By Attending This Conference?

Please answer the following questions to indicate the severity of each of the challenges of high-mix low-volume (HMLV) manufacturing that are listed below:

Our product mix widens every year but we do not rationalize it using Value Analysis.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

Our Work-In-Process and Finished Goods Inventory is a significant %age of Annual $ales.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

Our Time To Ship (TTS) for any order is high.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

Setup Times and Cycle Times in our routers are inaccurate.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

Vendor lead times are high, their deliveries are unpredictable and quality rejects are common.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

Our factory layout is not organized into work cells such that each cell produces a product family.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

Our factory could not handle changes in product mix and/or production volumes.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

We have no formal program to reduce setup times on bottleneck equipment.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

We use the daily production schedule from our ERP (Enterprise Resource Planning) system.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

Factory logistics finds it difficult to coordinate the timely delivery of kits of parts for assembly.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

Our on-floor tracking and control of tooling, inventory, consumables, dies/molds, etc. is poor.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

We do not track and display key metrics on factory performance on the factory floor.
☐ **Major Problem** ☐ **Minor Problem** ☐ **No Problem**

Appendix 2

Challenges Faced by Any Job Shop and Suggestions to Address the Challenges

Challenge	Suggestions to Address the Challenge
Our shop owner(s) do not walk their talk which makes our morning huddles a waste of our time!	1. Gemba Walks? Stand on the X? Obeyas? Morning Huddles? – all these "Lean tools" may be necessary but are far from sufficient. 2. Instead, if you can identify part families in your product mix **AND** you implement a cell to produce each part family, then on any given day you need to go to that areas in the shop where a cell is located and get a run down about their problems, their improvement ideas, their morale, their manpower needs, etc.
How to offset increase in material costs and lead times due to tariffs?	1. Partner with local competitors (or even non-competitors) to do bulk buys of key RMs to get quantity discounts to offset material costs? 2. Switch from Minimum Quantity purchasing by SKUs to Minimum $ purchasing regardless of SKUs?
AI: How Does a Job Shop Get Value From It?	I will defer to members of the audience take the lead on solving this challenge.
What to do about fluctuating demand?	1. You sleep in the bed you make! ☹ There is no question that being a Make To Order manufacturer (as does any job shop) is hard compared to being a Make To Stock manufacturer (as does Toyota). Frankly, the best job shop is no job shop! 2. When you buy (or get) the RM only after the order has been signed off with the customer, and that RM is coming in from China …..? 3. **My Solution?** Segment the product mix into Runners, Repeater and Strangers --- Produce the Runners + Repeaters in one shop and produce the Strangers in a "C-Cell" --- In the shop that produces the Runner and Repeaters, implement cells to the maximum extent possible (even if you have to revise your product mix along the way)! 4. Cull the Strangers from the product mix? 5. Find any part families in that segment then go seek out markets to move them into the other two segments? 6. Partner with a local mom-and-pop shop to be an extension of your shop?
How does one cash in on the re-shoring that is ongoing?	I will defer to members of the audience take the lead on solving this challenge
How do we tackle the shortage of skilled labor?	1. Are you sure that you have one? If you could, please record and share with me the video of your bottleneck machine (or department) in operation for an entire shift. Be sure to have the clock display time on the video! 2. **My Solution?** Segment the product mix into Runners, Repeater and Strangers --- Produce the Runners + Repeaters in one shop and produce the Strangers in a "C-Cell" --- In the shop that produces the Runner and Repeaters, implement cells to the maximum extent possible (even if you have to revise your product mix along the way to throw out the outliers)! 3. Cross train the operators in the cell so that multi-machine tending by the same operator becomes possible

	4. **My Humble Request?** Please do not fire employees as the first step to respond to lost sales, low sales, customers switching to competitors, etc. For each employee that you wish to fire, please consider cross-training them and repurposing them to fill a role (or roles) that are currently vacant.
Can a small shop retain employees by training and developing them …. or is that a sure way to lose them?	I will defer to members of the audience take the lead on solving this challenge
How does one tackled issues like work ethics, honesty, safety, mutual respect-without-boundaries, etc.?	I will defer to members of the audience take the lead on solving this challenge
Can a job shop justify a full-time Industrial Engineer?	1. I urge you to partner with academic department at a local university 2. If time permits, please meet with these speakers at the conference --- Abhinav Goyal and/or (Henry Weissenborn, Darin Alley and Sultan Ahmed Mohammed) .
Growth Planning: What are the pros and cons of (1) diversifying into new markets, (2) acquiring businesses, expanding the current facility or moving into another (bigger) facility, etc.?	1. How sure are you that you have all your ducks in a row in the shop that you are currently managing? 2. I believe firmly in the growing using knowledge of your part families to have "flexible focus" i.e. do not be reliant on one market, one customer, etc. but also not think that flexibility can be achieved with a snap of the fingers. 3. "Goodness of fit", even when you are going to buy out and absorb another business into your existing facility must take into consideration re-layout of the factory, merging of different shop cultures (and leadership styles), integrating ERP, QMS, MES and other IT systems, etc. 4. Now I would like to throw a helpline to the audience.
Can a small manufacturer form partnerships with suppliers in order to get better customer service (shorter lead times, less uncertainty about delivery dates, better quality, etc.)?	1. Co-Opetition? 2. Virtual OEM?
Is machine utilization an important metric? Or should capacity "win back" using the POOGI advocated by TOC practitioners be the priority?	1. OEE is a SH**metric --- my argument against (A*P*Q) in favor of (A+P+Q) to determine available capacity on any machine. Also, please read ***The Goal*** (because TOC offers the right advice on Machine Utilization). 2. What about OLE (Overall Labor Effectiveness) as a metric? 3. Do a time study of the video of at least a shift of uninterrupted operation of your bottleneck machine(s) ex. a welder because he/she is adding value to a product **if and only if** the arc on the welding gun is on (which is proof that welding is in-process). 4. Right-sized machines 5. Minimize machine sharing between cells by exploring the market for used machines (instead of buying new)
Production Planning and Control … uh, what is that?	1. Do **not** let your ERP do it for you! 2. Check out the better Finite Capacity Scheduling systems on the market to see if they do Demand Management. 3. Dr. Prasad Velaga has a valid claim --- in principle, a Finite Capacity Scheduler could be used for order slotting subject to resource constraints for each week of a 4-week rolling horizon. In principle, Schedlyzer can do dual resource-constrained JSS (Job Shop Scheduling) at both levels --- Master Production Schedule and Work Order Release (which is more challenging to implement successfully).

Can a job shop ever have a reliable schedule to work with every day (or at least for a week) – Part 1 of 2?	1. A job shop is not an assembly line. So please be warned if your favorite Toyota-trained Lean consultant recommends that you use "Pull Scheduling" which, in turn, requires you to use heijunka, part-specific kanbans, part-specific inventory buffers, etc.! 2. **However**, it may be possible to use this scheduling approach for a portion of your product mix if you have LTA (Long Term Agreements) from customers to produce those parts.
Can a job shop ever have a reliable schedule to work with every day (or at least for a week) – Part 2 of 2?	1. A schedule is only as good as the effectiveness of shop floor execution ex. Do you have an MES bolted onto your FCS? Are your material handlers trained to be "water spiders"? … and more 2. Beware of (i) "schedule nervousness" and (ii) indirect costs of updating shop floor status and feeding that data into the FCS so it can re-generate yet another schedule --- I urge initial focus on eliminating avoidable disruptions to the daily schedule
Are we using the correct metrics to measure the performance of our shop, our machines, our people, our suppliers, etc.?	1. There are Metrics and then there are SH**Metrics. 2. Cash Flow Velocity is a (valid) metric. 3. Total #of Pieces Shipped Per Day is a valid Sh**metric.
Overtime: Should it be an entitlement or an incentive (maybe even a reward) for good performance?	1. I am of the firm belief that O/T is not an entitlement. Instead, it should be a reward and selectively paid to employees depending on whether they are working in the Bottleneck department or any non-bottleneck department too.
To make or not to make this d##n part?	1. Unplanned proliferation of product mix is easily an example of self-increased complexity of a job shop's already high product mix. 2. I could provide (if requested by the individual) relevant literature that explains how to use Machine Learning (or Advanced Lean Six Sigma methods) to approach this problem with a data-driven decision-making mindset. 3. If time permits, please meet with this speaker at the conference --- Sultan Ahmed Mohammed --- as he is using a predictive analytics tool that you could adopt/adapt/reject as the case may turn out to be.
Are we pricing our jobs correctly (or incorrectly …. and therefore are losing money)?	1. This is a highly erroneous ill-informed statement "Estimating is not an exact science and the variation in demand makes accurate estimating difficult". I say this because Sultan Ahmed Mohammed is using a data-driven predictive analytics tool that was developed by a team of students from the Department of Statistics and Data Science at the University of Houston. 2. Especially today when Machine Learning algorithms are freely available online, I will humbly (but honestly) advise you that you should use either (or both) the Variant and Generative AI approaches that can work with mixed data. 3. If time permits, please meet with the team that is developing the GTS2021 app that was introduced during this session "**Apps to Simplify the Operational Challenges of Job Shops**" earlier in the conference.
How good is that Quoting and Estimating software?	I will defer to members of the audience take the lead on solving this challenge. Especially, if there are users of apps that do Quoting and Estimating such as Paperless Parts, Swarf and UpTool, then there is even more reason to do so.

Appendix 3

Debunking Myths about Running a High-Performance Job Shop

Myth	Reason(s) for Debunking the Myth
Cells do not work in job shops because (1) their product mix is diverse, (2) their product mix keeps changing (often frequently) and (2) the demand for the different products is volatile.	Since the 1960's, cells have been successfully implemented in a variety of high-mix low-volume job shop-like manufacturing facilities.
Heijunka is an effective method for Master Production Scheduling.	The underlying assumptions of this approach do not match the typical operational environment of any job shop. A job shop only commits to produce an order when the customer accepts price and due date (else a Make-To-Stock policy is ill-advised for any job shop)
Pull Scheduling using a kanban system works in any job shop.	Yes but for only those P/Ns in the product mix that are Runners (maybe even Strangers) with an LTA (Long Term Agreement) with their customers. Otherwise, if time buffers are preferable in job shops, it is a bigger challenge to have kanban sizes measured in hours of work on any machine (instead of # of units of product).
Master Production Scheduling (MPS) as done by any ERP on the market slots orders subject to delivery dates and resource capacity constraints.	I do not know of any ERP that has the capabilities of a genuine FCS (Finite Capacity Scheduler) like OpCenter to do this. The standard approach used by any ERP is to slot orders in the production schedule using the age-old proven-to-be-totally-wrong approach of backward scheduling from due dates using fixed Lead Times.
Work centers need not be sub-divided into smaller groups of machines with identical/interchangeable capabilities.	Here is the consequence (if you think that Operator Motion waste cannot be ignored), the supervisor of each work center makes a real-time decision to load a job on the earliest available machine using FIFO priority dispatching.
CONWIP is an effective method for Production Planning, Work Order Release and Job Shop Scheduling.	The underlying assumptions of CONWIP do not align with those of a job shop. Also, I have not come across well-documented success stories in the open literature.
Drum-Buffer-Rope is an effective method for Production Planning, Work Order Release and Job Shop Scheduling.	Drum-Buffer-Rope is an effective method for Production Planning, Work Order Release and Job Shop Scheduling.
If we are not making chips, we are not making money.	**First**, you are not making money if you are making chips on the non-bottleneck machine(s) in the shop. Every job shop owner ought to read (and understand) what Eliyahu Goldratt teaches in his book (and video) *The Goal*. **Next**, despite making a humongous amount of chips on the metal cutting machines in a shop, those gains could be nullified by the non-machining work centers like the Parts Washing Station or Inspection department, not to mention the high lead times (say 1-2 weeks) of your Outside Vendors (heat treatment, electroplating, thread grinding. etc.). **Finally**, what good does it do "to hurry up to slow down" when the functional/departmental layout is guaranteed to create a batch-and-queue mode of production which embeds the costs and delays of waste (TIMWOODS) in each and every order that you produce?
To implement Lean in a job shop, start with 5S.	It is foolhardy to undertake 5S as a goal unto itself. Instead, it should be undertaken with the intention to facilitate the implementation of more meaningful "higher level" projects such as Facility Layout, Shop Floor Communications, Inventory Control, etc.

We do not need a Finite Capacity Scheduler to schedule our shop. Instead, our scheduler has her spreadsheets and our ERP system. We have a morning huddle, and if need be, an afternoon huddle in our obeya on the shop floor. Our team communicates all the time to keep our orders on track.	Firefighting and expediting has been in use since the 1900s. If that is substitute for rejecting the time, effort and resources to objectively evaluate the pros and cons of integrating an FCS with the ERP …. I concede that I cannot win this argument with any job shop owner who thinks this way!
We are a data-driven shop. We have a machine monitoring system with TV monitors all over the shop displaying a range of operational metrics for all our machines such as OEE, production rates, scrap rates, etc.	A machine monitoring system presents only the "machines side" of the shop. What about the "parts side" of the shop? If being data-driven means to base planning and execution on junk metrics like the OEE of individual machines. I do not know of any job shop owner who seeks to impress their customers by boasting about their machine utilization and/or machine uptime. Instead, I think it makes more sense to track (and display) the progress of every active job on the floor to ensure on-time shipment by customer-specified due date. In particular, similar to have an andon works on a Toyota assembly line, the operators log problems/issues that they fixed (or were unable to fix) as the order flowed through the shop.
To implement Lean in a job shop, develop a Value Stream Map for one of the high-volume P/N's in the product mix.	And ignore the remainder of the product mix which typically consists of three segments --- Runners, Repeaters and Strangers?
A job shop, even one that does about $10-$15 million in sales per year, cannot afford to hire a full-time Industrial Engineer.	Please feel free to listen to the speakers in the afternoon session of this workshop --- **Darin Alley**, **Henry Weissenborn** and **Sultan Ahmed Mohammed**.
A job shop does not need to have a Finite Capacity Scheduler (FCS) as a front end to its ERP in order to generate viable production schedules subject to machine, labor, material, tooling, etc. constraints.	The case studies published on the website of FCS vendors like OpCenter, Tactic, PlanetTogether, Schedlyzer, Plataine, etc. will easily debunk this myth.
A job shop should focus on all-out shop wide elimination of the Eight Forms of Waste (TIMWOODS).	I believe that *Waste Elimination* is not the primary objective of any business! Instead, I contend that the Seven Forms of Waste are (1) symptoms and (2) quantifiable measure for the delays (and costs) of fulfilling every order placed by every customer. **IMHO**, I believe that *Lead Time Reduction* is the primary objective of any business! The reason is that a detailed timeline of all activities performed to fulfill an order constitutes the Lead Time for that order (and the individual costs that constitute the overall Fulfillment Cost for that order). And the easiest **and** simplest way to do this is to NOT do what we ought not to do at all in the first place --- NVA activities --- because every NVA activity equates to (1) a delivery delay added to the Lead Time, (2) an additional cost added to the Order Fulfillment Cost and, worst of all, (3) a potential loss of goodwill (and possibly business too) if the customer receives defective product(s) that need rework or, in the worst case, have to be scrapped!
We are a machine shop. We are in the business of selling capacity not products.	**First**, the product mix of any job shop contains Runners Repeaters and Strangers. So, depending on whether it was used to produce a P/N in one of those three typical segments in any job shop's product mix, a machine hour (and labor hour associated with that machine hour) is not going to earn the same Revenue (and Margin) for the shop. **Next**, which machine's capacity are you selling --- capacity on a bottleneck machine (or machines) or the (remaining) non-bottleneck machines? If any job shop owner has not yet read (and understood) what Eliyahu Goldratt teaches in his book (and video) *The Goal*, please do so (because it is a waste of capacity and hard-

	earned money to maximize utilization on the non-bottleneck machines in any job shop. **Finally**, if a job shop owner values his/her employees' talent and loyalty, would they not show off to customers the variety of complex P/Ns that are produced instead of photos of their expensive machines? A job shop must focus on selling CAPABILITY (not CAPACITY) to its customers.
It is the strategy of a job shop to convert all raw material for an order into finished parts. These extra parts can be sold at the higher small quantity price in the future. **Source:** Nathan Cline	Maybe if there is an LTA (Long Term Agreement) with a kanban system with minimum buy quantities on every pull, then I would agree? Otherwise, I know of cases where the job shop had to write off those parts at the end of the year for any number of reasons given to them by their customers. In that case, those parts (1) wasted bar stock (or forgings or casting or plate) that could have been used to produce parts if-and-when needed, (2) ate up machine and labor capacity that could have been used to produce other firm orders, (3) incurred inventory carrying costs, (4) (possibly) incurred tooling costs, etc. *On a somewhat unrelated note*, I worked with a "plastics produces manufacturer in Ohio" who would charge their customer top dollar to build a prototype for a new product that they wanted to introduce to the market. The price included all the above costs/losses that were listed earlier. Despite that marked-up price, the customer went with them because this supplier of theirs was their top-of-the-line supplier.
We do not need for the router for any order to show specific machines used for each operation in the router. We only specify the work center for that operation then let the supervisor on the floor take a real-time decision to load that order on a particular machine. Alternatively, if our client has purchased our MES, it will automatically route the order to the earliest available machine in the work center. **Source:** Prasad Velaga	An MES cannot (and never will) schedule because it needs an FCS (Finite Capacity Scheduler) sitting between it and the ERP system to perform that step. Job Shop Scheduling with dual resource (machine and labor) constraints is not an easy problem to solve. And even if it is solved on a computer using heuristic algorithms (today AI is claimed to be capable of doing that --- yeah right!), there is no telling that once the schedule hits the shop floor that it will not suffer from multiple disruptions due to any number of unanticipated and unplanned events. Ideally, per my experience, an FCS has "to sit between" an ERP and MES!

Appendix 4

Education, Training and Development of Job Shop Employees

Trade-related Skills[1]	**Employee**	**Supervisor**	**Engineer**	**Manager**	**Executive**
Trade-related skills like machining, welding, sheet metal fabrication, PCB assembly, etc.					
Soft Skills	**Employee**	**Supervisor**	**Engineer**	**Manager**	**Executive**
Conflict Resolution					
Teamwork: Leading versus Following					
Servant Leadership versus God Complex					
How can we learn what it takes to be flexible, agile and adaptable from: 1. ER personnel[2] 2. Firefighters[3] 3. Police who report to the site of a major traffic accident[4] 4. Detectives[5]					
Mentoring & Coaching					
Creativity⇔Ideation					
Morning Huddle Management					

[1] This training is best entrusted to Houston City College, trade schools, professional organizations such as NTMA and, best of all, the manufacturers themselves ex. a group of non-competing companies could team up and share the time, effort and money to develop a curriculum, host classes at each member company, oversee the updating and advancement of the curriculum as needed, etc.

[2] ER personnel possess key problem-solving traits including rapid assessment (triage) skills, critical thinking under high pressure, and the ability to multitask effectively in chaotic environments. They are decisive, observant, and adaptable team players who can quickly prioritize care to solve urgent patient health.

[3] Firefighters possess critical problem-solving traits centered on rapid decision-making, high-stress adaptability, and resourceful thinking. Key traits include situational awareness, critical thinking under pressure, adaptability to changing environments, and strong teamwork. They excel at identifying patterns, implementing tactical, creative solutions, and maintaining composure to ensure safety.

[4] Police at a traffic accident utilize problem-solving traits focused on rapid scene stabilization, methodical evidence gathering, and quick decision-making. Key traits include adaptability in securing dangerous scenes, analytical skills for accident reconstruction, communication for interviewing witnesses, and calm under pressure to prioritize medical aid and traffic flow.

[5] Detectives possess a combination of analytical and interpersonal traits, characterized by critical thinking, intense attention to detail, and tireless tenacity to solve complex problems. They use deductive and inductive reasoning to connect scattered information, often relying on curiosity and lateral thinking to uncover patterns or motives others miss.

Basic Problem-Solving	Employee	Supervisor	Engineer	Manager	Executive
Waste Identification					
Discussing a Problem using a Why? Mind Map[6]					
Solving a Problem using a How? Mind Map					
Work Cell Design • Layout Design • Space Requirements Planning • 5S & Visual Management • Systematic Handling Analysis (SHA) • Shop Floor Communications and Logistics using a Water Spider					
Quality-At-Source • 8D Problem-Solving • Seven Quality Tools • Error-Proofing					
Workplace (and Workstation) Ergonomics • Human Factors Engineering • Safety Engineering • Worker Injury Risk Assessment using www.Tumeke.io • HERCA (Human Error Root Cause Analysis)					
Setup Reduction					
Respect for Equipment • TPM 101 for machines (because there is a Maintenance department also) • Maintaining shared tools (especially in a multi-shift factory) • Shadow boards for storing fixtures, tools, gauges, etc. • Workspace Layout • Karakuri					
Inventory Management • Measuring Workload Variation for a Bottleneck Machine (or Cell/Line) • Quantity-based Kanbans versus Workload-based Kanbans • Visual Management of In-Queue and Out-Queue at any machine (or entire cell/line) • WIP Control • (s, S) inventory model for 2-bin kanban system • Replenishment Signals (flags, lights, walkie-talkies, pick ticket for water spider, etc.) • SRIGHT (**S**mart and **RIGHT**-sized) racks, containers, shelves, bins, etc.					
Project Reporting • A3 Report • SQDC Whiteboard • Metrics[7] versus Sh**metrics[8]					
Advanced Problem-Solving	**Employee**	**Supervisor**	**Engineer**	**Manager**	**Executive**
Employee Training for Flexibility, Agility and Adaptability					

[6] I use the Mind Map to integrate these Lean Six Sigma Tools --- 5 Why's, Fishbone Diagram, Tree Diagram
[7] Cash Flow Velocity, Revenue versus COGS, etc.
[8] Efficiency, Productivity, Machine Utilization, Labor Utilization, WIP is an ASSet, etc.

• What can we learn from Multi-Tasking Machines, Hybrid Machines and Flexible Machining Cells? • Skill Matrix for Multi-Skilling/Cross-Training (Example)					

SMART CHART: Enabling An Employee (or Team of Employees) Self-Improve their Work
• Flow Process Chart
  • Macro Work Analysis using ASME Activity Symbols
  • Micro Work Analysis using Therbligs
  • 5W1H Questioning Process
  • ECRSSA Thinking Process
  • Methods Analysis using Motion Analysis
  • Parallelization of Sequential Work using RCPSP
• Capture and feeding of legitimate "tribal knowledge" and other curated literature to train an LLM to be a reliable AI Teacherbot					

Visualization-aided Analysis, Rationalization and Simplification of High Mix Work Systems • Using a Decision Tree • Flexible Standard Work Instruction for a Part Family • Using a Flow Chart • Using a Group Technology Classification and Coding System • Using a Product-Process Matrix • Using Multivariate Statistical Analysis and Data Science • Using a Multi-Product Flow Process Chart • Using a Multi-Product Flow Diagram • Using a From-To Chart • Using a Gantt Chart • Using a Value Network Map					
Variety Reduction and Standardization • Using a Group Technology Classification and Coding System • Using Multivariate Statistics (and Machine Learning) and Data Science					
Design of a HMLV Job Shop-type Cell • See lecture notes for INDE6378 • See lecture notes for INDE6377					

Measuring and Exploiting Capacity Utilization on Bottleneck Machine
• TOC's Process of Ongoing Improvement (POOGI)
• [Video] The Goal
  • Q&A
• Scheduling 101 using LEKIN
  • Single Machine
  • Flow Shop
  • Job Shop
• Drum-Buffer-Rope versus Schedlyzer Lite
• Man-Machine Chart
  • OEE (Overall Equipment Effectiveness)
  • OLE (Overall Labor Effectiveness)					

Setup Reduction for High Mix with Sequence-dependent Setup Changeover Times					
Multi-Criterion Comparison and Trade-Off Analysis of Competing Ideas/Suggestions					
Production Line Simulation using FlowshopSim					
[Optional] Mixed Model Assembly Line Design using Taktiq					

Advanced Manufacturing Technology[9]	Employee	Supevisor	Engineer	Manager	Executive
Robotics & Automation					
Discrete Event Simulation (Digital Twin)					
MES					
Machine Monitoring Systems					
Machine Learning, Multivariate Statistics, Data Science, etc.					
Predictive Analytics					
Artificial Intelligence (AI)					

[9] How much is necessary (and useful) before it become unnecessary (and useless)?