Building Webapps to Help You Build a Jeep

David Johnson Jan 30, 2016



Outline

- Introduction to Traditional vs. Lean Manufacturing
- Build sheets (aka, broadcast sheets)
 Webapp implementation
- Sequenced pull (Sequencing)
 Webapp implementation
- Kanban Sequenced pull (Kitting)
 Native client
- Conclusion



Introduction to Traditional Manufacturing

- Pioneered by Henry Ford in 1904
- (Video 1: Megafactories Ford at 23:50)
- Principles of traditional manufacturing:
 - Estimate what will be needed and run each line to meet that target
 - **Push** from one production line to another.
 - Lines run independently at maximum speed.
 - Buy huge bulk orders to minimize per-item purchase costs and to prevent shortages





Input inventory

Intermediate inventory

 (Video 2: Ford F-150 Frame/Axle line 5:50-8:35)



Problems with Push Manufacturing

- **Push** systems require more input inventory and intermediate inventory
 - 5,000 engines in warehouse or production * \$2,000/engine = \$10M
 - 3 month inventory turnaround
 - 4% APR Interest = lots of \$\$\$ sitting on floor
- Inventory may become obsolete before being used!
- Speed of sub-assembly is independent of demand
- Can't tell where problems are, too focused on keeping the line running



Introduction to Lean Manufacturing

- (Video 3: Four Principles Lean Management)
- Principles of lean manufacturing:
 - Customer orders **pull** from lines and inventory
 - Eliminate waste by building only what is needed, just-in-time
 - Each line **pulls** from another, causing work. Lines are dependent. Speed dictated by demand.
 - One piece flow: work on only one job at a time
 - Takt (cycle) time: each operation should take the same amount of time, regardless of options
 - Zero defects: stop whole line to fix defects
- Continuous improvement: pay employees to make suggestions to improve operations





Input inventory

Intermediate inventory

- Pull systems reduce inventory to the minimum required to run production just-in-time
- Intermediate inventory is reduced or eliminated
- Input inventory is minimized
- Operating speeds are matched to demand



Build sheets ("broadcasts")

- Printed sheets are attached to each vehicle or module
- Sheets are in production order
- Contents of sheet:
 - ID: VIN, date of manufacture, sequence no
 - Parts: part numbers, quantities, colors, rev. levels
 - Categories: Sales codes, export market, trim level



FCA Broadcast



• (Video 4: Megafactories Dodge Challenger)

Example Toyota build sheet



Fo

Chrysler Build Sheet



F

Motivation to Stop Printing

- Broadcast sheets require a lot of printing:
 - 500,000 vehicles/year * 5 pages/vehicle * \$0.05/page = \$125,000/year!
 - Printer service contracts: \$1,000/printer
- Paper must be attached to vehicle
 - 5+ seconds/vehicle of operator time
 - Downtime when printer doesn't work
- Operators rarely look at broadcast sheets:
 - Computers now show part numbers and do error proofing
 - Everyone has mobile devices already...



Webapp – Broadcast Sheet

ML1	ML2			ENG	KA1 K/
^{Seq:} 201643	39 <mark>3670^{vin:}1С4АЈWA</mark>	G9 <mark>GL188610^{Type:}JK</mark>	JL72,LHD /DOM ^R	^{eceived:} 2016012304242	25
HOSE-FILTE	HOSE CONTR	EXH PIPE F	D-SHAF FRT	WIRDIO KIT	TUBE-FRESH
787AC 52059787AC	091AC 05147091AC	142AD 66065142AD	551AA 52123551AA	NO	NO
SHIELD-H-D	TUBE-BLOCK	BRAKE TUBE 436AA 68292436AA	HOSE-RR-LT 955AC 68171955AC	HOSERR-RT 956AC 68171956AC	CHURD NO
TUBE-EHCU 313AC 68111313AC	TUBE-HCU 117AD 52129117AD	SHIELD-H-G 199AA 04360199AA		PRESS-P/S 358AI 68078338AI	RETURN-D/S 359AL 68078359AL
RESERVOIR 151AG 52126151AG	HOSE PUMP 355AF 60078355AF		HOSE-F/AXL 049AC 52132049AC	TAM COOLER 450AE 35111450AE	
TUBE-EXTEN 097AG 05147097A0		ń.	TEMP SHR		RR BUIMPER 22RXF IBD22RXFAE
RR-APPLIQ	WASHER NO		CUSHION-D 676AC 55366676AC	FRT BUMPER 27RXE 1BD27RXFAE	FRT-APPLIQ
REINF 153AA 32126133AA	BUM-COVER 94RXF IBE94RXFAC	AIR DAM 95XXX 18895XXXAD	VAC-PUMP 586AB 04381586AB	HORN-BERKT	FOG LAMP



Build sheet - China

ML1	ML2			ENG	KA1 KA
^{Seq:} 201643	39 <mark>3710^{vin:}1C4BJWE</mark>	288 <mark>GL194745^{Type:}</mark> JK.	JP74,LHD / <mark>CHN</mark> Rece	^{rived:} 20160123042823	3
HOSE-FILTE 787AC 52059787AC	HOSE-CONTE 091AC 05147091AC	EXH PIPE-F 083AA 68249083AA	D-SHAF FRT 909AA 52123909AA	WIRING KIT	TUBE FRESH
SHIELD-H-D	TUBE-BLOCK	BRAKE TUBE 437AA 68292437AA	HOSE-RR-LT 955AC 68171955AC	HOSE RR-RT 956AC 68171936AC	снаяр
TUBE-ENCU 313AC 68111313AC	TUBE-HCU 117AD 53129117AD	SHIELD-H-G 199AA 04560199AA		PRESS-D/S 358AI 68078358AI	RETURN D/S 359AL 68078359AL
RESERVOIR 151AG 52126151A0	HOSE-PUMP 355AF 60070355AF		HOSE-FYAML 049AC S2132049AC	TAM COOLER 450AE SSIII450AE	
TUBE-EXTEN 489AL 52060489AL			TEMP SHR		RR BUMPER 23RAJ 18D23RXFAJ
rr-appliq	WASHER NO		CUSHION-D 234AA 52126234AA	FRT BUIMPER 28RXF 1BD28RXFAF	FRT-APPLIQ
PEINF	EUM COVER 47RXF SPE47RXFAA	AIR DAM 95XXX IBEDSDOOAD	VAC-PUMP 581AB 04581381AB	HOEN-BERT 165AA 68268165AA	FOG LAMP

• CHN in red, different parts are NO



Build Sheet - popup

Par	t Info for HOR	N-BRACKE	CT ((M087)	^{sceived} :20				
Selecte	d: 68268165AA (165AA	, 9 %).							
	091AC	083AA							
Others	: <mark>NU</mark> (91 %).								
	Seq	437AA		955AC sumesze		956AC Part Ne			
2123	3670	0L188610				NO			50 AT
	3690	GL 190700				ыо			
	3690	0fL188824				NO			
151/	3700	GL191095				HO			
	3710	GL 194745				163AA			
	3720	GL192616				NO			
	3730	GL 1864.59				NO			
	3740	0L181002				NO			
	3750	GL194215				NO			
	3760	0£189643				110			
Showin	g 1 to 10 of 141 entries	Previous	1	581AB 3	4	165AA	15	Next	NTO

Statistics: most vehicles don't get this horn
 bracket

Webapp – other lines

ML1	ML2	20164:	393710	ENG	KA1	KA2
^{Seq:} 201643	39 <mark>3710^{VIN:}</mark> 1C4BJWE	88GL194745 ^{Type:} JK	JP74,LHD / <mark>CHN^{Re}</mark>	ceived: 2016012304282	23	
ENGINE 559AC 60170559AC	HOSE-VACU 210AE 05154210AE	tq-consc NO	slave cvl <mark>NO</mark>	TRANSPER 497AA 52123497AA	1 71 521	RANS 1AD 18711AD
ALTERNATOR 950AB 68078950AB	PUMP-P/S 400AC 03154400AC	ENOWIR-DSL	A/C COMP 374AD 55111374AD	BRACKET-HY NO	CLU	тсн тив NO
	START-MOTO 852AA 56029052AA	HOSE-HOT B	HEAT-BLOCK	ISOL-ENG-L 190AC 05147190AC	150 15 051	LENG-R PIAC 17191AC
HOSE-CLEAN	sensor-k,c NO	BATT-WIR	HOSE INLET 394AC 55111394AC	COLLAR NO	FUE 44 520	L BUNDL 14AF 29444AF
EXH CAT.D	seal-gear NO	FILL-TUBE 140AA 04627140AA	ENGWIR GAS 516AC 68274516AC	VEN7.H0SE 882.AB 52105882AB	J.	
COVER-STAR	HOSE CLAMP	SENSOR-CRE	BELT 043AA 04627043AA	HEAT CORD		fan NO
DIFF BEKT	DISUL-TAM 193AA 05147193AA	SHIRLD-H-R 915AA 53013915AA	STRAD-GRD 283AJ 05064283AJ	HOSE LWR-R 195AA 68249195AA	HO	e o spr NO

• Engine line part numbers & QR code



Broadcast Webapp Review

- Broadcasts are needed for lean production
- But the webapp is cheaper
 - No paper or printers (i.e., use tablets or mobile devices)
 - Operators don't have to attach/remove paper
 - Easily change layout
- Real-time production information
 - Dynamically updating position, inventory levels
 - Interactive color display
 - Assists pull between production lines by looking at other lines



Production Line Layout



24G tank	16G tank
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- Adding part complexity creates storage
 problems on the production line
- Solutions: sequencing or kitting

Sequenced pull (Sequencing)



- Sequencing carts:
 - Single stations
 - Only a few part choices for same type of part (e.g., exhaust pipes, wiring harnesses)
 - Every vehicle must get this type of part, but some options are low runners
- Traditional approach: carts and printed sheets
- New approach: carts and tablets (webapp)

Sequencing carts





Printed Sequencing List

1- 335	2- 365	3- 335	4- 335	5- 335
6- <mark>349</mark>	7- 335	8- 338	9- 349	10- 335

- Every vehicle gets a chassis wiring harness
- Only a few part choices: 335 (reg.), 338 (long), 349 (foreign mkt), or 365 (rhd)
- 5x5 cart (25 harnesses), 2 carts

	Currer	ntly Selected: Chassis W	ire Select printer: *	
G	Start Seq. (Last 4	minimum): 20164402750	* Start	9
#	Sequence	CH-WIRING	Receive Time	#
1	4402750	335AB	01-24 14:54:13	1
2	4402760	365AA	01-24 14:55:35	2
3	4402770	335AB	01-24 14:56:46	3
4	4402780	335AB	01-24 14:58:11	4
5	4402790	335AB	01-24 14:59:23	5
6	4402800	349AB	01-24 15:00:32	6
7	4402810	335AB	01-24 15:03:44	7
8	4402820	338AB	01-24 15:05:21	8
9	4402830	349AB	01-24 15:06:30	9
10	4402840	335AB	01-24 15:08:07	10

- Operator clicks each row when the part is placed into the sequencing cart.
 - The row turns green
 - Less common parts are colored differently
 - E.g., foreign market parts, low runners

	Curre	ntly Selected: Chassis	Wire Select printer: •	
G	Start Seq. (Last 4	4 minimum): 20164402750	Start	€
#	Sequence	CH-WIRING	Receive Time	#
1	4402750	335AB	01-24 14:54:13	1
2	4402760	365AA	01-24 14:55:35	2
3	4402770	335AB	01-24 14:56:46	3
4	4402780	335AB	01-24 14:58:11	4
5	4402790	335AB	01-24 14:59:23	5
6	4402800	349AB	01-24 15:00:32	6
7	4402810	335AB	01-24 15:03:44	7
8	4402820	338AB	01-24 15:05:21	8
9	4402830	349AB	01-24 15:06:30	9
10	4402840	335AB	01-24 15:08:07	10

	Currer	ntly Selected: Chassis	Wire Select printer: •	
G	Start Seq. (Last 4	minimum): 20164402750	Start	€
#	Sequence	CH-WIRING	Receive Time	#
1	4402750	335AB	01-24 14:54:13	1
2	4402760	365AA	01-24 14:55:35	2
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4	4402780	335AB	01-24 14:58:11	4
5	4402790	335AB	01-24 14:59:23	5
6	4402800	349AB	01-24 15:00:32	6
7	4402810	335AB	01-24 15:03:44	7
8	4402820	338AB	01-24 15 05:21	8
9	4402830	349AB	01-24 15:06:30	9
10	4402840	335AB	01-24 15:08:07	10

	Currer	tly Selected: Chassis	Wire Select printer: •	
G	Start Seq. (Last 4	minimum): 20161402750	E Start	€
#	Sequence	CH-WIRING	Receive Time	#
1	4402750	335AB	01-24 14:54:13	1
2	4402760	365AA	01-24 14 55 35	2
3	4402770	335AB	01-24 14:56:46	3
4	4402780	335AB	01-24 14:58:11	4
5	4402790	335AB	01-24 14:59:23	5
6	4402800	349AB	01-24 15:00:32	6
7	4402810	335AB	01-24 15:03:44	7
8	4402820	338AB	01-24 15.05.21	8
9	4402830	349AB	01-24 15:06:30	9
10	4402840	335AB	01-24 15:08:07	10

Sequencing Review

- Bring to the production line only what is needed, when it is needed (pull)
 - Less storage on main line
 - Less work in progress
- Sequencing carts minimizes operator errors due to:
 - Forgetting which vehicle you're working on
 - Accidentally grabbing the wrong parts
- Sequencing is appropriate for:
 - Single stations
 - Only a few part choices
 - Every vehicle must get the part
- New webapp is cheaper and faster



Intro to Kanban Pull



- (Video 5: Kanban Pull Simple)
- Kanban uses visual cues to trigger upstream production lines to run
- Output is a multi-part assembly (kit)

Kitting on production line



- (Video 6: Sonic Production at Lake Orion, GM)
- Kitting area is used for complex sub-assemblies
 - Kit is made per vehicle, not per station

— Kit rides down production line together with vehicle FoxCon 2016, David Johnson

Kanban Sequenced pull (Kitting)



- Almost as good as single-piece flow
 - Just-in-time sub-line provides groups of parts to Main line
 - More complex than sequencing
- Digital picking system (aka, pick to light)
 - Don't have to know what different parts look like
 - Don't need broadcast sheets
 - Just grab the parts where the lights are turned on



Digital Picking System



- Picklights are per-part
- Remove number of parts indicated by counter
- Push button to confirm



- Kit is designated for a specific VIN on the main line
- Lights only turn on if part is required
- Button must be pushed to proceed

Kitting Area Server



 Server communicates with picklights wirelessly



Kitting Area Client

REFRE	SH	KA1	Client		Check	
ZONE	KITNO	REAR	FRONT	ADDR	PARTNO	LAMP
000	171	20164394060	20164394870	8099	START	1
010				0101	52060298	0
010				0102	52060278	U
010				0199	EndO/Zone1	0
020	170	20164394850	20164394860	0201	52060051	0
020	170	20164394050	20164394060	0202	52060444	0
020	170	20164394850	20164394860	0299	EndOfZone2	1
030				0301	52059983	U
030				0302	06104246	0
030				0303	52060284	0
0.30				0304	60195016	0
030				0305	06507649	0
030				0307	06510998	0
030				0399	EndOlZone3	U
040				0401	04680647	0
040				0402	68186563	D
040				0403	04600646	0
040				0499	EndOfZone4	0
060				0601	05090019	0
060				0602	52060428	0
060				0699	EndOfZunefi	0
000				0001	52059902	0
080				0899	EndOtZone8	0
090	169	20164394840	20164394850	0901	68069123	1
090	169	20164394840	20164394850	0902	68067124	U
090	169	20164394840	20164394850	0903	52060056	0
090	169	20164394840	20164394850	0904	52060057	0
090	169	20164394848	20164394850	0999	EndOfZone9	1

 Floor operators can check batteries and verify picklight status

Kitting Area Overview



- Part complexity is confined to kitting area
 - New parts don't require more space on the Main line
 - Build more carts, push back and forth
- Inventory management is simplified
 - Minimum intermediate inventory
 - Fork trucks don't drive into Main line
 - Boxes are sent back to OEM (dunnage)

Review

- Lean manufacturing
 - Pull from inventory, don't push
 - Waste is eliminated by building only what is needed, just-in-time
 - Visual indicators are used to drive workflow
 - Computers are an integral part of the process
- Broadcast sheets are not printed
- Sequenced pull is used for simple part sublines
- Kanban sequenced pull is used for complex sublines

Sources and Acknowledgements



Toyota Way Fieldbook



Ford, GM, FCA: various youtube videos



Thank you to my employer for permission to give this talk



Questions?



Now it's too lean

(Shuttered GM plant in Janesville, WI, closed in 2009)

