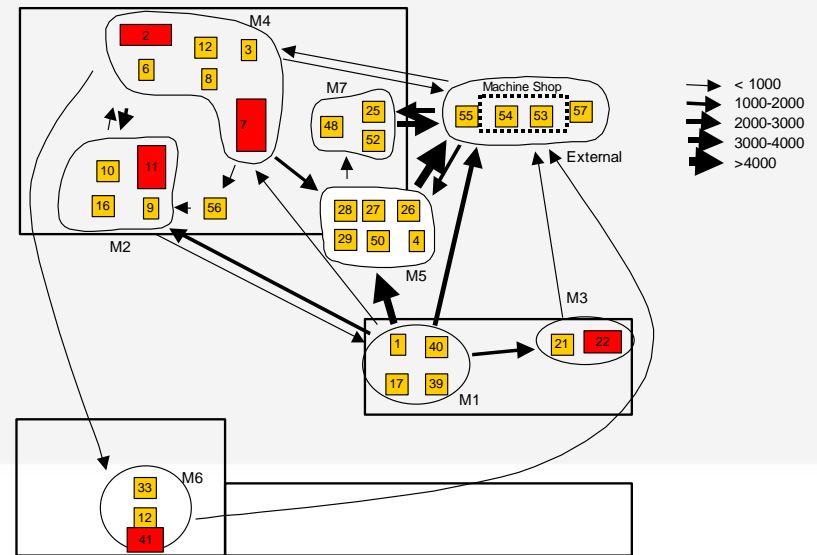
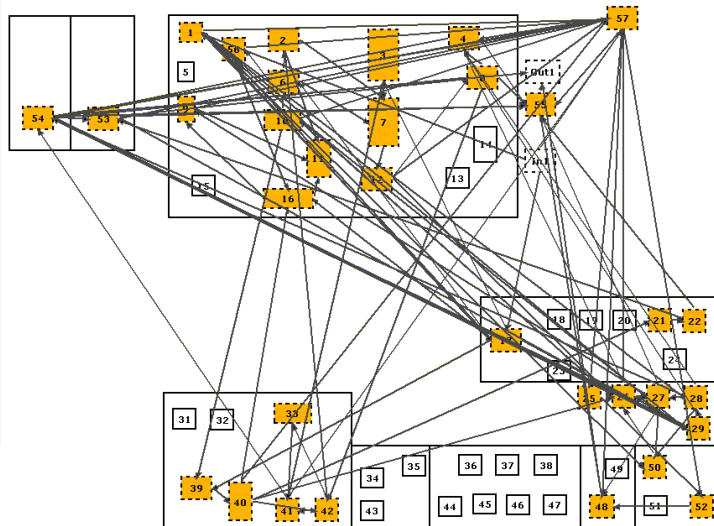


Advancing Lean Tools Beyond their Pencil-and-Paper Legacy

February 26, 2015



Introduction to Presenters



Tom Knight

- **Founder & CEO of Invistics.**
- **Invistics provides consulting services and supporting software tools to implement Lean Supply Chain improvements**
- **Keynote presenter for IIE, APICS, and NCLSI on Lean**



Shahrukh Irani

- **Founder and President , Lean & Flexible, llc**
- **Former faculty at The Ohio State University**
- **Published Author and Speaker**
- **Inventor, PFAST (Production Flow Analysis and Simplification Toolkit) software for facility layout**

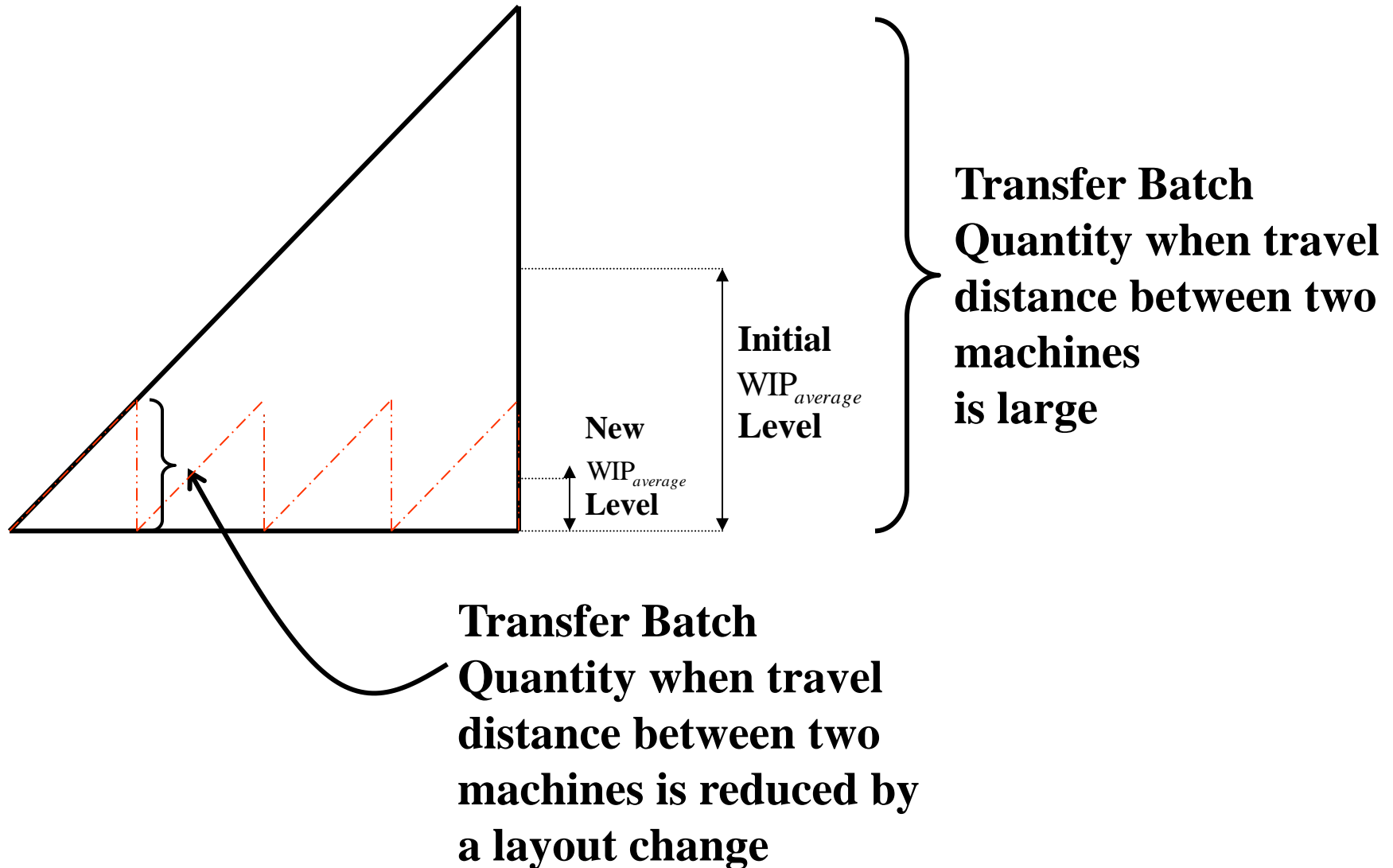
Presentation Agenda

- ➔ ■ Reducing Waste using Lean Factory Layout Principles
- Using Flow Diagrams to Design Lean Factory Layouts
 - Hand-drawn Flow Diagrams & When to Use Them
 - Automated Flow Diagrams & When to Use Them
- Case Study: Hardy Machine and Design Inc.
- Q&A

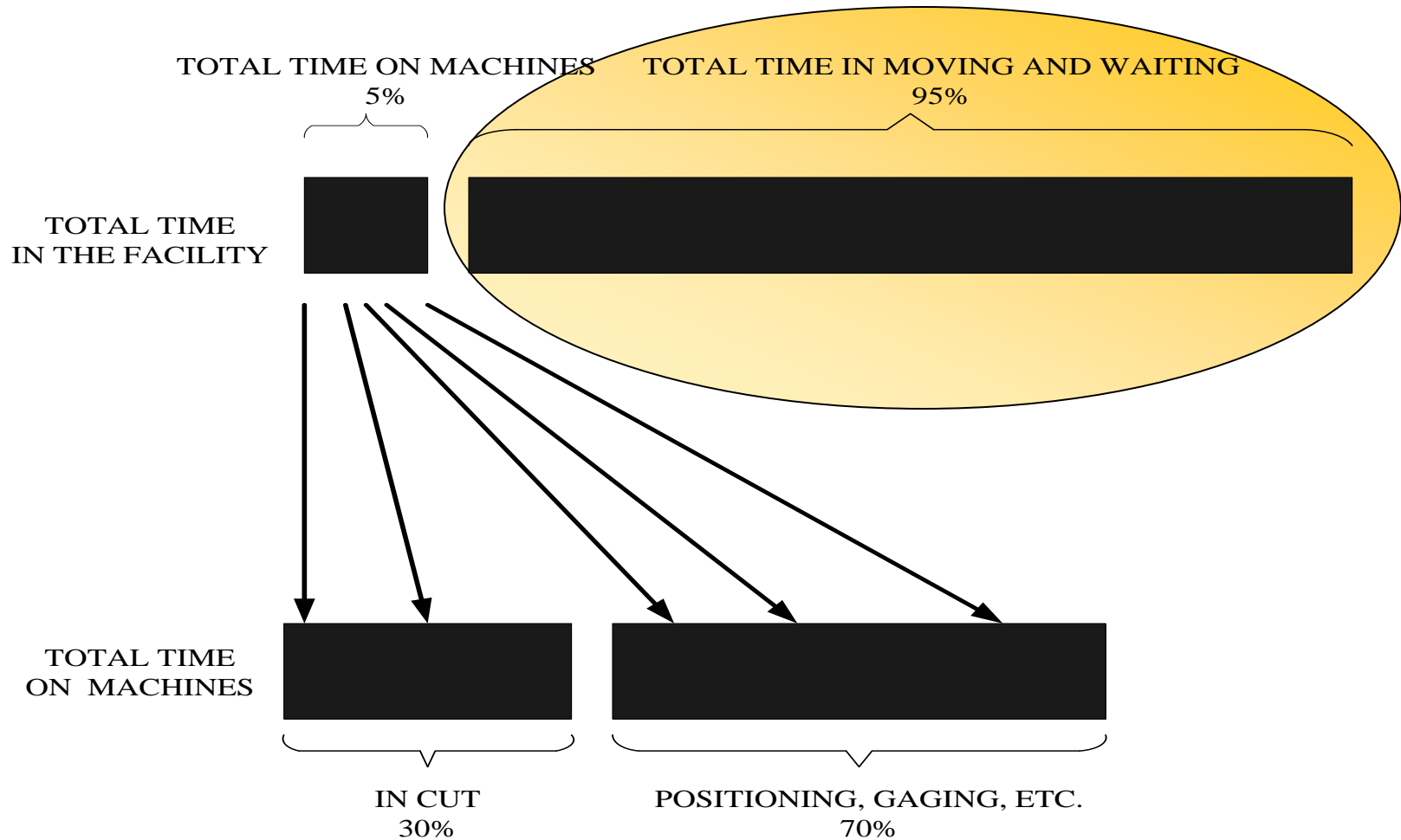
Eight Wastes that Lean Seeks to Eliminate

- 1. Defects**
- 2. Over Production**
- 3. Waiting**
- 4. Non-Utilized Talent**
- 5. Transportation**
- 6. Inventory**
- 7. Motion**
- 8. Extra Processing**

A Bad Layout Increases Work In Process



A Bad Layout Increases Transportation and Waiting



A Bad Layout is Bad for Business

Flow Time (days) = WIP (\$)/Throughput (\$/day)

Therefore, to....

Reduce Flow Time

....we have to reduce the delays that are caused by the Seven Types of Waste.

Importance of a Good Factory Layout

- (Page 11) “... As an experiment, I arranged the various machines in the sequence of machining processes ...”
- (Page 54) “...Toyota’s main plant provides an example of a smooth production flow accomplished by rearranging the conventional machines after a thorough study of the work sequence ...”
- (Page 100)“...By setting up a flow connecting not only the final assembly line but all the processes, one reduces production lead time ...”
- (Page 128)“...The first aspect of the TPS...means putting a flow into the manufacturing process...Now, we place a lathe, a mill and a drill in the actual sequence of the manufacturing processing ...”



SOURCE: Ohno, T. 1988. *Toyota Production System: Beyond Large-Scale Production*. Portland, OR: Productivity, Inc. ISBN 0-915299-14-3.

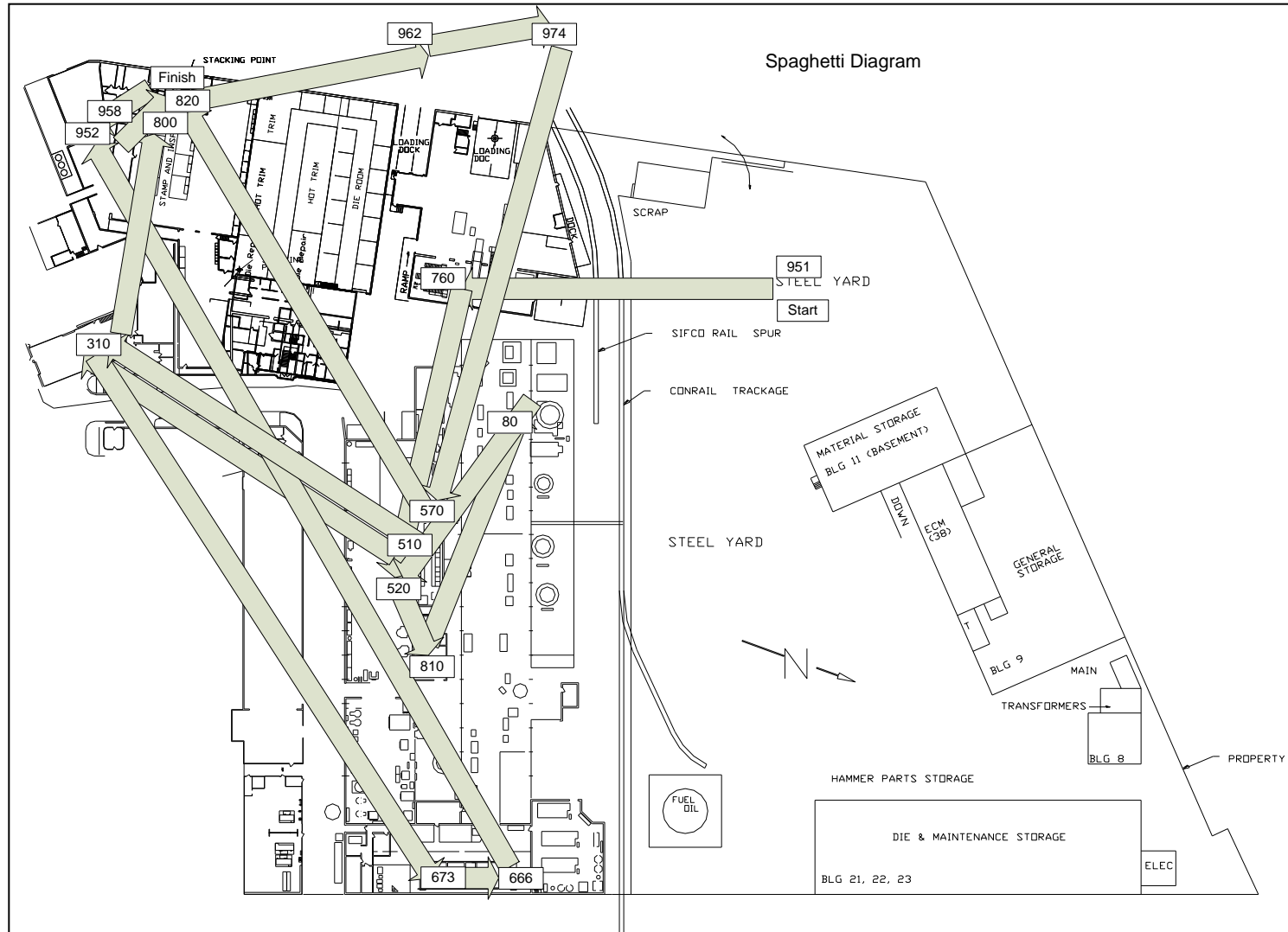
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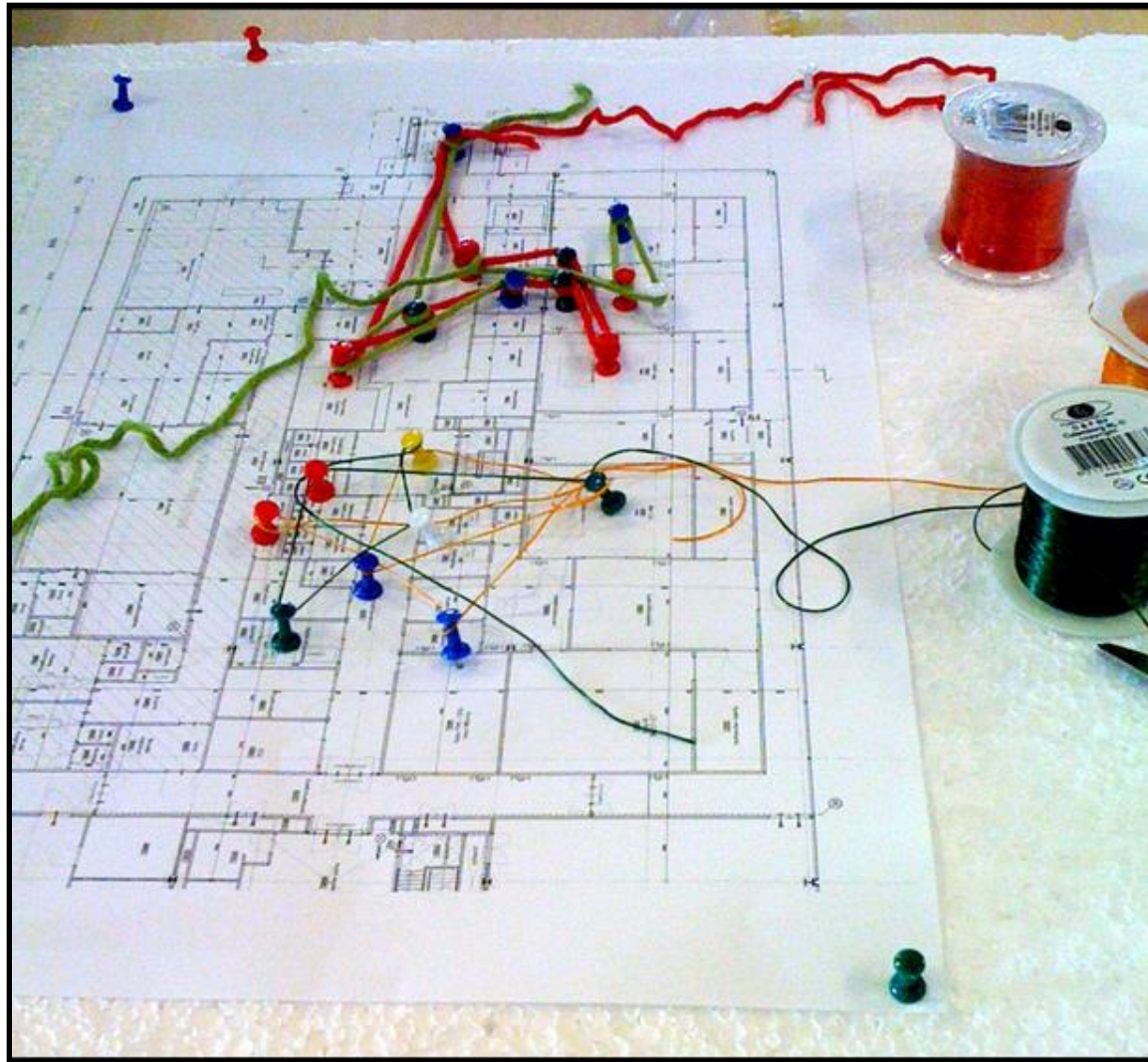
What is a Flow Diagram?

A drawing of the facility layout with arrows showing movement of product/s, material handling equipment, people, etc. between different locations in the facility.

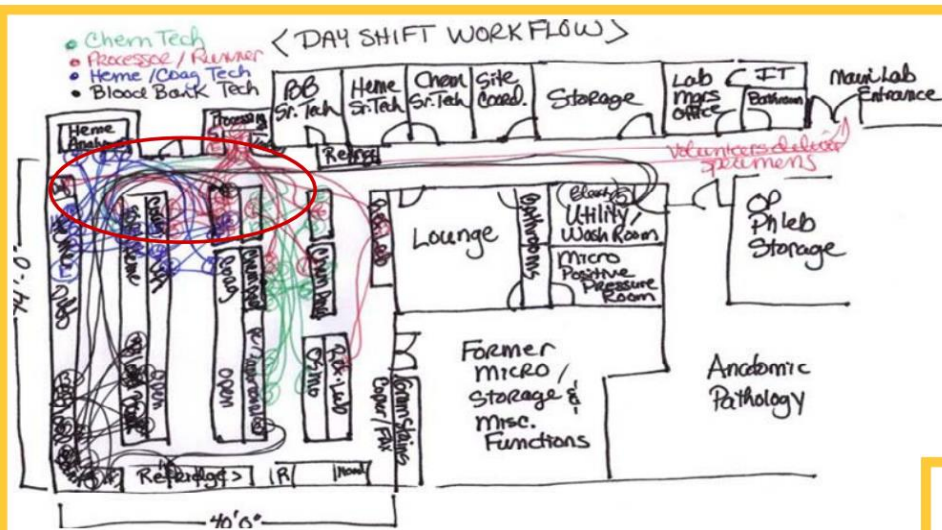
Custom Forge Shop Layout Design



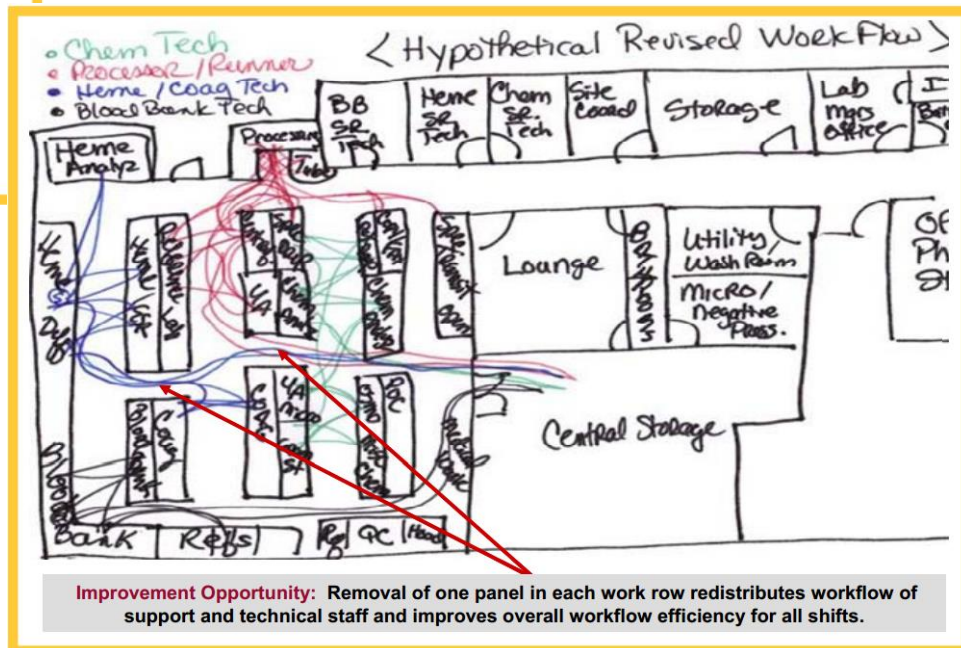
Hospital Layout Design



Laboratory Layout Design

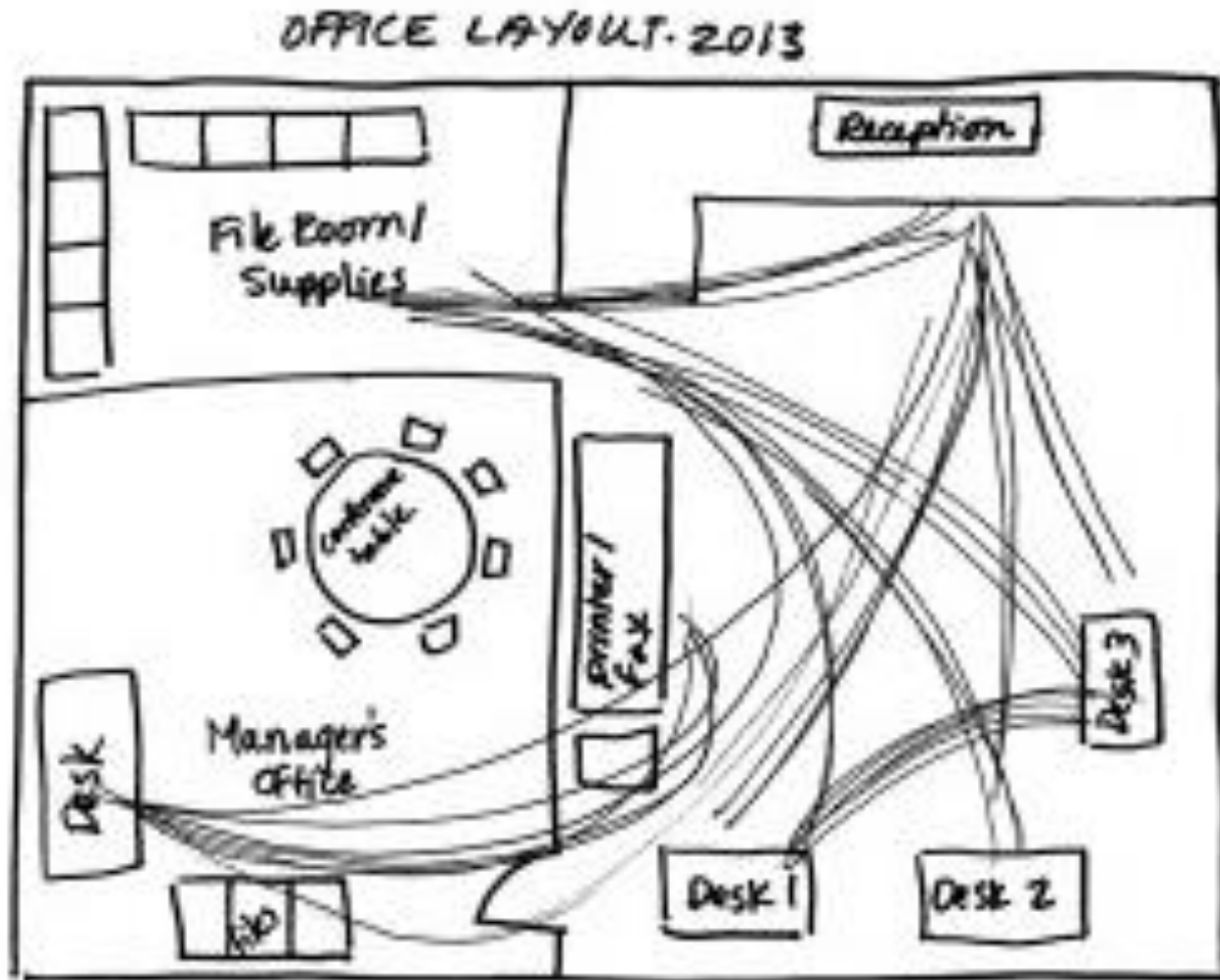


Findings: Heavy traffic and bottleneck in specimen processing area. Technical workbenches spaced far apart when techs need to cover multiple areas, which results in overall excessive movement by staff.



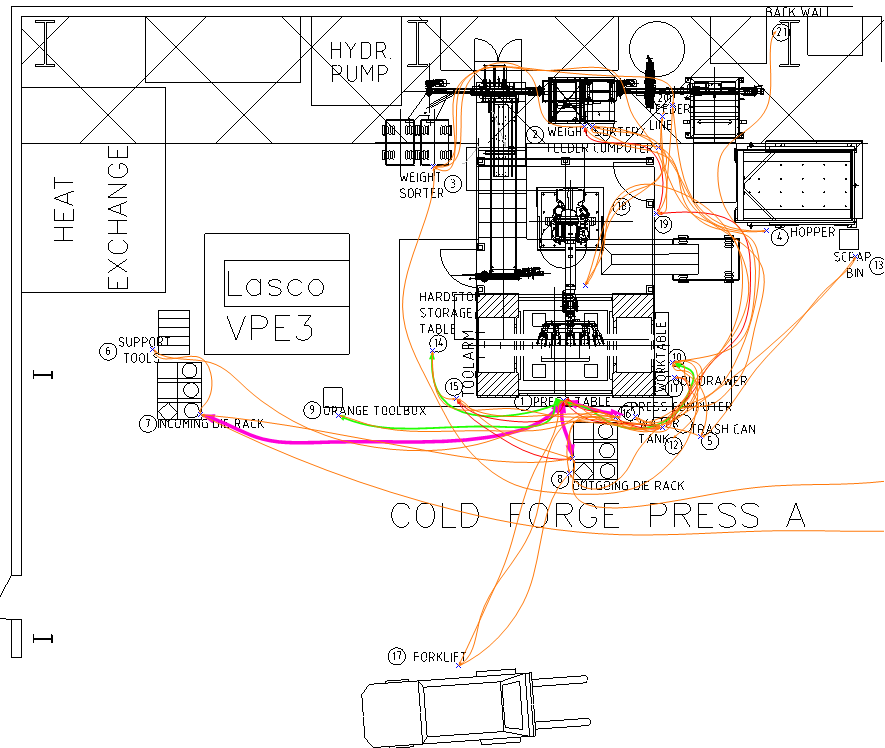
Improvement Opportunity: Removal of one panel in each work row redistributes workflow of support and technical staff and improves overall workflow efficiency for all shifts.

Office Layout Design

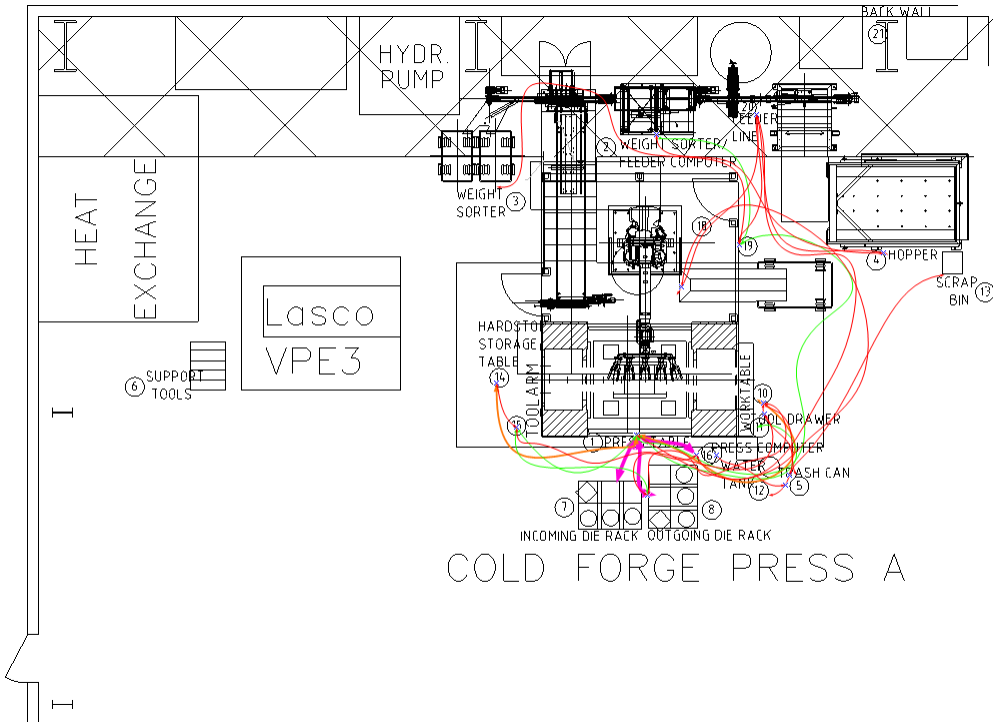


Workstation Layout Design

Current State of Operator Motion Waste



Future State of Operator Motion Waste



How a Flow Diagram Helps to Design a Factory Layout

- Does material flow along a continuous linear path?
 - *Or have back tracks and cross flows resulted in a "spaghetti" flow?*
- Is there heavy traffic between work centers that are a large distance apart?
 - *Should one or more work centers be re-located?*
- Is there LOS (Line Of Sight) between work centers connected by heavy traffic?
- Is there heavy bi-directional traffic in any aisle (or corridor)?
- Is there heavy traffic in/out of a particular work center?
 - *Do orders experience significant queuing delays at this work center?*

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What the Flow Assessment App is Able to Do

- Sort product mix in order of decreasing/increasing Volume/Quantity
- Extract (and display) any sample of products from the complete product mix
 - *Single product with the highest qty.?*
 - **This map would complement a Value Stream Map and the Flow Process Chart based on a facility walkthrough of that product's routing.**
 - *80-20 Pareto Sample?*
 - *A part family?*
 - *Only those parts being sent to a particular vendor?*
 - *Etc.*

What the Flow Assessment App is Able to Do (contd.)

- Move one or more work centers to new locations to visualize the impact of implementing flow improvement scenarios such as:
 - *Eliminate some products?*
 - *Assign machines to make an order based on relative proximity?*
 - *Bring several machines together and implement a manufacturing cell?*
 - **If a pure cell cannot be implemented, could at least a partial cell be implemented by co-locating 2-3 machines operated by a single cross-trained employee?**
 - *Change routings of the parts in a family so they all use the same machine(s)?*
 - *Move department(s) to new location(s)?*
 - *Combine two (or more) departments (even buildings)?*

Hand-drawn vs. Computer-generated Flow Diagrams

Hand-drawn

Easy and quick to produce

Effective for 5 ($\leq 10-15$) routings

Paper, pencil and string are cheap

Tedious to re-draw for every change in routings, layout, product mix, etc.

Requires little training

Visual assessment of good/bad material flow is empirical

Computer-generated

Easy and quick to produce

Effective for 100's of routings

Commercial software is expensive

This is the key merit of a software tool!

Requires considerable training

Several levels for assessment of good/bad material flow can be:

- **Visual**
- **Simple Quantitative Metrics: Line of Sight Efficiency (LOSE), Total Travel Distance, Travel Cost**
- **Complex Quantitative Metrics: Throughput, WIP, Queues at Work Centers, etc.**

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About Hardy Machine and Design Inc.

- **Ownership:** Private (www.hardymachine.com)
- **Location:** Houston, TX
- Precision machine shop
 - Approx. 40 machines
 - Combination of manual and CNC
 - Stand-alone CMM services
- **Primary market served:** Oil and Gas
- **Annual revenue:** < \$15 mil
- ISO9001:2008 Certified
- Approx. 60 employees
- 2 shifts
- 30,000 sq. ft. (2 buildings)

What They Wanted Us To Investigate

- **Is there need for a layout change?**
- **Are cells feasible for a CNC machining jobshop like Hardy Machine and Design Inc.?**
- **Should we build a new building to consolidate the existing two buildings into one?**
- **How can we efficiently track orders that are in-process?**
- **How can we reduce idle time on machines caused by missing tools, waiting for parts, missing fixtures, etc.?**
- **Should we buy a machine monitoring software (ex. Predator) or Manufacturing Execution System (ex. FORCAM)?**

Input Data for the App: Parts

Part ID	Description	Annual Quantity	Revenue
23500	Adapter	1	180
23501	Mdrl,Vlv Slv,9 5/8 Vlh, With L	6	657
23502	Clamp Assembly, Spacer, 10 3/4	3	1031.2
23503	7-5/8"/4-1/2" SWAGE CLAMP	2	194.6
23504	7"/5" SWAGE CLAMP	2	451.4
23505	6-5/8"/5-1/2" SWAGE CLAMP	2	375.2
23506	Guide 31759 03.000	1	447.2
23507	LEAD SCREW, LEVELWIND ASSY,	2	1089
23508	Spacer, Lower Sub (2-7/8 IZC)	1	339.6
23509	Bnt 3 1/8 2M-3M-5M FMC 120 EE	2	230.2
23510	Male Pkg Adr 3.000 6FA	4	229.6
23511	BK-UP Ring 3.494 X 3.006 X .60	6	59.8
23512	Disk, Load, Sleeve (2-7/8)	2	160.8
23513	0.65 Pitch Mandrel	1	20
23514	Nose, Protector (2-7/8 IZC)	1	280.8
23515	Mandrel Rework, ECC Test	1	633.6
23516	Hsg,Spg,7-5/8 In, Model 3L Ret	4	299
23517	Flg,4 1/8-8 UN X 10.78 Rdl Bol	2	128.2
23518	Ball Seat Sub, Ball Dia	2	439.4
23519	Mdrl,Vlv Slv,9 5/8 Vlh, With L	6	14.8
23520	HYD CYL 3.000 AUH	2	17.2
23521	Bdy,Mech Slip, 7 In Model 3L P	1	18.2
23522	B-NPPL,13 3/8 BUTT ML x 2" FIG	1	13.4
23523	MDRL,PSTN,HHC,5 9/16-6 AC-2G x	3	280.6
23524	MAND,SPR,TP,9 5/8 IN,MOD 3L	3	126
23525	Endplate, Fwd	1	653.4
23526	Endplate, Aft	1	27.4
23527	Cam Bearing	2	188.2
23528	Encoder Adapter	2	377.2
23529	Bearing Spacer	2	163
23530	Guide Flange 1900 L/PI	4	30
23531	Case, Sing Nit, Full LG- Armad	1	171

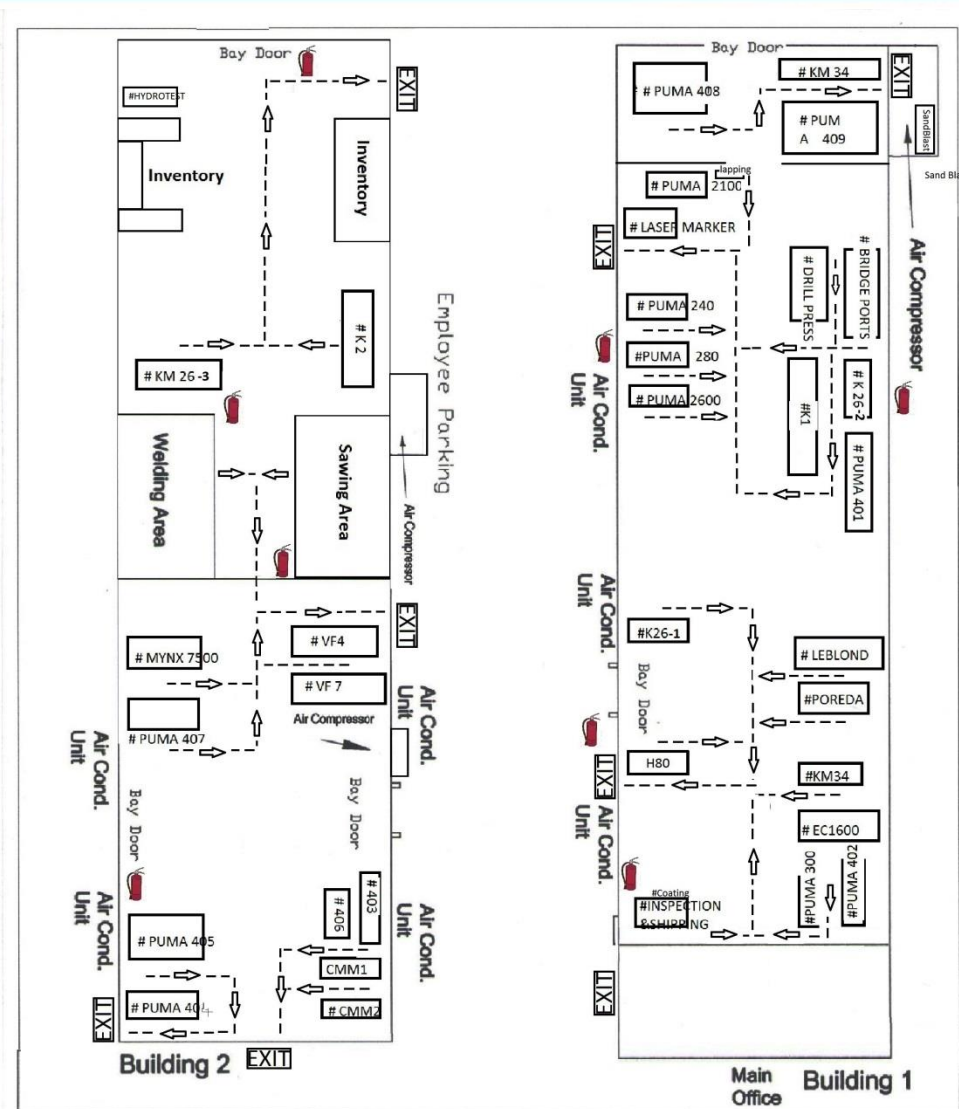
Input Data for the App: Routings

	Part	Quantity	Revenue	Routing
1	23500	1	180	110->KM34-1->210->OO1->110->KM34-1->210->OO1->110->113->111->210
2	23501	6	657	110->210->OO1->110->KM34-1->401->VF7->113->210->OO1->110->111->210
3	23502	3	1031	110->210->OO1->110->405->7500->113->210->OO1->110->114->111->210
4	23503	2	195	110->117->K2->117->K2->VF4->111->210
5	23504	2	451	110->117->K2->117->K2->VF4->111->210
6	23505	2	375	110->117->K2->117->K2->VF4->111->210
7	23506	1	447	110->210->OO1->110->111->210
8	23507	2	1089	110->118->KM26-2->VF7->113->210->OO1->110->111->210
9	23508	1	340	110->2600->111->113->210
10	23509	2	230	110->405->210->OO1->110->402->VF7->113->210->OO1->110->114->111->210
11	23510	4	230	110->KM26-1->111->113->210
12	23511	6	60	110->KM26-1->113->111->210
13	23512	2	161	110->2600->113->210->OO1->110->111->210
14	23513	1	20	110->KM26-1->7500->111->210
15	23514	1	281	110->2600->113->111->210
16	23515	1	634	110->K2->VF7->113->210
17	23516	4	299	110->K2->111->113->210
18	23517	2	128	110->210->OO1->110->402->1600->111->113->210
19	23518	2	439	110->408->113->111->114->210
20	23519	6	15	110->210->OO1->110->KM34-1->KM34-2->401->VF7->113->210->OO1->110->111->210
21	23520	2	17	110->405->210->OO1->110->402->VF4->112->210->OO1->110->111->210
22	23521	1	18	110->402->1600->210->OO1->110->113->111->210
23	23522	1	13	110->403->210->OO1->110->403->VF7->210->OO1->110->111->210
24	23523	3	281	110->210->OO1->110->408->210->OO1->110->113->111->210
25	23524	3	126	110->KM26-1->402->VF4->111->113->210
26	23525	1	653	110->406->111->210
27	23526	1	27	110->406->111->210
28	23527	2	188	110->KM26-1->111->210
29	23528	2	377	110->406->VF4->111->210
30	23529	2	163	110->406->111->210
31	23530	4	30	110->300->111->210
32	23531	1	171	111->210->OO1->110->KM26-1->VF7->113->111->210
33	23532	1	132	110->210->OO1->110->KM34-1->408->VF7->113->210->OO1->110->111->210

Input Data for the App: Workcenters

Work Center	Description	Area			
110	Receiving	1			
210	Shipping	1			
OO1	Vendor	1			
111	Inspection	1			
112	Dress Marking	1			
113	Marking	1			
114	Coating	1			
115	Hydrotest	1			
116	Lapping	1	Isn't this an outsourced operation?		
5005	Sandblasting	1	Do they still do this in-house?		
K26-1	Manual Lathe	1			
K26-2	Manual Lathe	1			
KM26-3	Manual Lathe	1			
VF4	Milling Machine	1			
VF7	Milling Machine	1			
403	CNC Lathe	1			
406	CNC Lathe	1			
CMM1	Coordinate Measuring Machine	1			
CMM2	Coordinate Measuring Machine	1			
404	CNC Lathe	1			
405	CNC Lathe	1			
MYNX7500	Milling Machine	1			
408	CNC Lathe	1			
KM34-1	Kingston Lathe	1	This is a small manual lathe		
KM34-2	Kingston Lathe	1	This is a small manual lathe		
409	CNC Lathe	1			
2100	CNC Lathe	1			
240	CNC Lathe	1			
280	CNC Lathe	1			
2600	CNC Lathe	1			
H80	Milling Machine	1			
300	CNC Lathe	1			

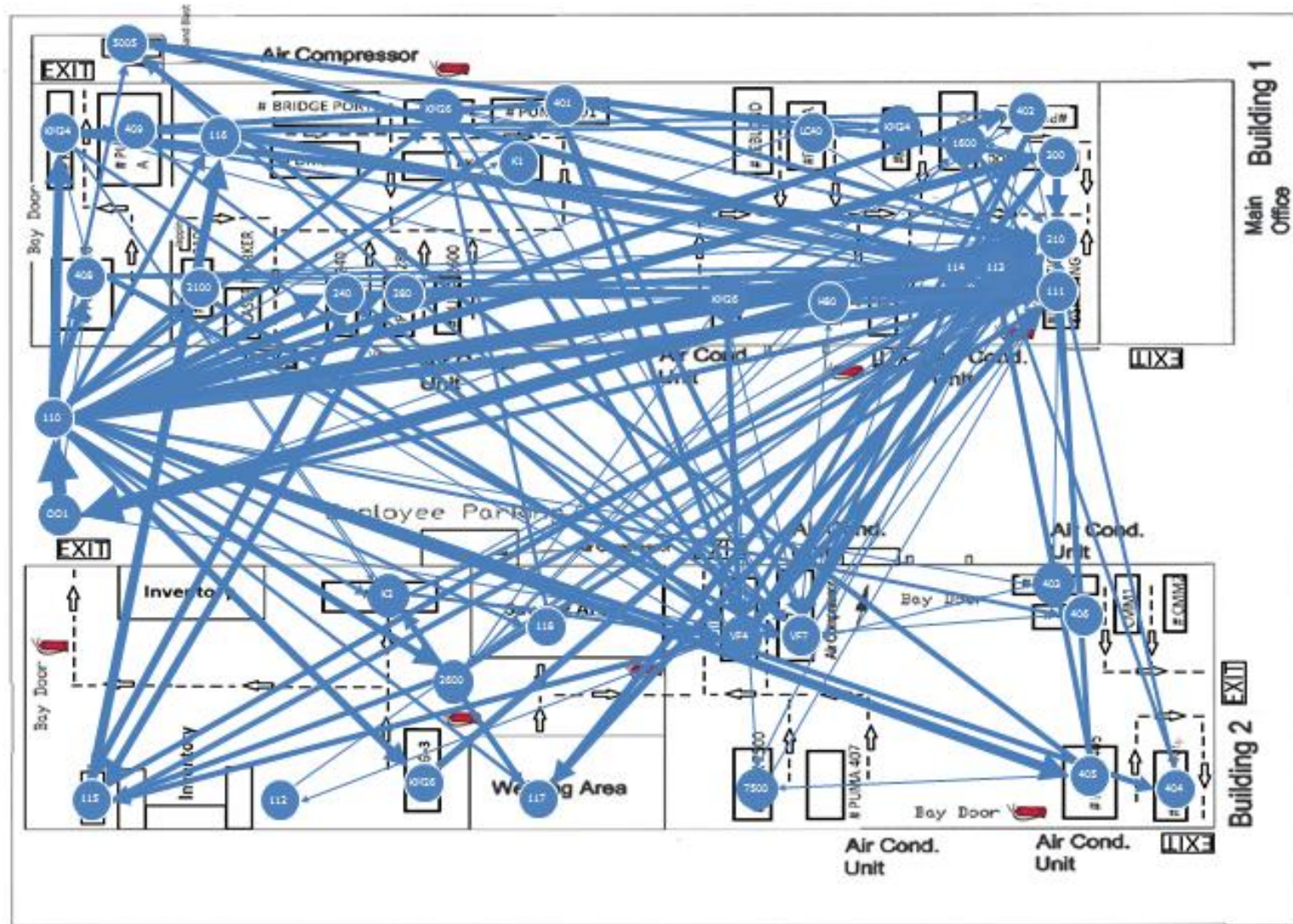
Input Data for the App: Facility Layout

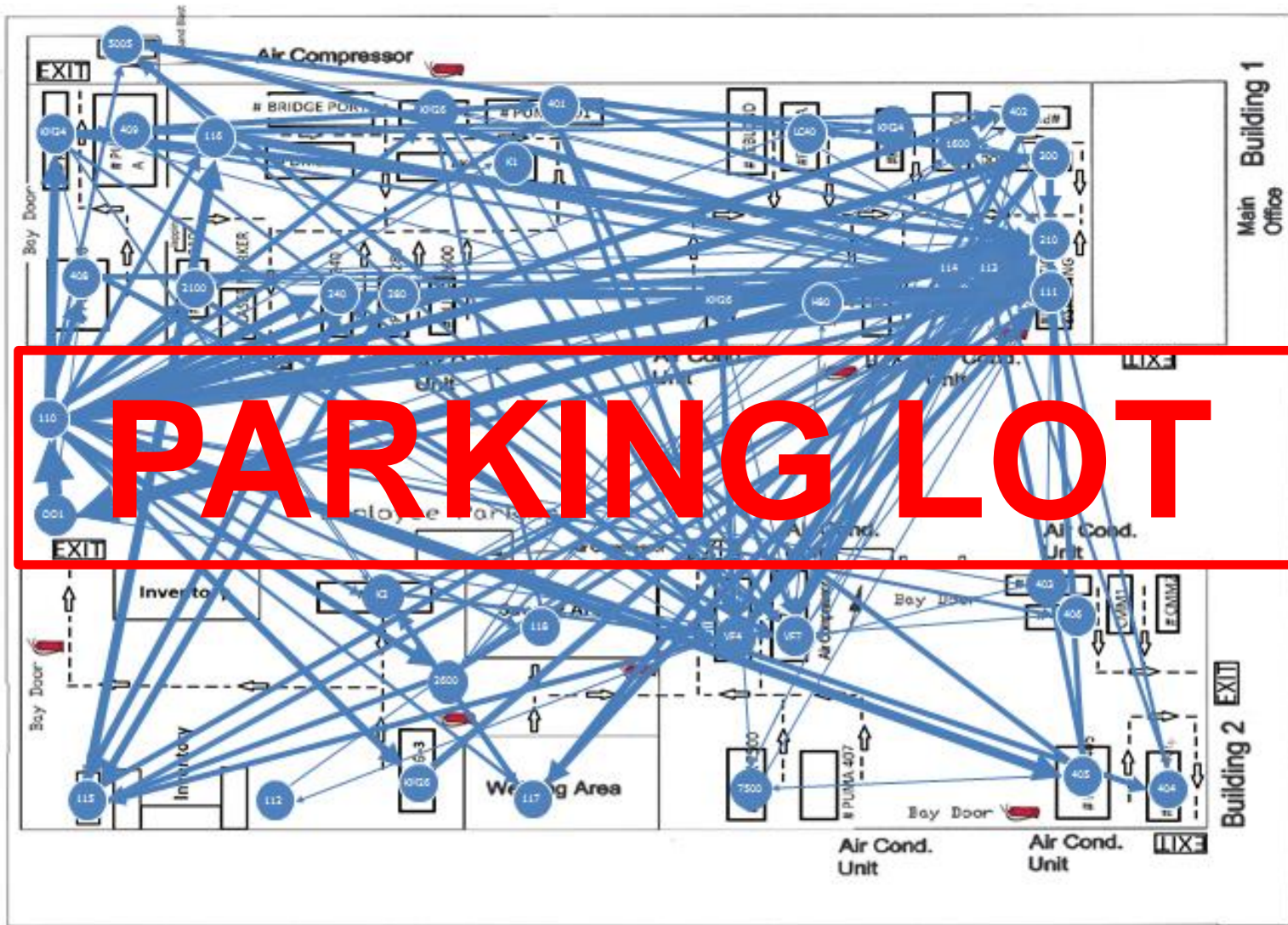


Production Flow Analysis in a CNC Machine Shop

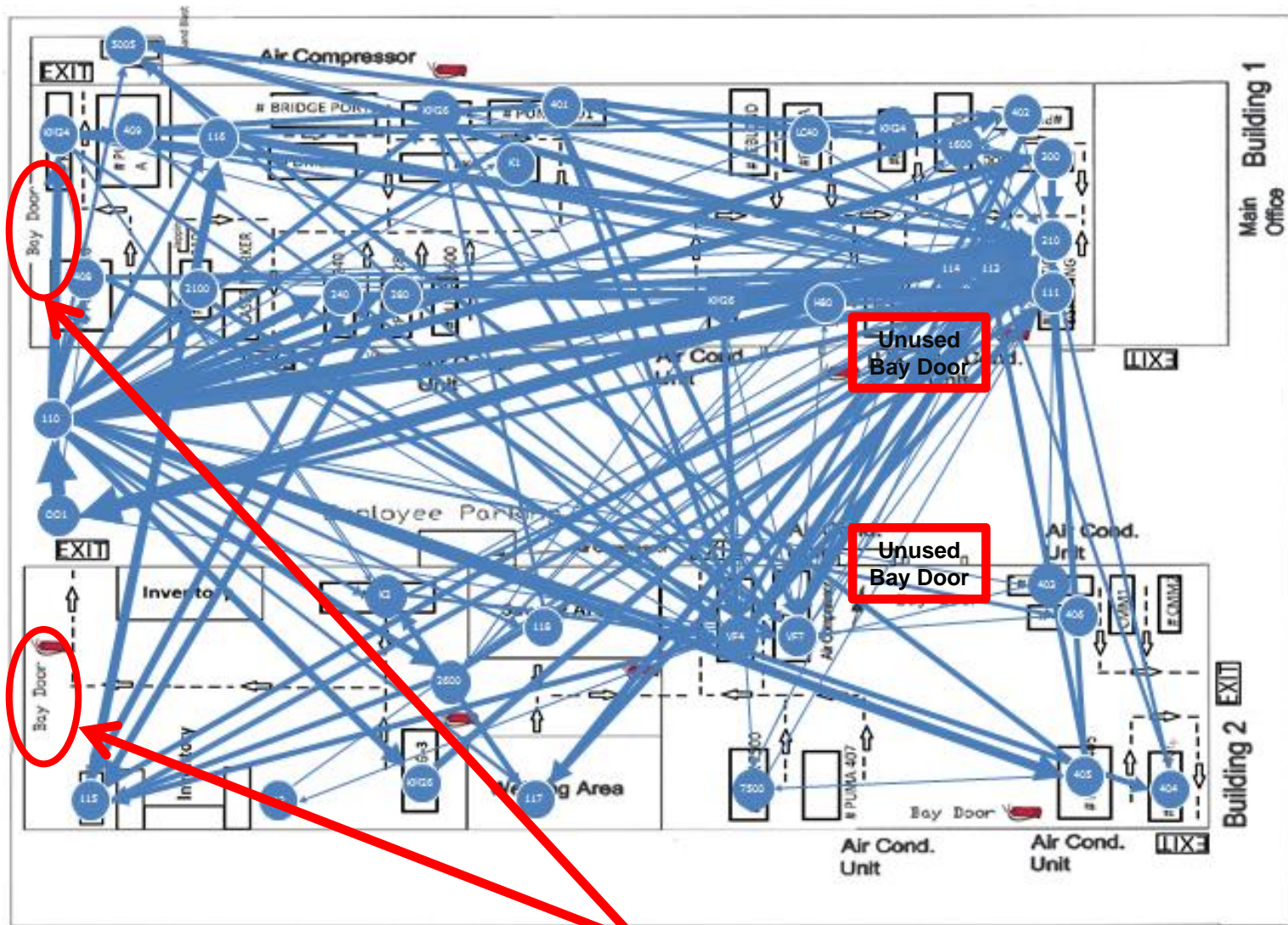
App Demo

Current State of Material Flow in their Facility

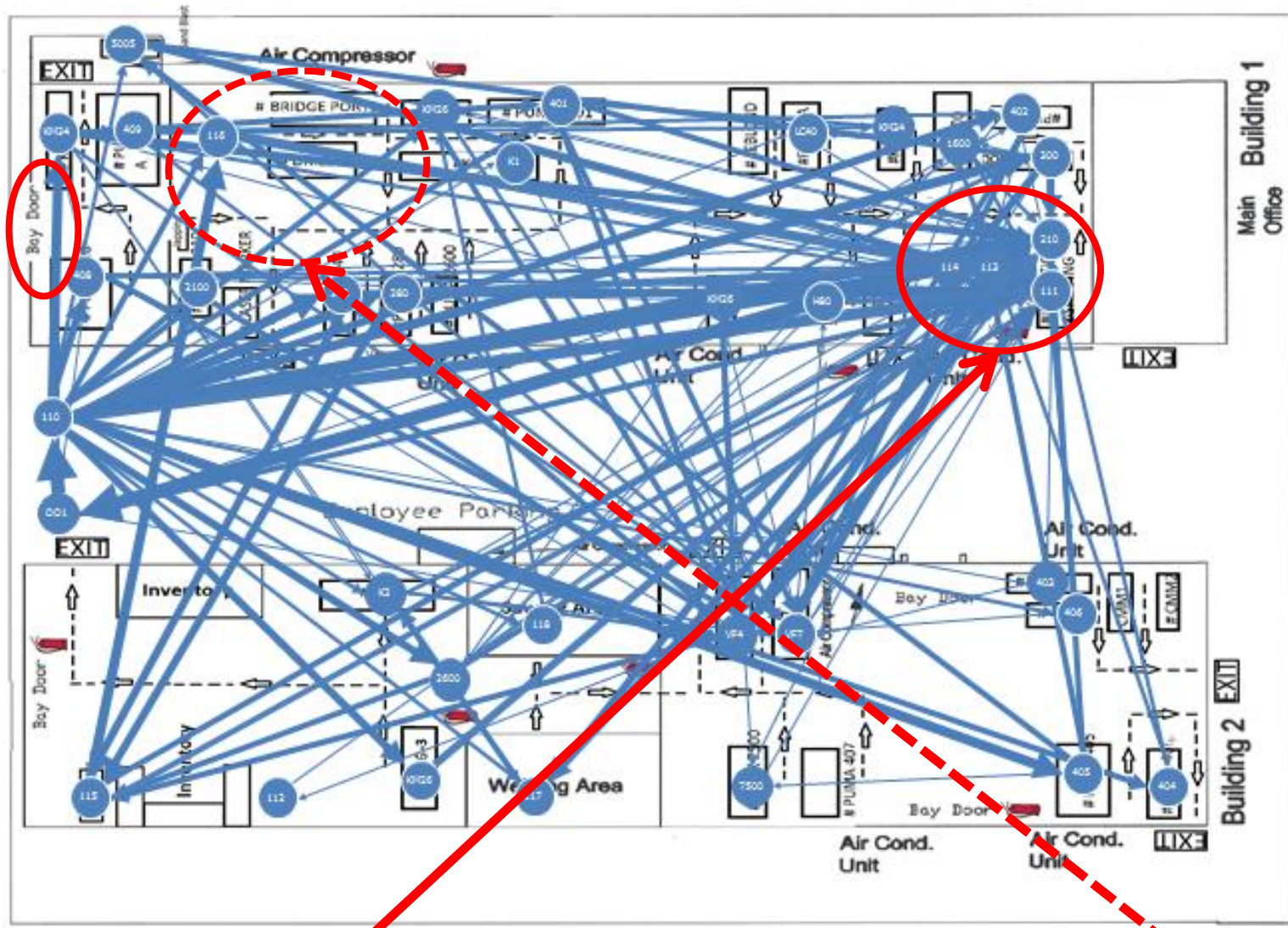




There is significant inter-building material flow. What if both buildings were merged into a single new building? The Parking Lot between the two buildings could be converted into a new building. Then the machines in Building 2 could be moved into this new building and the wall separating the two buildings can be demolished.

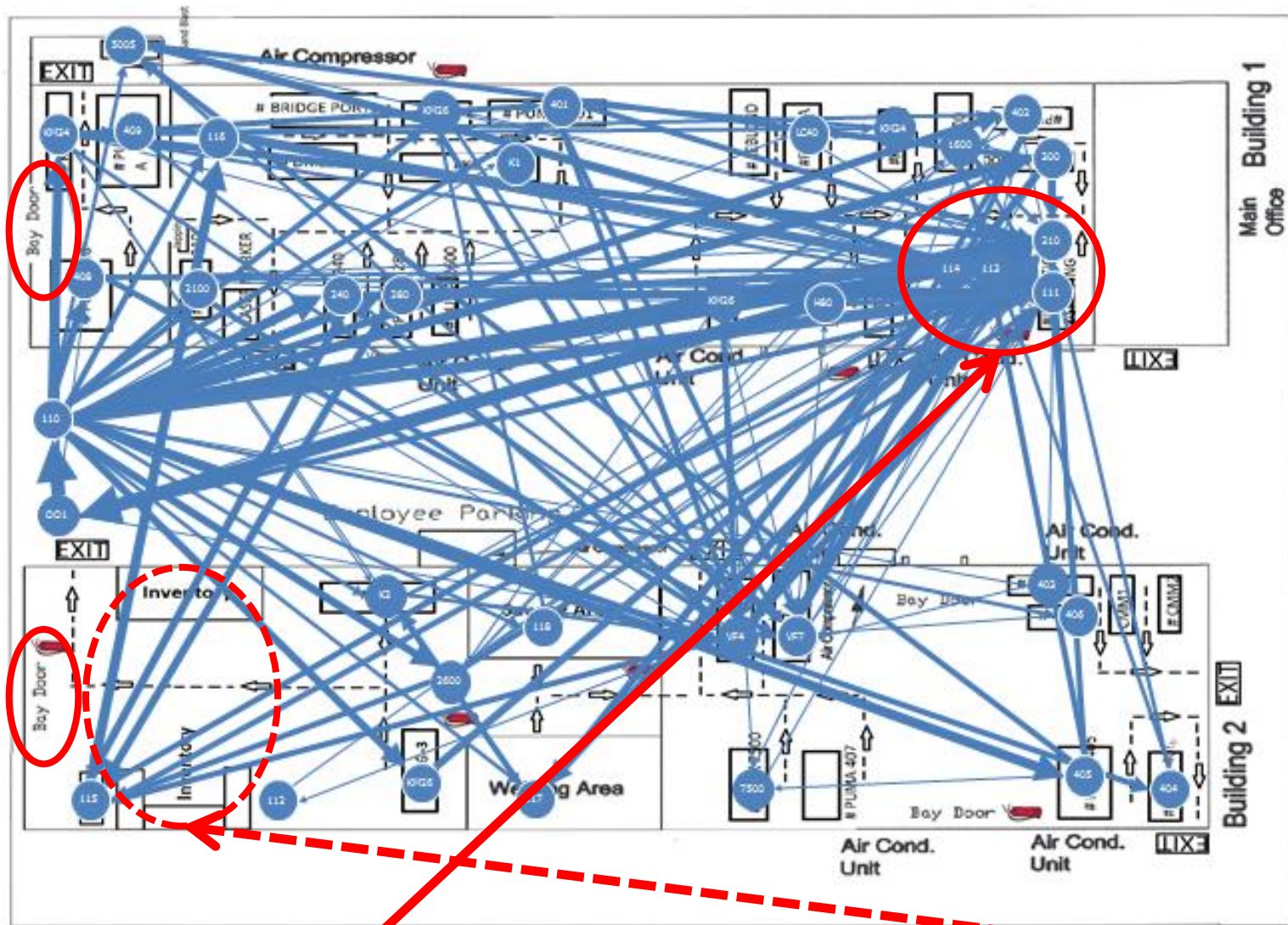


There is significant inter-building material flow. Currently, all inter-building flow occurs through the two Bay Doors at the left end of either building. Could the two unused Bay Doors on the side of either building be used instead?



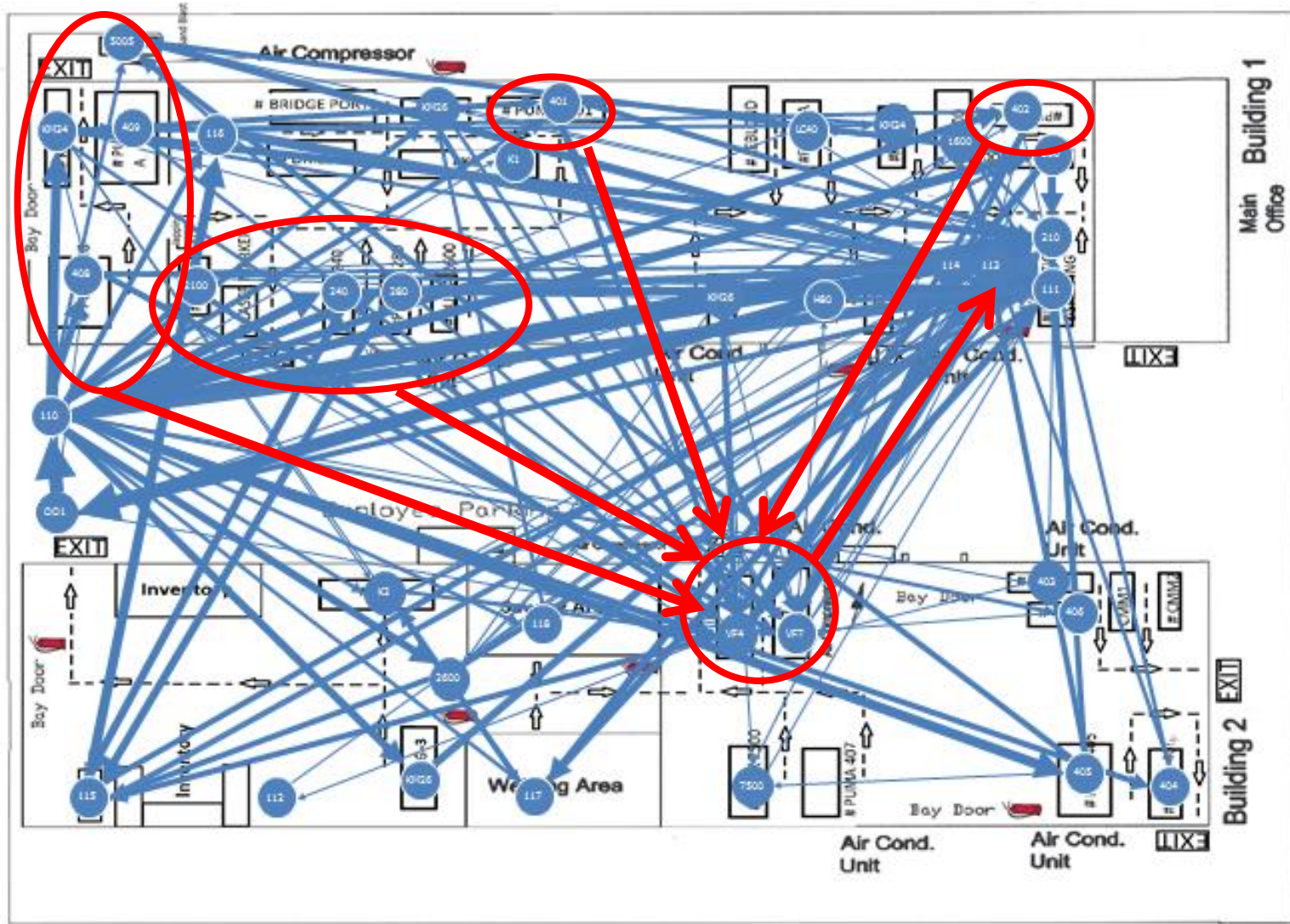
There is heavy material flow in the material handling aisle in Building 1. That is because Inspection, Marking and Shipping are next to the Main Office on the right side of Building 1. But parts are shipped to customers through the Bay Doors on the left side of the building (as shown)!

Could Inspection, Marking and Shipping be re-located into the area where the Radial Drill, Bridgeports and other manual machines are located (as shown)?



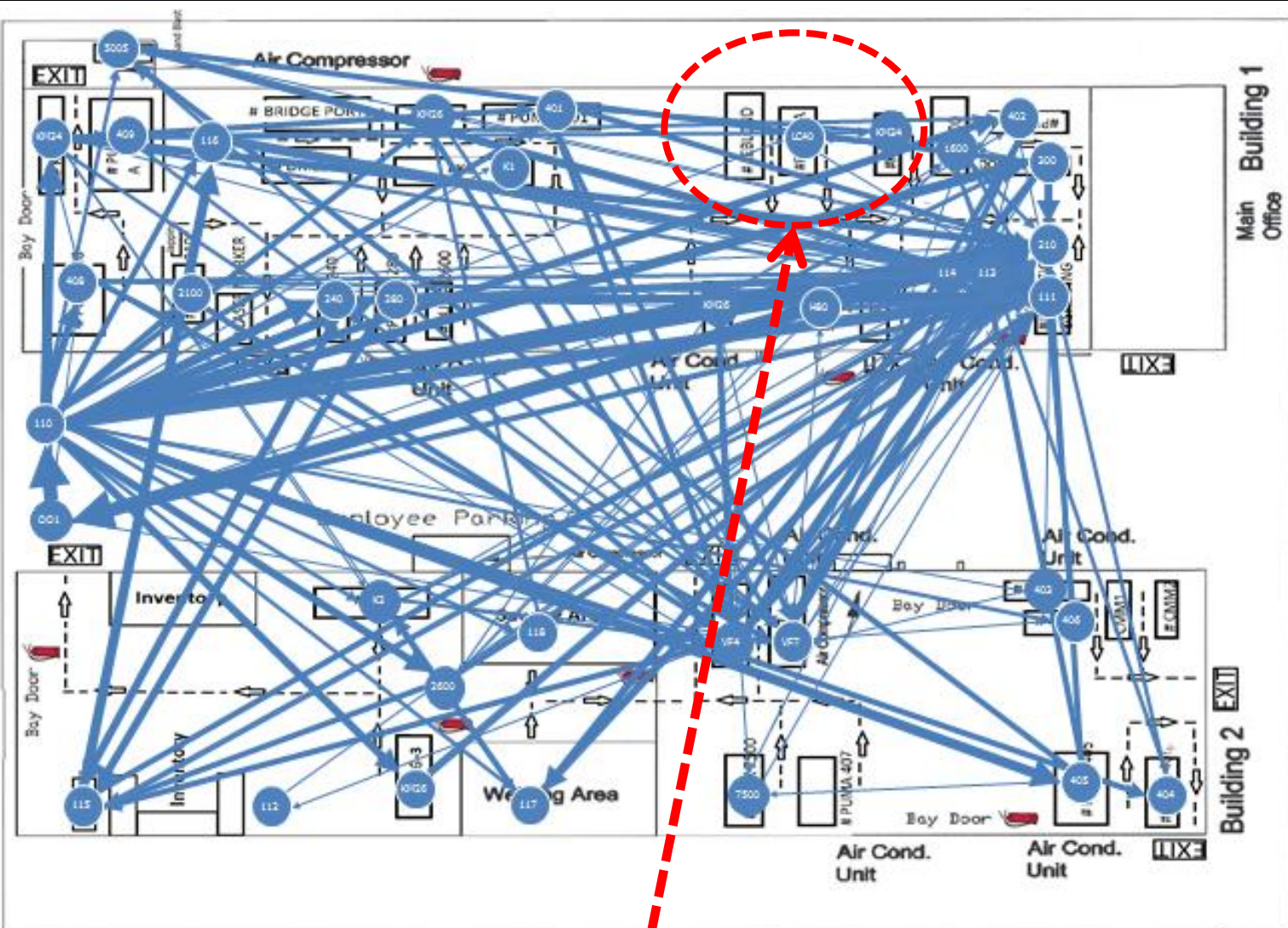
There is heavy material flow in the material handling aisle in Building 1. That is because Inspection, Marking and Shipping are next to the Main Office on the right side of Building 1. But parts are shipped to customers through the Bay Doors on the left side of the building (as shown)!

Could Inspection, Marking and Shipping be re-located into Building 2 where Inventory is anyway being stored near the main entrance to Building 2 (as shown)?



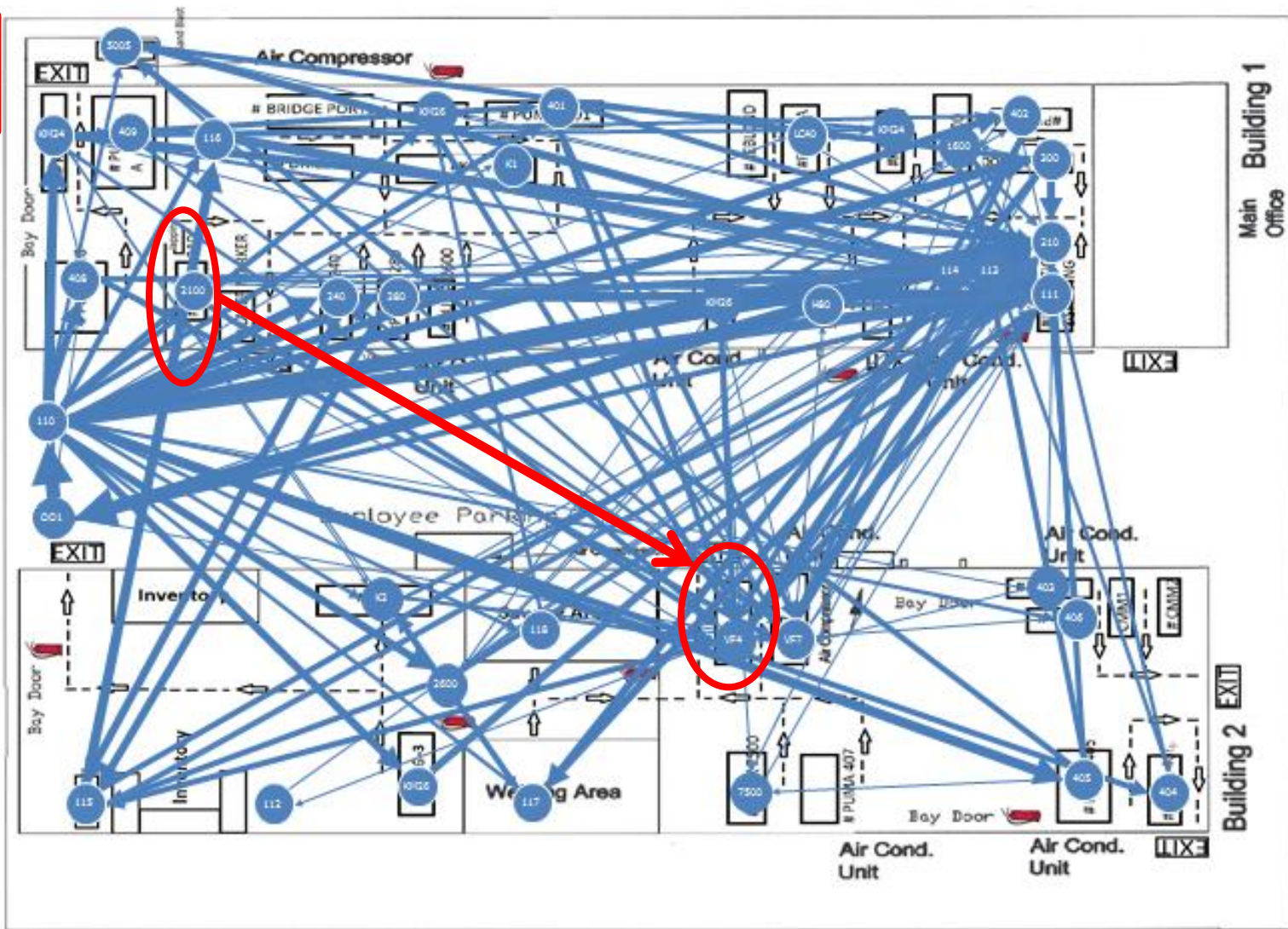
There is significant inter-building material flow between the two mills in Building 2 (VF-4 and VF-7) and the following groups of machines in Building 1: (1) the small Puma lathes (P240, P280, P2600, P300, P2100) in Building 1, (2) the large Puma lathes in Building 1 (P401, P402, P408, P409) and (Inspection, Marking and Shipping) in Building 1. Could VF-4 and VF-7 be re-located into Building 1? That would still leave milling capacity in Building 2 (MYNX7500 and the new VF-10).

X



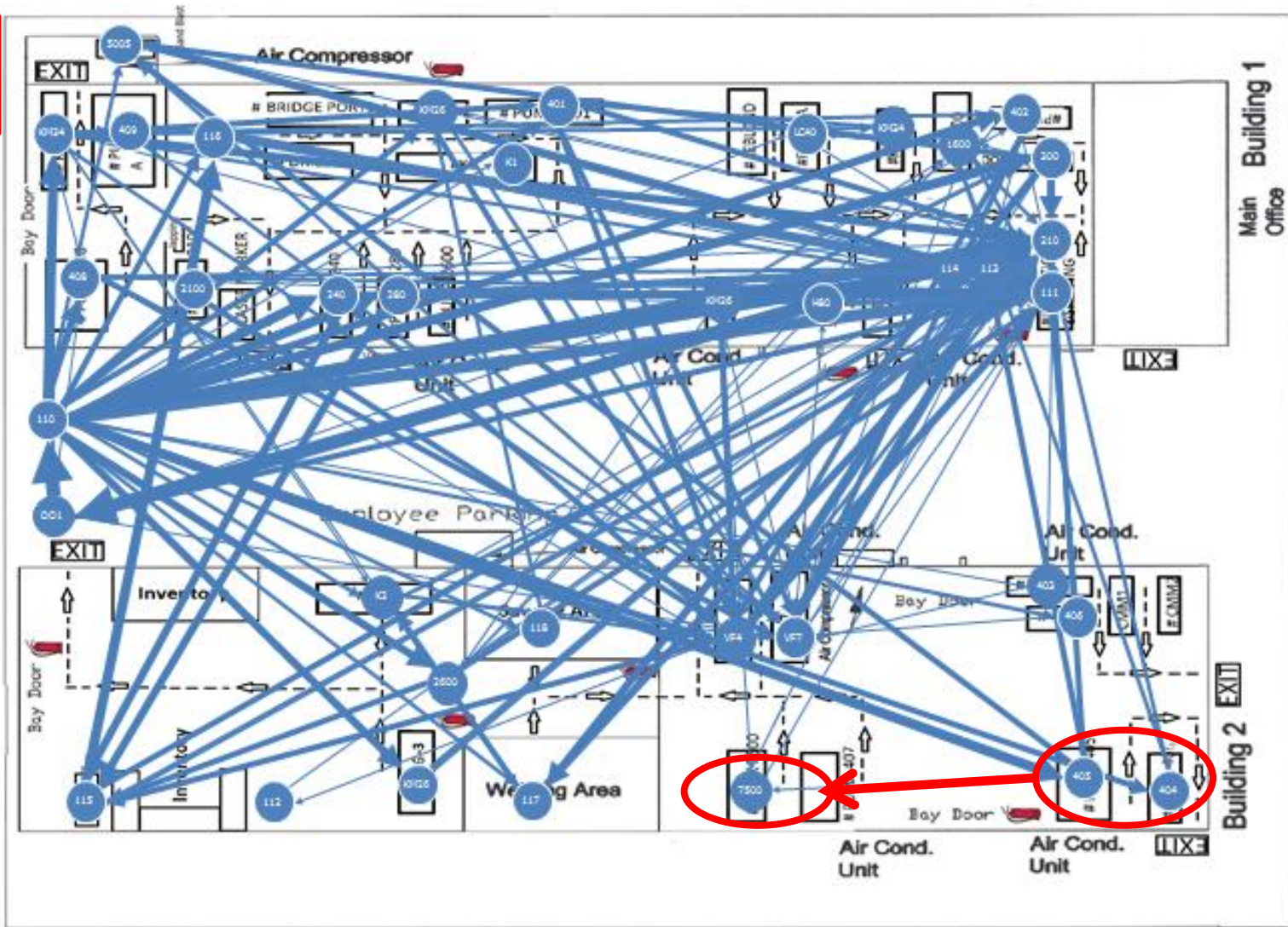
Currently, Building 2 has NO manual lathes. They are used to “skin” bar stock before it is loaded on the CNC lathes. For example, notice the KM34 next to P409 in Building 1? The From-To Chart shows significant flows between KM34-1 (Building 1) and P401, P402, P408 and P409 (Building 1). Building 2 has P403 and P406 which are identical to P401, P402, P408 and P409. So it may be advantageous to move KM34-2 and LC40 to Building 2 near to P403 and P406 in Building 2. Also, their removal from Building 1 would also free up space to accommodate VF-4 and VF-7 near EC1600 in Building 1.

X



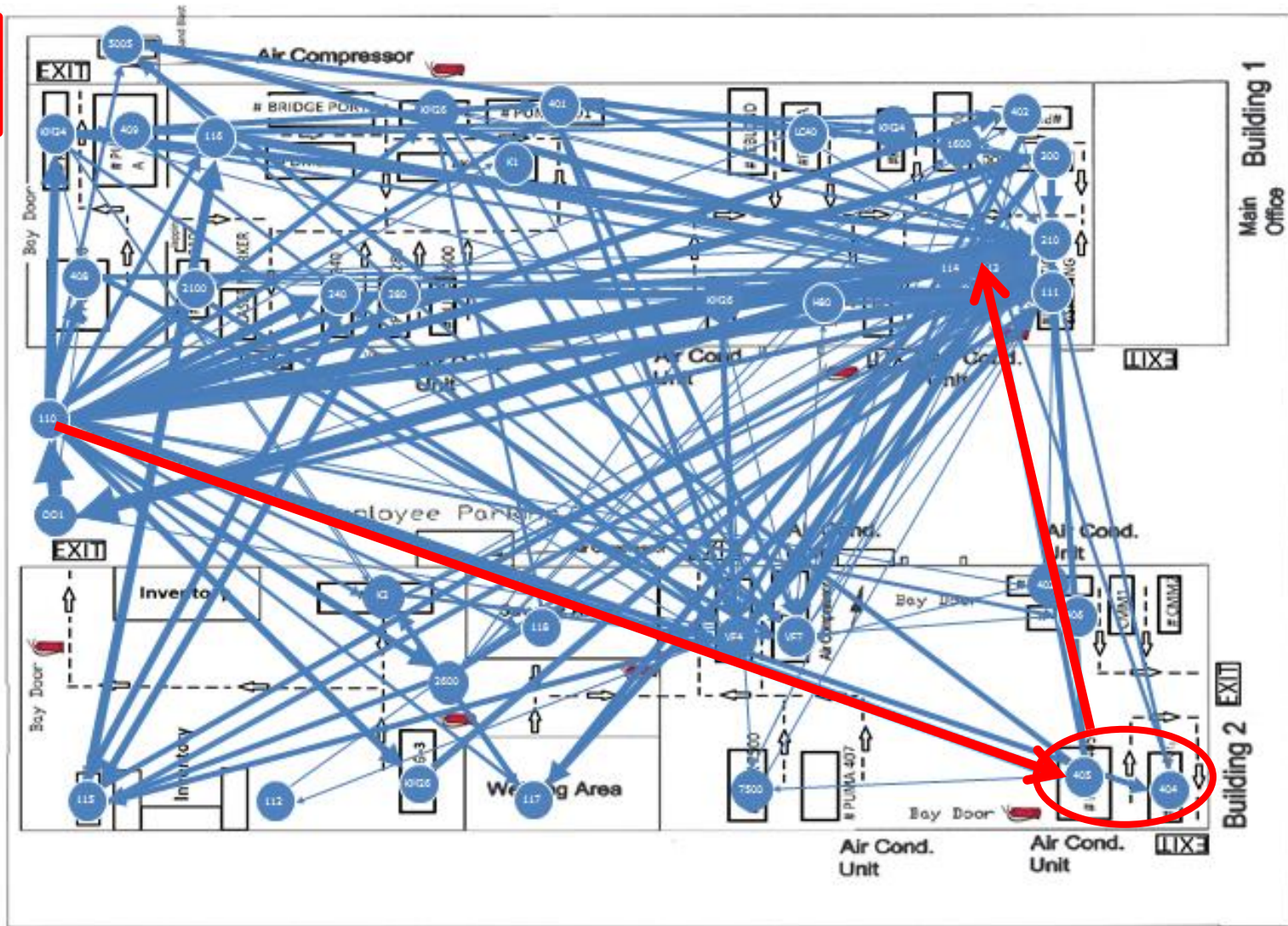
P2100 sends parts to VF-4. It does not send any parts to machines in Building 1. Since it is a small lathe, and Building 2 does not have any, could it be moved to Building 2 to form a cell with VF-4? Else could its work be done on any of the medium Puma lathes (P404, P405, P407)?

X



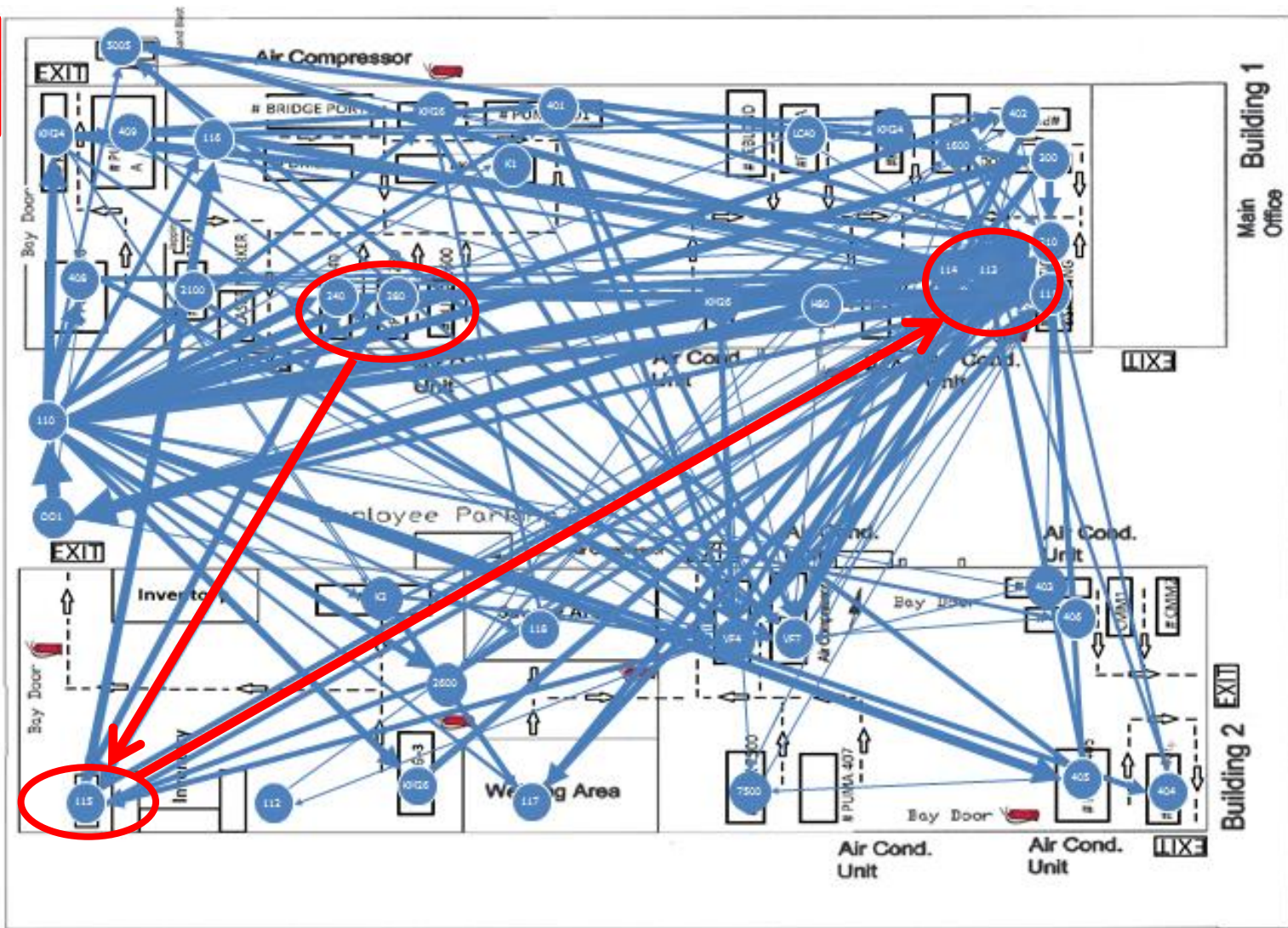
Medium Puma lathes (P404, P405) in Building 2 send parts to the mill, MYNX7500, in Building 2. P407 is an identical Puma lathe like P404 and P405. **P407 and MYNX7500 are located side-by-side and constitute a natural cell.** In the future, for parts that require turning + milling, if it is available, P407 should always be preferred over P404 or P405.

X



Medium Puma lathes (P404, P405) in Building 2 get bar stock from Receiving. Then, except for MYNX7500, these two lathes send the parts they complete mainly to work centers in Building 1 (from where they are shipped to customers). Could these lathes be re-located into Building 1, say between K26-1 and P280?

X



Hydrotest (#115) receives parts from the small Puma lathes (P240, P280 and P2600) in Building 1 and sends parts to the following departments in Building 1 – Inspection (#111), Marking (#112, #113) and Shipping (#210). Could Hydrotest be placed within the Inspection department?

Benefits of this Consulting Project

- **Management decided not to implement any layout changes**
 - Material flow was not perceived to be a problem
 - Too many machines would need to be moved
 - Capacity would be lost if machines were shut down for re-location
 - *Around the time we presented this assessment the Houston economy had begun to tank*
- **Management decided to implement some of our other improvement ideas**
 - Hired a full-time Industrial Engineer
 - Implemented a dedicated tool crib to control all tools, fixtures and gauges
 - Improved ERP use for WIP tracking and shop loading

Future Enhancements of the App (In Process)

- **Quantitative metrics to assess any layout changes**
 - Visualization is fine for starters but?
 - Line Of Sight Efficiency (LOSE)
 - Total Travel Distance
- **Provide the From-To Chart that was used to generate the Flow Diagram as an editable Excel spreadsheet**
- **Allow user to change routings**
- **Allow user to modify the original product mix**
- **Allow user to insert their plant layout**
 - Currently, this has to be done on a project-by-project basis by the app developer
 - **This service is a fee-based service**

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- ➔ ▪ Q&A

Questions? Comments? Feedback?

- Email us if you are interested in learning more on this topic.
- Visit www.Invistics.com and www.LeanandFlexible.com .
- Read an article by a former member of Shahrukh's research team at The Ohio State University "The Quick-Start Approach to JobshopLean: How to Initiate the Implementation of Lean in a High-Mix Low-Volume Manufacturing Facility"
[file:///C:/Users/Shahrukh%20Irani/Downloads/RequestedFile%20\(5\).pdf](file:///C:/Users/Shahrukh%20Irani/Downloads/RequestedFile%20(5).pdf)



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