TED YEE

I'm here to work as an engineer because somebody once told me that engineers fix problems. Though I'm a mechanical engineer, the problem I want to fix is the environment and I'm all in on it.

I'm graduating this spring (2025) from Northeastern University in Boston with a Bachelor's in Mechanical Engineering and a minor in International Affairs because I think a world working together is a goal worth chasing. As part of the undergraduate curriculum at Northeastern, we get job experience working at two 6-month, full-time coops, and I worked at Civil and Environmental firms to get closer to fixing the environment.

When I'm not at schoolwork, I spend a lot of time running and cross-country skiing. I sank 4 years of college into starting a ski team and in the last year we were able to fly across the country to compete at nationals!

WHAT'S HERE

01 **WIRE STRANDER**

CAPSTONE PROJECT | 6 MONTHS

02 **VIOLIN**

PERSONAL WOODWORKING PROJECT | 5 MONTHS

03 **POLARIS**

AUTOMATION AT WRIGHT-PIERCE | 4 MONTHS

FIND ME

01.

WIRE STRANDER

CAPSTONE PROJECT | 6 MONTHS

01

02

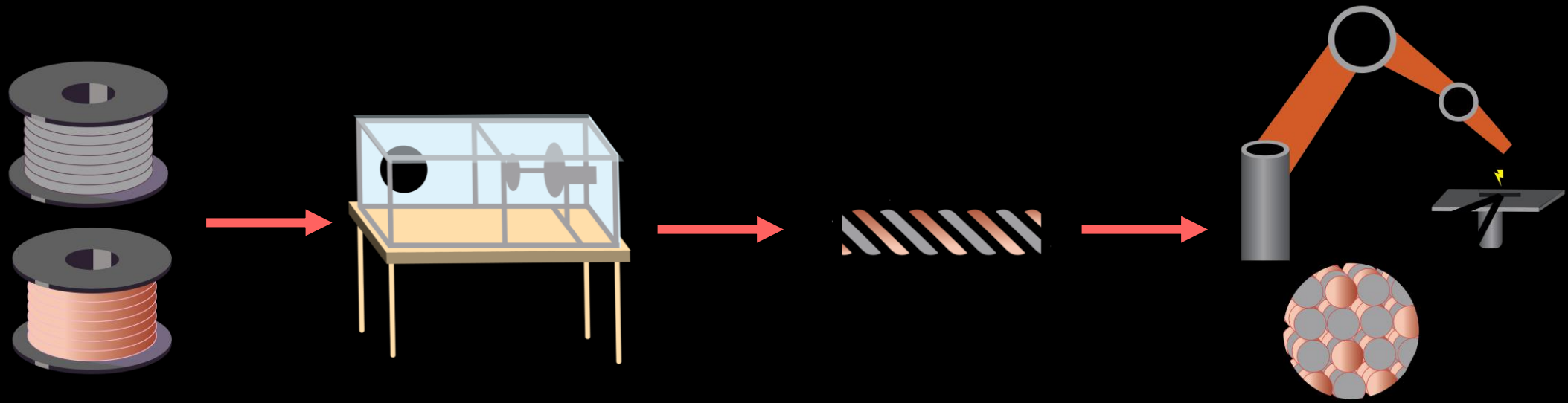
03

Wire Arc Additive Manufacturing (WAAM) is an experimental type of metal 3D printing that can be leveraged in alloy creation, particularly High Entropy Alloys (HEA's). If feedstock contains multiple metals, they will be can be melted together into custom alloys during deposition. My primary tasks were electrical, power, safety, and UI systems and alloy analysis procedures

"A benchtop machine that creates twisted cable feedstock for use with WAAM"

CHALLENGE

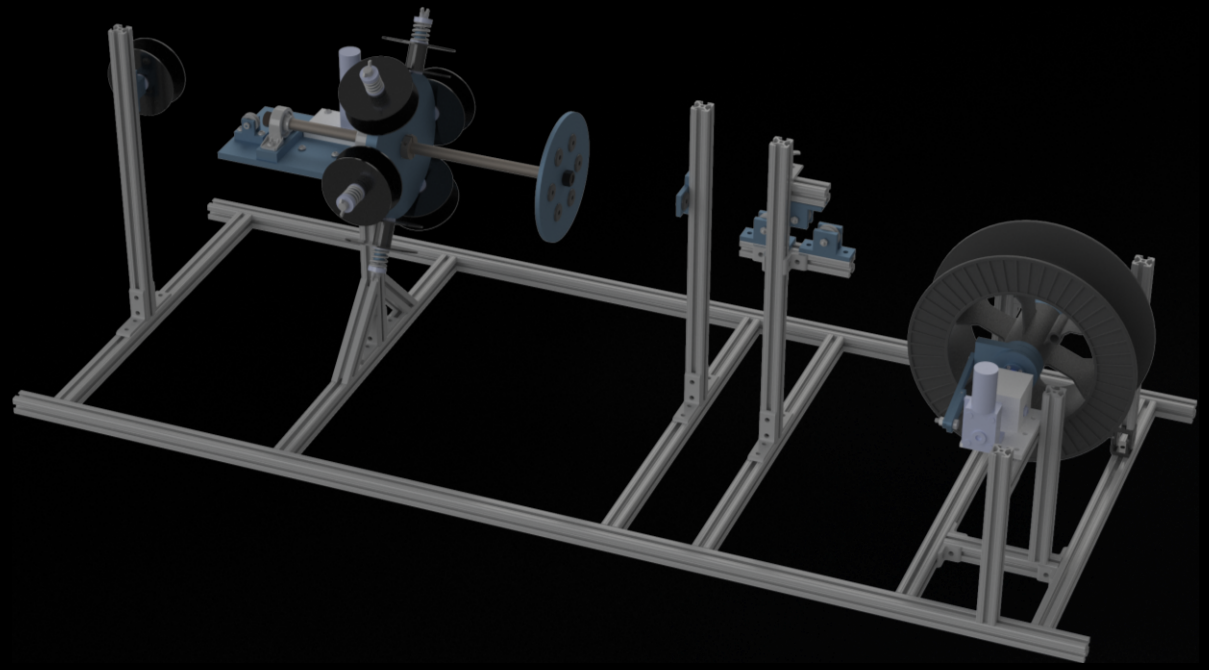
By twisting together various metals, alloys can be formed during deposition that cannot be commercially purchased as wire for feedstock. In particular, the near-equal concentrations are good for making High Entropy Alloys (HEA's). A materials professor posed the project to manufacture large volumes of twisted feedstock and my senior engineering capstone group took it on.



SOLUTION

With my team of 5, we got to practice product design, specifically working to interface with the university's Fronius/ABB WAAM cell's feeder, tubing, and plasma torch, where the machine is currently used for alloy research.

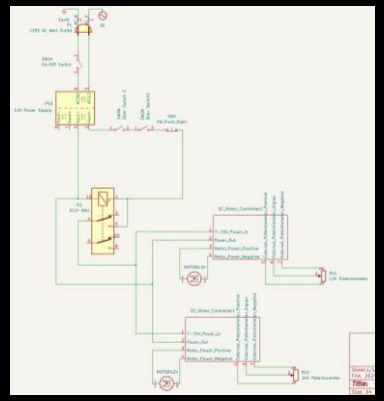
I also took on the design of an O&M manual, which is available online on my LinkedIn: https://www.linkedin.com/in/ted-yee/

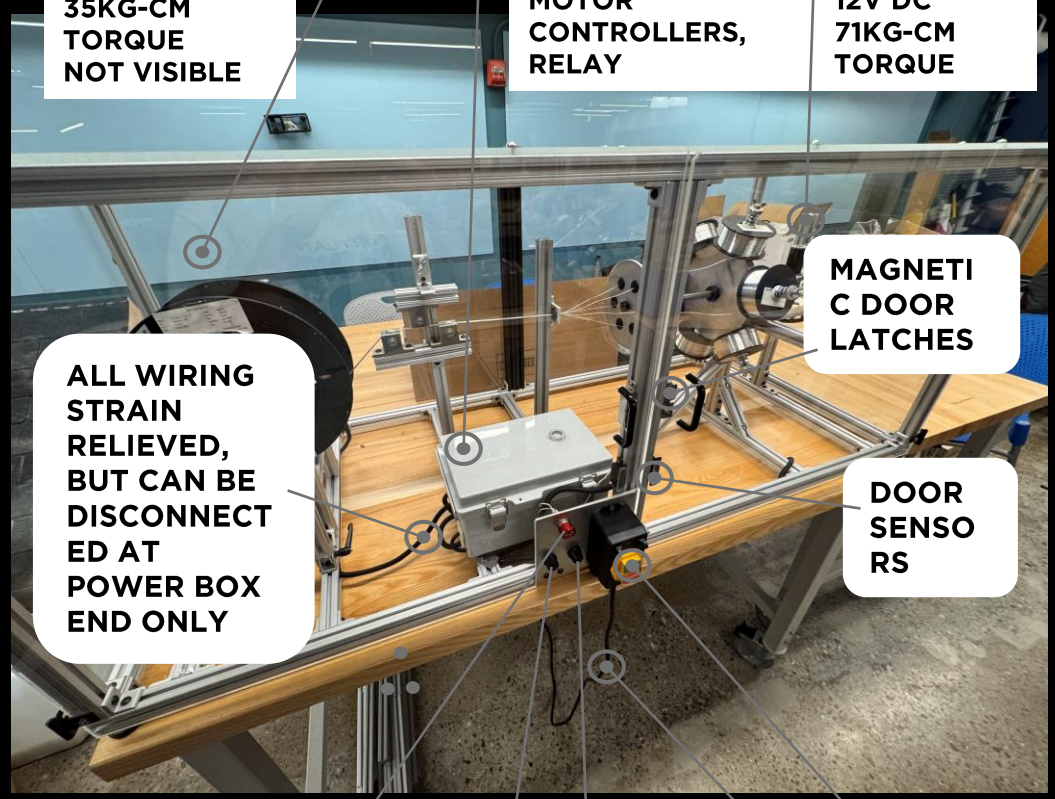


PROCESS

Personally, I spearheaded electrical, safety, and UI systems.

It was a lot of fun being able to consult with the team about what features we wanted, then allocate enough budget to buy quality components and assemble them in a professional machine rather than just hobby-scale.





I was also in charge of alloy analysis procedures, where we looked at the springback that was preventing out early motors from being able to yield the wire into a strand.

Luke Bottger, Cody Clifford, Karen Hamaguchi, Kendrick Langenbach, Ted Yee

Prof. Scott Julien

Wire Strander

Background

As part of Northeastern Additive Manufacturing Lab's Wire Arc Additive Manufacturing (WAAM) research, researchers want to create alloy feedstock that cannot be extruded as a solid wire by stranding together constituent metals.

To do this successfully, they need a wire stranding device that:

- Strands multiple diverse metals
- Has an **adjustable pitch length** and tensioning
- Is **easy** and **safe** to operate
- Is relatively **small** and **affordable**

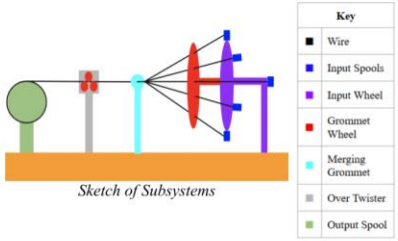
Large Industrial Wire Strander

Problem Statement

To design a device that **strands** together **wires of diverse metals** into a single twisted feedstock for Wire Arc Additive Manufacturing.

Design Overview

1. 7 **input spools** are tensioned by clutch friction
2. The wires meet at a **joining grommet**
3. Stranded wire goes through an **over twister**
4. Stranded wire is spooled onto an **output spool** which will be placed into the WAAM cell



Sketch of Subsystems

Challenges:

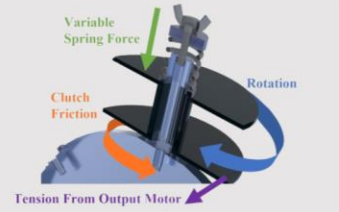
- Lack of literature on mechanics of wire twisting
- Tension system design
- Center wire routing

Motors and Tension

- The properties of our desired materials guided our spring choice
- We designed our tensioner and motors to satisfy this range of tensions

Maximum Tension		
Spring Type	Spring Force (lbf)	Wire Tension (in-lbf)
Soft Spring	25.7	3.2
Hard Spring	68.0	8.5

Target Motor Specs	
Pitch Length	0.5-2 in
Linear Speed	1 in/s
Acceleration Time	10 s
Tension	1 in-lbf



Tensioning System

Less speed, more torque

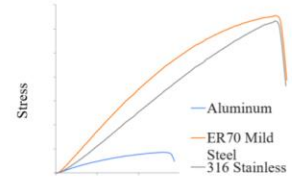
Motor Iteration

Strand Integrity

- Factors affecting strand integrity:
  - **Yielding** of the wire
  - **Springback** in the wire
  - **Friction** between the wires
- Springback: tendency to **regain** original shape
- Frictional forces between wires are difficult to characterize but **help integrity**
- Ultimately, changing parameters allowed us to **maximize** how well our wire stays together
- Stainless steel had **higher** yield strength than mild steel
- **Stress concentration** on Instron mounting caused failure during testing

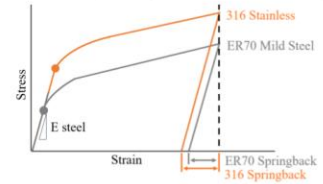
90° Springback Test	
Material	Springback (degrees)
4043 Aluminum	13.7
ER70S-6 Mild Steel	17.0
316L Stainless Steel	32.0

Stress vs. Strain Testing



Conclusion: Stainless Has Higher Yield Strength

Yield Strength & Springback Relationship



Conclusion: Higher Yield Strength & Same Elastic Modulus Equals More Springback

Testing and Results

All 4043 aluminum wires:

- ✓ Successful at a range of pitch lengths and held together well
- ✓ Did not snap during stranding despite being the weakest material
- ✗ Poor feedability in welding feeder - flattened by the feeder

All 316L stainless steel wires:

- ✗ Failed to stay together after stranding
- ✗ Input motor did not have the torque necessary to overcome resistance to stranding

All ER70S-6 mild steel wires:

- ✓ Successful, when powered by hand
- ✓ Successful in welding feeder
- ✗ Input motor did not have the torque necessary to overcome resistance to stranding

3 mild steel and 4 aluminum wires:

- ✓ Successful, but less uniform at short pitch
- ✗ Poor feedability in welding feeder - aluminum flattened by the feeder

Pitch Length:

- ✓ Can produce ½" to 2" pitch lengths, this covers the desired range

Exit Strategy / Future Work

This device will be delivered to the Northeastern Additive Manufacturing Lab to assist them in their WAAM research.

Future Work:

Our device could be improved with:

- Higher torque motors
- Easier spool loading
- Easier startup processes

Acknowledgements

The Wire Strander Team would like to recognize Professors Scott Julien, Michael Allshouse, Andrew Gouldstone, Laurie Nardone, Ahmad Nourian, the entire Capstone Lab staff, and Jon Gager for their support and aid throughout the duration of this project. Thank you!

02.

VIOLIN

PERSONAL WOODWORKING PROJECT | 5 MONTHS

01
02
03

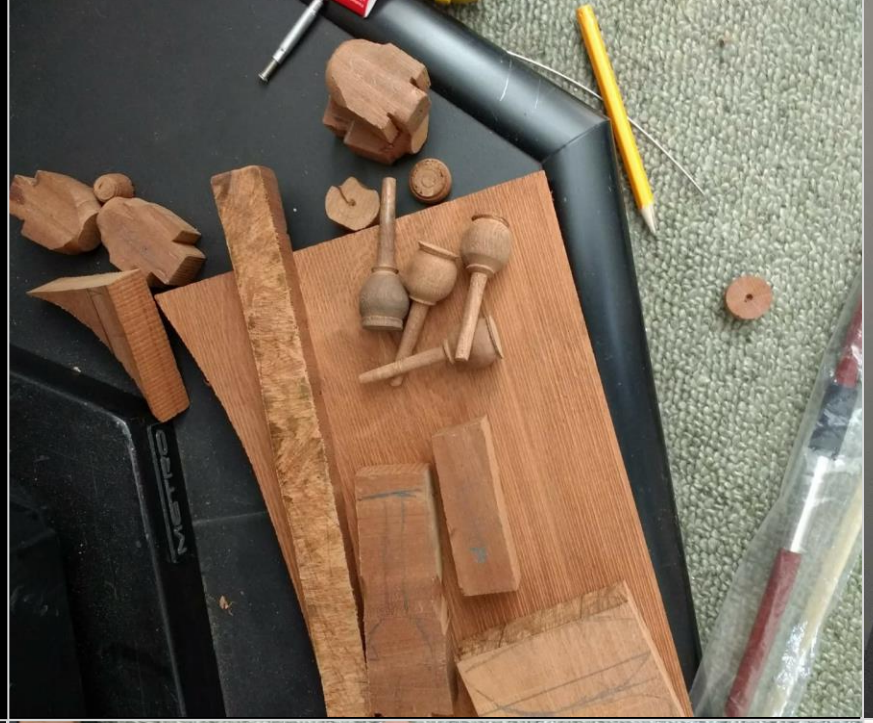
One time I thought it would be cool to have a violin. Then I saw that violins are expensive. So, I just made one. No template because those are trade secrets, no power tools to make it a challenge.

"To create a violin with only hand tools"

2

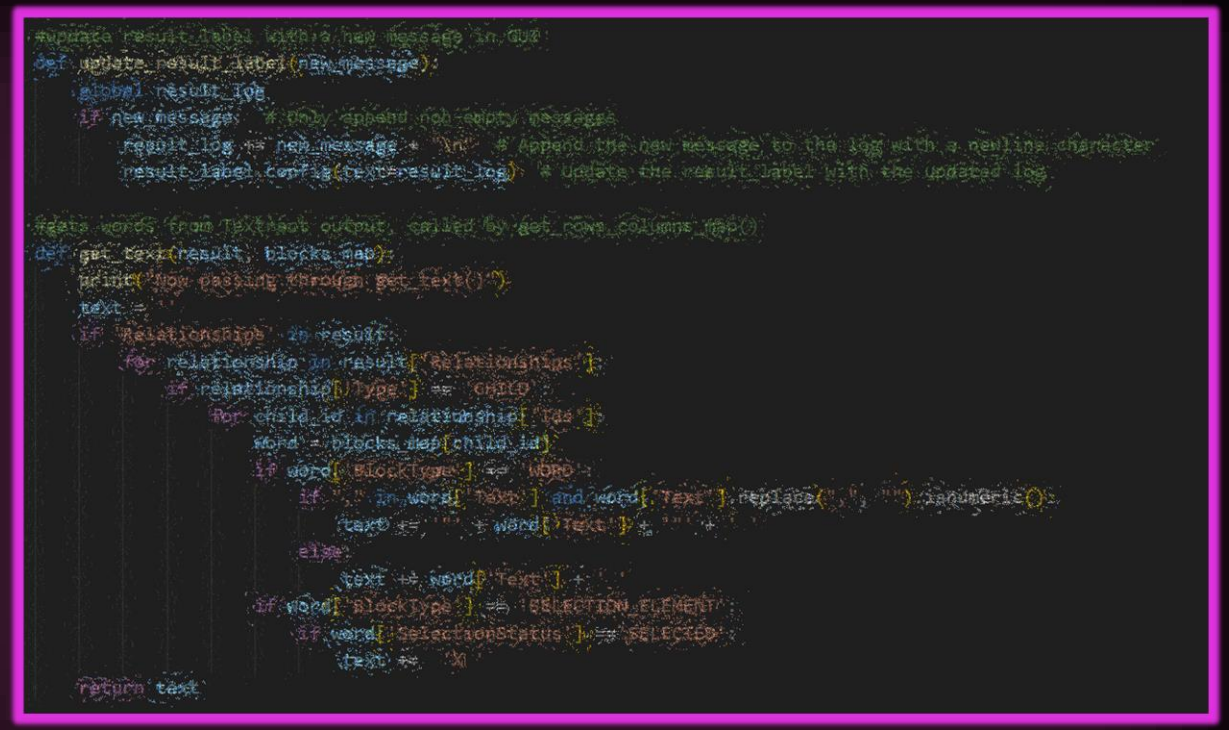
CONTEXT

Luthiery (the art of making and repairing stringed-instruments) is the pinnacle of fine mechanical woodworking. My violin had 30 pieces, with details smaller than a mm, requiring some very sharp planes, chisels, and files. Assembly and finishing was a complex process requiring hide-glue, steam bending, varnishing and tuning. I completed the whole project despite doubt from a group of lifelong woodworkers, and the finished violin is playable, if a bit unique.



FINAL PRODUCT

03.



POLARIS

AUTOMATION AT WRIGHT-PIERCE | 4 MONTHS

01
02
03

To meet an EPA mandate about reporting every lead pipe in the country by Oct 2024, every town in the country needed to go through their records. To help my coop complete their consulting jobs on this, I led this project of automating the process.

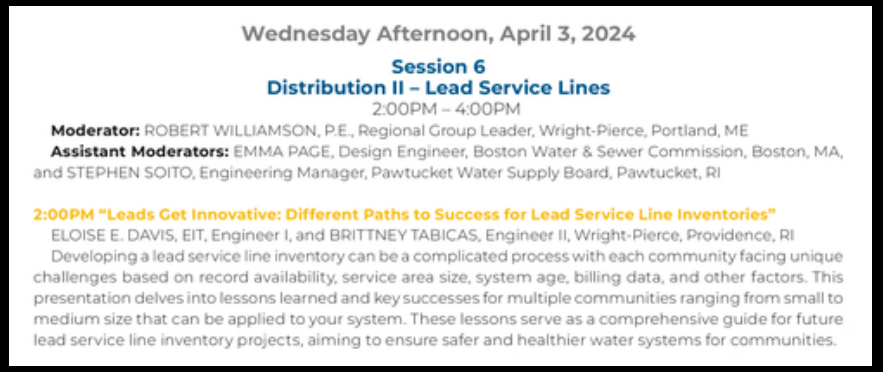
"To automate data entry of handwritten public records"

CONTEXT

WRIGHT-PIERCE
Engineering a Better Environment

As part of Northeastern University's Coop Program, I spent January to June of 2024 working with Wright-Pierce Environmental Engineering Firm. While learning about water engineering and doing everything from bid writing to field tests, I was able to take on my own project. With some knowledge of coding and machine learning resources, I set up a process to decrease a data collection method from months to days.

At the end of my coop, I was the only intern to ever give a company-wide presentation, where I pitched the process to every branch and why it was a viable business branch. My work was featured in a session at the New England Water Works Association annual conference. Check out the conference proceedings here: https://www.journalofnewwa-digital.com/newq/0324_september_2024/MobilePagedReplica.action?pm=2&folio=52#pg54



Wednesday Afternoon, April 3, 2024

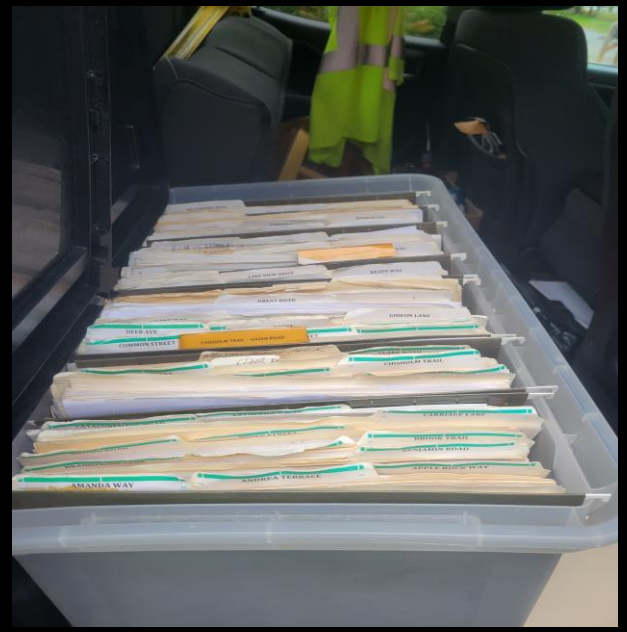
Session 6
Distribution II – Lead Service Lines
2:00PM – 4:00PM

Moderator: ROBERT WILLIAMSON, P.E., Regional Group Leader, Wright-Pierce, Portland, ME
Assistant Moderators: EMMA PAGE, Design Engineer, Boston Water & Sewer Commission, Boston, MA, and STEPHEN SOITO, Engineering Manager, Pawtucket Water Supply Board, Pawtucket, RI

2:00PM "Leads Get Innovative: Different Paths to Success for Lead Service Line Inventories"
ELOISE E. DAVIS, EIT, Engineer I, and BRITTNEY TABICAS, Engineer II, Wright-Pierce, Providence, RI
Developing a lead service line inventory can be a complicated process with each community facing unique challenges based on record availability, service area size, system age, billing data, and other factors. This presentation delves into lessons learned and key successes for multiple communities ranging from small to medium size that can be applied to your system. These lessons serve as a comprehensive guide for future lead service line inventory projects, aiming to ensure safer and healthier water systems for communities.

CHALLENGE

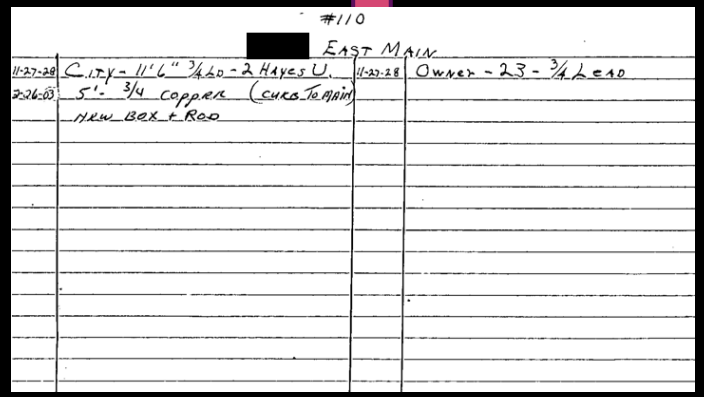
To minimize lead in drinking water, an EPA mandate (CFR40, §141.84) required an inventory of the location and material of every pipe in every water system in the country by Oct 16, 2024. Wright-Pierce was often hired as a consultant to help clients organize and submit their records, but that meant that engineers were spending hours a day reading addresses and pipe info off scanned records.

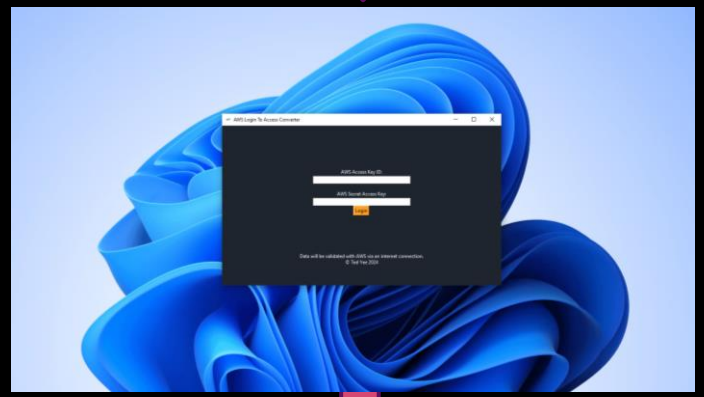


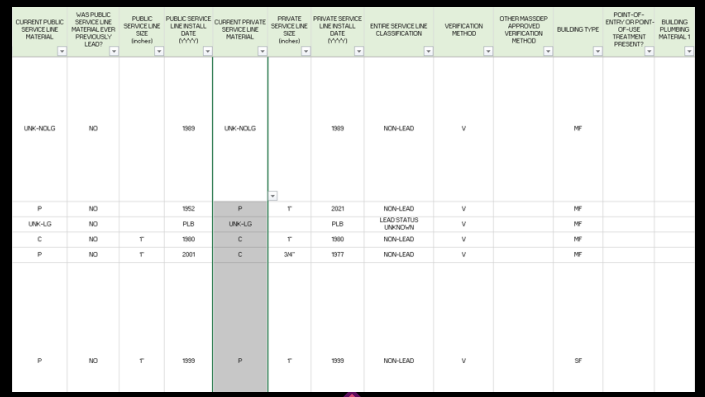
SOLUTION

We turned to computer-vision models and set up a GUI where Wright-Pierce employees could access computer use a user could use company credentials to access an Amazon Web Services (AWS) model that detected handwriting in pdfs.

Though we didn't make the process foolproof, and it still heavily involved my coworker, we were able to use it during my coop and it proved itself over manual entry







CURRENT PUBLIC SERVICE LINE MATERIAL	WAS PUBLIC SERVICE LINE MATERIAL EVER PREVIOUSLY LEAD?	PUBLIC SERVICE LINE SIZE (inches)	PUBLIC SERVICE LINE INSTALL DATE (YYYY)	CURRENT PRIVATE SERVICE LINE MATERIAL	PRIVATE SERVICE LINE SIZE (inches)	PRIVATE SERVICE LINE INSTALL DATE (YYYY)	ENTIRE SERVICE LINE CLASSIFICATION	VERIFICATION METHOD	OTHER/MASSDEP APPROVED VERIFICATION METHOD	BUILDING TYPE	POINT-OF-ENTRY/BUPOINT-OF-USE TREATMENT PRESENT?	BUILDING PLUMBING MATERIAL?
UNK-NOLG	NO		1989	UNK-NOLG		1989	NON-LEAD	V		MF		
P	NO		1952	P	1"	2021	NON-LEAD	V		MF		
UNK-LG	NO		PLB	UNK-LG		PLB	LEAD STATUS UNKNOWN	V		MF		
C	NO	1"	1980	C	1"	1980	NON-LEAD	V		MF		
P	NO	1"	2001	C	3/4"	1977	NON-LEAD	V		MF		
P	NO	1"	1999	P	1"	1999	NON-LEAD	V		SF		

PROCESS

I learned my way around the Amazon Web Services (AWS) suite and was able to set up an enterprise organization structure with access to AWS Textract, a computer-vision model for extracting handwriting from images.

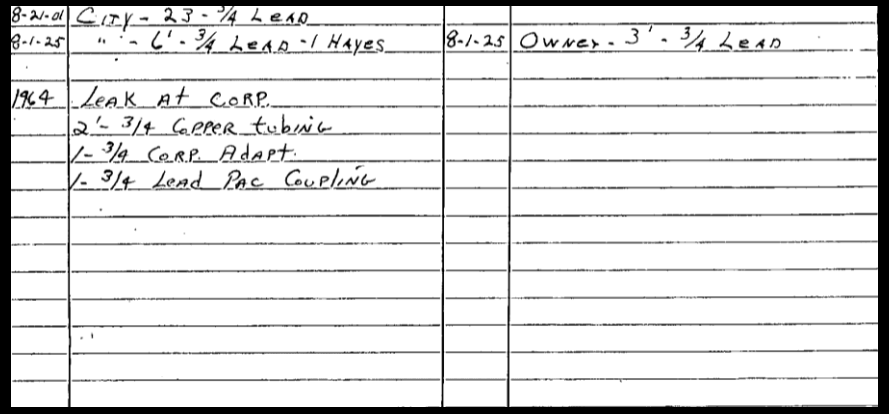
During my 6months there, I worked with one other employee who had some coding experience, and we were able to make a user-friendly portal to pass images through Textract. Without training our own models though, the process still required manual interpretation of the data and lots of QC.

1 — Upload files

2 — Use Textract to create JSON

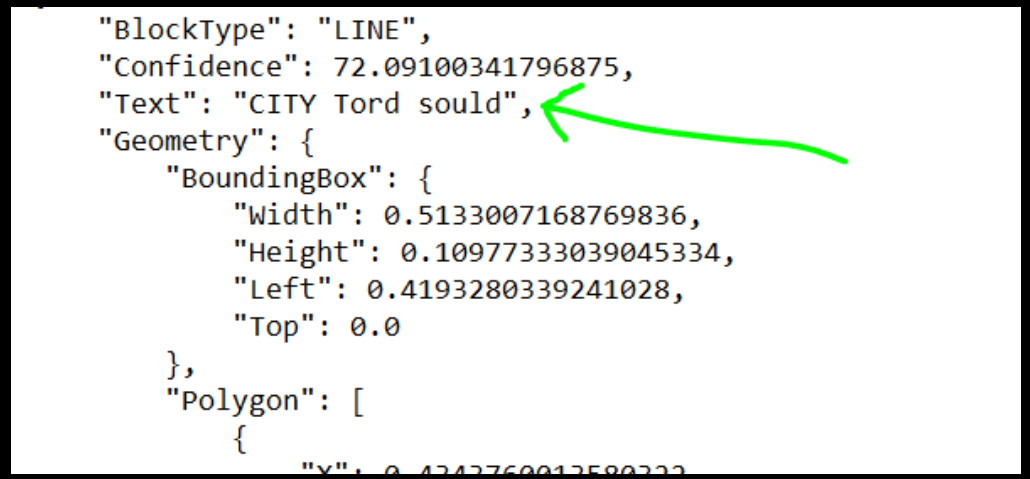
3 — Turn JSON into spreadsheet

4 — Clean Up and Import



8-21-01 CITY - 2 3 - 3/4 LEAD
8-1-25 " " - 6' - 3/4 LEAD - 1 HAYES
8-1-25 OWNER - 3' - 3/4 LEAD
1964 LEAK AT CORP.
2'- 3/4 COPPER TUBING
1- 3/4 CORP. ADAPT.
1- 3/4 LEAD PAC COUPLING

Prop. Address	Service No.	Meter No.	Entity	Date	Data	Lead	Min. Confidence	Avg. Confidence	Max. Confidence
	7688	3860968	City	NOV/0/1982	30' - 3/4 plastic 1- 8x 3/4 saddle 1- 3/4 corp 1- - 5/4 curd	FALSE	33.3838617	78.24118347	99.96372223
	7688	3860968	City	9/10/2012	8'-3/4 copper (at main) 1-3/4 x8 saddle Corp 1-3/4 1-3/4 union w1insert	FALSE	35.85698318	80.77662373	99.76037598
	7688	3860968	City	7/2/2019	Curb to main relay 30' 3/4 copper 1- open right curb Reamed corp	FALSE	60.55500412	82.18465018	99.98804474
	7688	3860968	Owner	NOV/0/1982	91 3/4 plastic 1- 5/4 male adapt 1- 3/4 gate valve 1- - 5/8 meter	FALSE	67.52280426	87.10707601	98.09493256
	7688	3860968	Owner	5/4	1- - male adapt 1- 3/4 gate valve 1- - 5/8 meter	FALSE	44.60352707	67.8714695	93.28643036
	7688	3860968	Owner	1/29/08	5'- 3/4 copper 2 - 3/4 inserts 2- 3/4 unions Repair made 42 from curb	FALSE	55.54922104	82.33606021	99.86844635



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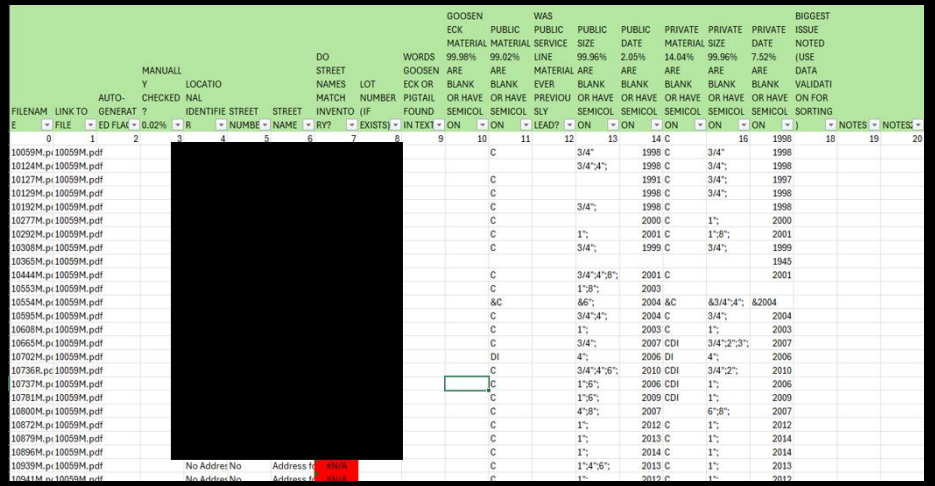

FILENAME	LINK TO FILE	AUTO-GENERATED FLAG	MANUALLY CHECKED?	LOCATIONAL IDENTIFIER	STREET NUMBER	STREET NAME	DO STREET NAMES MATCH INVENTORY?	LOT NUMBER (IF EXISTS)	WORDS GOOSENECK OR PIGTAIL FOUND IN TEXT	GOOSENECK MATERIAL 99.98% ARE BLANK OR HAVE SEMICOLON	PUBLIC MATERIAL 99.02% ARE BLANK OR HAVE SEMICOLON	WAS PUBLIC SERVICE LINE MATERIAL EVER PREVIOUSLY LEAD?	PUBLIC SIZE 99.96% ARE BLANK OR HAVE SEMICOLON	PUBLIC DATE 2.05% ARE BLANK OR HAVE SEMICOLON	PRIVATE MATERIAL 14.04% ARE BLANK OR HAVE SEMICOLON	PRIVATE SIZE 99.96% ARE BLANK OR HAVE SEMICOLON	PRIVATE DATE 7.52% ARE BLANK OR HAVE SEMICOLON	BIGGEST ISSUE NOTED (USE DATA VALIDATION FOR SORTING)	NOTES	NOTES
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	C	16	1998	18	19	20
10059M.pr	10059M.pdf									C		3/4"	1998	C	3/4"		1998			
10124M.pr	10059M.pdf											3/4";4";	1998	C	3/4";		1998			
10127M.pr	10059M.pdf									C			1991	C	3/4";		1997			
10129M.pr	10059M.pdf									C			1998	C	3/4";		1998			
10192M.pr	10059M.pdf									C		3/4";	1998	C			1998			
10277M.pr	10059M.pdf									C			2000	C	1";		2000			
10292M.pr	10059M.pdf									C		1";	2001	C	1";8";		2001			
10308M.pr	10059M.pdf									C		3/4";	1999	C	3/4";		1999			
10365M.pr	10059M.pdf																1945			
10444M.pr	10059M.pdf									C		3/4";4";8";	2001	C			2001			
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10595M.pr	10059M.pdf									C		3/4";4";	2004	C	3/4";		2004			
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10939M.pr	10059M.pdf			No Addres	No	Address fo	#N/A			C		1";4";6";	2013	C	1";		2013			
10941M.pr	10059M.pdf			No Addres	No	Address fo	#N/A			C		1";	2012	C	1";		2012			

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