NPOI Vacuum Manifold

Wyatt Clark | Cydny Clark | Alex McClinton

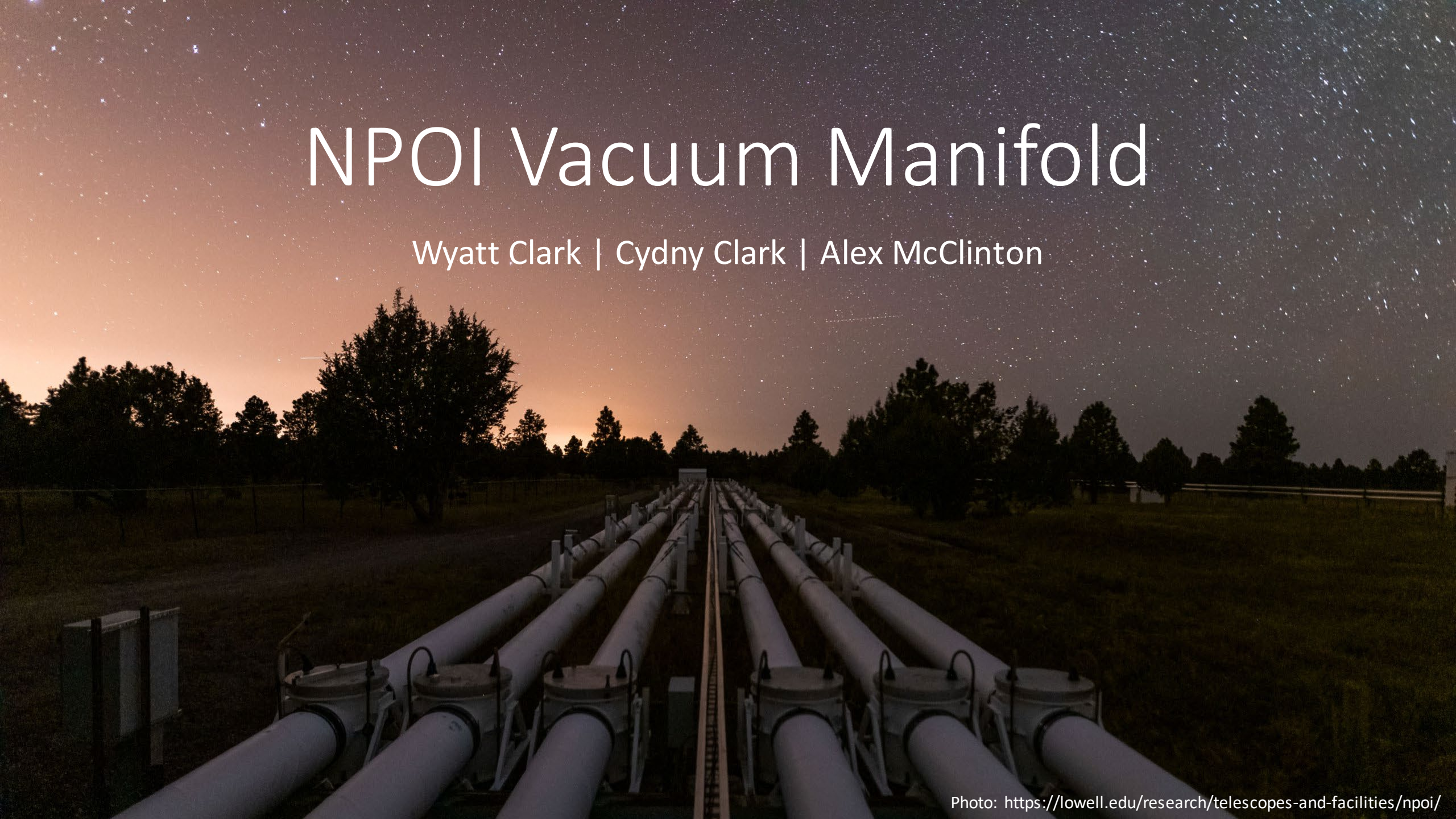


Photo: https://lowell.edu/research/telescopes-and-facilities/npoi/

Quick Overview of Project

Description:

- The Capstone team has been tasked to design, manufacture, install, and validate a new Fast Delay Line vacuum manifold

Requirements:

- Large safety margins, accommodate future expansion, easy to use, eliminates current design flaws

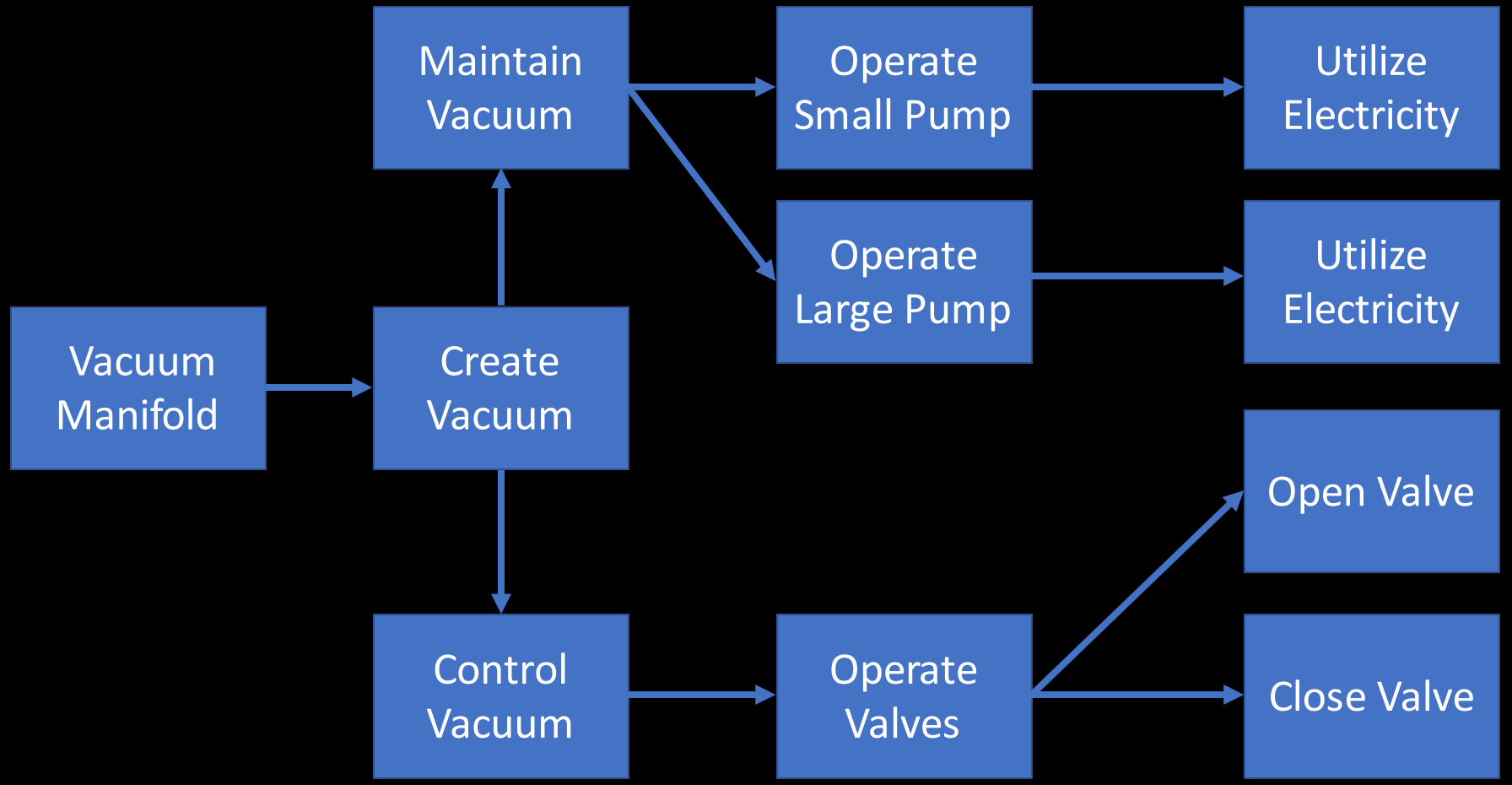
Timeline:

- Deliver operational prototype by December 2021
- Perform system analysis and validation May 2022

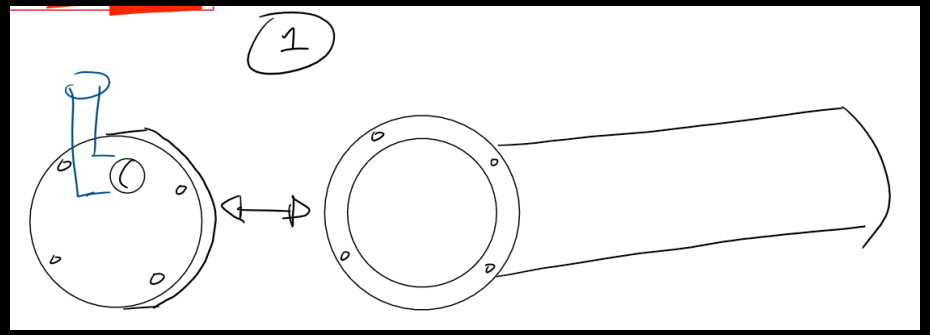
Wyatt , 10/4/21, NPOI Vacuum Manifold, 21F03

Black Box Model

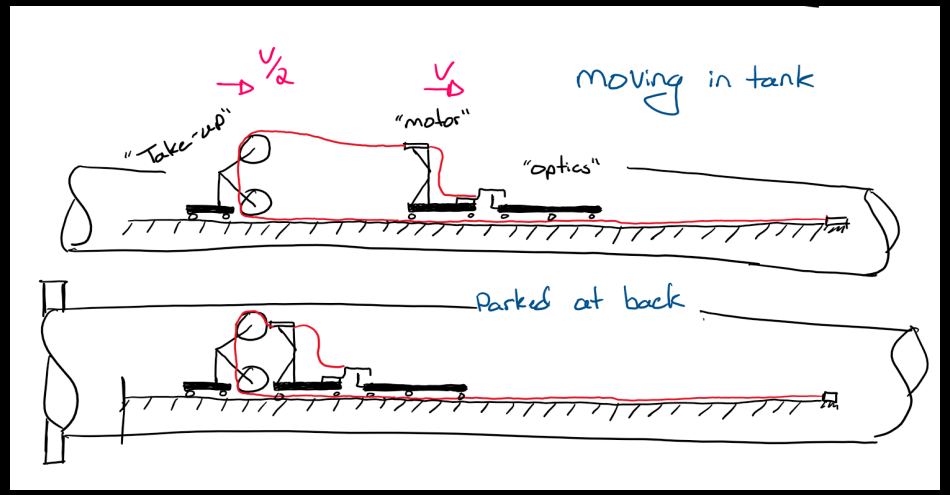
Functional Decomposition

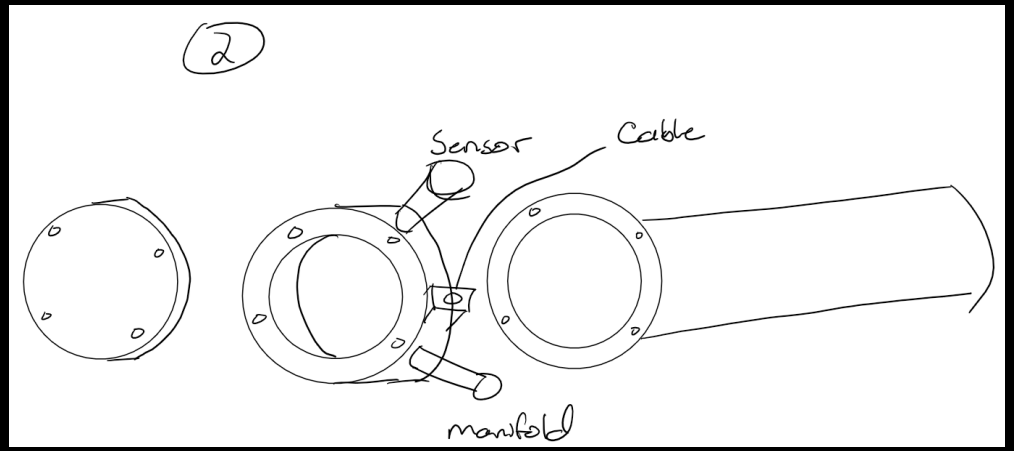


How Concepts Were Generated



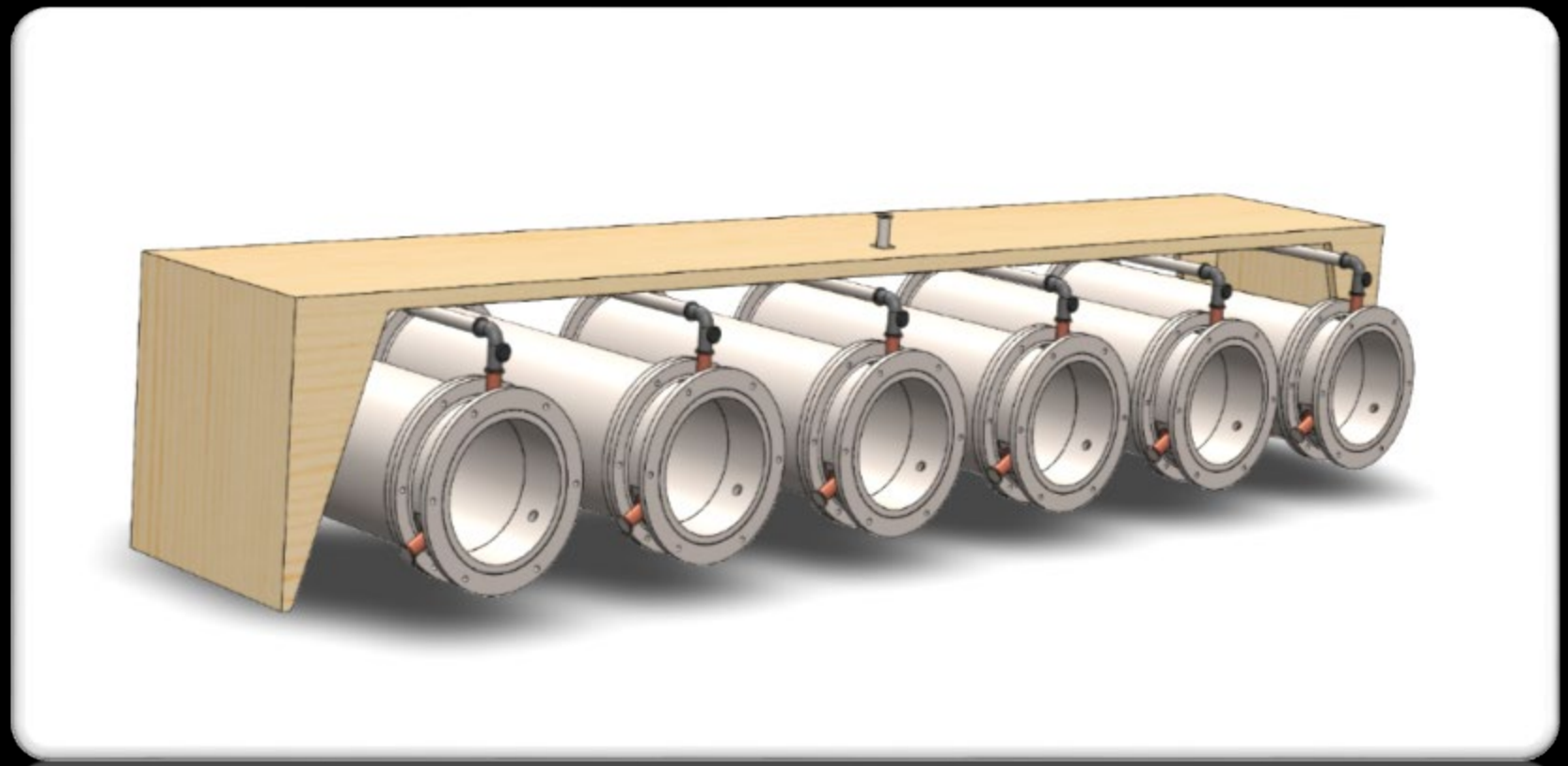
1. Used black box/decomposition to guide ideas where improvements could be made to manifold
2. Start with “white-board” sketches
3. Produce 3D CAD concepts for Client





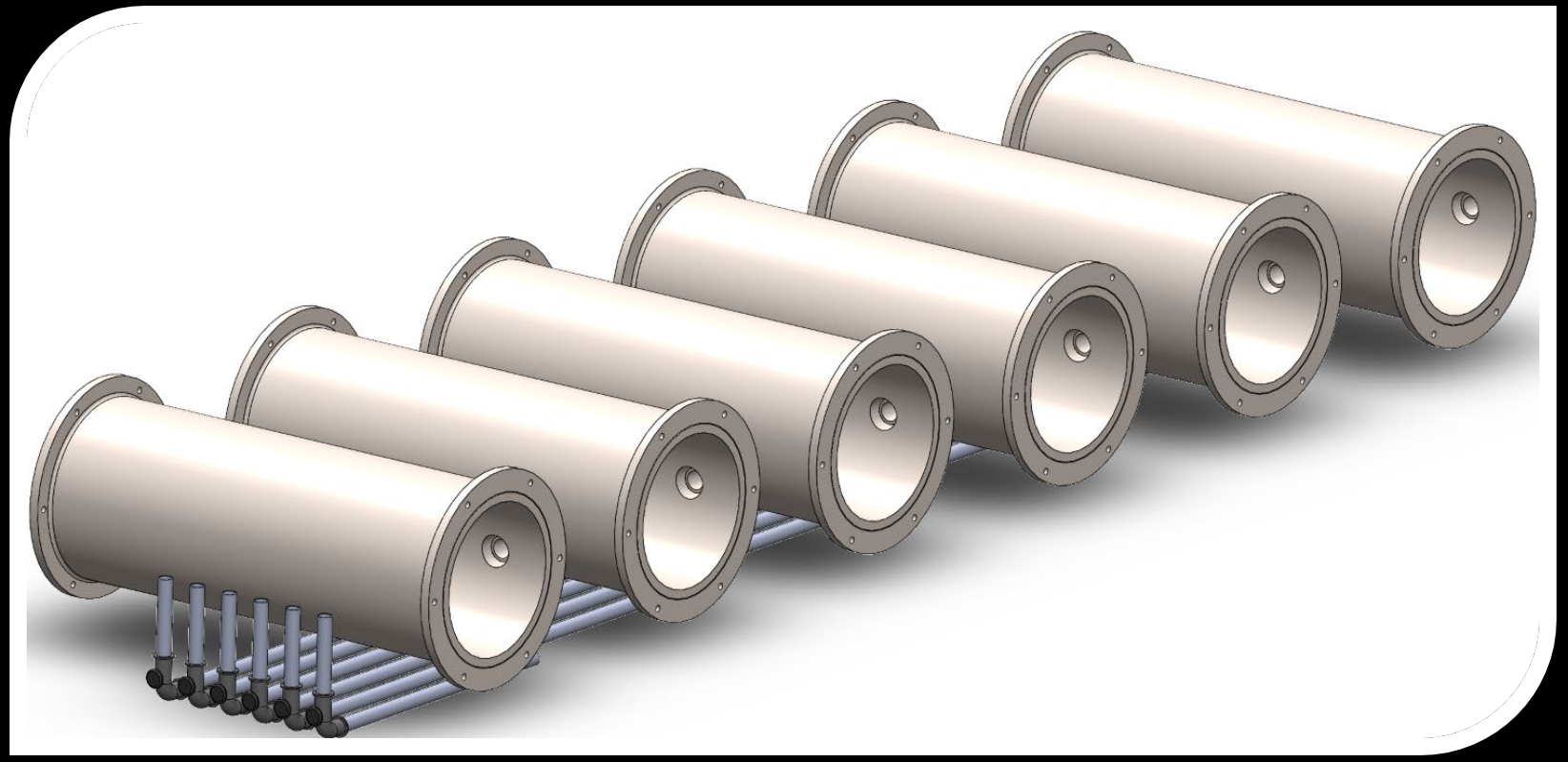
Concept 1

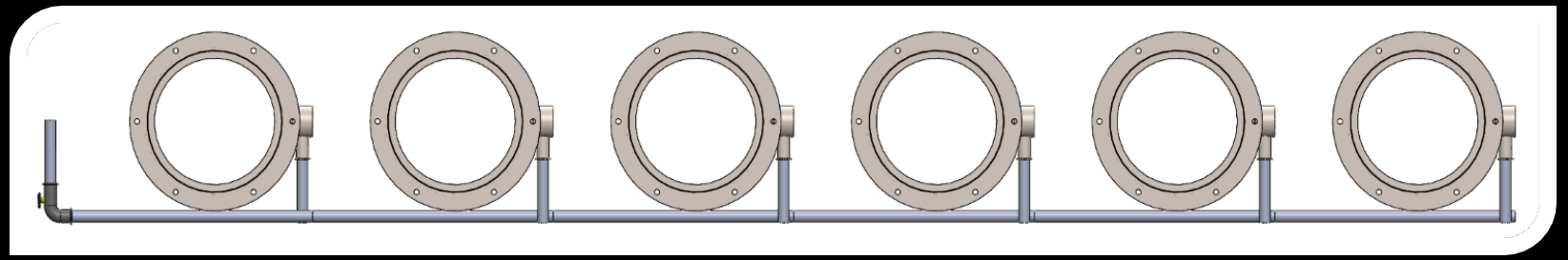
- Back of tank extension connected to stationary bridge support structure
- **Advantages**: Reduce vibrations by connecting bridge to isolated concrete slabs. End plate storage on bridge for maintenance. Provides more feed through ports.
- **Disadvantages**: Impedes motion of crane, must design bridge, expensive extension pipe.



Concept 2

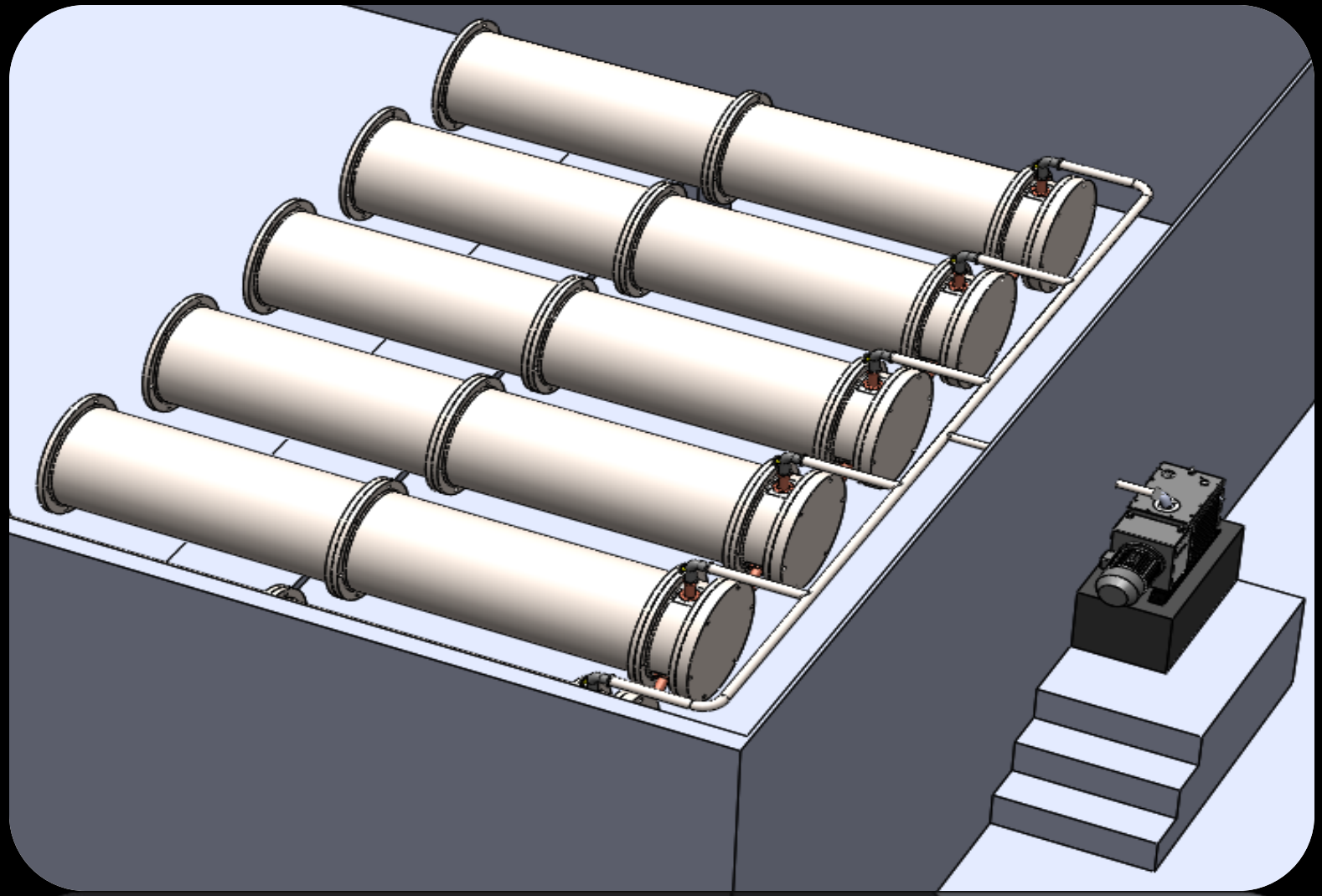
- Utilize front electrical feed through, extend manifold to FDL 1 to eliminate bridge
- **Advantages**: Attached to ground for static stability. No bridge needed to operate valves. Replaces bad electrical feed through.
- **Disadvantages**: More pipe = more $, consumes space.





Concept 3

- Same adapter as first concept. Vacuum pump [1] is now in the SID-Lab on rubber isolator
- **Advantages**: Reduces vibrations from the pump, allows easier pump maintenance.
- **Disadvantages**: Requires support structure, requires building in two rooms, takes up space.



Concept Evaluation

Image: Failure of Ribbon Cable System Inside FDL

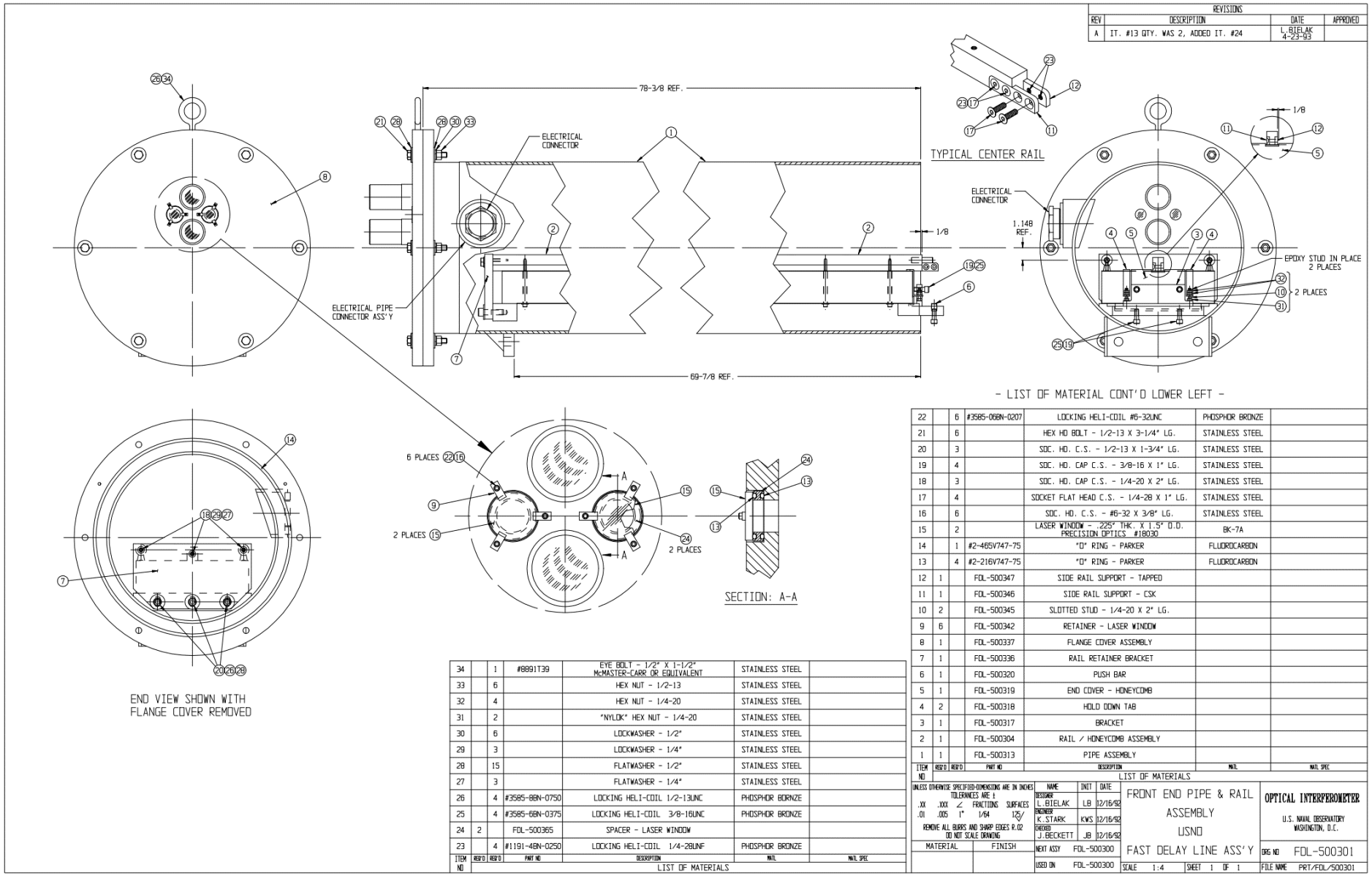
1	Perform “back-of-envelope” cost analysis of the three leading concepts
2	Perform client “show-and-tell” to discuss the advantages of each design
3	Select leading concept by combination of clients wishes and decision matrix

Decision Matrix

		RAW		WEIGHTED
Criterion	Weight	Front with bridge		
Material Cost	15%	9		1.35
Manufactureing Cost	25%	8		2
Reliablility	50%	8		4
Assembly	10%	6		0.6
Totals		31		7.95
Relative Rank		1		

		RAW		WEIGHTED	RAW		WEIGHTED	RAW		WEIGHTED	RAW		WEIGHTED	RAW		WEIGHTED
Criterion	Weight	Back with Bridge			Back to Sid-Lab			Front with bridge			Front long-pipes			Simple front plate		
Material Cost	15%	1		0.15	2		0.3	9		1.35	6		0.9	10		1.5
Manufactureing Cost	25%	1		0.25	2		0.5	8		2	7		1.75	7		1.75
Reliablility	50%	9		4.5	9		4.5	8		4	9		4.5	5		2.5
Assembly	10%	3		0.3	2		0.2	6		0.6	6		0.6	1		0.1
Totals		14		5.2	15		5.5	31		7.95	28		7.75	23		5.85
Relative Rank		8			7			1			3			5		

		RAW		WEIGHTED	RAW		WEIGHTED	RAW		WEIGHTED	RAW		WEIGHTED	RAW		WEIGHTED
Criterion	Weight	Front long pipe under			Front long pipe Over			Giant Lung			Apex Manifold			Move pump to back keep manifold		
Material Cost	15%	6		0.9	6		0.9	1		0.15	6		0.9	2		0.3
Manufactureing Cost	25%	7		1.75	7		1.75	1		0.25	4		1	7		1.75
Reliablility	50%	9		4.5	9		4.5	1		0.5	6		3	3		1.5
Assembly	10%	5		0.5	7		0.7	1		0.1	5		0.5	3		0.3
Totals		27		7.65	29		7.85	4		1	21		5.4	15		3.85
Relative Rank		4			2			9			6			7		



REVISIONS

REV	DESCRIPTION	DATE	APPROVED
A	IT. #13 QTY. WAS 2, ADDED IT. #24	L.BIELAK 4-23-93	

- LIST OF MATERIAL CONT'D LOWER LEFT -

ITEM NO		REQ'D	PART NO	DESCRIPTION	MATL	MATL SPEC
22		6	#3585-06BN-0207	LOCKING HELI-COIL #6-32UNC	PHOSPHOR BRONZE	
21		6		HEX HD BOLT - 1/2-13 X 3-1/4" LG.	STAINLESS STEEL	
20		3		SOC. HD. C.S. - 1/2-13 X 1-3/4" LG.	STAINLESS STEEL	
19		4		SOC. HD. CAP C.S. - 3/8-16 X 1" LG.	STAINLESS STEEL	
18		3		SOC. HD. CAP C.S. - 1/4-20 X 2" LG.	STAINLESS STEEL	
17		4		SOCKET FLAT HEAD C.S. - 1/4-28 X 1" LG.	STAINLESS STEEL	
16		6		SOC. HD. C.S. - #6-32 X 3/8" LG.	STAINLESS STEEL	
15		2		LASER WINDOW - .225" THK. X 1.5" O.D. PRECISION OPTICS #18030	BK-7A	
14		1	#2-465V747-75	"O" RING - PARKER	FLUOROCARBON	
13		4	#2-216V747-75	"O" RING - PARKER	FLUOROCARBON	
12	1		FDL-500347	SIDE RAIL SUPPORT - TAPPED		
11	1		FDL-500346	SIDE RAIL SUPPORT - CSK		
10	2		FDL-500345	SLOTTED STUD - 1/4-20 X 2" LG.		
9	6		FDL-500342	RETAINER - LASER WINDOW		
8	1		FDL-500337	FLANGE COVER ASSEMBLY		
7	1		FDL-500336	RAIL RETAINER BRACKET		
6	1		FDL-500320	PUSH BAR		
5	1		FDL-500319	END COVER - HONEYCOMB		
4	2		FDL-500318	HOLD DOWN TAB		
3	1		FDL-500317	BRACKET		
2	1		FDL-500304	RAIL / HONEYCOMB ASSEMBLY		
1	1		FDL-500313	PIPE ASSEMBLY		

LIST OF MATERIALS

ITEM NO		REQ'D	PART NO	DESCRIPTION	MATL	MATL SPEC
34		1	#8891T39	EYE BOLT - 1/2" X 1-1/2" McMASTER-CARR OR EQUIVALENT	STAINLESS STEEL	
33		6		HEX NUT - 1/2-13	STAINLESS STEEL	
32		4		HEX NUT - 1/4-20	STAINLESS STEEL	
31		2		"NYLOK" HEX NUT - 1/4-20	STAINLESS STEEL	
30		6		LOCKWASHER - 1/2"	STAINLESS STEEL	
29		3		LOCKWASHER - 1/4"	STAINLESS STEEL	
28		15		FLATWASHER - 1/2"	STAINLESS STEEL	
27		3		FLATWASHER - 1/4"	STAINLESS STEEL	
26		4	#3585-8BN-0750	LOCKING HELI-COIL 1/2-13UNC	PHOSPHOR BRONZE	
25		4	#3585-6BN-0375	LOCKING HELI-COIL 3/8-16UNC	PHOSPHOR BRONZE	
24	2		FDL-500365	SPACER - LASER WINDOW		
23		4	#1191-4BN-0250	LOCKING HELI-COIL 1/4-20UNF	PHOSPHOR BRONZE	

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED-DIMENSIONS ARE IN INCHES
TOLERANCES ARE ±
.XX .XXX ∠ FRACTIONS SURFACES
.01 .005 1° 1/64 125
REMOVE ALL BURRS AND SHARP EDGES R.02
DO NOT SCALE DRAWING

MATERIAL | FINISH

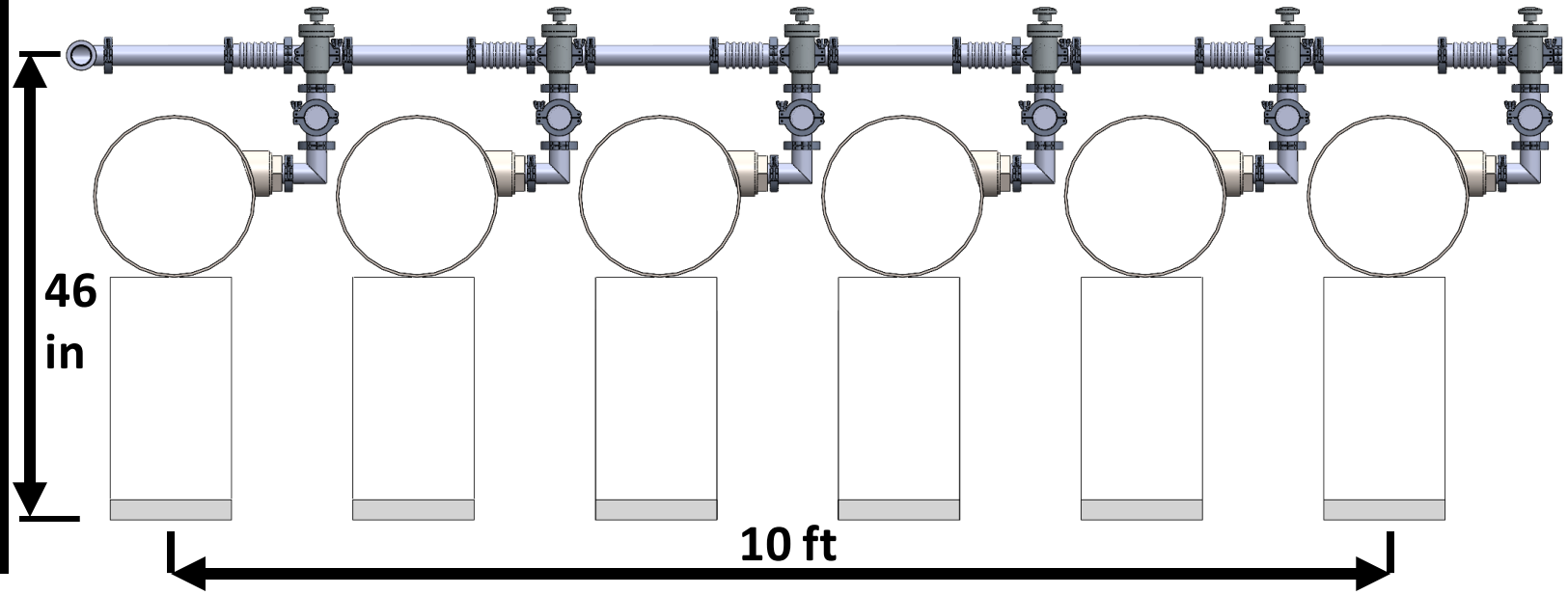
	NAME	INIT	DATE
DESIGNER	L.BIELAK	LB	12/16/92
ENGINEER	K.STARK	KWS	12/16/92
CHECKED	J.BECKETT	JB	12/16/92
NEXT ASSY	FDL-500300		
USED ON	FDL-500300		

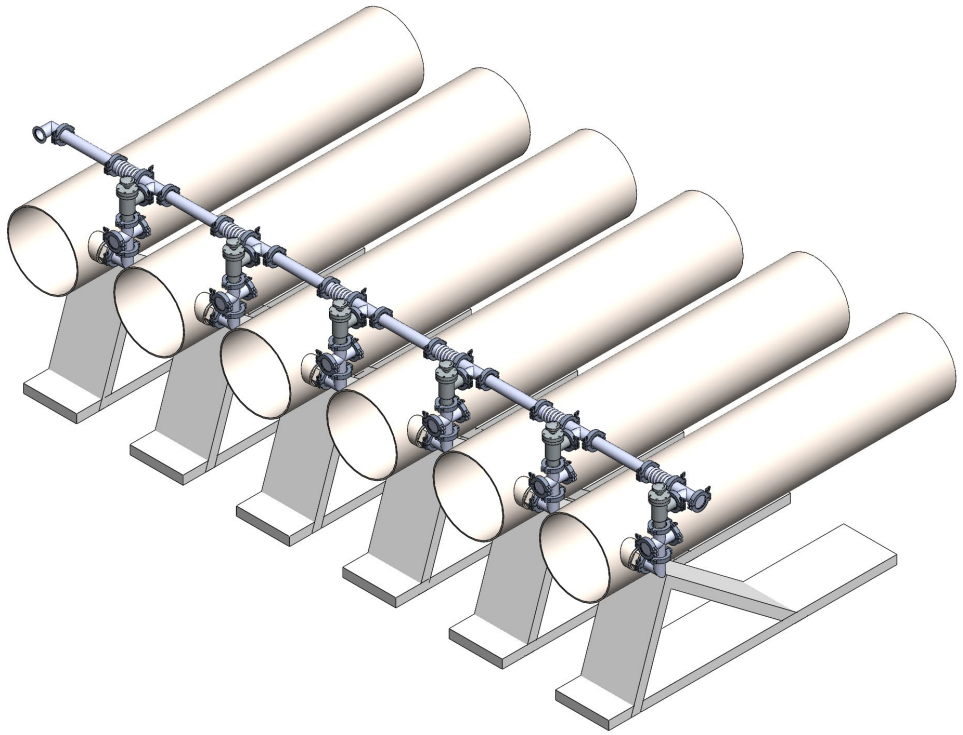
FRONT END PIPE & RAIL ASSEMBLY
USNO
FAST DELAY LINE ASS'Y

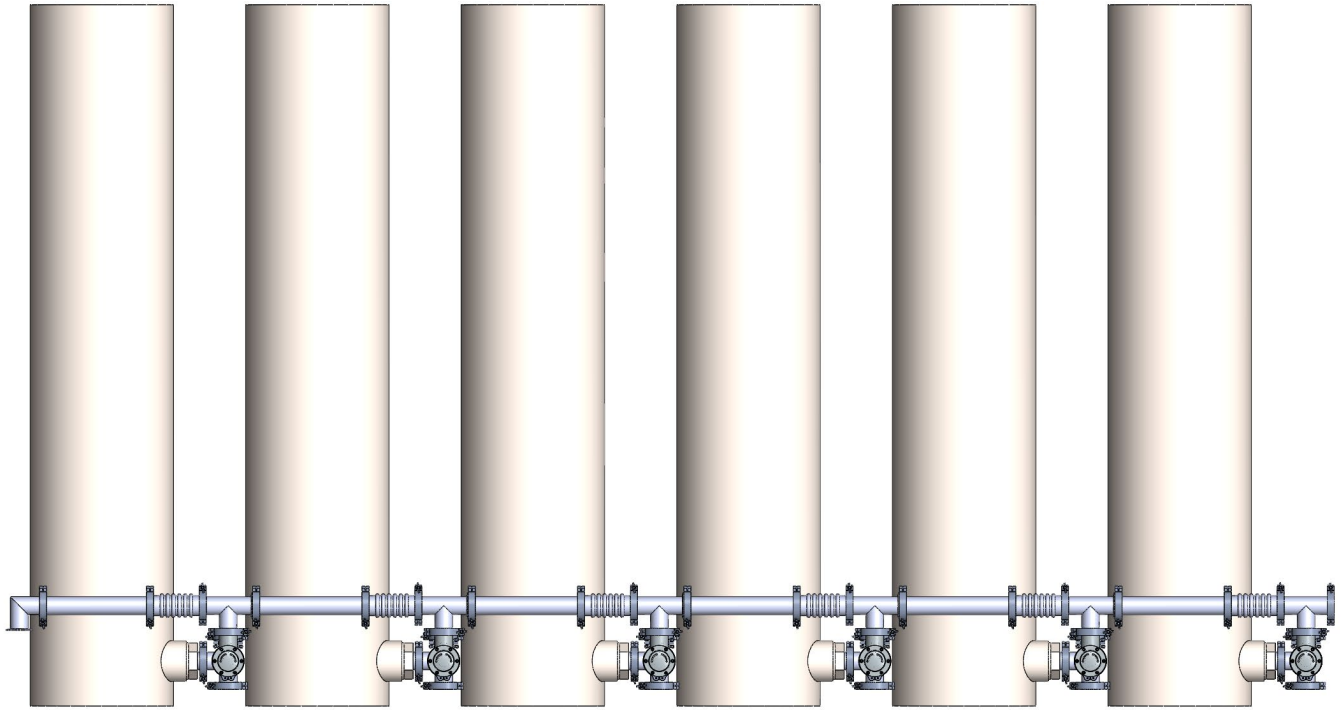
OPTICAL INTERFEROMETER
U.S. NAVAL OBSERVATORY WASHINGTON, D.C.

DRG NO FDL-500301
SCALE 1:4 SHEET 1 OF 1
FILE NAME PRT/FDL/500301

Final Concept







Final Design Criteria for selection

Overview

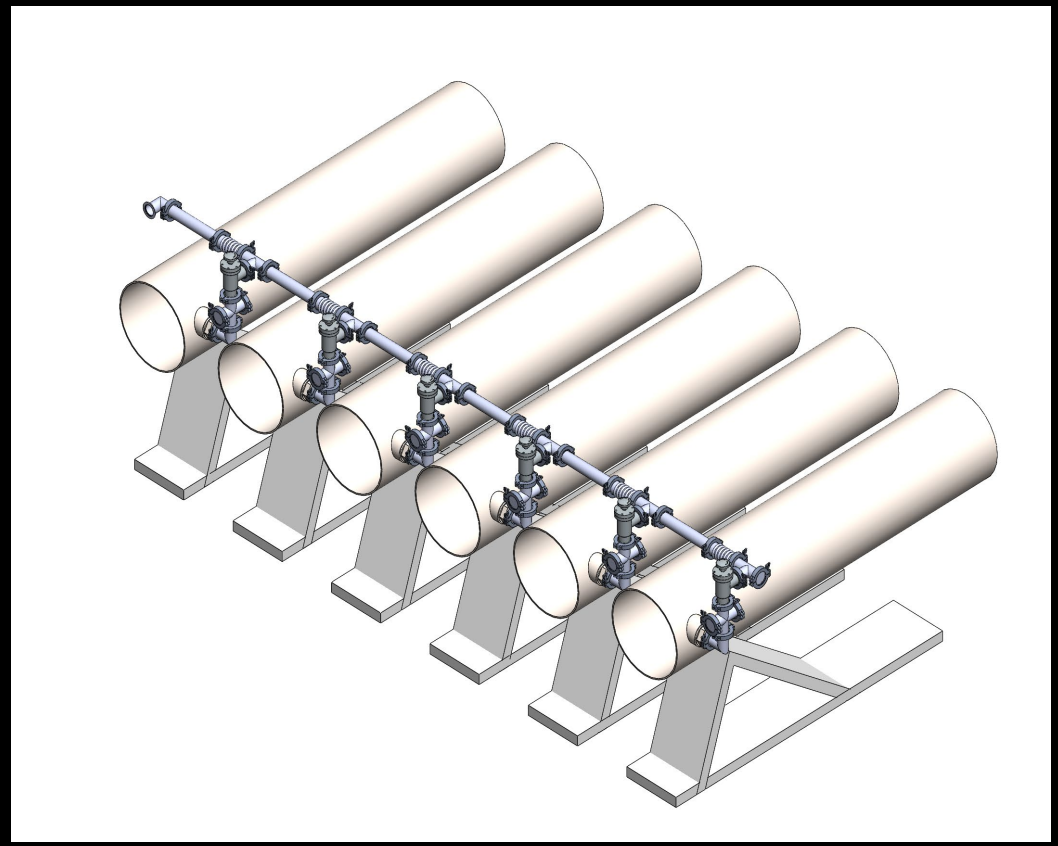
- Utilizes electrical feed through for interface
- Simple long manifold to reduce cost
- Requires “bridge” to access valves (not shown)

Customer Needs

- Increases safety
- Disconnected from Snoots
- Solves ribbon cable pass-though problem

Engineering Requirements

- Bellows for thermal expansion
- Industry standard interfaces for reliability
- External support structure (not shown) for static rigidity



Budget Planning

Total Cost of Materials For 6 Pipes
$8041

Cost For 1 Pipe
$1340

Total Tax/Shipping Expenses
$1207

Prototype Money
$1500

Spare/Broken Part Money
$1500

Grand Total
$13588

Bill Of Materials			
Item	**Quantity**	**Unit Cost (USD)**	**Total Cost (USD)**
QF 50 Blanking Plate [3]	13	20.00	260
QF 50 Tee [4]	6	146.00	876
QF 50 Cross [5]	6	220.00	1320
QF 50 Al Clamp [6]	55	17.00	935
QF 50 Mitred 90 elbow [7]	7	96.00	672
QF 50 Valve [8]	0 (reused)	557.00	0
QF 50 6" long Bellows [9]	6	123.00	738
QF 50 Center O-Ring Fluorocarbon [10]	55	12.00	660
Costome 12.5 double nippe QF 50 [11]	6	230.00	1380
Interface	6	200.00	1200

References

- [1] GVD 275 (Solidworks CAD model, accessed September 24,2021). https://grabcad.com/library/gvd-275-1
- [2]“Kurt J. Lesker Company | Flange Systems Overview | Vacuum Science Is Our Business.” https://www.lesker.com/newweb/flanges/flanges_technicalnotes_overview_1.cfm [Accessed 9,22, 2021].
- [3] “QF50-200-SB FLANGE,BLANK,SS,QF50,” Kurt J. Lesker Company. [Online]. Available: https://www.lesker.com/flanges/flanges-kf-blank/part/qf50-200-sb. [Accessed: 03-Oct-2021].
- [4] “QF50-200-SB FLANGE,BLANK,SS,QF50,” Kurt J. Lesker Company. [Online]. Available: https://www.lesker.com/flanges/fittings-kf-tees/part/qf50-200-t. [Accessed: 03-Oct-2021].
- [5] “QF50-200-SB FLANGE,BLANK,SS,QF50,” Kurt J. Lesker Company. [Online]. Available: https://www.lesker.com/flanges/fittings-kf-crosses/part/qf50-200-x. [Accessed: 03-Oct-2021].
- [6] “QF50-200-SB FLANGE,BLANK,SS,QF50,” Kurt J. Lesker Company. [Online]. Available: https://www.lesker.com/newweb/flanges/hardware_kf_clamps_machined.cfm?pgid=al2. [Accessed: 03-Oct-2021].

References

- [7] “QF50-200-SB FLANGE,BLANK,SS,QF50,” Kurt J. Lesker Company. [Online]. Available: https://www.lesker.com/flanges/fittings-kf-elbows/part/qf50-200e90m. [Accessed: 03-Oct-2021].
- [8] “QF50-200-SB FLANGE,BLANK,SS,QF50,” Kurt J. Lesker Company. [Online]. Available: https://www.lesker.com/newweb/valves/anglevalves_bellowssealed_ss_man.cfm?pgid=kf. [Accessed: 03-Oct-2021].
- [9] “QF50-200-SB FLANGE,BLANK,SS,QF50,” Kurt J. Lesker Company. [Online]. Available: https://www.lesker.com/newweb/flanges/bellows_kf_hydraulicallyformed.cfm?pgid=standard. [Accessed: 03-Oct-2021].
- [10] “QF50-200-SB FLANGE,BLA” Kurt J. Lesker Company. [Online]. Available: https://www.lesker.com/newweb/flanges/hardware_kf_centeringrings.cfm?pgid=al.[Accessed: 03-Oct-2021].
- [11] “QF50-200-SB FLANGE,BLANK,SS,QF50,” Kurt J. Lesker Company. [Online]. Available: https://www.lesker.com/newweb/flanges/nipple_builder.cfm. [Accessed: 03-Oct-2021].


Questions?