24TH ANNUAL

24TH LCI CONGRESS
OCTOBER 18-21

Supporting Lockheed Martin: Skunk Works® Need for Rapid and Reliable Validation

PRESENTED BY

A combined Burns & McDonnell and Lockheed Martin team

Safe Lean Thinking

Industry commitment to safety has been effective at reducing physical injuries, but lives are still being ruined and wasted.

- Suicide rate in construction industry ~ 4 times rate for US general population
  - 25 attempts for every suicide & countless miserable experiences for every attempt

Lean Thinking Can Help

- Respect for people mindset helps alleviate numerous underlying factors
- What we are doing is important!

Topics

- Introductions
- Burns & McDonnell Lean Journey
- Defining “Fundamental Scope Blocks” and “Scope Activities”
- Application at Lockheed-Martin Skunk Works®
- Next-Generation Applications
- Take-Aways, Key Points & Questions

Presentation Team

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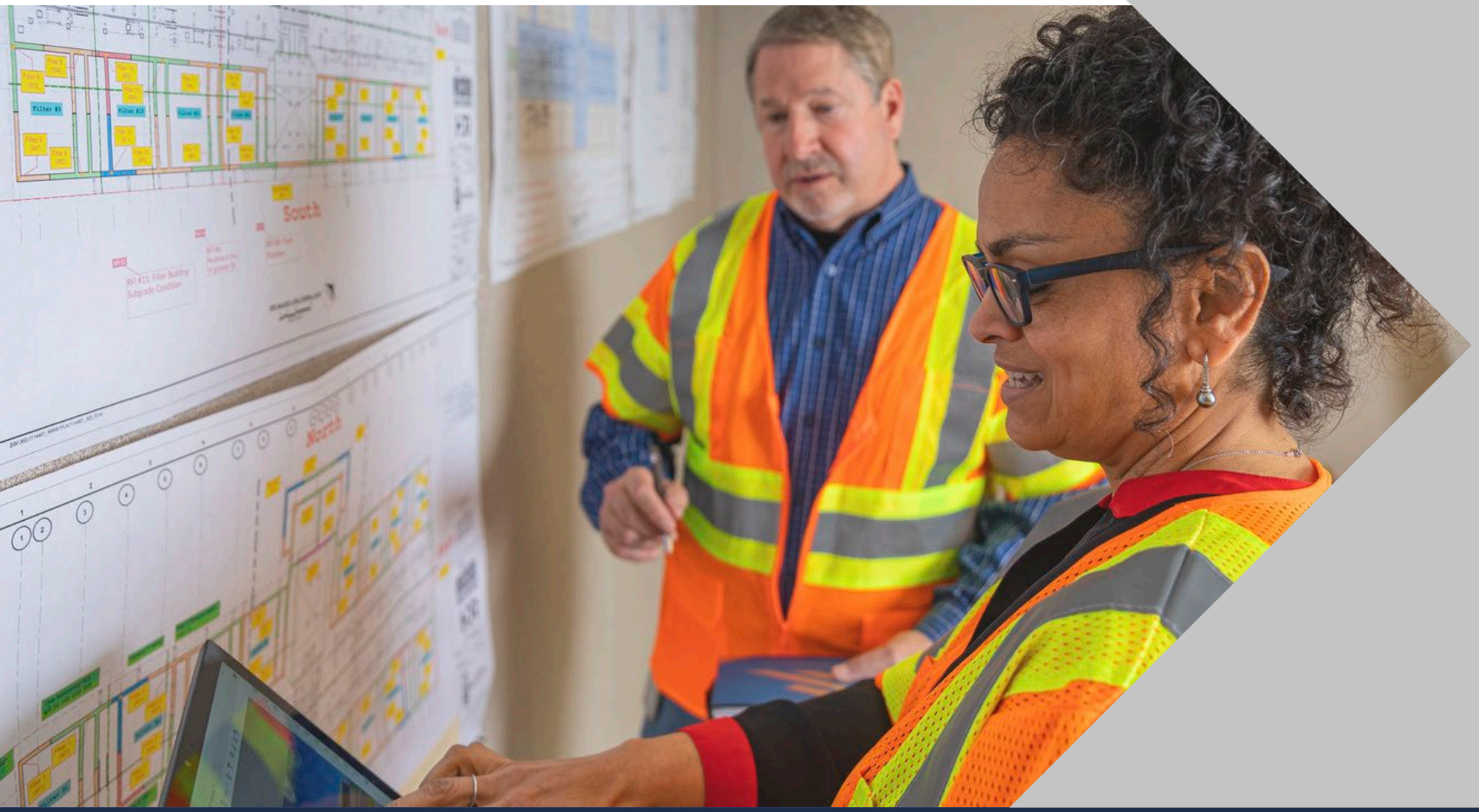
Focus on Integrated Design-Build



1898
YEAR FOUNDED

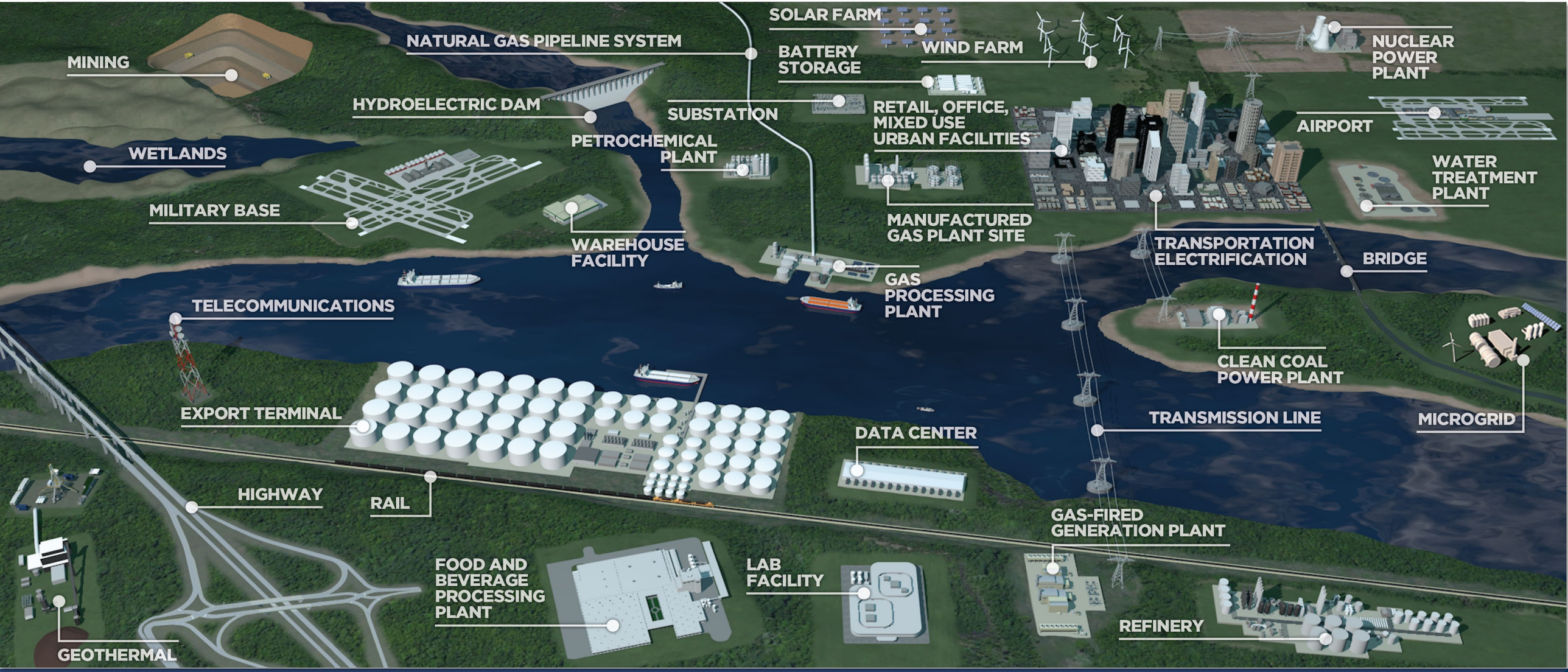
100%
EMPLOYEE-OWNED

10,000
PROFESSIONALS

90%
REPEAT BUSINESS

$5B+
ANNUAL SALES

Key Industries & Markets We Serve



Burns & McDonnell’s Lean Journey

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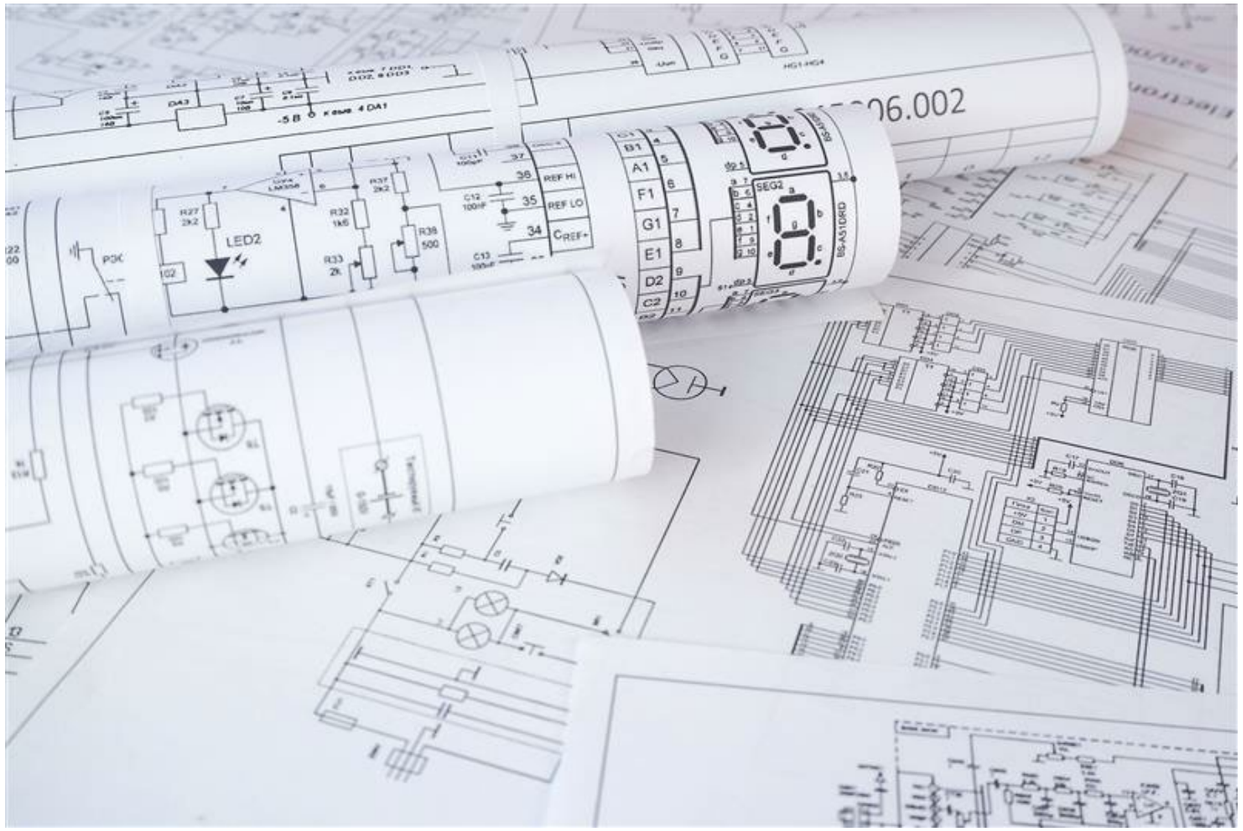
Burns & McDonnell – Lean Journey

Visualizing Projects as a Network of Commitments Customer Conditions of Satisfaction - Internal - External Psychological Safety / Inclusion Systems Thinking (Optimize the Whole) 8 Symptoms of Waste	"Pull Conversations" Collaborative Problem Solving Basic Scoping App (FSBs & Scope Activities) Simple, Internal Collaborative Design & Scoping "Trade Partners" Replace "Subcontractors"	Formal Pull-Based Scheduling & Coordination Formal CDS & Advanced Scoping App	Managing Throughput (Flow) Advanced Networking Conversations
Broad Acceptance & Use of These Concepts Demonstrated by Leadership Team	All GFS FCP Lane by end Q2 2021 Part of Formal Career & Business Planning	Multiple Teams Moving by Q1 2021	Pioneers & Future SMEs Emerging

Pipe Fab Shop Case Study – Traditional Approach

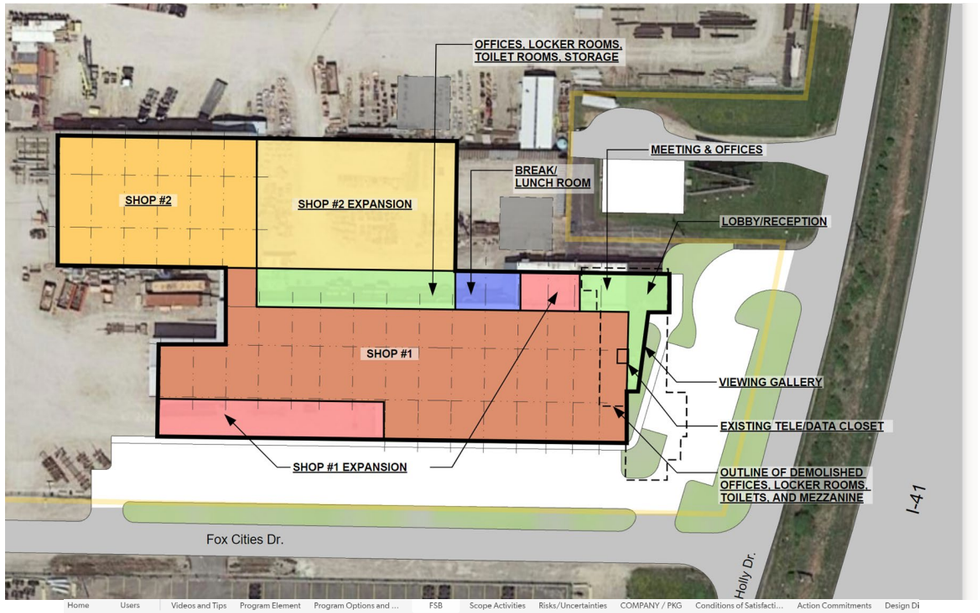
- Extensive design effort over several months
- Formal design documents – lots of detail
- Conceptual estimate – far beyond allowable cost
- Not much usable content when project had to be abandoned
- Reciprocal frustration

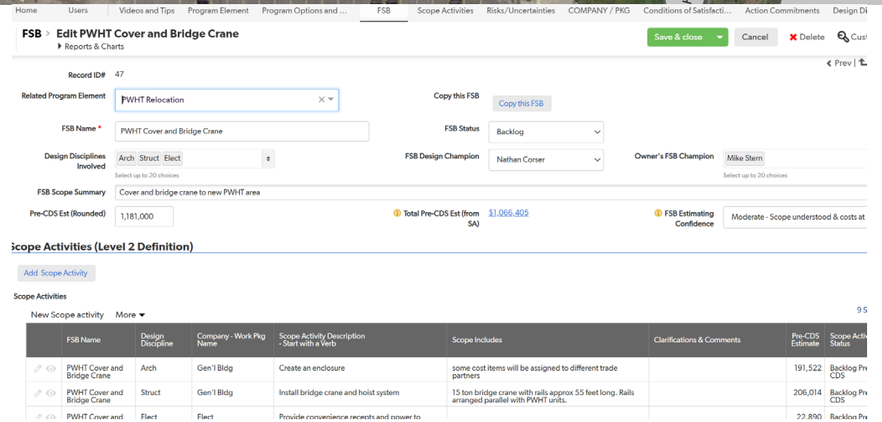


Pipe Fab Shop Case Study – CDS & SCOPE LIST

- Campus-wide upgrade with multiple moves, expansions and upgrades
- Three "mini" collaborative design and scoping (CDS) sessions
- “Sketch level” drawings supporting Fundamental Scope Blocks (FSBs) and scope activities
- Much better information for customer developed at a much lower cost
- Great team and customer experience

+/- 15% Estimating Accuracy with 2% Engineering





Skunk Works® Lean Journey

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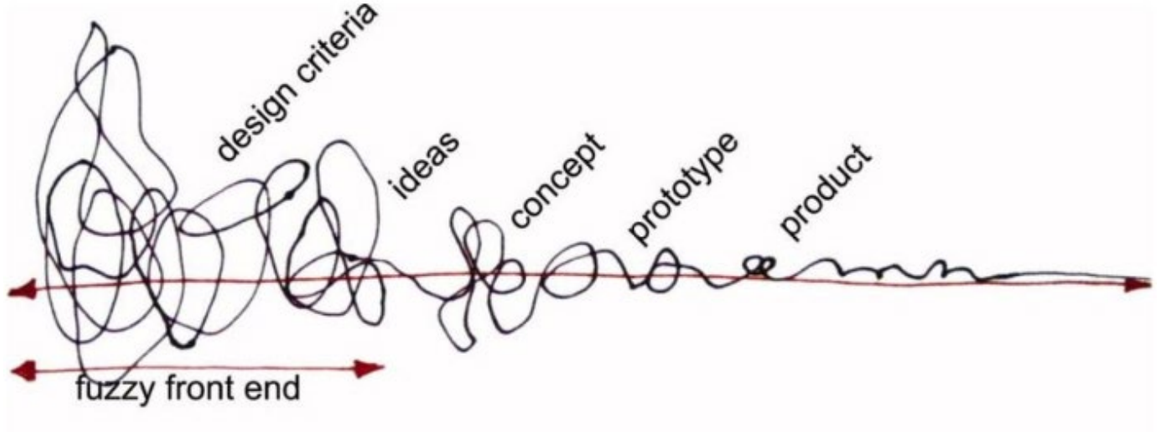
Lockheed Martin Skunk Works® History

- Notable Aircraft (Collier Trophies)
- F-104 Starfighter (1958)
- USAF A-11 Mach 3 Aircraft (1963)
- F-117 Nighthawk (1989)
- U-2S/ER-2 Dragon Lady (1998)
- JSF/X-35B STOVL (2002)
- F-22 Raptor (2006)
- X-47B (2013)
- Auto CGAS (2018)

It Ain’t Rocket Science… or is it?

- Developmental site = fuzzy requirements
- Several programs competing for limited funding
- Prioritization and simplification is key



Fuzzy front end of the design process (Sanders, Stappers 2008)

Early Lean Thinkers

Lockheed Skunk Works founder Kelly Johnson (left) and successor Ben Rich (right). (Photos: Lockheed Martin)

Kelly's 14 Rules: Early Lean Thinking

The Skunk Works Manager must be delegated practically complete controls of his program in all aspects.	✓
Strong but small project offices must be provided both by the military and industry.	✓
The number of people having any connection with the project must be restricted in an almost vicious manner. Use a small number of good people.	✓
A very simple drawing and drawing release system with great flexibility for making changes must be provided.	✓
There must be a minimum number of reports required, but important work must be recorded thoroughly.	✓
There must be a monthly cost review covering not only what has been spent and committed but also projected costs to the conclusion of the program.	✓
The contractor must be delegated and must assume more than normal responsibility to get good vendor bids for subcontract on the project. Commercial bid procedures are often better than military ones.	✓

The inspection system as currently used by the Skunk Works, which has been approved by both the Air Force and Navy, meets the intent of existing military requirements and should be used on new projects.	✓
The contractor must be delegated authority to test his final product in flight. He can and must test it in the initial stages. If he doesn't, he rapidly loses his competency to design other vehicles.	✓
The specifications applying to the hardware must be agreed to well in advance of contracting. The Skunk Works practices of having a specification section stating clearly which important military specification items will not knowingly be complied with and reasons therefore is highly recommended.	✓
Funding a program must be timely so that the contractor doesn't have to keep running to the bank to support government projects.	
There must be mutual trust between the military project organization and the contractor, the very close cooperation and liaison on a day-to-day basis. This cuts down on misunderstanding and correspondence to an absolute minimum.	✓
Access by outsiders to the project and its personnel must be strictly controlled by appropriate security measures	
Because only a few people will be used in the engineering and most other areas, ways must be provided to reward good performance by pay not based on the number of personnel supervised.	

Putting it all Together

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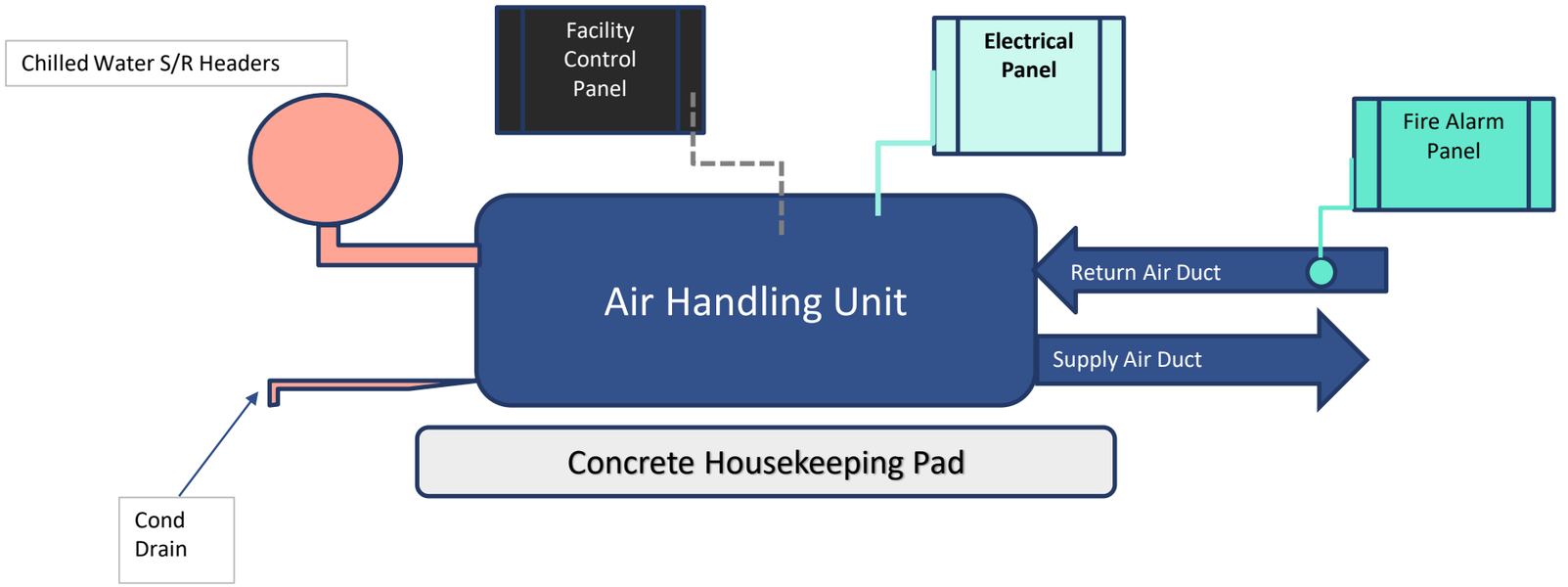
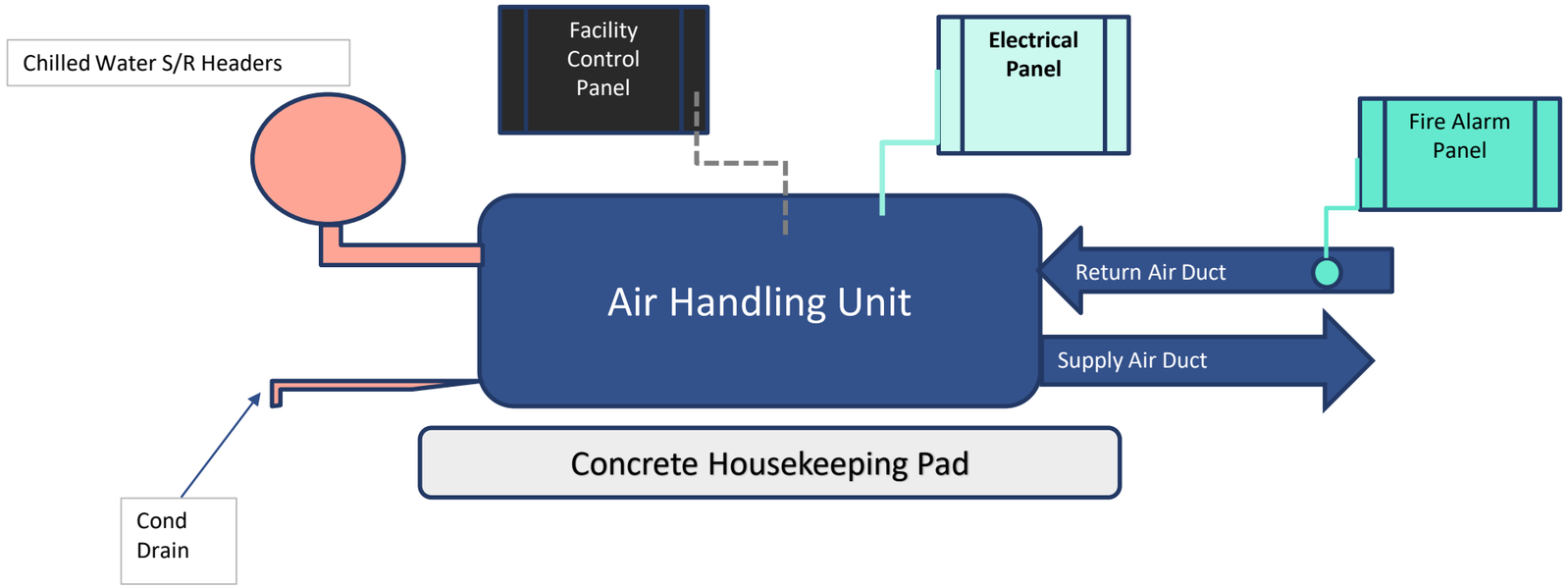
Developing Fundamental Scope Blocks (FSBs)



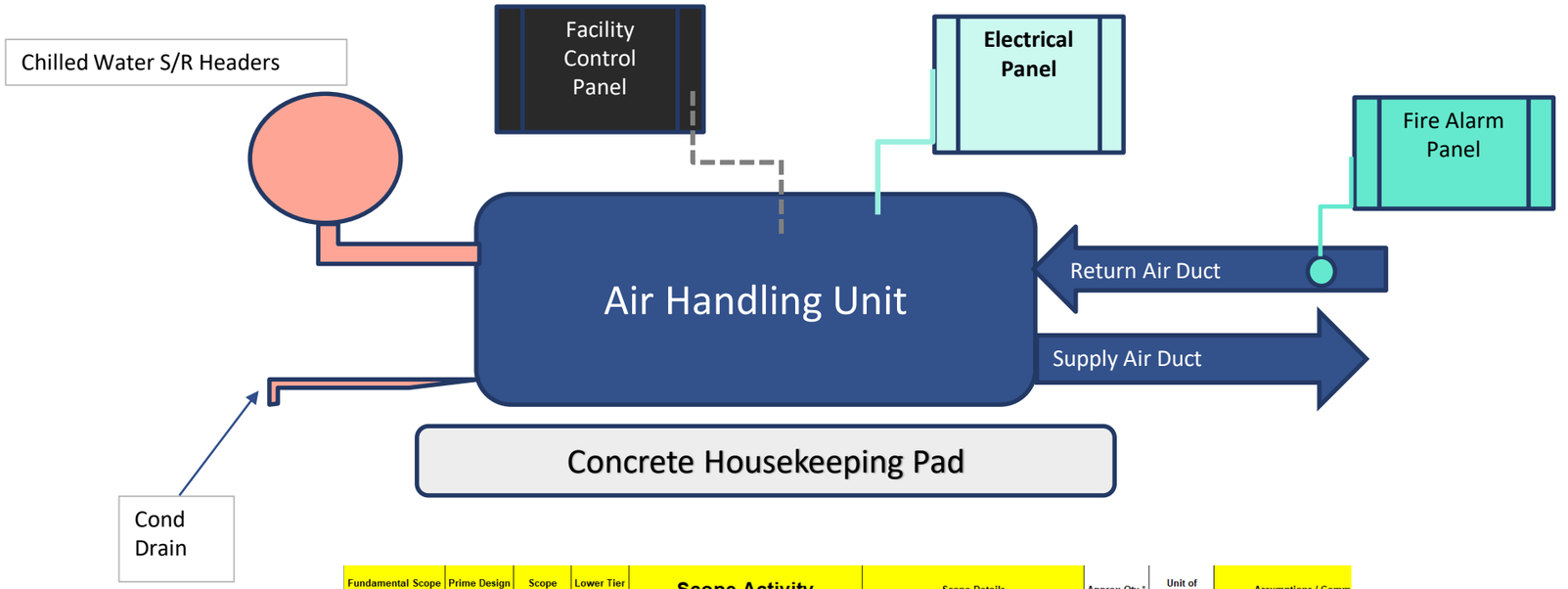
FSBs & Scope Activities

- "What" – defined by nouns
- Chunks of scope that provide a specific function important to Owner and/or project
- Natural points of coordination spanning disciplines and crews
- Means to visualize the "How"



FSBs & Scope Activities

- Actions – always starting with a verb
- Means to visualize
  - “What?”, “Who?”, and “How?”
  - Complete installation
  - Linkage between FSBs
- Unique discipline, crew and system enables very flexible work breakdown structure (WBS)



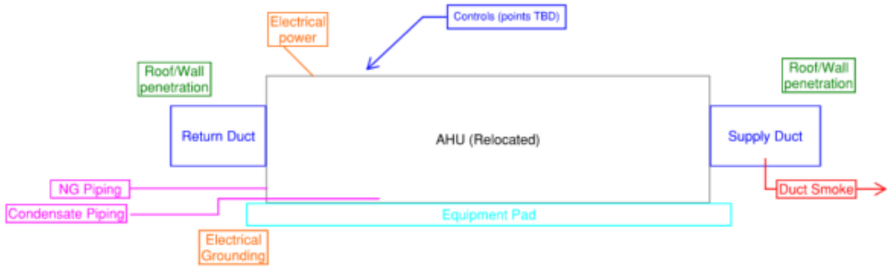
Fundamental Scope Block	Prime Design Discipline	Scope Owner	Lower Tier TP	Scope Activity	Scope Details	Approx Qty *	Unit of Measure	Assumptions / Comm
MAH	Structural	Ace Building Co	n/a	Provide concrete housekeeping pad	Provide CIP Pad 8' x 12' 5.5"; reinforce with WWF; coordinate with seismic restraints	96	sf	
MAH	Structural	Ace Building Co	na	Provide seismic anchor points	Provide anchor points per attached sketch	6	ea	
MAH	Mechanical	MechCo	n/a	Provide, Install, set & anchor 20000 cfm MAH	Match existing unit if possible; verify dimensions of modules for move in path			
MAH	Mechanical	MechCo	n/a	Install36" Supply and return air duct to main header	36" galvanized steel; Provide access port in RA duct for smoke detector	220	LF	duct will not require seismic bra
MAH	Mechanical	Piper	n/a	Connect chilled water S/R to MAH	6" carbon steel pipe spec XXXXX; Each line is approx 60 ft	120	lf	
MAH	Mechanical	Piper	Insul	Insulate chilled water supply & returne				
MAH	Elect	Sparky Co	n/a	Provide main power feed to MAH	Install conduit & cable from panel xxx to connection on MAH; 3" conduit, 3 conductor + ground	190	lf	
MAH	Elect	Sparky Co	I/C	Connect on-board control panel with facility panel xx	Install conduit & cable; terminate cable with facility engineer present			
MAH	Mechanical	MechCo	NA	Install condensate drain	route 3/4" copper line to adjacent floor drain			
MAH	Elect	Sparky Co	I/C	Install smoke detector and connect to LSS panel				
MAH								

FSB Examples at Lockheed Martin Skunk Works®

Legend
- Civil
- Arch
- Struct
- HVAC
- Plumb
- Process
- Elec
- Fire
- Owner

Air Handling Unit

RELEASED FOR DETAILED DESIGN: YES



DESIGN REQUIREMENTS:

GENERAL:
- REUSE EXISTING EQUIPMENT
- MINIMUM MONITORING FOR INTEGRATION TO APOGEE SYSTEM

FIRE PROTECTION:
- PROVIDE DUCT SMOKE DETECTOR IN SUPPLY DUCTWORK

STRUCTURAL:
- FOUNDATION PAD AND ANCHORAGE
- (E) WALL OPENING SUPPORT FRAMING

DESIGN INFORMATION NEEDS:

- PROVIDE NEW ELECTRICAL DISCONNECT OR RELOCATE EXISTING?

- EXISTING AHU ANCHOR BOLT SIZE AND LAYOUT

SCOPE ACTIVITIES AND DETAILS:

DEMOLITION:
1. DEMOLISH SUPPLY AND RETURN DUCTWORK AND DRUM LOUVERS
2. DEMOLISH DUCT SUPPORTS
3. INFILL WALL PENETRATIONS
4. DISCONNECT POWER, DUCTWORK AND UTILITIES
5. REMOVE AHU AND TEMPORARILY STORE FOR REINSTALLATION
6. DEMOLISH AHU PAD

NEW WORK:

EQUIPMENT PAD:
1. EXCAVATE, FORMM AND POUR 4" TALL EQUIPMENT PAD. TOTAL EQUIPMENT PAD THICKNESS TO BE 12" WITH #4 REBAR @ 12" O.C. EACH WAY TOP AND BOTTOM.
1a. EQUIPMENT PAD DIMENSION: 21'L X 9.5'W
2. PLACE NEW AHU GROUND ROD
3. PLACE AHU ON EQUIPMENT PAD. ATTACH TO NEW EQUIPMENT PAD WITH SAME LAYOUT, QUANTITY AND SIZE OF BOLTS USED IN EXISTING INSTALLATION. ASSUME TOTAL OF (10) NEW STAINLESS STEEL EXPANSION TYPE ANCHOR BOLTS
4. REMOVE RUST ON EXISTING ANCHOR BOLT ANGLE CLIPS AND REPAINT WITH COLD-GALVANIZING TOUCH-UP PAINT.

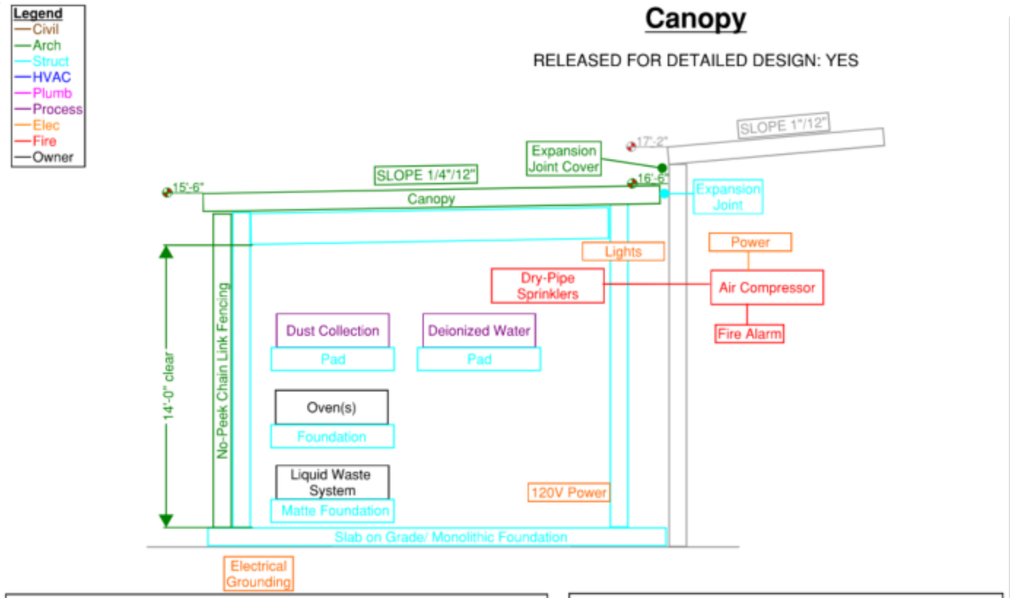
FRAMED OPENINGS:
3. FRAME NEW DUCT OPENINGS IN BUILDING, RETURN: 4'-0" x 8'-0", SUPPLY: 3'-6" x 2'-8"
3a. INSTALL C10x15.3 STEEL CHANNEL JAMB POSTS EACH SIDE OF RETURN AIR SUPPLY OPENING ATTACHED TO EXISTING CONCRETE CURB AT BOTTOM AND EXISTING STEEL CHANNEL WIND GIRT AT TOP WITH L4x4x1/4 STEEL ANGLE CLIPS AND (2)-5/8" DIA. BOLTS EACH ANGLE LEG EACH END OF CHANNEL JAMB POSTS.
3b. INSTALL 600S200-54 METAL STUD JAMB POSTS EACH SIDE OF SUPPLY AIR OPENING WITH 600S200-54 METAL STUD HEADER AND SILL, ABOVE AND BELOW THE NEW OPENING RESPECTIVELY. ATTACH METAL STUD JAMB POSTS TO EXISTING STEEL CHANNEL WIND GIRTS WITH L4x4x12 GA. ANGLE CLIPS WITH (4)#12 METAL SCREWS TO METAL STUD JAMB POSTS AND (2)-1/8" FILLET WELDS TO EXISTING STEEL CHANNEL WIND GIRTS. ATTACH HEADER AND SILL STUD MEMBERS TO JAMB POSTS WITH L4x4x12 GA. ANGLE CLIPS WITH (4)#12 METAL SCREWS EACH LEG.
4. CUT WALL FOR NEW DUCT PENETRATIONS

DUCTWORK & PLUMBING:
6. ROUTE RETURN DUCTWORK FROM WALL OPENINGS TO AHU: 20 LF OF 40x30 DUCTWORK. EXTERIOR DUCTWORK WILL BE INSULATED WITH 2" MINERAL FIBER INSULATION AND INCLUDE WEATHERPROOF JACKET.
7a. ROUTE SUPPLY DUCTWORK FROM WALL OPENINGS TO AHU: 25 LF OF 40x30 DUCTWORK. EXTERIOR DUCTWORK WILL BE INSULATED WITH 2" MINERAL FIBER INSULATION AND INCLUDE WEATHERPROOF JACKET.
7b. ROUTE A TOTAL OF 155 LF OF INTERIOR DUCTWORK, ALL INSULATED WITH 2" MINERAL FIBER BLANKET WRAP. INTERIOR DUCTWORK WILL HAVE FACTORY APPLIED FSK JACKETING: 35 LF OF 40x30 DUCTWORK, 20 LF OF 36x30 DUCTWORK, 20 LF OF 32x30 DUCTWORK, 20 LF OF 28x30 DUCTWORK, 20 LF OF 28x24 DUCTWORK, 20 LF OF 24x24 DUCTWORK, 20 LF OF 24x14 DUCTWORK
7c. INSTALL (16) 30x8 DRUM LOUVERS (BASIS OF DESIGN TITUS DL) EACH WITH A VOLUME DAMPER.
7d. ALL DUCTWORK TO BE GALVANIZED STEEL SHEET METAL.
8. ROUTE NG PIPE DOWN WALL TO AHU: APPROX 30 LF OF 1.5" BLACK STEEL PIPE
9. CONNECT CONDENSATE PIPING TO THE UNIT AND ROUTE TO WASH STATION CONTAINMENT AREA LOCATED IN BUILDING: APPROX 25 LF OF 1 1/4" COPPER PIPE.

POWER:
10. INSTALL AHU DISCONNECT ON BUILDING WALL: (480V 200A 3PH NEMA 3R RATED FUSED DISCONNECT)
11. ROUTE CONDUIT FROM PANEL MDP TO AHU DISCONNECT/AHU. APPROX 230' LF OF (3)#1/0 & (1)#4 GND IN 2" EMT CONDUIT
12. GROUND PAD FOUNDATION REBAR AND EQUIPMENT ENCLOSURE WITH #6WG TO STRUCTURAL STEEL

FIRE ALARM:
15. ROUTE CONDUIT FROM FIRE ALARM PANEL TO SUPPLY DUCT FOR SMOKE DETECTOR: APPROX (QTY) LF OF (SIZE) (TYPE) CONDUIT
16. INSTALL DUCT SMOKE DETECTOR IN SUPPLY DUCTWORK AND PULL CABLE (SIZE) BACK TO FIRE ALARM PANEL.

FSB Examples at Lockheed Martin Skunk Works®



DESIGN REQUIREMENTS:

- ROOFING: SLOPED STANDING SEAM METAL ROOF ATTACHED TO METAL ROOF DECK
- WATER TIGHTNESS: YES
- MONOLITHIC SLAB ON GRADE/FOUNDATION FOR CANOPY, DESIGNED FOR FORKLIFT LOADING
- EQUIPMENT HOUSEKEEPING PADS/FOUNDATIONS ISOLATED FROM CANOPY PAD/FOUNDATION (COMPRESSIBLE JOINT)
1. OVENS
- NO PEAK FENCING REQUIREMENT TO MATCH EXISTING NORTH CANOPY
- GUTTER/DOWNSPOUTS?

ELECTRICAL:
- LIGHT FIXTURES: WALL MOUNT FIXTURES
- LIGHTING LEVEL: 25 FC
-CONVENIENCE RECEPTACLES
-GROUNDING: NEW GROUND RING/EQUIPMENT
- POWER: RELOCATE GOLF CART CHARGERS

FIRE PROTECTION:
- PROVIDE NEW DRY PIPE SPRINKLER SYSTEM FOR PROTECTION OF EXTERIOR CANOPY AND EQUIPMENT (OVEN(S) AND DUST COLLECTOR)
-PROVIDE FIRE ALARM MONITORING OF NEW SPRINKER RISER (VALVE TAMPER SWITCH, WATERFLOW SWITCH, PRESSURE SWITCH)

DESIGN INFORMATION NEEDS:

- DRYING OVEN(S) LAYOUT, SIZE AND WEIGHT
- LIQUID WASTE SYSTEM EQUIPMENT LAYOUT AND SIZES
- DUST COLLECTION LOCATION, SIZE AND WEIGHT
- DEIONIZED WATER LOCATION, SIZE AND WEIGHT
- LOCATION OF GOLF CART CHARGERS

SCOPE ACTIVITIES & DETAILS:

GEOMETRY:
HEIGHT: 16'-6" @ PEAK, APPROX 1/4"/FT SLOPE
FOOTPRINT: 24' W (MAY CHANGE PENDING LIQUID WASTE DESIGN) X 180 FT LONG

CANOPY ROOF SYSTEM:
BASIS OF DESIGN AEP SPAN - SPANSEAM METAL ROOFING (REGAL WHITE) OVER COVERBOARD/UNDERLAYMENT ON TOP OF METAL DECKING.

STRUCTURAL FRAMING:
RE: 30% STRUCT DRAWINGS
FRAMING FOR OVEN AND DUSTCOLLECTION EXHAUST PENETRATIONS?

4. LIGHTING:
4a. 8 QTY OF WALL FIXTURES: LITHONIA WALL PACKS
4b. LIGHTING CONTROL: TIME CLOCK
4C POWER VIA (2) #12 & (1) #12 GND IN 3/4"C (250'LF) PANEL LP1

5. CHAIN LINK FENCING:
FULL PERIMETER (3 SIDES) @ FULL HEIGHT (15'-6") SECURED TO STRUCTURE. 10' ROLLING GATE AT ACCESS DRIVE. 4" SCH 40 STEEL PIPE FENCE POSTS AT 10'-0" O.C. MAXIMUM ANCHORED AT BOTTOM TO SLAB ON GRADE WITH POST-INSTALLED ANCHORS AND AT TOP TO STEEL CANOPY BEAMS WITH BOLTED VERTICAL SLIP CONNECTIONS.

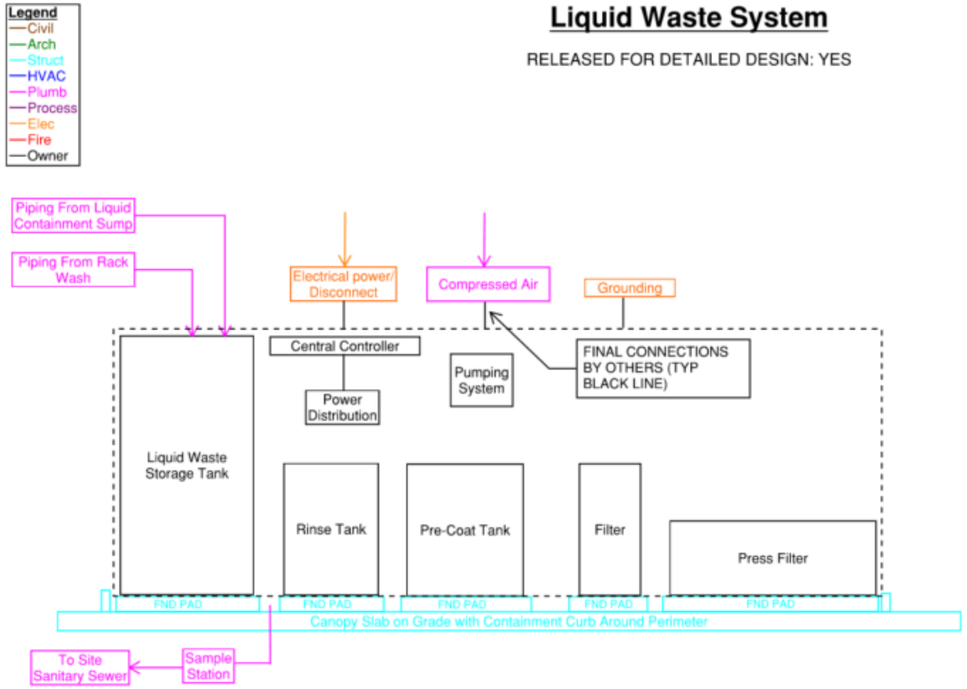
6. CONVENIENCE COMPRESSED AIR
SEE INTERIOR IMPROVEMENTS FSB FOR CONVENIENCE COMPRESSED AIR UNDER CANOPY.

7. POWER:
7a. (6) WEATHERPROOF 120V RECEPTACLES THROUGHOUT CANOPY AREA VIA (2) #12 & (1)#12 GND IN 3/4"C (220'LF)
7b. POWER CONNECTION TO AIR COMPRESSOR FROM PANEL MDP/NEW LOCAL 480V 3PH 30A FUSED DISCONNECT VIA (3)#10 & (1)#10GND IN 1"C (150'LF)

8. GROUNDING:
8a. GROUND RODS (SPACED EVERY 25') TIED VIA #4/0 AWG ENCOMPASSING CANOPY AND TIED TO STRUCTURAL BUILDING STEEL AND EQUIPMENT VIA #2/0 AWG GREEN INSULATED GROUNDING CABLE.

9. SLAB ON GRADE FOUNDATION SYSTEM:
8" THICK CONCRETE SLAB ON GRADE WITH #6 @ 12" O.C. EA. WAY AT CENTERLINE OF SLAB POURED MONOLITHICALLY WITH SPREAD FOOTINGS AND GRADE BEAMS SUPPORTING STEEL CANOPY COLUMNS. AT GRAVITY ONLY STEEL CANOPY COLUMNS, SPREAD FOOTINGS TO BE 18" THICK WITH #5 @ 9" O.C. EACH WAY @ BOTTOM OF SPREAD FOOTING. AT STEEL CANOPY MOMENT FRAME COLUMNS, SPREAD FOOTINGS TO BE 18" THICK WITH #5 @ 9" O.C. EACH WAY TOP AND BOTTOM.

FSB Examples at Lockheed Martin Skunk Works®



SCOPE ACTIVITIES & DETAILS:

LIQUID WASTE SYSTEM (BY OWNER):
1a. COMPONENTS ARE TBD, LIKELY TO CONSIST OF 4000 GAL LIQUID WASTE STORAGE TANK, PRE-COATING TANK, RINSE TANK, POLISHING FILTER, AND FILTER PRESS

STORAGE TANK AND PUMP FOUNDATION:
2a. MINIMUM 6" TALL HOUSKEEPING PAD POURED ON TOP OF EXISTING SLAB ON GRADE WITH #4 @ 12" O.C. EACH WAY AT CENTERLINE OF HOUKEEPING PAD. HOUSEKEEPING PAD TO BE ATTACHED TO EXISTING SLAB ON GRADE BELOW WITH ADHESIVE INSTALLED REBAR DOWELS @ 24" O.C. AROUND PERIMETER OF PAD.
JRC - IT IS CURRENTLY TBD WHETHER A MOBILE BERM OR STRUCTURAL SECONDARY CONTAINMENT WILL BE REQUIRED. ACTION ITEM HAS BEEN GENERATED. AWAITING DECISION.

THE GENERAL ARRANGEMENT PLAN SHOWS DIMENSIONS THAT ARE PRETTY CLOSE TO THE B637A EXISTING SYSTEM FOR TANK DIAMETERS THAT COULD BE USED FOR THIS EFFORT.

POWER:
3a. (1) SINGLE POINT POWER CONNECTION TO MAIN CONTROLLER VIA (2) #12 & (1) #12 IN 3/4"C (200"LF).
3b. PROVIDE (2) 208V 3PH 30A FUSED DISCONNECTS FOR WASTE PUMP VIA (3) #12 &(1)#12 GND IN 3/4"C FROM PANEL PP1
3c. PROVIDE (1) 480V 3PH 30A FUSED DISCONNECT FOR PRESS FILTER VIA (3) #10 &(1)#10 GND IN 1"C FROM PANEL MDP

GROUNDING:
4a. #6 AWG GREEN INSULATED GROUNDING CABLE TO STRUCTURAL STEEL FROM FILTERS AND VACUUM PRODUCER

PLUMBING:
5a: RE: CANOPY FSB FOR COMPRESSED AIR. FINAL CONNECTION TO LIQUID WASTE SYSTEM BY OTHERS
5b: RE: LIQUID SYSTEM AND RACK CLEANING SYSTEM FSBS FOR CONNECTION TO LIQUID WASTE TANK
5c: RE: SITEWORK DRAWINGS FOR SANITARY SEWER.
5d: PROVIDE SAMPLING BOX ON SS LINE (REQUIREMENTS TBD)

SCOPE DEFINITIONS:

STRUCTURAL:
- TANK, FILTER AND PUMP FOUNDATION PADS & ANCHORAGE
- STEEL STANCHIONS FOR PIPING SUPPORT

ELECTRICAL:
- LIGHTING: GENERAL CANOPY LIGHTING (SEE CANOPY SHEET)
- POWER: PROCESS EQUIPMENT
- GROUNDING: EQUIPMENT GROUNDING

PLUMBING:
- SIZED FOR 120,000 GALLONS ANNUALLY
- SEPARATE INK WASTE FROM WASTE WATER
- NON HAZARDOUS WASTE STREAM

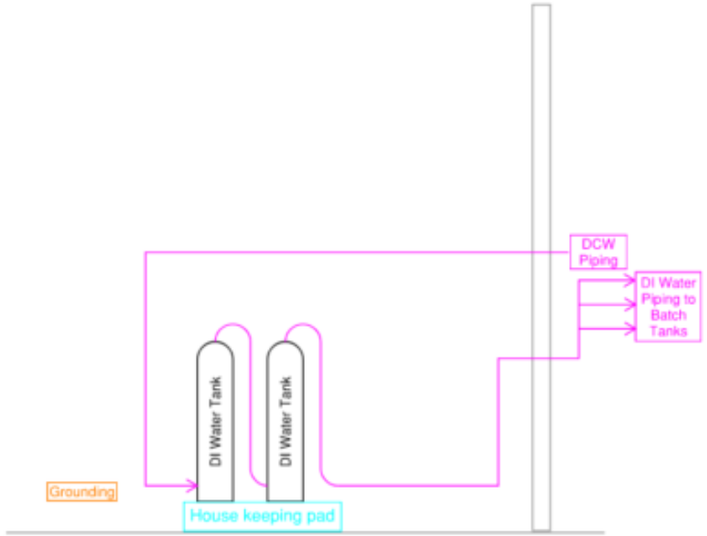
DESIGN INFORMATION NEEDS:
- LOCATION, SIZE AND WEIGHT OF TANKS, PUMPS AND FILTERS
- PIPE ROUTING LAYOUT
- WHO IS PROVIDING SAMPLE STATION? BMCD OR LIQUID WASTE SYSTEM SUPPLIER?

FSB Examples at Lockheed Martin Skunk Works®

Legend
- Civil
- Arch
- Struct
- HVAC
- Plumb
- Process
- Elec
- Fire
- Owner

DI Water System

RELEASED FOR DETAILED DESIGN: YES



SCOPE ACTIVITIES AND DETAILS:

1. HOUSEKEEPING PAD: MINIMUM 6" TALL HOUSKEEPING PAD POURED ON TOP OF CANOPY SLAB ON GRADE WITH #4 @ 12" O.C. EACH WAY AT CENTERLINE OF HOUKEEPING PAD. HOUSEKEEPING PAD TO BE ATTACHED TO CANOPY SLAB ON GRADE BELOW WITH CAST-IN-PLACE OR ADHESIVE INSTALLED REBAR DOWELS @ 24" O.C. AROUND PERIMETER OF PAD AND INTERMEDIATE ROWS @ 4'-0" O.C. MAXIMUM EACH WAY.
1a. PRELIMINARY SIZE OF HOUSEKEEPING PAD: 8'-0"x4'-6"

2. DOMESTIC WATER PIPING
2a. SEE INTERIOR IMPROVEMENTS FSB FOR DOMESTIC WATER PIPING.
2b. PROVIDE TAP OUT OF BUILDING AND PROVIDE VALVE AND CAMLOCK FITTING FOR HOSE CONNECTION

3. DI TANKS: 2 DI TANKS
3a. PURETEC FLOMAX37 TANKS (BY OWNER).
3b. 2 INCH HOSE: (2) AT APPROX 6 LF AND (1) AT APPROX 10 LF. EACH HOSE WILL HAVE CAMLOCK FITTINGS ON BOTH ENDS (ONE MALE AND ONE FEMALE).
3c. DI WATER TANK ANCHORAGE: ASSUME MANUFACTURER PROVIDES MOUNTING ANCHORAGE LOCATIONS INTEGRATED INTO THE DI TANKS (VERIFCATION W/ MANUF. REQUIRED). ASSUME (4) 3/4" DIA STAINLESS STEEL EXPANSION ANCHOR BOLTS (POST-INSTALLED) REQUIRED AT EACH TANK.

4. DEIONIZED WATER
5a. APPROX 100 LINEAR FEET OF 2" DI WATER PIPING.
5b. DI WATER PIPE SHALL BE SCH 80 CPVC WITH CONTINUOUS METAL SUPPORT.

6. GROUNDING
6a. #6 AWG GREEN INSULATED GROUNDING CABLE TO STRUCTURAL STEEL FROM DI TANK

DESIGN REQUIREMENTS:

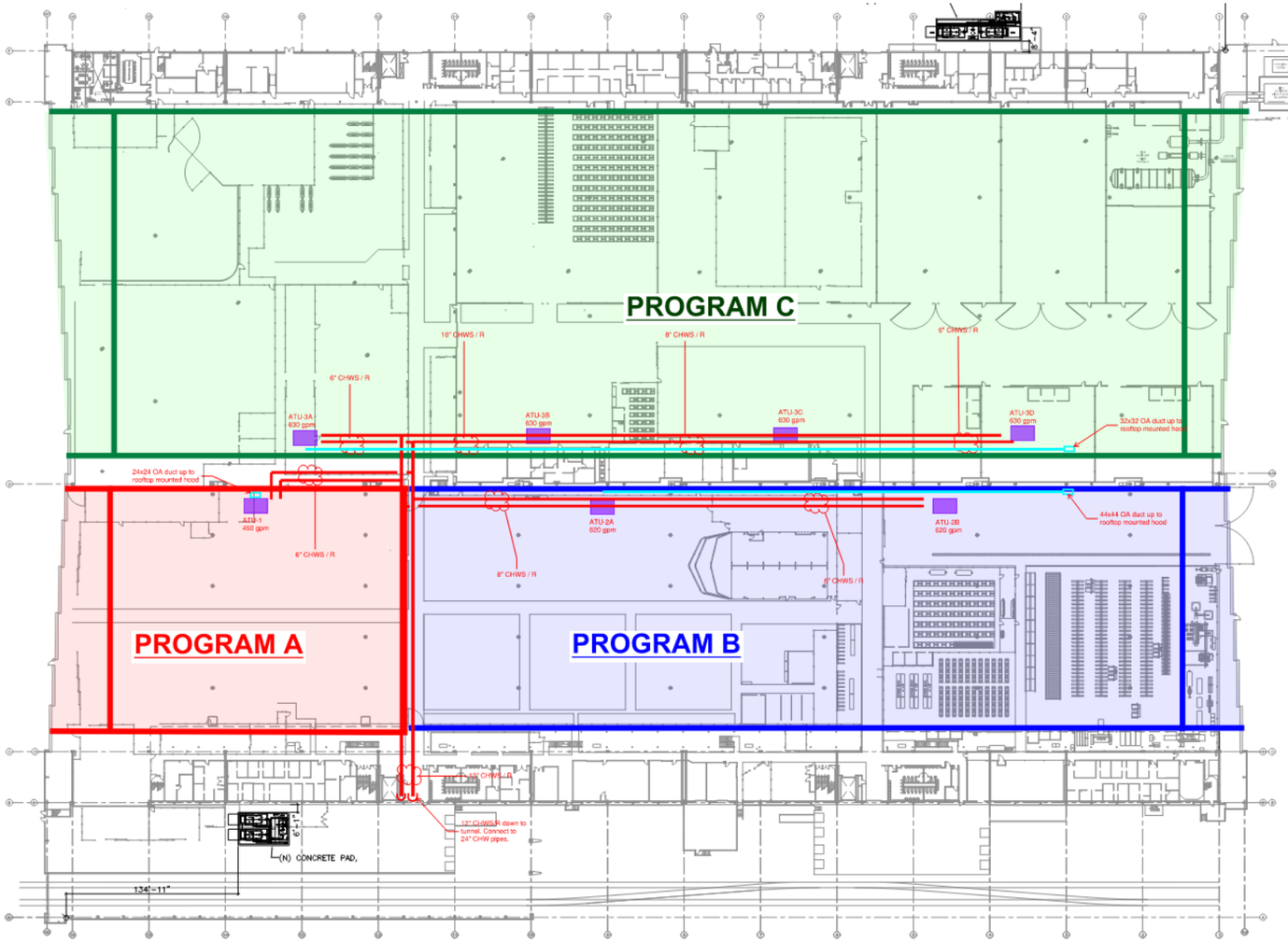
STRUCTURAL:
- DI WATER TANK EQUIPMENT PAD
- DI WATER TANK ANCHORAGE

ELECTRICAL:
- DI WATER TANK GROUNDING

PLUMBING:
- MIXED BED TANK MATERIAL
- 70 GPM OF DI WATER FLOW REQUIRED

DESIGN INFORMATION NEEDS:
- LOCATION, SIZE AND WEIGHT OF TANKS
- MANUFACTURER'S ANCHORAGE MOUNTING TYPE/LAYOUT OR SUPPLEMENTAL STEEL SUPPORT FRAME ASSEMBLY REQUIRED?

FSB Examples at Lockheed Martin Skunk Works®



ATU-1: New Air Rotation Unit; 100,000 cfm; 176 Tons cooling, 2,100 MBH natural gas heating

ATU-2A / B: (2) New Air Rotation Unit; each at: 135,000 cfm; 240 Tons cooling, 2,350 MBH natural gas heating

ATU-3A / B / C / D: (4) New Air Rotation Unit; each at: 139,000 cfm; 328 Tons cooling, 2,800 MBH natural gas heating

ALL need to be seismically rated for Zone 4

CHWS / R Pipe Materials List:
*6" = 225'
*8" = 650'
*10" = 500'
*12" = 700'

NG Pipe Materials List:
*3" = 750'
*4" = 250'
*6" = 200'
*8" = 150'

Duct Materials List:
*800' of 24" x 24" sheet metal, rated at -2" w.g.
*300' of 32" x 32" sheet metal, rated at -2" w.g.
*500' of 44" x 44" sheet metal, rated at -2" w.g.

1 ARCHITECTURAL GROUND FLOOR PLAN
SCALE: 1/32" = 1'-0"

Results & Next Steps

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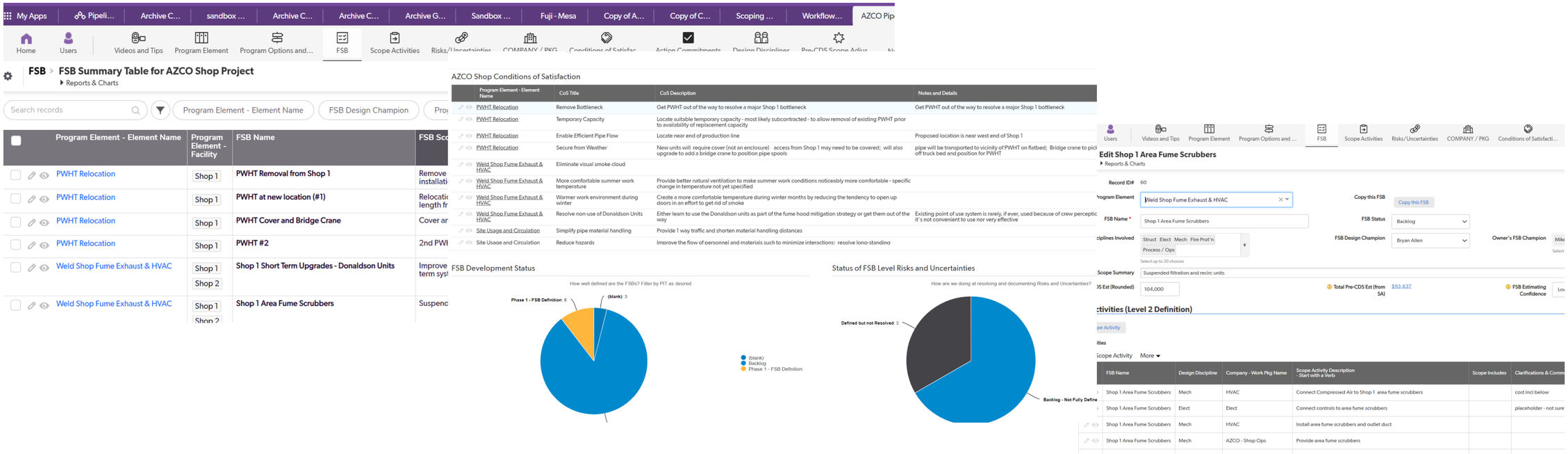
Scalability

Fundamental scope blocks can be developed in multi-user relational database

- Portfolio of projects
- Next generation micro-electronics fab with flexibility to fit multiple locations (>1000 FSBs)



"Next Gen" Advanced Work Packaging (AWP)

Linking Lean / IPD to Advanced Work Packaging

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CURT

Key Takeaways

- Understand "minimum viable product" concept
  - Similar in some respects to "last responsible moment"
- Rapid visualization is very helpful
  - “A picture is worth a thousand words”
- Simple is sometimes better
  - It takes effort to take something complicated and distill it into something si
- Define the problem before solving it
  - Solving the wrong problem is a waste of time
  - Ready, aim, fire!, *not* fire, ready, aim!

Q & A

Send your questions to this team via chat.

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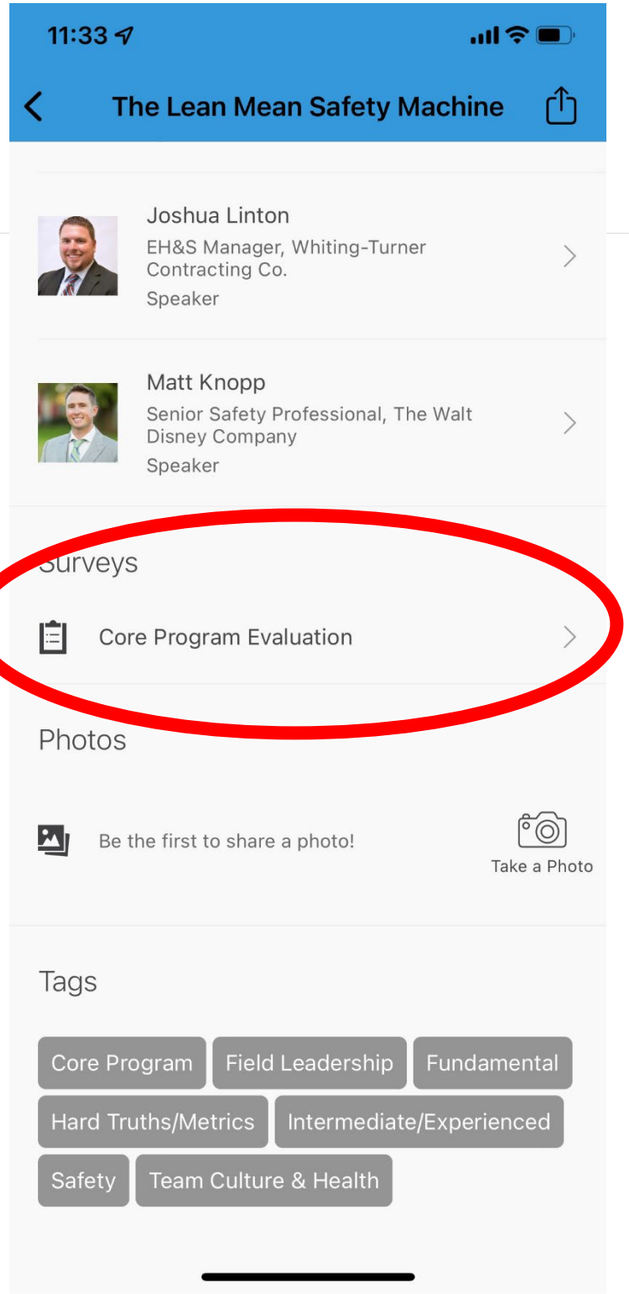
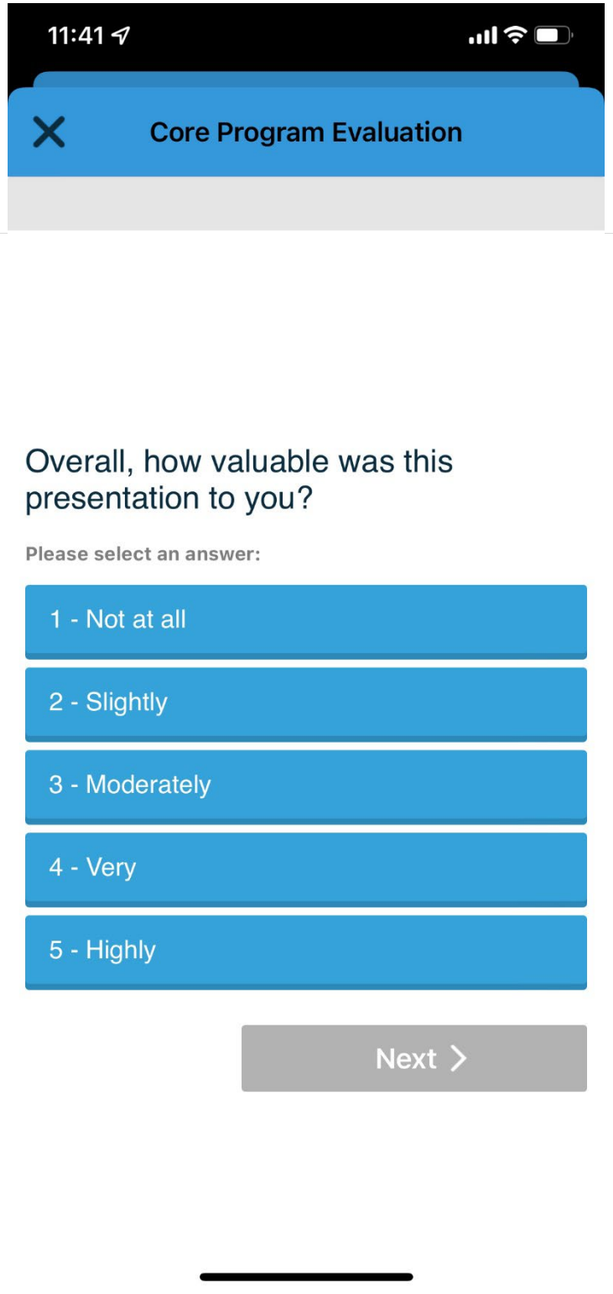
Rate Presentations in the App

Continuous improvement: give presenters your feedback by taking the session evaluation!

1. Find the session under “schedule”
2. Click on it then scroll down
3. Click “core program evaluation”
4. Complete the 5-question evaluation

This information will determine the top 5 presentation teams and the top Live Lab





24TH LCI CONGRESS
OCTOBER 18-21

In the spirit of continuous improvement, we would like to remind you to complete this session's survey! We look forward to receiving your feedback.

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Thank you for attending this presentation. Enjoy the rest of the 24th Annual LCI Congress!