

CPA Production for DUNE

BOE – M&S and Labor estimates

Production factory configuration

CPA BOE Update

- Final drawings for 10 kt DUNE TPC
 - Curved profiles on CPA Array ends
 - FSS cutout for PD calibration diffusers
 - HV Bus modifications
 - Shipping configuration
 - Installation improvements
- Updated/streamlined BOE

Part #	Description	Revisor	Assembly	# per Unit			# Units	Material	Notes	M&S \$/UNIT
				F	B	D				
DFD-20-F000,B000,D000		1		2	96	2	100	ANL		
DFD-20-F400,B400,A400	Upper Modules	1					0	ANL		
DFD-20-A401	Center Support Block	6	DUNE-1-1A,B,C	1	1	1	100	ANL	x 7.8" x 5.1" aluminum	\$1,500.00
DFD-20-A402	Main Support Bar		DUNE-1-1A,B,C	1	1	1	100	ANL	5" x 3" x 4 FR4	\$731.43
DFD-20-A404	Upper Side Bar LH			1		1	4	ANL		\$650.00
DFD-20-B404	Upper Side Bar LH		DUNE-1-1A,B,C		1		96	ANL	5" x 1" x 9 FR4	\$646.05
DFD-20-A403	Resistive Panel		DUNE-1-1A,B,C	1	1	1	100	CERN	FR4	\$480.00
DFD-20-A405	Intermediate Bar		DUNE-1-1A,B,C	10	10	10	1000	ANL	5" x 2.5" x 4 FR4	\$245.33
DFD-20-A406	Upper Side Bar RH		DUNE-1-1A,B,C	1	1	1	100	ANL	5" x 2.5" x 9 FR4	\$631.09
DFD-20-A101	Top/Bott Horz FSS R		F100,D100	1		1	4	ANL		\$40.80
DFD-20-A118	Top/Bott Horz FSS L		F100,D100	1		1	4	ANL		\$40.80
DFD-20-A102	Horizontal FSS		F100,B100,D100	2	2	2	200	ANL		\$34.80
DFD-20-A103	Top/Bott Int Vert FSS L		F100,B100,D100	1	2	1	196	ANL		\$46.80
DFD-20-A104	Top/Bott Int Vert FSS R		F100,B100,D100	1	2	1	196	ANL		\$46.80
DFD-20-A105	Exterior/Upper FSS L		F100,D100	1		1	4	ANL		\$55.20
DFD-20-A106	Exterior/Upper FSS R		F100,D100	1		1	4	ANL		\$55.20
DFD-20-B101	Top/Bott Horz FSS		B100		2		192	ANL		\$40.80
DFD-20-C500,B500,A500	Middle Modules		DFD-20-				0	ANL		
DFD-20-A502	Side Middle Bar LH			4		4	16	ANL		\$390.00
DFD-20-B502	Side Middle Bar LH		DUNE-1-2A,B		4		384	ANL	5" x 1" x 9 FR4	\$387.03
DFD-20-A503	Resistive Panel		DUNE-1-2A,B	4	4	4	400	CERN	FR4	\$480.00
DFD-20-A501	Side Middle Bar RH		DUNE-1-2A,B	4	4	4	400	ANL	5" x 2.5" x 9 FR4	\$364.85
DFD-20-A102	Horizontal FSS		F100,C200,B100,B200	8	8	8	800	ANL		\$34.80
DFD-20-A107	Middle Ext Vert FSS L		F100,C200,D100,A200	4		4	16	ANL		\$55.20
DFD-20-A108	Middle Ext Vert FSS R		F100,C200,D100,A200	4		4	16	ANL		\$55.20
DFD-20-A109	Middle Int Vert FSS L		F100,C200,B100,B200,D1	4	8	4	784	ANL		\$46.80
DFD-20-A110	Middle Int Vert FSS R		F100,C200,B100,B200,D1	4	8	4	784	ANL		\$46.80
DFD-20-F600,B600,A600	Lower Modules									
DFD-20-A603	Bottom Center Support Tab		DUNE-1-3A,B,C	1	1	1	100	ANL	ALUMINUM	\$1,500.00
DFD-20-A601	Bottom Support Bar		DUNE-1-3A,B,C	1	1	1	100	ANL	5" x 3" x 4 FR4	\$709.90
DFD-20-A602	Lower Side Bar LH			1		1	4	ANL		\$640.00
DFD-20-B602	Lower Side Bar LH		DUNE-1-3A,B,C	1	1		98	ANL	5" x 2.5" x 9 FR4	\$640.43
DFD-20-A604	Lower Side Bar RH		DUNE-1-3A,B,C		1	1	98	ANL	5" x 2.5" x 9 FR4	\$665.95
DFD-20-A403	Resistive Panel			1	1	1	100	CERN		\$480.00
DFD-20-A101	Top/Bott Horz FSS R		F300,D300	1		1	4	ANL		\$40.80
DFD-20-A301	Lower Int Vert FSS L		F300,B300,D300	1	2	1	196	ANL		\$46.80
DFD-20-A302	Lower Int Vert FSS R		F300,B300,D300	1	2	1	196	ANL		\$46.80
DFD-20-A303	Exterior/Lower FSS L		F300,D300	1		1	4	ANL		\$55.20
DFD-20-A304	Exterior/Lower FSS R		F300,D300	1		1	4	ANL		\$55.20
DFD-20-A118	Top/Bott Horz FSS L		F300,D300	1		1	4	ANL		\$40.80
DFD-20-B101	Top/Bott Horz FSS		B300		2		192	ANL		\$40.80
HV Bus	Lifting Fixture							ANL		

HV Bus

DFD-20-A409	Horizontal High Voltage Cable	F400,F600,A400,A600,B40	4	4	4	400	KSU		\$56.74
DFD-20-A411	Vertical High Voltage Bus Upper	F400,A400	2		2	8	KSU		\$60.00
DFD-20-A505	High Voltage Bus Vertical	A500,A600,C500,F600	10		10	40	KSU		\$60.00
DFD-20-A113	Section-to-Section wire	A200	20	20	20	2000	KSU		\$2.29
DFD-20-A114	Donut Jumper	D100,F100	1		1	4	KSU		\$2.50
DFD-20-A115	Profile Jumper	A100	18	6	18	648	KSU		\$2.63
DUNE-1-41	Panel to Panel Wire	DUNE-1AB	4	4	4	400	KSU		\$2.97
DFD-20-A040	Mini-Electrical Board, Front	D100,D300,F100,F300,B1	2	2	2	200	KSU		\$28.08
DFD-20-A021	Mini-Electrical Board, Rear	D100,D300,F100,F300,B1	2	2	2	200	KSU		\$28.08

Profiles

DFD-20-A015	Short Z Bracket	A140,A145,A310	6	6	6	600	ANL-CS	304 SS	\$12.50
DFD-21-A012	Profile Nut Type 1B		20	6	20	656	ANL-CS	304 SS	\$12.50
DFD-20-A017	Long Z Bracket	A130	14		14	56	ANL-CS	304 SS	\$12.50
DFD-20-A145	Profile Assy; 19.2" Short Profile	A100	1	2	1	196	CERN	ALUMINUM	
DFD-20-B310	Profile Assy; 45.28" Bottom Profile	B300			1	96	CERN	ALUMINUM	
DFD-20-A120	Profile Assy; 76.4" Vert Middle		4		4	16	CERN	ALUMINUM	
DFD-20-A130	Profile Assy; 71.7" Vert Upper		1		1	4	CERN	ALUMINUM	
DFD-20-F320	Profile Assy; 74.2" Vert Lower		1		1	4	CERN	ALUMINUM	
DFD-20-D116	Profile Assy; 90 Top	D300	1			2	CERN/ANL	ALUMINUM	
DFD-20-D117	Profile Assy; 90 Bottom	D300			1	2	CERN/ANL	ALUMINUM	

Hardware

DFD-20-A412	Electrical Tab Plate		18	8	18	840	ANL-CS	BRASS	\$200.00
DFD-20-A025	Connection Plate	A000	1		1	4	ANL-CS	BRASS	\$250.00
DFD-20-A052	Contacto Base	A050	1		1	4	ANL-CS	316 SST	\$250.00
DFD-20-A111	Electrical T Strap		20	20	20	2000	ANL-CS	BRASS	\$50.00
DFD-20-A112	Electrical Strap		8	8	8	800	ANL-CS	BRASS	\$30.00
McMasterCarr #92196A552	1/4-20 x 2.5LG Socket Hd		8	8	8	800	ANL	SS	\$0.57
McMasterCarr #92196A551	1/4-20 x 2.25 LG Socket Hd		28	28	28	2772	ANL	SS	\$0.55
McMasterCarr #92196A249	#10-24 x 1.25LG Socket Hd.		20	20	20	2000	ANL	SS	\$0.15
McMasterCarr #90145A725	0.5 Dia x 3.0 LG Dowel Pin		4	4	4	400	ANL	SS	\$6.24
McMasterCarr #90145A551	.250 Dia x 2.5LG. Dowel Pin		14	14	14	1400	ANL	SS	\$1.75
McMasterCarr #90145A716	0.5 Dia x 1.5LG Dowel Pin		1	2		194	ANL	SS	\$3.66
McMasterCarr #97715A143	BHHDS; #8-32 x 0.5 LG		220	220	220	22000	ANL	BRASS	\$0.48
McMasterCarr #92196A340	Flat Washer; #8		220	220	220	22000	ANL	BRASS	\$0.07
McMasterCarr #91235A105	Belleville Washer; #8		220	220	220	22000	ANL	SS	\$0.34
McMasterCarr #97715A178	BHHDS; #10-24 x 0.5 LG		20	20	20	2000	ANL	BRASS	\$0.49
McMasterCarr #92916A350	Flat Washer; #10		20	20	20	2000	ANL	BRASS	\$0.09
McMasterCarr #91235A109	Belleville Washer; #10		20	20	20	2000	ANL	SS	\$0.48
McMasterCarr #92671A011	Hex Nut; #10-24		20	20	20	2000	ANL	BRASS	\$0.09
McMasterCarr #97715A801	BHHDS; #10-24 x 1.0 LG		36	16	36	1680	ANL	BRASS	\$0.65
McMasterCarr #3177T14	No. 3 Dia Damping Loop Clamp		16	4	16	448	ANL		\$1.40
McMasterCarr #92240A537	HHCS; 1/4-20 x 0.5 LG		20	6	20	656	ANL		\$0.08

BOE Summary – M&S

Total -- 100 12m CPA Panels \$2,086,699.32

Summary of M&S Costs

Hardware Costs	\$325,588.32	ANL
HV Bus	\$44,290.24	KSU
Profiles	\$16,400.00	CERN/ANL
Frames (HB, RPs, FSS)	\$1,700,420.76	ANL/CERN
Frames - RPs, FSS	\$1,248,577.56	ANL
FSS Upper	\$33,907.20	CERN/ANL
FSS Middle	\$102,988.80	CERN/ANL
FSS Lower	\$26,947.20	CERN/ANL
FSS Total	\$163,843.20	CERN/ANL
RPs	\$288,000.00	CERN

Production Labor Estimate

2 panels produced per week per factory by 4 people (2 days per panel + 1 day packing, etc)

Day 1 - 4 people, 8 hours each (2 Techs, 2 postdoc, 1 Supervisor) Assembly, QC

Day 2 - 4 people, 8 hours each (2 Techs, 2 postdoc, 1 Supervisor) Assembly, QC, Packing

Day 3 - 4 people, 8 hours each (2 Techs, 2 postdoc, 1 Supervisor) Assembly, QC

Day 4 - 4 people, 8 hours each (2 Techs, 2 postdoc, 1 Supervisor) Assembly, QC, Packing

Day 5 - 2 people 8 hours each (2 PostDoc, 1 Supervisor) QC, Shipping, Prep for next week

2 Panel hour breakdown per week

64 Tech hours (need skilled techs to align and install pins, drill and tap holes for FSS)

80 PD hours (PostDoc/Grad Student/Undergrad make connections, do QC when needed)

16 Supervisor hours (helps when needed, helps with final QC, shipping, prep)

Total CPA Production Totals for 10 kt TPC (Assembly of 100 CPA Panels)

3200 Tech hours

4000 PostDoc/Grad Student/Undergrad hours

800 Supervisor hours

Additional requirements :

- Production Setup

- Raw materials processing

Requires some Engineer

Additional Labor Estimates

Additional Engineer/Designer hours:

Production setup : FR4 frame sonic cleaning/drying baths

Production : assembly tooling, production table

Additional Technician hours:

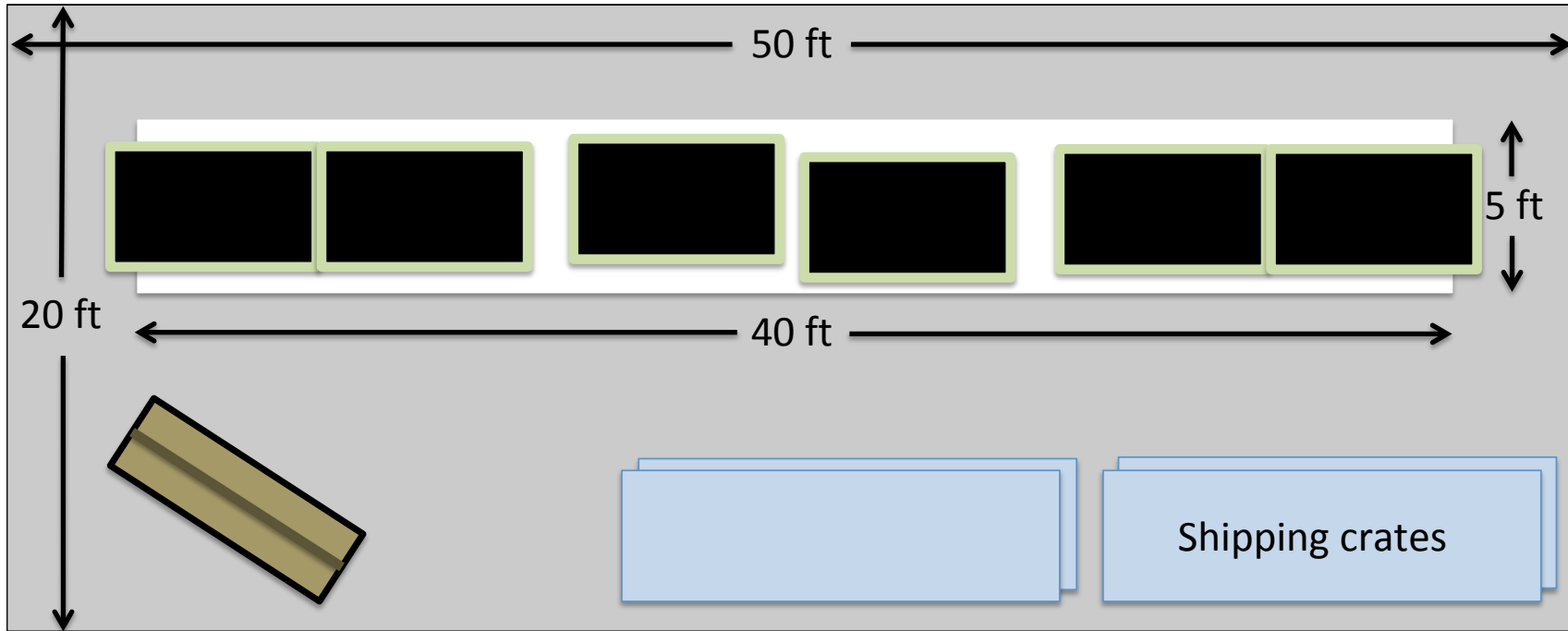
Production setup : assembly tooling

Production : crates, FSS edge gluing, FR4 cleaning

	Engineer	Designer	Technician	Ugrad, Grad Student	PostDoc	Faculty/ Staff	Total Labor Cost
Production Setup	360	280	640			320	
Production	520	80	4120		4580	920	
Cost (ANL)*	\$124.1K	\$50.8K	\$437.9K		\$366.4K	-	\$979.2K

* Not yet optimized – no change to setup, some production optimization

CPA Factory Configuration



Room dimensions: 50 feet X 20 feet

Table dimensions: 40 feet X 5 feet

Module dimensions: 2 m X 1.2 m (~6.7 ft X 4 ft)

Crate dimensions: 14 feet X 4 feet

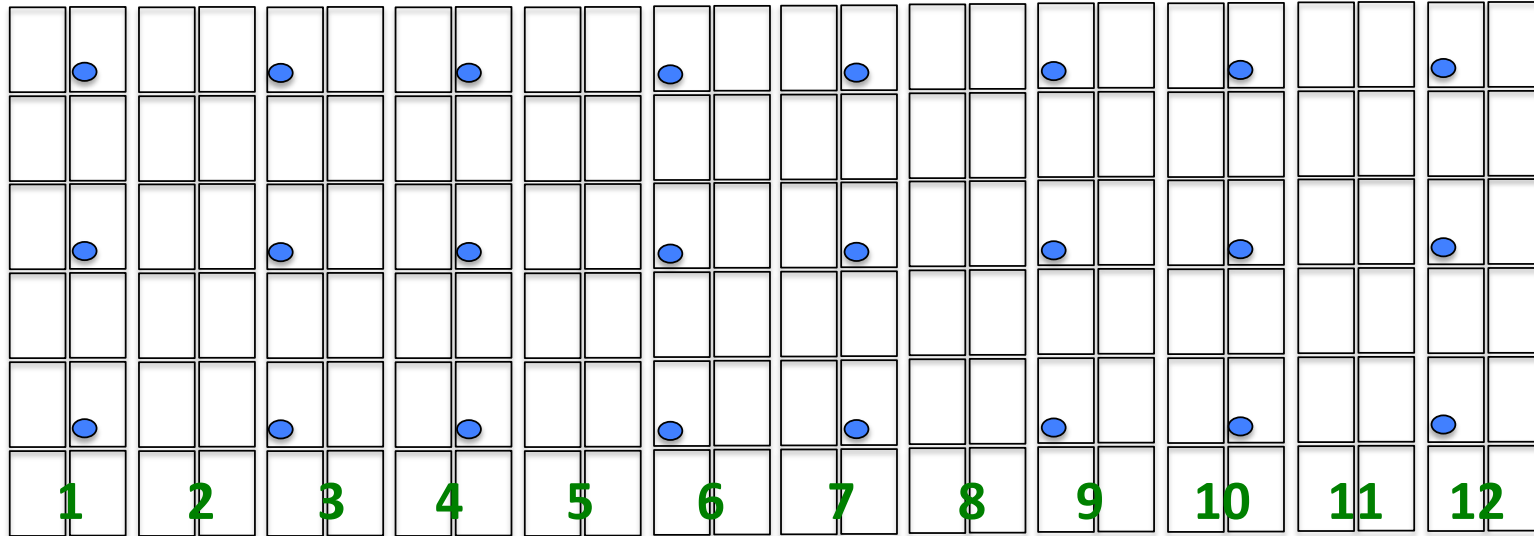
A-frame storage cart dimensions: 8 feet X 2.5 feet

Common Production Tooling

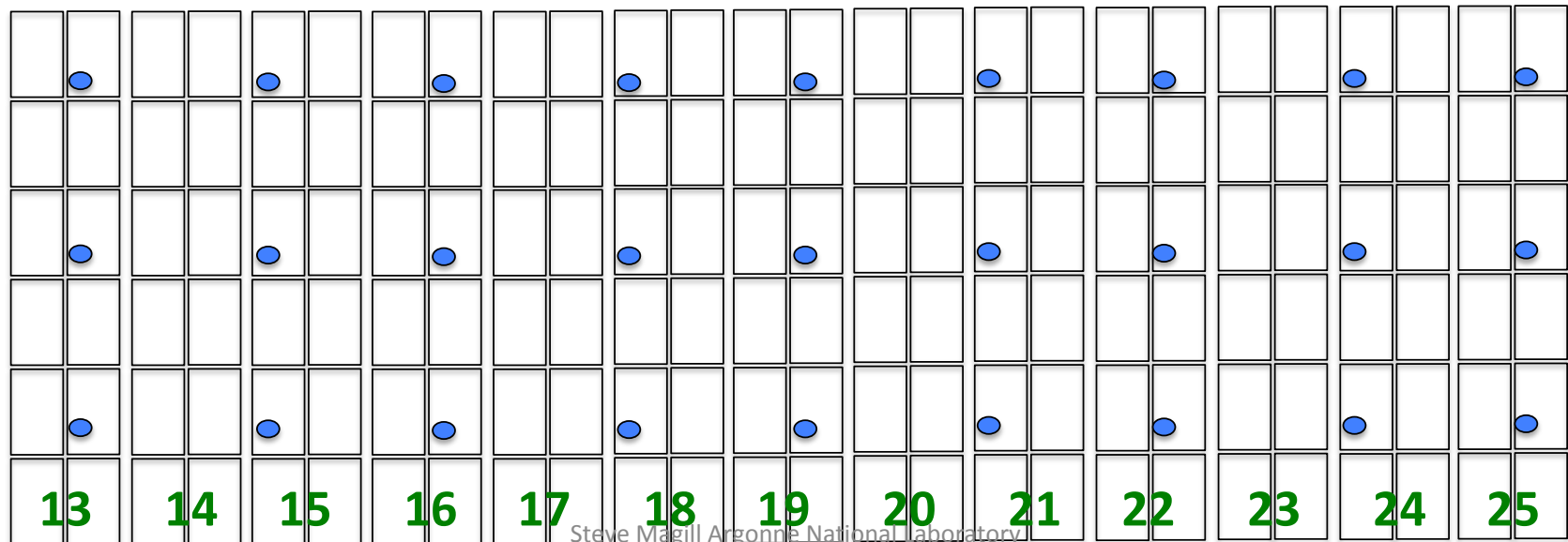
- Lead factory
 - Receives raw materials, QC, pack into CPA Plane packages, distribute to 2 factories
 - RPs, FSSs, Frames, HV Bus, Hinge Blocks, MRBs, Profiles, Brass hardware
 - Template jigs, Ohm/square device, Megger
- All Factories
 - Hex-drive adjustable torque screwdriver
 - Laser “tape” measure
 - iPad for QC

CPA Array Configuration

UpStream End of CPA Array



Cont.
below



DownStream End of CPA Array

Factory Division of Labor

- Configuration of CPA Panels:
 - F type (upstream end), D type (downstream end), B type (interior Panel), E type (B type w/diffusers)
 - FE – BB – 7 X (EB – BE – BB) – EB – BD
 - For 10 kt CPA : 50 total CPA Planes (100 CPA Panels)
 - 2 FE Planes
 - 2 BD Planes
 - 16 BB Planes
 - 16 EB Planes
 - 14 BE Planes
- 3 Factory division of labor
 - Lead Factory : 2 FE, 2 DB, 14 BE (+ raw material distribution)
 - Factory 2 : 16 BB
 - Factory 3 : 16 EB } Combine in same location -> 2 Factories
- Recommendation :
 - Lead Factory – ANL
 - Factory (2 +3) - University