UW Work Scope: Bottom CRP Supports

Value Engineering Meeting

Ian Jentz

April 19th, 2024

Feedback/Questions from March Value Engineering Meeting

1. Is it better to **epoxy adapter plate** rather than bolt on to CRP?
2. Can we **water jet cut the holes** or cut-outs of adapter plate rather than machine them with a CNC?
3. Would we save costs by **injection molding the supports**?
4. Is there a **FRP Unistrut system for mounting supports** the supports that would be better than the adapter plates?
5. Are the **height adjustment** bolts **necessary**?
6. What is the **cost/benefit** for **motorized tine controls**?

1. Is it better to epoxy adapter plate rather than bolt on to CRP?

No, epoxy drastically changes CRP manufacture and is irreversible

- CRP composite structure design and manufacture has been set for FD2. Adding a gluing step would require the CRP composite structure design to be re-evaluated.
- Mistakes in matching adapter plates to CRUs/CRPs would be permanent with epoxy
  - Mistakes would lead to scraping a $10k CRU structure if the adapter plate were miss glued
  - Need to design accurate glue-up fixturing
- Bolts allow last minute correction within FD2 and provide a path for rectifying assembly errors
  - Could remove and replace an adapter plate on site.

2. Can we water jet cut the holes or cut-outs of adapter plate rather than machine them with a CNC?

No, CNC features are necessary & water jet processes damages the FR4

- At the onset of the project we did some testing to see if we could water jet the smaller holes and got delamination of the FR4
- Machined features via CNC process are already necessary
  - Counterbore mounting holes to interface with raised rivet nuts in the CRP structure
  - Threaded bolt holes for supports; threaded inserts were tried but could strip and produced brass particulate
  - Engraving of adapter plate number for inventory control
- CNC allows tight tolerance and control
  - Accurate placement of support
  - All features are made in one setup, eliminates risk of mixing up feature layout-i.e. wrong support position or wrong label

3. Would we save costs by injection molding the supports?

No, this is not more economical and would still require some machining

- Cost of machined aluminum posts is comparable to injection molding
  - A mold is ~$30k (or more depending on tolerances)
  - Cost of machined aluminum posts is $88.32 per post. For a total of ~$29k for full quantity of 328 posts.
- Mold is not as high tolerance as machining, and we would still have to do machining of threaded holes and facing of end.
- Additional question of plastic creep deformation. The CRPs are going to sit for months at room temp. If using a plastic post, we would have to consider/calculate if that will creep under load.

4. Is there a Unistrut system for mounting supports that would be better than the adapter plates?

No, this drastically changes CRP manufacture and makes support mounting inaccurate

- CRP composite structure design and manufacture has been set for FD2. Adding Unistrut would require redesign of the CRP composite structure.
- Attaching supports to Unistrut would not be accurate or consistent. Technicians would have to adjust with placement of supports while in the FD2 cryostat.
- New tools and systems would need to be made to ensure proper support alignment.

5. Are the height adjustment bolts necessary?

Yes, height and ability to level is needed

- Edge-to-edge alignment of neighboring CRPs is needed because step changes >1mm from CRP to CRP introduce undesirable E-field perturbations at the CRP edge
- Ability to comply with any non-level features of the cryostat floor adds flexibility for the installation process
- Low incremental cost of including leveling feature, total of ~$9k for full quantity of 328 posts

6. What is the cost/benefit for motorized tine controls?

Motorized tine controls are beneficial and don't cost much

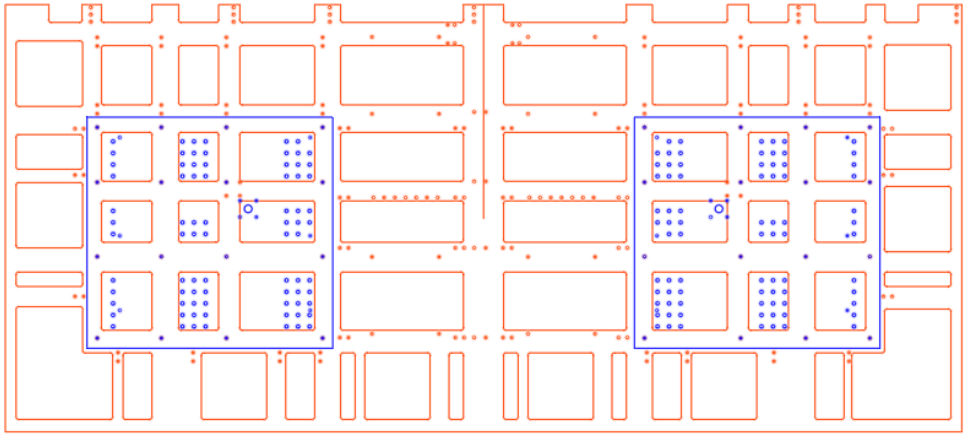
- The incremental cost of the lifting system automatization is estimated to be $10k total, including parts and labor.
- Module 0 install test demonstrated that we need the control and safety of a motorized system.
  - Personnel can not be near the suspended CRP while in motion.
  - Module 0 required an exemption for manual adjustment of tine incline.
- ES&H will likely require motorized control.
  - Limit switches on winch motion and stops on the tine incline/decline are good design features to improve safe operation.
  - Motorized version creates much needed fine control in what is a pretty "bouncy" system.
  - ES&H will not like a design where someone must go up to the suspended lifting system and crank a wheel.

Bottom Support Design cost improvements are possible

- Cost has improved over course of bottom support design and verification
  - March 2022, Preliminary Design Review: $11,232 cost per CRP
  - March 2023, Module 0 install: $6,790 cost per CRP
  - March 2024, FD2 production estimate: $4,887 cost per CRP
  - April 2024, FD2 production with small adapter plates $2,620 cost per CRP

Adapter Plates:

Module 0 and original FD2 design
Larger adapter plates carry all support configurations



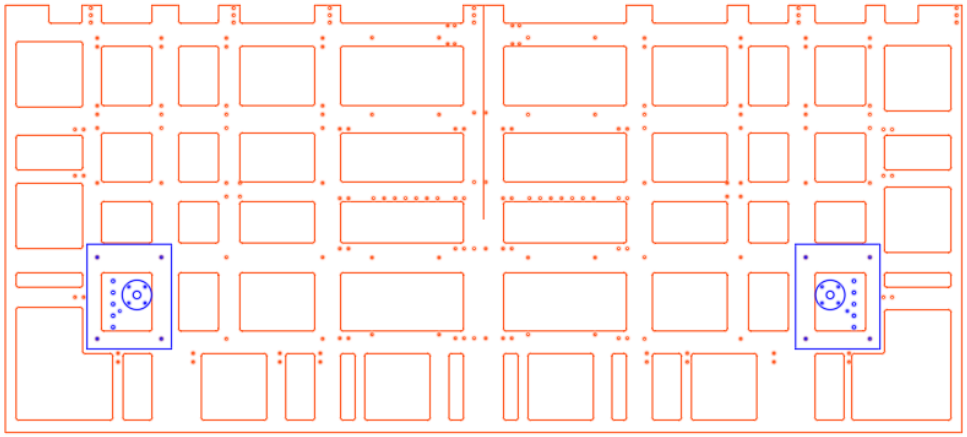
Opportunities for redesign with new CRP 6 structure

- Additional C-channel braces
- Increased number of rivet nut attachment points

Small Plates

- Plates are sized for opening in CRP 6 structure
- 328 total plates each with unique support placement
- 11 different plate configurations

Cost saving Adapter plates
Smaller footprint, 11 variations



adapter plate	Module 0
mm x mm	850 x 795
m2	0.67575

	A, A'	B, B'	C, C'
4	292 x 381 0.111252		403 x 381 0.153543
3	292 x 275 0.0803	317 x 275 0.087175	403 x 275 0.110825
2	292 x 342 0.099864	317 x 342 0.108414	403 x 342 0.137826
1	292 x 362 0.105704	317 x 362 0.114754	403 x 362 0.145886

Cost savings will have to be balanced against additional design analysis requirement

Original Plates have had full complement of design and integration work completed

- Has been **verified in structural analysis**
- **Deflection of detector** at edge boards was **within tolerance**
- **Demonstrated with installation tools**
- Tines pick up by contacting the adapter plates. This protected the more fragile CRP composite structure, **no risk to CRP structure**
- **CRP factory** tools have been **designed to interface** with the large plates (stacker tool)

Small Plates require additional design and implementation work

- Would need to **re-run structural analysis**
  - Do small plates **provide enough support** to keep **edge deflections** within tolerance
- Determine if **picking up with tines** would work
  - **Tines** have to **contact CRP** composite structure
  - **Risk in damage** to CRP structure
- CRP factory would need to **reconsider build procedure** and interface with stacker tool

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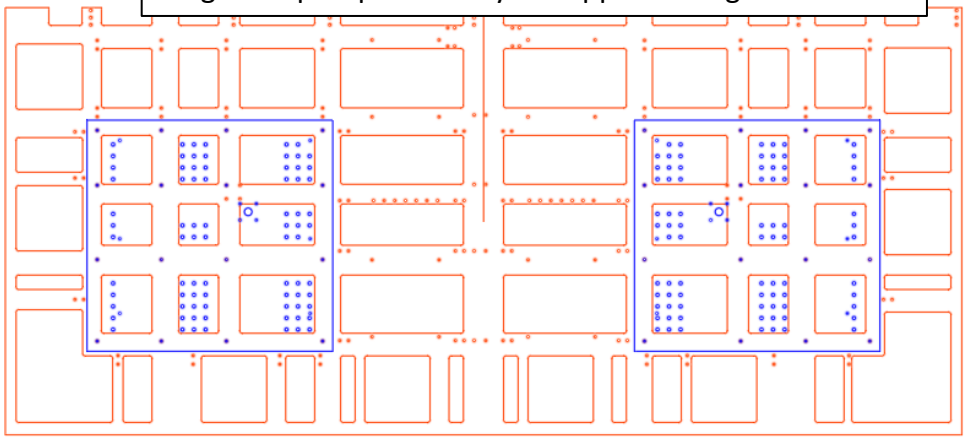

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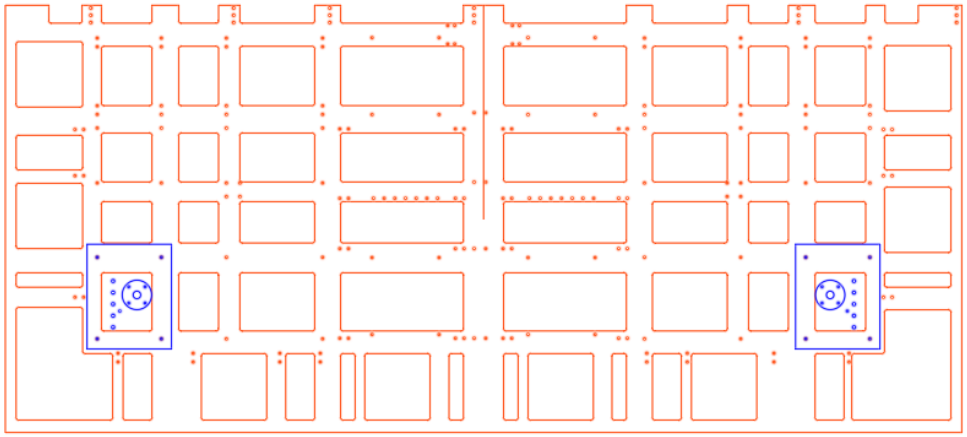
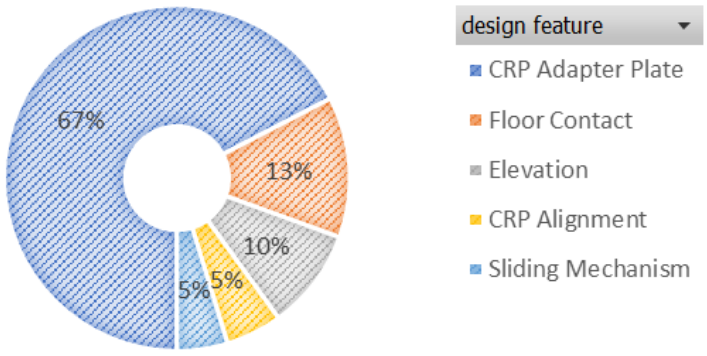


Improvement through adapter plate size reduction

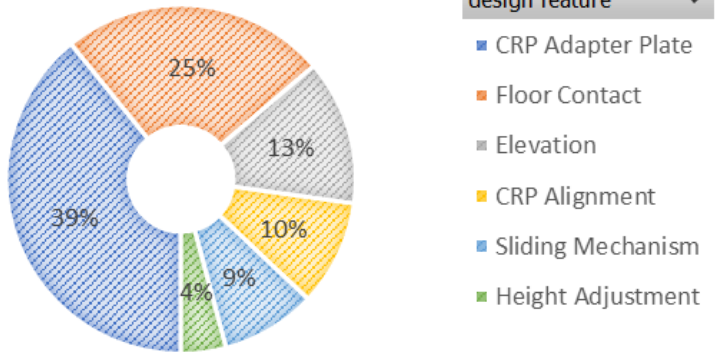
March 2024, FD2 Estimate
$390k for 80 FD2 bottom CRPs

$4,887 PER CRP



April 2024, FD2 Estimate
$210k for 80 FD2 bottom CRPs

$2,620 PER CRP



Cost savings realized by

- Reducing size of adapter plates, 11 versions of adapter plate in 328 configurations
- Is a ~$180k reduction in FD2 bottom support cost sufficient to offset the extra work/risk of small adapter plate design