# Design Alternatives

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Informal Cold Box Review

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# Testing at a single site, option A: one factory tests 4 CRU per week

Idea: Cold testing of all CRUs at one factory, with either one 4-CRU cold box or two 2-CRU cold boxes. CRUs would be shipped to cold test factory from the other factory.

Cost Reduction: Only one nitrogen storage tank would be required.

Added project risks:

- Creates bottleneck in CRU production. Any problems with cold box will halt production completely.
- If a problem is found in cold testing, may require transport back to other factory.
- Problems at factory without cold testing may go undetected.
- Risk in additional transport of CRUs (schedule, accidents, etc.)

Drawbacks:

- Throughput of CRUs remains the same, meaning the box(es) would need to cycle 4/week.
- Requires either much larger box or two boxes, runs into issues with space available at factory sites.
- No reduction in nitrogen consumption.
- Added cost of transporting CRUs (estimated $30,000 to $70,000)
- Even without cold testing, the other factory cannot assemble 4 CRU per week -> cold testing factory must also assemble CRU. Logistical difficulties with assembly, receiving CRU from other factory, cold testing 4 per week
- Imbalance in personnel requirements – additional labor required at cold test site.

# Reduced and added costs

Assuming one testing site and one primary assembly site.

- Nominal Bottom CRU shipping box holds 3 units, footprint 4m x 2m.
- A container (40')/trailer(53') can hold 2 to 3 boxes
  - 6 to 9 CRUs per shipment
- The 82 CRUs would require 10 to 14 shipments.
- Past shipments of this scale were between $3,000 to $5,000.

| | 10 shipments of 9 CRUs | 14 shipments of 6 CRUs |
|---|---|---|
| $3,000 per shipment | $30,000 | $42,000 |
| $5,000 per shipment | $50,000 | $70,000 |

- Cost reduction: $84,000 (storage tank not needed at non-testing site)
- Cost increase: $35,000 to $70,000 (larger storage tank needed at testing site)
- Cost increase: $30,000 to $70,000 (CRU transportation)
- **Total cost difference one vs. two sites: -$19,000 to +$56,000**

# Testing at a single site, option B: one factory tests 2 CRU per week

Idea: Build one cold box at one factory, test all CRU at that factory.

Cost Reduction: Only one nitrogen storage tank would be required.

Added project risks:

- Creates bottleneck in CRU production. Any problems with cold box will halt production completely.
- If a problem is found in cold testing, may require transport back to other factory.
- Problems at factory without cold testing may go undetected.
- Risk in additional transport of CRUs (schedule, accidents, etc.)

Drawbacks:

- Schedule slows down by factor of two - 80+ weeks required for testing
- Requires either much larger box or two boxes, runs into issues with space available at factory sites.
- No reduction in nitrogen consumption.
- Added cost of transporting CRUs (estimated $30,000 to $70,000)
- Even without cold testing, the other factory cannot assemble 4 CRU per week -> cold testing factory must also assemble CRU. Logistical difficulties with assembly, receiving CRU from other factory, cold testing 4 per week
- Imbalance in personnel requirements – additional labor required at cold test site.

# Testing at a single site, option C: third site tests all CRU

Idea: Perform cold testing at a third site (e.g. BNL)

Cost Reduction: Only one nitrogen storage tank would be required.

Added project risks:

- Creates bottleneck in CRU production.  Any problems with cold box will halt production completely.
- If a problem is found in cold testing, may require transport back to other factory.
- Problems at factory without cold testing may go undetected.
- Risk in additional transport of CRUs (schedule, accidents, etc.)

Drawbacks:

- Throughput of CRUs remains the same, meaning the box(es) would need to cycle 4/week.
- Requires either much larger box or two boxes, runs into issues with space available at factory sites.
- No reduction in nitrogen consumption.
- Added cost of transporting CRUs (estimated $30,000 to $70,000)
- Additional labor required at test site

# Gravity-drained dual cold box

Idea: Full liquid tests with two 1-CRU cold boxes at each factory. Box 2 can be raised above box 1 or lowered below box 1. After each test, use gravity to drain the nitrogen to the other box.

Cost reduction: Reduces nitrogen consumption by saving liquid instead of boiling off.

Drawbacks:

- Requires significantly larger footprint at each factory site, running into issues of space
- Cost of building two cold boxes greater than single cold box
- Additional cost of lifting mechanism
- Testing schedule more difficult
- Similar reduction in nitrogen consumption to the cold gas option.

# Nitrogen recovery with pump

Idea: Full liquid tests.  Pump liquid nitrogen back into bulk storage instead of boiling off.

Cost reduction: Reduces nitrogen consumption by saving liquid instead of boiling off.

Drawbacks:

- Significant additional infrastructure required
- Cost of nitrogen recovery infrastructure greater than nitrogen savings ($50k starting price for pump)
- Similar reduction in nitrogen consumption to cold gas option

# Gas testing with two cold boxes

Idea: Test in cold gas but with two 1-CRU cold boxes instead of one 2-CRU cold box

Cost reduction: Reduced nitrogen consumption

Drawbacks:

- Requires larger footprint, running into issues of space
- Cost of building two cold boxes greater than building one
- More complex operation with two cold boxes
- Nitrogen consumption turns out to be slightly greater than with one 2-CRU cold box