DIFFUSER

1. **Carousel**
   Moves disc to position

2. **“30 degree”**
   Transfers discs from carousel to carrier

3. **Carrier**
   Moves disc in/out of solenoid

Carousel (~50kg)
DISC TRANSFER – the critical item

Discs transferred between Disc-holders and Carrier

Each disc has 4 pins to fit 4 holes on both of 2 Sides
There are 5 Discs
Each has (up to) 4 Orientations

→ 160 pins & holes to align

→ Trickiest operation
AS OF CM25

• Building mock-up of Disc-holder – Carrier
  – Test various ideas for locking pins & to develop transfer procedure

• Built it, played with it....  ...proved invaluable ➔

‘Cool’ catches
Easy insert / hard extraction
LEARNT...

• Can’t rely on friction
  – Need latches on both the disc-holders & the carrier

• New profile for pins & rethink positions
  – Reduce number of pins by 1/2 (good!)

• Steel + aluminium = bad combination
  – Use brass pins
  – Re-make disc-holders in SS

• Allow for back-forward misalignment & small tilt
  – Design new floating front plate for carrier ➔
    • Accommodates misalignment of 0.5 – 1 mm in x,y,z
40 springs allow L/R, U/D & B/F compliance of ~0.5 – 1mm
  - Getting compressions right may be a bit tricky

Most components made
  - Some ‘fettling’ to do
## MECHANICAL COMPONENTS

<table>
<thead>
<tr>
<th>Components</th>
<th>Need</th>
<th>Have</th>
<th>To make</th>
<th>Time per item (days)</th>
<th>Time to mfr all</th>
<th>Made?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carousel encoder ring</td>
<td>1</td>
<td>1</td>
<td>0.25</td>
<td>0.25</td>
<td>Grinding profiles</td>
<td></td>
</tr>
<tr>
<td>3-D degree encoder ring</td>
<td>1</td>
<td>1</td>
<td>0.25</td>
<td>0.25</td>
<td>Grinding profiles</td>
<td></td>
</tr>
<tr>
<td>Disc holders in Stainless Steel</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>Done</td>
<td></td>
</tr>
<tr>
<td>New stacking plates for lead discs</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0.25</td>
<td>Done</td>
<td></td>
</tr>
<tr>
<td>Latches for disc holders</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0.5</td>
<td>Done</td>
<td></td>
</tr>
<tr>
<td>SS latches</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0.5</td>
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<td></td>
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<tr>
<td>New pins for discs</td>
<td>20</td>
<td>20</td>
<td>0.25</td>
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<tr>
<td>Spring loaded floating front plates for carrier</td>
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<td>0</td>
<td>0.5</td>
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<td>CAD model</td>
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<td>Review model</td>
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<td>Done</td>
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<td>New inner carrier ring</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>New</td>
<td></td>
</tr>
<tr>
<td>New floating plate &amp; top</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>New</td>
<td></td>
</tr>
<tr>
<td>New floating plate &amp; bottom</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>New</td>
<td></td>
</tr>
<tr>
<td>SS latches</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0.5</td>
<td>Done</td>
<td></td>
</tr>
<tr>
<td>SS Pins</td>
<td>12</td>
<td>12</td>
<td>0.25</td>
<td>0</td>
<td>Done</td>
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<tr>
<td>Springs</td>
<td>6</td>
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<td>0</td>
<td>0</td>
<td>Arrived</td>
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<td>Machining of carrier encoder mast head support</td>
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<td></td>
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<td>Modify support for 3D degree encoder mast head</td>
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<td>1</td>
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<td></td>
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<tr>
<td>Modify support for carousel encoder (??)</td>
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<td>Flap valves for piston</td>
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<td>Limit switch extension for carrier</td>
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<td>1</td>
<td>1</td>
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<td></td>
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<tr>
<td>Enlarge holes in lead discs to fit new pins</td>
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<td>20</td>
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<td>0.05</td>
<td>Done</td>
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<tr>
<td>TOTAL TIME (days)</td>
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<td>TOTAL TIME (weeks)</td>
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<tr>
<td>ETA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26 March 2010</td>
<td></td>
</tr>
</tbody>
</table>

- New carrier plate & other mods (e.g. SS disc-holders)
  ~ 7 – 8 weeks workshop time – almost complete;
  ETA ~ end of this week, then start dis/re-assembly

- Some odd jobs will remain
CONTROLS

Fibre Optic link

Electronics Crate

VME Mother Board

FPGA

Relay Driver & Interface Daughter Board

12V Control

Air Crate

12V Solenoid Air Valves

Air out

Compressed Air Supply

LabView

Diffuser

Carousel

Air motor

Encoder

Carrier

Encoder

Disc Holder

Air motor

Encoder

Limit switches & sensors

Fibre optic link

Hardware – Done

Protocols – Development

FPGA firmware:

Basic manual control – Done

Remote controls – Development

LabView control – Development

Encoders – 2 of 3 tested

Local Control Panel Switches

Control

Status

FPGA

Done

Development

Development

Development

2 of 3 tested
CONTROLS – ENCODERS & OVERRUNS

- **Encoders**
  - Measure (relative) rotation
    - Must align to ~ 3 microns
      - 2 days on CMM machine
  - Tested 2 of 3
    - 3rd needs new support ring

- **‘OVERRUNS’**
  - Motors run on after electronic ‘stop’
    - Time for valves to close + air in pipes (~0.2 sec)
      - Had been up to 12mm with 100 rpm motor
        - Now using 11 rpm motor
  - Measured overrun of Carousel using encoder
    - About 0.8 mm at position of interest
      - Depends a bit on air pressure / back-pressure
  - Reproducible to ~ 0.25 mm
    - Should be able to position to required fraction of mm
      - Clearance is +/- 1 mm
        - Other misalignments of +/- 0.5 mm also contribute
STILL TO DO

• **Hardware**
  – Dis- / re-assemble with new components
  – Install alignment rings for disc-holder ‘zero position’
    • Optical sensor + gold strips
    – Fragile & not yet tried for real
  – Various miscellaneous items
    • e.g. Guards, Installation drawings....

• **Firmware**
  – Develop FPGA firmware & RS232 interface
    • Incrementally
    – Space in FPGA is tight

• **Controls**
  – Develop LabView controls
    • In parallel with firmware
    – Think about EPICS only when LabView system developed
      » Probably EPICS / LabView interface (*Anyone know?*)

• **Acceptance tests**
ACCEPTANCE TESTING

The Professor’s invention for peeling potatoes.
ACCEPTANCE TESTING

• **Must be turn-key operation**
• Don’t have $Bn development resources of (say) Toyota
  – Can’t test to destruction
  – Can’t build second, third....

• **What are the acceptance criteria?**

• **Minimally:**
  – Require some number of unaided disc transfers (~1 hr each)
    • 10 would be too few
    • 1000 would take ~25 working weeks and risk wear of bearings
    • **Where to test?**
      – In Oxford (ideal environment) or in the [magnetic] field?

• **Have allowed 6 weeks in schedule for acceptance tests**
ASPIRATIONAL SCHEDULE CM26

Experimental verification of Zeno’s paradox

As of 22 March 2010 (assumes 16 weeks to install tracker)