Survey and Alignment -Automation Possibilities

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Alignment
Motivation

- Frequency of re-alignments
  - Millimetric movements in initial years (10 y?)
  - Movements may continue in some areas
- Access to the Accelerator
  - YETS: 12 weeks
  - Technical Stops: 1 week?
  - Re-alignment time?
Position and Orientation Determination

- Accelerator elements in the **Arcs**
  - FCC-ee ~11500 (81 km)
  - Booster Ring ~9500 (84 km)
  \[ \sim 21000 \]
- Element Position and Orientation Determination
  - 3D Measurement of at least 2 Reference Pts + Roll angle
- Measurements 6 h / day
- ElemPOD / min
  \[ = \frac{\text{NumElem}}{(\text{measDays} \times (\text{mins/day}))} \]
  \[ = \frac{21000}{(\text{measDays} \times (6\times60))} = \sim 60 / \text{measDays} \]
Available Time

• FCC-ee YETS (≥12 weeks)
  • Alignment → 4 weeks? = 20 days
  • ElemPOD /min = 3
• Requires longer days or more “teams”
  • 1 “team” / sector => 1 ElemPOD / 4 mins
  • and 12 h day => 1 ElemPOD / 8 mins
Available Time

• TS (~5 days)
  • Alignment → 2 days?
    • ElemPOD / min ~ 30
    • 1 “team” / sector => 2.5 ElemPOD / min
    • and 12 h day => ~1.5 ElemPOD / min
Notes

• Only considered the Arcs
• Only looked at one position determination
  • 3D Position and Orientation
• An alignment of an element may take longer
• Smoothing a sector is an iterative process
  • e.g. 100% meas -> Calculation -> 30% align
    -> 30% meas -> Calculation -> 10% align
    -> 10% meas -> Calculation
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- SU experience from Smoothing  
  => 1 team, ~25 elements / week!
CDR Baseline
-Full Remote Alignment System

- WPS Wire Replacement System:
  - Mechanics
  - Height x width → 0.5 x 0.3 (m)
- WPS Wire Replacement System:
  - Suction
  - Height x width → 0.3 x 0.3 (m)
- HLS Pipe (curved in horizontal plane)
  - Slope = 1.4%, length 38 m
  - Height x width → 0.65 x 0.1 (m)
- HLS Refill System
  - Height x width → 0.3 x 0.4 (m)
- HLS Sensor
  - Height x width → 0.2 x 0.15 (m)
- Element Girder
- Survey Equipment Support
Survey train

• A collimator Survey train developed at CERN
  • W.r.t known position of quads
  • Photogrammetry and offset to a stretch wire

  • Tested in 2011-2012 and currently refurbished
  • Accuracy not so good in vertical because of the sag of the wire
  • Installation of the wire is manual
  • Replacing the offset measurements by photogrammetry on the wire

Courtesy: P. Bestmann
Survey train: new concepts

- Vertical survey train
  - 2 measurement wagons
  - HLS hold by a robotic arm
  - cameras
Survey train: new concepts

- Horizontal survey train
  - 1 measurement wagon
  - 2 auxiliary wagons for fixing the wire
  - A tension system
  - A robotic arm to fix on the magnets
FCC-ee possibility
Other Automation Possibilities
Marking Out

[Image of people working with equipment inside a tunnel]

[Diagram showing a red paint head and reference points]
Aligning Positioning System Head

Alignment Cup
Vertical movement

Reference Points

Jack Head
Thank you for your attention