Appendix 32. Sugar Yield monitor data manipulation

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Yield monitoring equipment, no matter what the commodity group, works best when operating conditions are not changing rapidly. In order to have confidence in the sugar data that is to be mapped, the following data manipulation and filtering should be undertaken prior to mapping. These instructions should be used as an addendum to the 'Yield mapping protocol' detailed by Bramley and Jensen at the 2013 ASSCT conference (Appendix 31).

Under the harvesting conditions that the project team has encountered during the life of CSE022, we make the following recommendations. First, check that harvester is not operating outside of normal speeds – that is, that in situations where the crop is very light, that the operator is not pushing ground speed to increase the pour-rate etc.)

Preliminary data processing

1. All data to be processed on a per harvest event basis.
2. Check data entry has spatial positioning (i.e. latitude/longitude). If not delete.
3. Check for free running values of all sensors. Ideally, the ask the harvester driver to carry out the following test and note time performed:

- 30 sec engine idle
- 30 sec engine harvest revs
- 30 sec engine harvest revs + all feed train on
- 30 sec engine harvest revs + all feed train on + moving at operating speed

(Note, this should only be performed once engine has warmed up. Ideally done at the start of the day and the end of the day.)

Figure 32.1 shows an example of the above procedure performed on a 1996 Austoft 7000 harvester. This graphic shows sensor values for ground speed (GS), load cell (LC), elevator speed (ES), chopper power (CP) and elevator power (EP) and roller opening (RO).

With the engine idling, the RO and LC sit at a constant value. The EP and CP are also constant and close to zero. As the engine is taken to full revs, the chopper pressure (purple) and elevator pressure (light blue) build up, with no change in the other sensors. However, with the feed train being engaged, there is a noticeable jump in both the CP and EP and also some machine vibration noticeable in the LC. The addition of the harvester moving also slightly changes the values.

The free running values were averaged over the 30 seconds of data where the engine was at full revs with the full feed train operating and the harvester moving at operating speed. The resultant free running values from this graph were;

RO (orange dots) – 47

CP (purple dots) – 46

EP (blue dots) – 32

LC (red dots) – 4.0

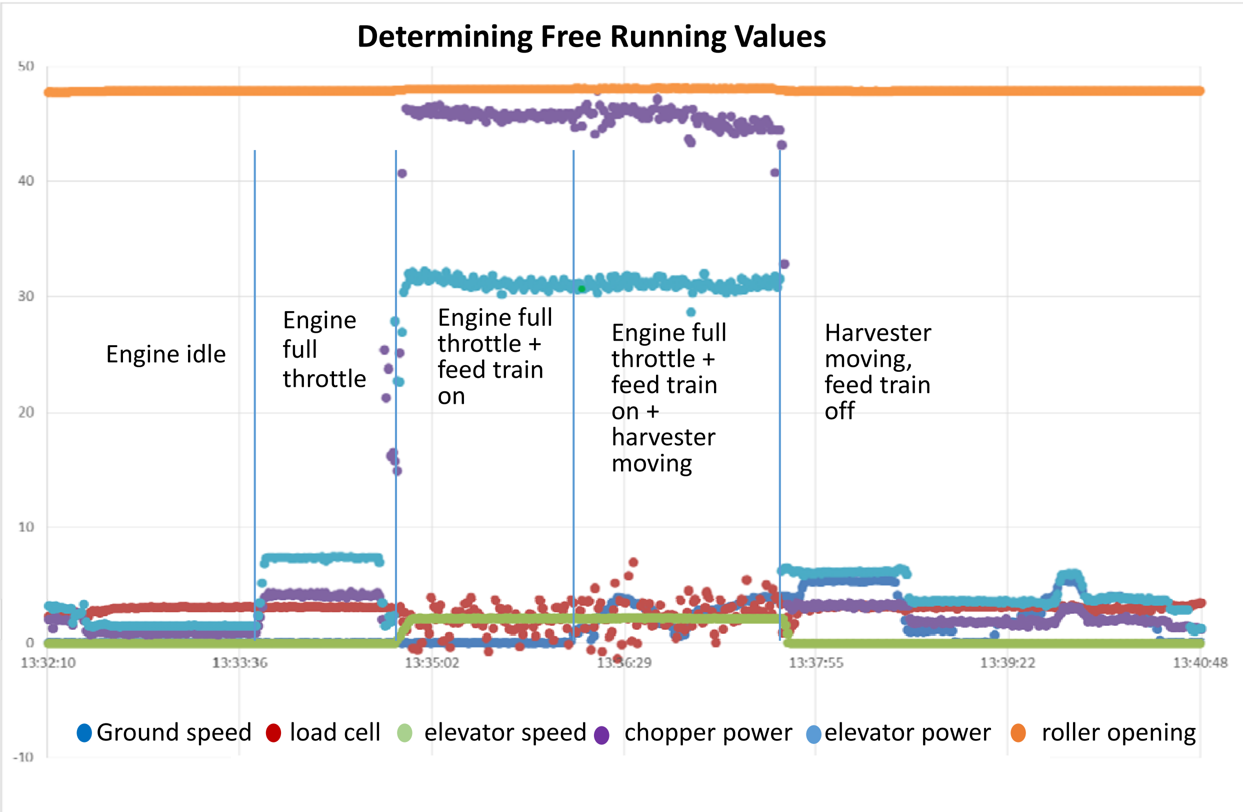

Figure 32.1 Determining free running values when the operator has followed procedures

If this procedure is not undertaken or was not possible for some reason, although not as accurate, these points can be determined retrospectively. An easy way to determine the values is to plot a graph of sensor values against time. Take particular note of the values end/start of rows when the machine is still running but not cutting cane (see figure 32.2)

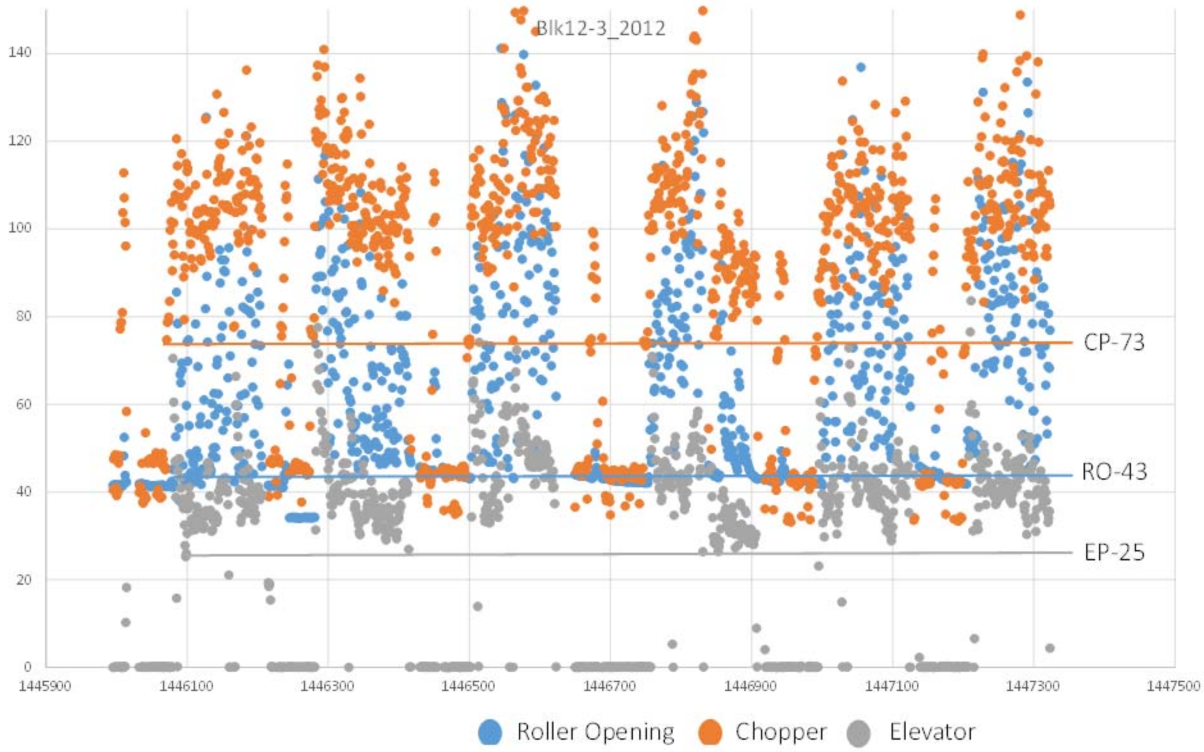

Figure 32.2 Determining free running values from random data

Figure 32.2 shows sensor values of interest for a 2000 Cameco 3600 (RO-roller opening, CP- chopper power, EP - elevator power) collected every second overs 20 minutes of cutting (approximately 6 rows of cane). This data is displayed before filtering so that when the harvester is not cutting cane/elevator is off, is clearly evident—the EP(grey dots) dropping to zero and the CP(orange dots) and RO(blue dots) hovering around 40. In this example, the RO sensor is a linear potentiometer and when the harvester is not cutting cane, averages a reading of 43, hence its free running value. The CP/EP sensors are pressure sensors either side of the hydraulic motor driving the mechanism of interest (chopper/elevator). To choose these free running values, identify values as the harvester enters/exits the field and before the feed train is disengaged, but with no cane in the system. There is a concentration of data points around 73 for the CP and 25 for EP.

Hence, the free running values selected from this graph were;
RO (blue dots) – 43
CP (orange dots) – 73
EP (grey dots) - 25

4. In order to remove data associated with the harvester not being at operating speed, filter the data so ground speed values conform to >0.75 m/s and <3.0

m/s. Also filter the data on elevator speed so only values >1.5 m/s are in the dataset.

After considerable interrogation of the datasets, anomalies were still encountered at edges of field and also due to haulouts changing over (evident in Figure 32.3). This presented as pulses in the yield due to a number of conditions:

- the boot being filled when entering/leaving the field, with the elevator being turned off,
- the elevator being turned off as haulouts change over and the harvester continuing to process material

To overcome these operator imposed anomalies, the continuity of the data source was investigated. A considerable number of high (and low) predicted yield values (t/ha) occurred at the edges of the field. By looking at the time delay between consecutive data points in the yield file, entering and leaving the field/haulout change overs could be accurately identified. Where there is more than a 4 sec gap between 3 consecutive data points, these values were deleted. The consequence of running this filter is displayed in Figure 32.3. The predicted yields are all well above the paddock average and predominately occur as the harvester is entering/leaving the field with some values also occurring at haulout changeover. Note that there is a transition from blue (more than double the block yield average) to red (average block yield) as the harvester re-enters the field from the W heading E.

This filtering is conducted prior to the calibration co-efficient being calculated and imposed to predict the yield in t/ha.

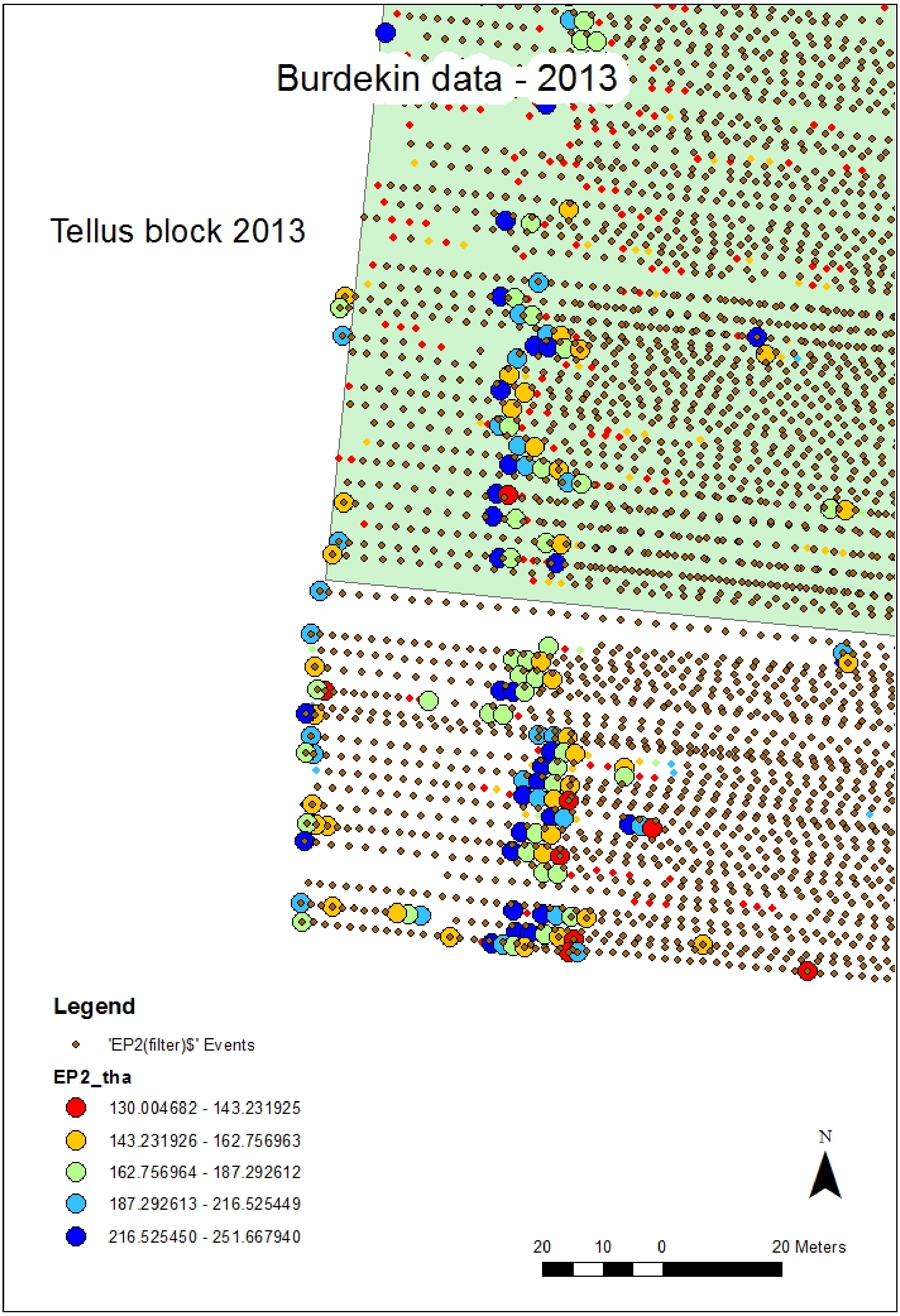

Figure 32.3 Pulses in the yield values due to entering/exiting field and also haulout changeovers

5. Step 4 has performed a coarse filter on the data to remove turning at the edge of fields, haulout changeovers etc.. After events such as haulout changeover, it still takes a few seconds for the harvester to slow down/get back up to speed before/after a stoppage. In order to remove these transition events, a 3 sec gap filter is also initiated. This should be performed on both the slow down and also on the speed up. This is easy to perform in excel and can be conducted on any sequential number sequence (time, record identification number……), after the initial ground and elevator speed filtering has been undertaken. A snippet of harvest data is shown in Table 32.1 where a haulout changed over at approximately 18:42. Data from when the harvester turned off the elevator and when below 0.75 m/s has been deleted (18:40:59-18:43:17). The idea of this filter is to remove 3 seconds of data on the shoulder of the slow down/speed up. A formulae is started in line 4 of the Gap forward column that subtracts the value of Record ID in line 1 from that of line 4 (resulting in a 3). This formulae is continued down. When the haulout changeover is encountered, the number changes from 3 indicating the speed up has been detected. Similarly for the Gap back column, a formulae is started in line 1 that subtracts the value of Record ID in line 4 from that of line 1 (resulting in a -3). This formulae is continued down. When the haulout changeover is encountered, the number changes from -3 indicating the slow down has been detected. A filter is used on both columns to delete values > 3 in the Gap forward column and >-3 in the Gap back column. The results of using this filter are shown in Figure 32.4. The purple dots are data points that are considered valid using the above protocols. The lime green points shown here have been deleted due to the slowing and speeding up of the harvester. Note, this pattern would not normally be evident in a commercial field. Shown here, is a fertiliser trial where each block is only 10 m long.

6. Use the free running values determined in step 3 to subtract from the sensor values to indicate the measure of material being cut.
    - Roller opening- the average RO value – FR
    - Chopper pressure – average of sensor before and after motor – FR
    - Elevator pressure – pressure drop across motor – FR
7. If the resultant values < 0, delete. Copy values to a new spread sheet.
8. The calibration number (CN) is calculated from the following equation
    - CN = mill total (t) / sum of sensor values
9. The yield prediction is calculated from the following equations
    - Yield (t/ha) = Sensor value * CN * 10000/width row(m)/speed (m/s)
10. Calculate the following summary statistics for the yield prediction; average, maximum, minimum and standard deviation (SD)

Table 32.1 Example of the 3 second gap filter

Date	Time	Record ID	Gap forward	Gap back
20/10/2012	18:40:45	10	3	-3
20/10/2012	18:40:46	11	3	-3
20/10/2012	18:40:47	12	3	-3
20/10/2012	18:40:48	13	3	-3
20/10/2012	18:40:49	14	3	-3
20/10/2012	18:40:50	15	3	-3
20/10/2012	18:40:51	16	3	-3
20/10/2012	18:40:52	17	3	-3
20/10/2012	18:40:53	18	3	-3
20/10/2012	18:40:54	19	3	-3
20/10/2012	18:40:55	20	3	-3
20/10/2012	18:40:56	21	3	-142
20/10/2012	18:40:57	22	3	-142
20/10/2012	18:40:58	23	3	-142
20/10/2012	18:43:18	163	142	-3
20/10/2012	18:43:19	164	142	-6
20/10/2012	18:43:20	165	142	-6
20/10/2012	18:43:21	166	3	-6
20/10/2012	18:43:25	170	6	-3
20/10/2012	18:43:26	171	6	-3
20/10/2012	18:43:27	172	6	-3
20/10/2012	18:43:28	173	3	-3
20/10/2012	18:43:29	174	3	-3
20/10/2012	18:43:30	175	3	-3
20/10/2012	18:43:31	176	3	-3

11. Filter the yield prediction (t/ha) to average ± 3SD
12. Repredict the CN base on residual data and apply to sensor values to come up with new yield prediction.
13. Continue this iterative process so that the yield prediction falls within the limits. The data filtering is now finished
14. This data can now be used in the mapping protocol.

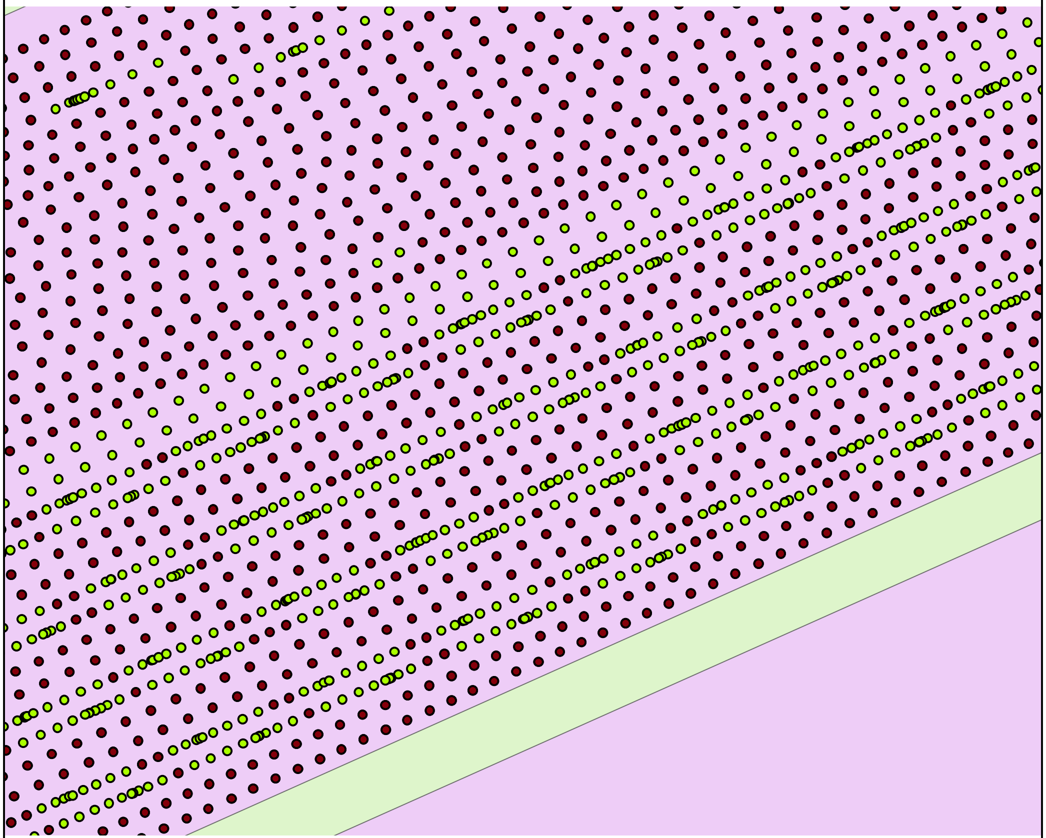

Figure 32.4 The effects of using the 3 sec gap filter