



2018 BC DATA SCIENCE WORKSHOP

SSR Mining – Predictive Maintenance Challenge

SSR Mining - Vancouver

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Background



Marigold Mining Corporation is primarily an open pit gold mine that is producing 200,000+ gold ounces per annum. Marigold Mine is located 3 miles south of I-80 from Valmy, Nevada.

Currently, Marigold is operating a mixed fleet of haul trucks, shovels, drills and support equipment. The current mine fleet consists of:

(This challenge focuses on equipment highlighted in **Bold Blue** text)

OEM refers to Original Equipment Manufacturer (i.e. P&H, Komatsu, Hitachi and etc.)

Shovels and production loader:

- P&H 4100 XPC (Joy Global) – Electric Shovel (343)
- 2 Hitachi EX5500 – Diesel Shovel (340, 341)
- Komatsu WA1200 – Front end loader (337)
- CAT 992D – Front end Loader (331) – rarely used for production

Haul trucks:

- 6 Hitachi EH5000 ACI (470, 471, ..., 475)
- **6 Hitachi EH5000 ACII (476, 477, ..., 481)**
- 9 Komatsu 930E (482, 483, ..., 491)

Drills:

- 2 Atlas Copco DML45 (118, 119)
- 2 Pit Viper electric drill (120, 121)

Support Equipment: majority of CAT support equipment like track and tire dozers, graders and excavators

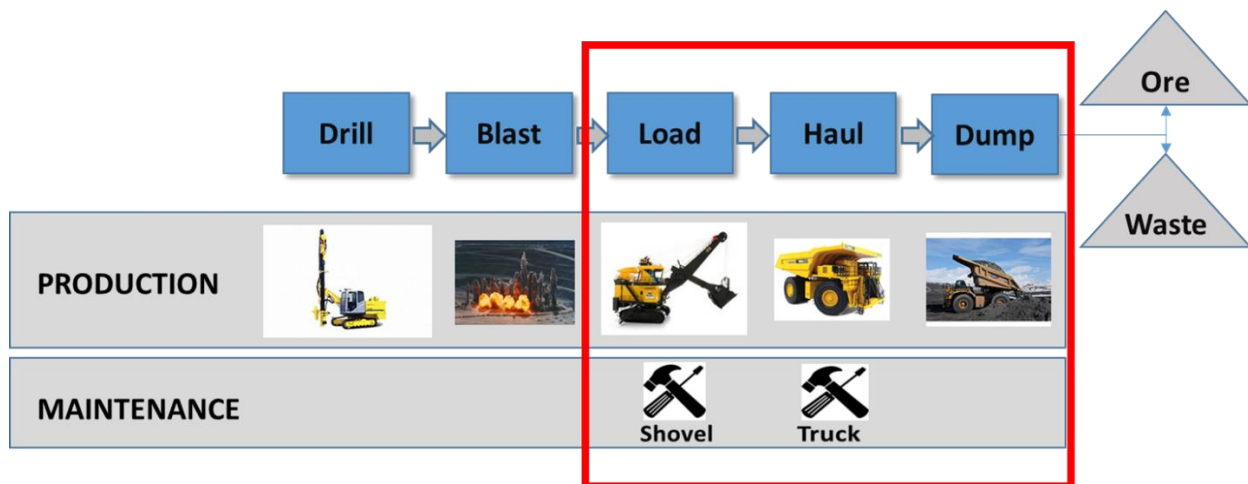
Mine operates on a 4 days on 4 days off rotations. There are four operating crews - A, B, C and D. A and D crew are on the same rotation and B and C crew are on another.

Marigold runs a 12-hour shift with shift times as follows:

Day shift: 6AM – 6 PM

Night shift: 6 PM – 6 AM (the next day)

Process flow for the Open Pit Mining Process

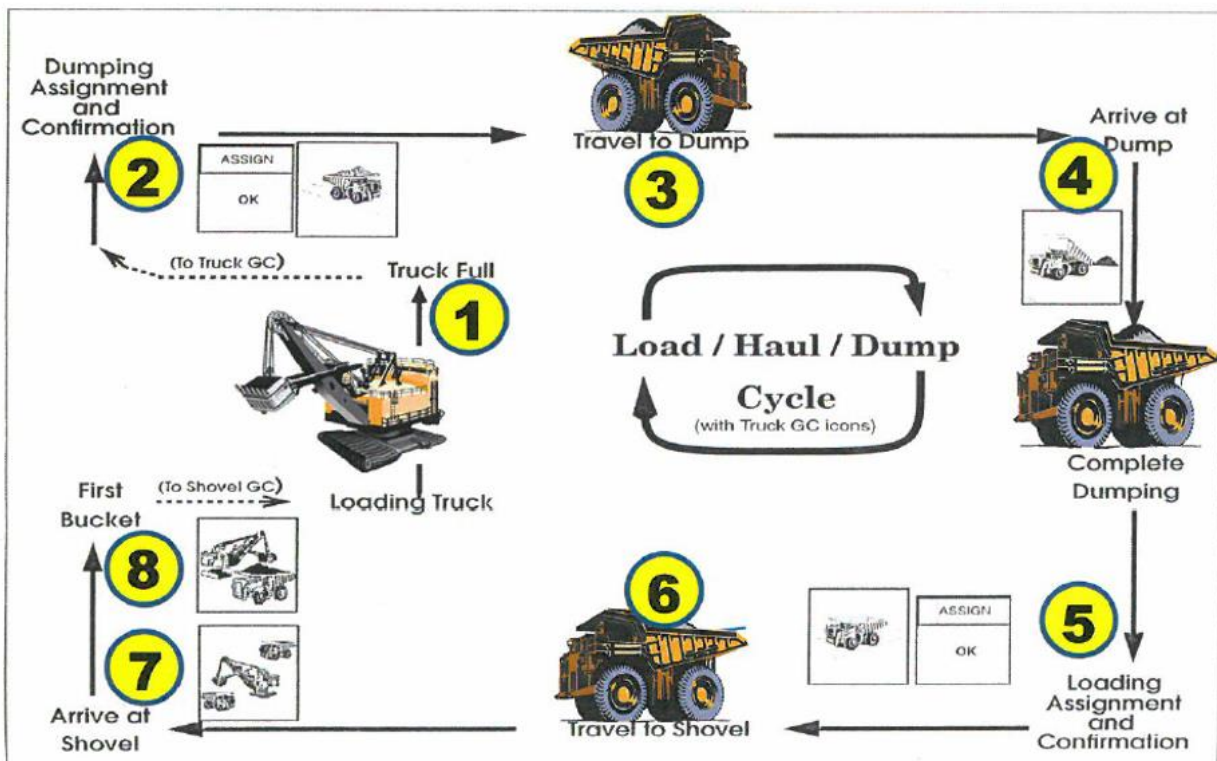


Focus for this challenge is mainly on the production and maintenance parameters in the red box (Load, Haul, Dump) for all Hitachi ACII trucks.

There is no expectation to work with all the files. They are provided for the sake of completeness and to provide as much data as possible.

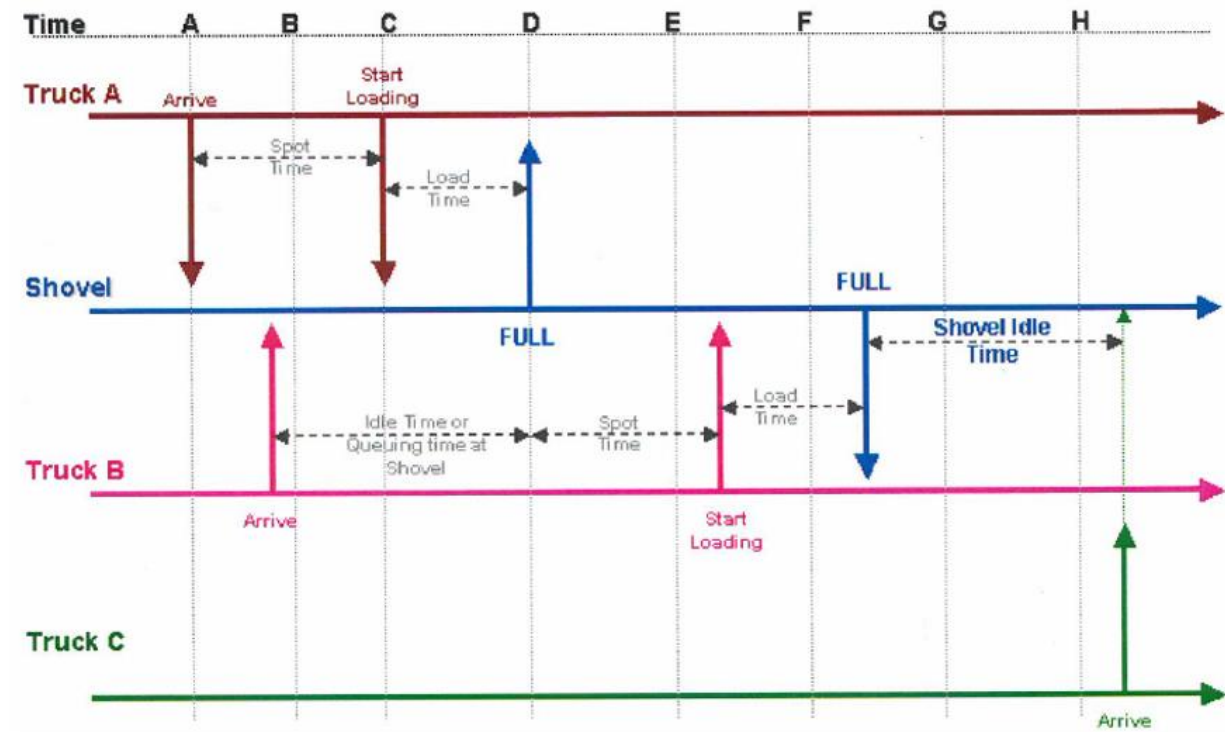
Understand the Haul Cycle Model

Haul Cycle Model



Understand the loading sequence times

Loading Sequence Times



Understand the current process and information to be extracted

Process	System	Parameters and Functions
Production (Shovels and Trucks)	Modular Dispatch	<ul style="list-style-type: none"> - Dispatch Mine equipment - Track material movement by equipment and material type - Track details equipment activities through out the shift e.g. location, distance traveled, fuel usage, etc. - Haul trucks and Shovel cycle time and payload
Maintenance (Trucks only)	eMaint	<ul style="list-style-type: none"> - CMMS handling maintenance work orders - Maintenance planning and scheduling - Work order history - Work order parts usage
	Modular Minecare	<ul style="list-style-type: none"> - Vehicle status management - Alarms notifications and acknowledgement - Equipment status trends (engine temperatures, rpm, oil pressure, etc.)

PRODUCTION:

Dispatch: Modular Dispatch system dispatches equipment and record equipment time, distance traveled, as well as production information automatically via the modular interface installed in the equipment cockpit. Certain delays and downtime codes are entered by the operators via modular interface also. The dispatch system is manned by dispatch operators 24/7.

MAINTENANCE:

eMaint: Work orders are created in eMaint system. Parts information is then added as appropriate. Works orders are then planned and scheduled. Once completed by mechanic, supervisors review and close out work orders.

Minecare: This is a Modular product that allows dispatch operators to monitor equipment performance, statuses and also to handle alarms events. The system collects information automatically via the modular interface installed in the equipment's cockpit. Currently, mostly the trucks are connected into this system. The Minecare system is manned by minecare operators 24/7.

Overview of Dataset

The table below indicates if the data pertains to Production or Maintenance with the allocated number linked to the more detailed descriptions further below. Also, this table indicates the file and folder structures of this dataset.

Folder	File
Production	TruckEventHistory (File is in the Maintenance folder) TruckProductionSummary ProductionDetails TruckMachineData (File is in the Maintenance folder)
Maintenance	TruckEventHistory TruckMachineData/ TruckMachineData_{HT476...HT481} WorkOrders NotificationDetailsReport EuipmentStatus
Supplemental Data	MarigoldWeatherData EquipmentList ReasonStatusTable OilAnalysisData

Time period: May 2017 – Apr. 2018 for everything

Data Dictionary

1. TruckEventHistory.csv

The event history tables contain detailed record of vehicle activities throughout the shift.

Equipment downtime and event can be picked up from the equipment reason code e.g. **StatusId**

= 1 is a Down event, StatusId = 2 is Operating

TruckEventHistory	Description	Sample Data
EventId	Event Id	7349874591902685614
EquipmentId	Equipment Id	1711276052
Equipment	Full equipment name	HT480
UpdateTime	Event Update Time	2017-05-01T00:00:46.0000000
ReadTime	Event Read Time	2017-05-01T00:00:46.0000000
Location	Location of the Event: MB being the digging location - 5050 is elevation in feet 07 is the digging slot	MB-4775-01
OperatorId	Operator ID	282
MaterialType	Material carried by the equipment during the event (Empty, Waste, Ore)	Empty
GpsLocation	Location of the equipment at the start of the event	NaN
LastAction	Last action: Assign: Equipment assigned to a location or equipment Standby: Equipment standby (standby, shift Change, Delay) First Bucket: First bucket recorded Full: Truck being loaded is full Down: Equipment down (Planned and Unplanned Maintenance) Ready: Equipment in Ready Status Arrive: Equipment arrive at the assigned location or equipment	Assign
LastActionTime	Last action time	2017-05-01T07:00:09.0000000
NextAction	Similar to last action	Arrive
NextActionTime	Next action time	2017-05-01T07:05:59.0000000
ReasonCode	See Supplemental ReasonStatusTable	101
StatusId	See Supplemental ReasonStatusTable	2

2. TruckProductionSummary.csv

The TruckProductionSummary contains production summary grouped by shift and truck name. Each row contains production information for each truck per shift, which includes truck time profile (total hours, operating hours, delay, downtime, shift change, availability % and Utilization %) along with production information (load Tons and truck cycle Time). These are shift based information. This is the rolled up shift summary of table 3 (ProductionDetails)

TruckProductionSummary	Description	Sample Data
WorkcanterName	Equipment Group	Trucks
shiftdate	Date of this shift	2017-05-01 00:00:00
Shift	Short Shift Name (Day Shift / Night shift)	Day Shift
Shiftname	Full Shift Name	01-MAY-17 Day Shift
Crew	There are 4 operating crews (A, B, C, D)	B
EquipmentNumber	Equipment Name	HT476
EquipmentModel	Equipment Model and Fleet	EH5000ACII
TotalHours	Total Shift Duration (Hr) - Fixed	12
OperatingHours	Total Operating Duration (Hr)	10.323889
OperatingPlanDelay	Planned Delay Duration (Hr)	1.564444
OperatingNonPlanDelay	Non Planned Delay Duration (Hr)	0.000000
ShiftChange	Shift Change Duration (Hr)	0.111667
Stanby	Standby Duration (Hr)	0.000000
PlanMaintDown	Planned Maintenance Duration (Hr)	0.000000
NonPlanMaintDown	Non Planned Maintenance Duration (Hr)	0.000000
OtherNon	Other Non Planned Duration (Hr)	0
TireMaint	Tire Maintenance Duration (Hr)	0
AvailabilityActual	Availability (%) (Available Hour/Total Hour)	100
UseOfAvailabilityActual	User of Availability (%) (Operating Hour/Available Hour)	86.032407
UtilizationActual	Utilization (%) (Operating Hour/ Total Hour)	86.032407
LoadTons	Total Tons Loaded	4800
AVGIdleTimeTruck	Average Truck Idle Time (Minutes)	2.697917
SUMIdleTimeTruck	Total Truck Idle Time (Minutes)	43.166667
AVGCycleTime	Average Truck Cycle Time (minute) Truck Cycle = Load + Full Haul + Dump + Empty Haul + Spot)	37.688542
SUMCycleTime	Total Truck Cycle Time (minute)	603.016667

3. ProductionDetails.csv

This table contains detailed loading transactions through out each shift. Each row contains information regarding loading time, location, payload, cycle time, distance and time traveled.

Note: EFH (EFU in this dataset) stands for Effective or Equivalent Flat Haul, which is a 'relative' distance measure used to compare haulage routes. The usual definition accounts for the effect of "grade" (i.e. Traveling uphill or downhill)

ProductionDetails	Description	Sample Data
Shiftdate	Date	2017-05-01 00:00:00
Crew	There are 4 operating crews (A, B, C, D)	B
shiftindex	Shift index	34574
Truck	Haul Truck Name	HT476
TruckFleet	Equipment Fleet (Hitachi)	EH5000ACII
Shovel	Shovel Name	EX341
LoadingLocation	Loading Location	MB-4775-01
DumpLocationAssignment	Assigned Dumping Location	SEC29 DUMP
DumpRecord	Dumping record	391594
MeasuredTon	Measured payload	324.86963
timearrive	Time Truck Arrived At Shovel (seconds since current shift starts)	2135
timeload	Time that the truck start loading (seconds since current shift starts)	2895
timefull	Truck full (seconds into shift) since current shift starts	3492
ctrteh	Expected empty travel time to shovel (in seconds)	518
ctrtfh	Expected full travel time to dump (in seconds)	784
atrteh	Actual travel time to shovel (in seconds)	1468
atrtfh	Actual travel time to dump (in seconds)	1319
lift_up	Total uphill lift (in feet)	290
lift_down	Total downhill lift (in feet)	675
Liftdistance_up	Total uphill distance traveled (in feet)	6120
Liftdistance_down	Total downhill distance traveled (in feet)	8561
DistanceEmptyHaul	Distance Empty Haul	16072
DistanceFullHaul	Distance Full Haul	13530
EFU-EmptyHaul	Equivalent Flat Empty Haul Distance	24969
EFU-FullHaul	Equivalent Flat Full Haul Distance	42807
loadtons	Load tons (default 300 tons per load)	300
TruckOperator	Truck Operator ID	000417
ShovelOperator	Shovel Operator ID	000244
beginspot	Time Begin Spot (seconds since current shift starts)	2824

queuetime	Queue Time (s): starts when the GPS/operator arrives at the shovel and ends at full from last truck. (only when there is another truck already being loaded)	689
spottime	Spot Time (s): Case 1: if another truck is getting loaded, spot time = time starts at full from last truck to the first bucket of the current truck Case2: if the shovel is waiting for a truck, spot time = time starts when the speed of the truck drops & GPS arrive and ends at first bucket	71
loadingtim	Loading Time (s) = Time Full – Time to First Bucket (start loading). It is the time from the truck operator pressed “first bucket” to time when the shovel operator “kicked out” the truck.	597
fullhaul	Full Haul Time (s) = Time arrive at Dump – Time Full. It is the time from when the truck was kicked out by the shovel to time when the truck arrived at the dump.	1319
dumptime	Dump Time (s)	158
emptyhaul	Empty Haul Time (s) = Time arrive at shovel – Time assign from Dump. It is the time from when the truck tipped his load to time when the truck arrived at the shovel.	589
hangtime	Truck Hang Time (s)	0
idletime	Idle Time	0
excavnxtl	Shovel Next Load Number	24
excavprevl	Shovel Last Load Number	15
loadnumber	Load Number	20
shifthour	Current working hours in this shift	0
LocktoShovel	Truck Locked to Shovel	NONE
LockToDump	Truck Locked to Dump Location	SEC29 DUMP

4. NotificationDetailsReport.csv

This dataset contains the history of alarms and alerts given off by the equipment. The alerts are recorded in and reported from the Minecare database, which captures maintenance related and equipment status events.

NotificationDetailsReport	Descriptions	Sample Data
NotificationID	Notification ID - Ignored	7349874591868921366
EventId	Event ID	7349874592051472913
Description	Describes what the operator did	notified dispatch
AcceptedPrincipal	Operator	randy.maxson
ModelName	Equipment Model (EH5000, 930E, etc)	EH5000
EquipmentName	Equipment Name	HT478
OemEventId	Native event ID from OEM	922946617

OemEvent	OEM event description	Service Brake Limit Warning (EH5000)
OemId	OEM ID for type of event	62184
Interface	Communication Interface on the equipment - use to communicate with Dispatch and Minecare	ContronicsJ1939 EH5000
Level	Alarm level - 1, 2, 3 - 1 is critical	2
NLevel	N level in Minecare	1
ReadTime	Event Read Time	2017-05-01T00:07:14.0000000
GPSLocation	Site GPS location	18602.611373:9305.567264

5. TruckMachineData.csv

The OEM Parameter Values contains machine data (engine RPM, engine air flow and etc.) and sensors reading (machine temperatures, pressure, and etc.) from the equipment. Currently, **only haul truck** parameter values are being transferred to Minecare. This information, however, is **not continuous** for the reported equipment due to inconsistent connectivity. **To reduce the size of this dataset, this file was split into 6 files according to the truck name. Each file contains data only for that truck. You can choose the trucks you want to use, or use all of them.**

TruckMachineData	Description	Sample Data
Equipment	Full Equipment Name	HT478
Event	Current active OEM event description	Adec Ecu Fault Code Internal Alarm - Active
Level	Alarm level - 1, 2, 3 - 1 is critical	2
Parameter	OEM Parameter Name	Motor A DE Bearing Temperature (EH5000)
ParameterInterface	Communication Interface on the equipment - use to communicate with Dispatch and Minecare: 1: ContronicsJ1939 EH5000 2: Contronics 3: ADECLegacy 4: ContronicsJ1939 EH5000Ddec	1
ParameterValue	Parameter Value	43.0000
EventTime1	Time the alarm raised	2017-07-19T22:56:12
ParameterReadTime1	Parameter read time	2017-07-19T22:55:56

6. WorkOrders.csv

The information in this table refers to the actual maintenance works performed on the equipment during Down events (Statusid = 1).

WorkOrders	Description	Sample Data
COMPID	Equipment Number (last 3 digits of equipment name)	481
COMP_DESC	Equipment description - Data in this field is inconsistent but it has the information regarding equipment model/fleet and group. Ignore if possible.	EH5000 HAUL TRUCK
DATE_WO	Work order creation date	2017-05-01
SCH_DATE	Schedule date for work	2017-05-01
DATE_CMPL	Date work completed - Date when work order is closed, sometimes later than the date when work was actually completed.	2017-05-01
wo	Work Order Number	93757
WORK_DESC	Description of the work	DRIVE FAULT (LOST FIELD REGULATOR)
COMMENTS	Detail comment of the work	TROUBLESHOOT AND REPAIR
WORKSTATUS	Work Order Status O: Open H: Closed X: Canceled	O
PROBTYPE	Problem Type: Accident Damage: Work order created to fix damage done to equipment as the result of an accident Breakdown: Work Order created to fix a non-planned breakdown - i.e. Engine failed prematurely Corrective: Work Order Created to fix a problem detected via inspection or vehicle walk around report Emergency: Emergency work - usually due to safety reason PM: Planned preventive work None: not defined	Breakdown
ACCTDESC	Equipment component to be fixed. (Engine, transmission, Final Drive, etc..)	24V MECHANICAL
SCHED	Was the work scheduled (Yes/ No)	No
SCHEDULED	Same as above (Scheduled/Unscheduled)	UNSCHEDULED
DEPARTMENT	Work Order written to different site departments (Mobile maintenance, Process, Engineering, etc.) - For the purpose of this exercise, most work order will be under Maint or Mob Maint and (blank)	MAINT
PRIORITY	Work priority - 1 being the lowest and 5 is the highest	3.0
STANDARD	Scheduled Work Duration - How many hour the work is scheduled for	2.0
ACTUAL	Actual Work Duration	2.0

7. EquipmentStatus.csv

This table contains the status with duration of the trucks during the shifts

EquipmentStatus	Description	Sample Data
shiftindex	Shift index	35303
shift	Short Shift Name (Day Shift / Night shift)	Night Shift
EventDate	Date of this event	2018-04-30 00:00:00
ShiftCrew	There are 4 operating crews (A, B, C, D)	B
eqmt	Equipment Name	HT478
operid	Operator ID	000261
starttime	Event start time since this shift (Seconds)	5858
endtime	Event end time since this shift (Seconds)	5872
Start Time	The exact start date and time of this event	2018-04-30 19:38:00
end Time	The exact end date and time of this event	2018-04-30 19:38:00
comment	Detail comment of the event	HIGH BRAKE ACCUM PRESSURE
Duration_Hr	Duration of this event (Hour)	0.003889
Reason	Reason code, See Reason Status Table	334 BRAKE SYSTEM
Status	See status in Reason Status Table	Down
Category	See category in Reason Status Table	Non Planned Maint
eventCount	eventCount: 1 : Start of a new event 0 : This event is the continuous from the previous event	0

SUPPLEMENTAL DATA

8. MarigoldWeatherData.csv

This dataset contains the weather site weather information, collected at the weather station near the site's main gate. The difference in elevation between the weather station and the mine operations area is between 1000 and 1500 ft. Therefore, the condition recorded in this data file is not the exact weather condition on site. However, since it is within very close proximity to the site, it is representative of the actual condition on site.

MarigoldWeatherData	Description	Sample Data
Date Time	Time when reading was taken	05/01/2017 01:00 AM
Wind Speed (m/s)	Wind speed	5.6
Wind Direction (°)	Wind direction	302
Sigma Theta (°)	horizontal wind direction fluctuations	6
Temperature (°C)	Temperature	8.2
Temperature 10 Meters (°C)	temperature 10 meters	9.2
Relative Humidity (%)	Relative humidity	44.3
RH Temp (°F)	Relative humidity temperature	47.7
Precipitation (in)	Precipitation	0

Barometric Pressure (inHg)	barometric pressure	25.43
Solar Radiation (W/m ²)	solar radiation	0
Battery Voltage (V)	battery voltage	13.49
Net Solar Radiation (W/m ²)	net solar radiation	-76.3
Delta Temperature 10-2 (°C)	delta temperature 10-2	1.05
Gust (m/s)	Gust	7.9
Time of Gust	Time of Gust	0:51
QC	Reading type	Raw

9. EquipmentList.csv

For your reference, this table contains a full list of our equipment for this challenge. As the equipment number in the Work Order is represented as Equipment number instead of the full equipment name, this Table can be used to relate the Work Order history with the Production, Activities and Notification table.

EquipmentList	Description	Sample Data
Equipment Group	Equipment Group	Truck
Equipment Model	Equipment Model and Fleet	EH5000ACII
Equipment Name	Equipment Name	HT476
Equipment Number	Equipment Number (Relate to Work Order History)	476

10. ReasonStatusTable.csv

This table contains the distinct reason code, Reason description, status code and description used to explain the activity reason and status in the event history table.

ReasonStatusTable	Description	Sample Data
Reason_Code	Reason Code - Use to connect to the event History Table	101
Reason_desc	Reason Description	PRODUCTION
status	Status Code - Use to relate to the Event History Table 1: Down 2: Ready = Operating 3: Standby 4: Delay	2
Status_desc	Status Description	Ready
category	The Profile category number Operative 1 Planned Delay 2 Non Planned Delay 3 Shift Change 4 Standby 5 Planned Maintenance 6 Non Planned Maintenance 7	1
Category_Name	Time Profile Category Description	Operative

11. OilAnalysisData.csv

This table contains the historical oil analysis results. Each sample contains information regarding sample chemical compositions, viscosities and contamination. As oil results are lagging indicators, they can and should probably be used for training dataset.

OilAnalysisData	Description	Sample Data
unitno	Equipment number	476
model	Equipment Model	EH5000
make	Equipment Fleet	HITACHI
compartid	Component ID	E
compart	Component Name	Engine
compartsn	Component Serial Number	
oiltypeid	Oil Type	CHEVRON DELO 400 LE
oilgradeid	Oil Grade	15W40
coolantid	Coolant ID	
notesos	Analysis Note	Wear Rate; Oil Condition and Particle Generated Analysis are acceptable for this sample. No action is required at this time. Please continue to build a reliable operating trend by sampling at the next regular scheduled service interval.
sampledate	Sample Date	22/Apr/2018
oiladded	Was oil added? Yes No	
oilhours	Hours on oil	405.0
actual_fluid_hours	Same as above	405.0
meterread	Equipment meter hour (equipment age)	58442
oilchanged	Was the oil changed at the time of sampling? TRUE FALSE	True
filterchanged	Was the filter changed at the time of sampling? TRUE FALSE	True
evalcode	Result score	A
Problem Solved	Was the problem solved? TRUE FALSE	FALSE
Action Taken	Was action taken? TRUE FALSE	FALSE
Water	Water detected in the oil?	Neg
V40	Oil viscosity at 40 degree Celsius	
V100	Oil viscosity at 100 degree Celsius	14.35
VI	Viscosity Index	
Fe	Iron	9
Cu	Copper	0
Pb	Lead	0

Sn	Stannum	0
Cr	Chromium	0
Ni	Nickle	0
Ti	Titanium	0
Al	Aluminum	3.0
Si	Silicon	4.0
Na	Sodium	2.0
K	Potassium	2.0
B	Boron	464.0
Ca	Calcium	1646.0
Mg	Magnesium	380
P	Phosphorus	1093.0
Zn	Zinc	1293.0
Mo	Molybdenum	90.0
Li	Lithium	0
Sb	Antimony	0
Ba	Barium	0
Cd	Cadmium	0
Mn	Manganese	0
Ag	Silver	0
V	Vanadium	0
4u	Number of particles larger than 4 microns	177437
6u	Number of particles larger than 6 microns	21635
14u	Number of particles larger than 14 microns	398
21u	Number of particles larger than 21 microns	86
38u	Number of particles larger than 38 microns	7
70u	Number of particles larger than 70 microns	0
ISO	ISO count	25/22/16
Cutting	Oil Cutting	7
Sliding	Oil Sliding	65
Fatigue	Oil fatigue	145
Non Metallic	Non Metallic counts	94
Fibers	Fibers counts	0
Total Part/ml	Total parts per million	177437
NO2	Nitrogen dioxide	69
pqL Index	ppl index	0
Soot	Soot level	21
OXI	Oxidation	18
NIT	Nitration	8