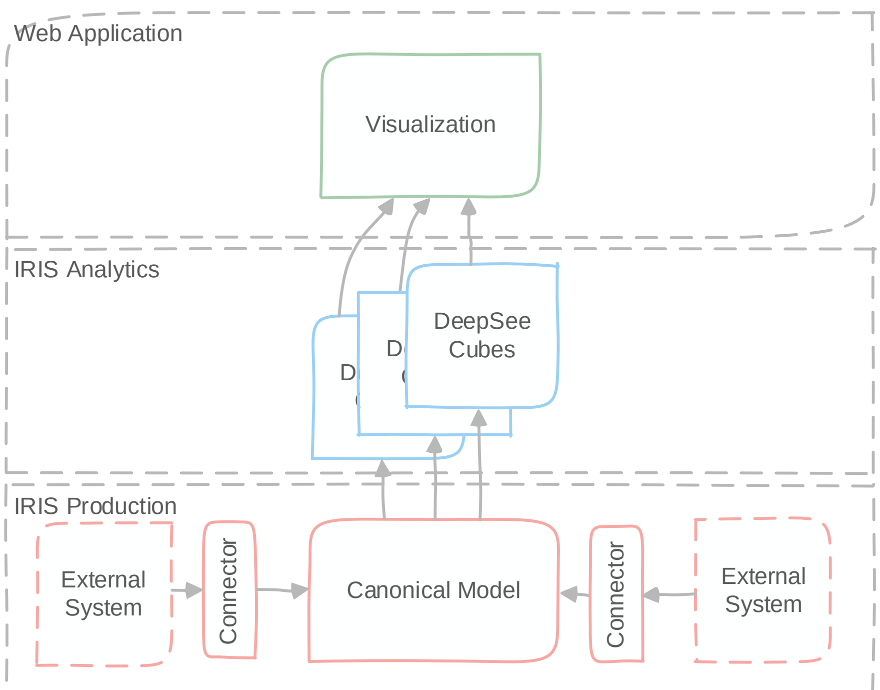
ASP Mining - Analytics Description

1 INTRODUCTION

The scope of this document is to describe the logical steps and behaviour of the data processing behind the sample ASP Mining Starter pack and the included components, it's not a source code documentation (which is available in other documents and the source code itself), but a higher level technical description of what the software does.

The ASP Mining Starter Pack has 3 layers:

1. IRIS Production: integrates mining systems data and transform it into IRIS Mining Canonical Model.
2. IRIS Analytics: performs calculations on top of the Canonical Model to generate higher value KPIs.
3. Visualization: using IRIS as a backend, implements a web-based application using standard web tools to navigate and visualize the IRIS Analytics results.

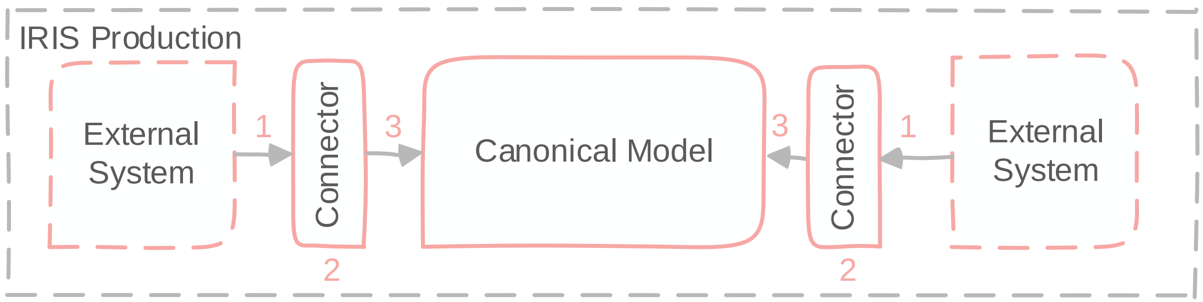


2 IRIS PRODUCTION: CONNECTORS AND DATA FLOW

The IRIS production consists of one or more Connectors that follow the pattern:

1. External System Connection
2. Service for data collection and transformation to Canonical Model
3. Operation for storage of new data into Canonical Model

The connectors also include a Task to keep updated the relevant cubes that are used with them.



One of the main tasks in the data transformations performed by the included connectors and any other connector, is the transformation **of the Timestamps** in the data source systems, which are not always standard types, but local timestamps relatives to a shift or to other non-standard DB time datatypes.

Since the Canonical Model uses only IRIS TimeDate types, this step is crucial for being able to navigate across different sections of the model with consistency and allow proper "drill through" in the cubes.

2.1 MineCare Connector

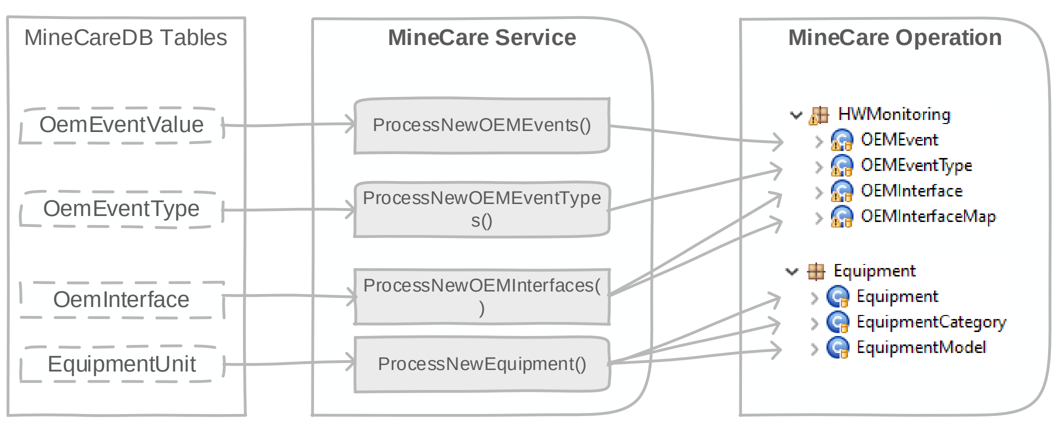
2.1.1 External System Connection

The External System connection of this connector if done using a JDBC connection to the MineCare database which runs on SQL Server (v2019+), the connector uses a standard IRIS SQL Inbound Adapter to perform this connection.

2.1.2 Service for data Collection and transformation to Canonical Model

The Service of the MineCare connector brings information about multiple health signs of the mining equipment specified by the client into the MineCare software. This data is mainly used to track sensor related events such as: overspeed, valve pressures out of range, fuel levels, temperature of internal components, and many others.

Is important to note, that that the raw sensor data is not being collected by the connector, but the events that this data generates (i.e: one or more sensor values are out of a determined range), is the data that is being collected and saved in IRIS.



Source Table	Data obtained	Data Usage
OemEventValue	Numeric/Text value of an event	Analysis and Plotting
OemEventType	Type or category of the event	Filtering and categorization
OemInterface	Phyisical interface that made the reading in the truck	Link between Sensor and Equipment
EquipmentUnit	Equipment metadata (capacity, category, model)	Equipment Information

2.1.3 Storage of new data into Canonical Model data

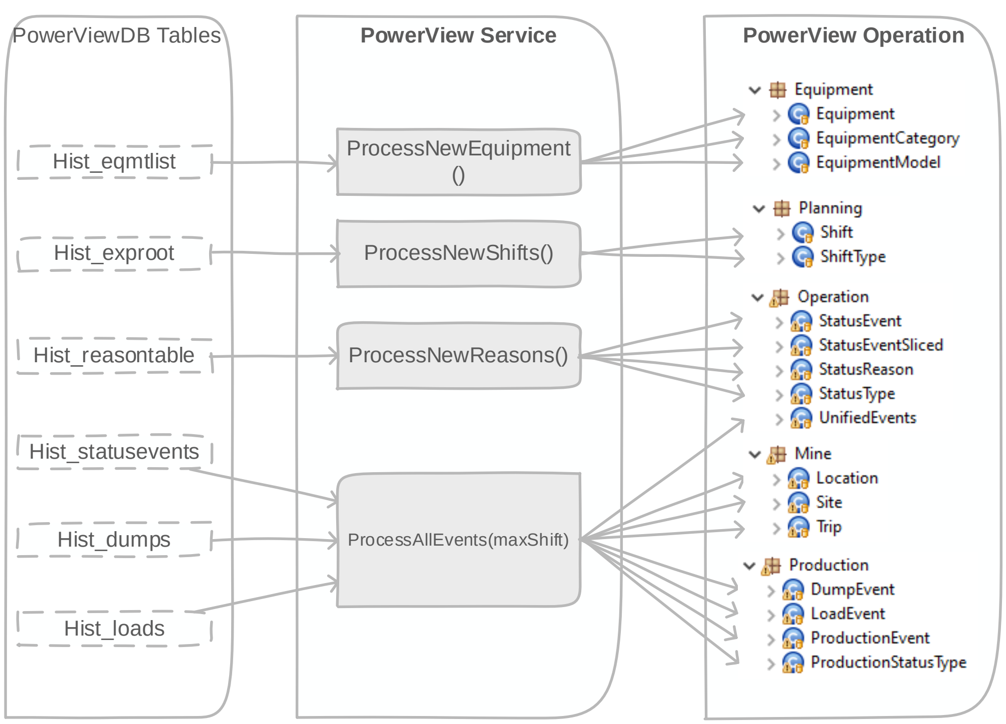
The Operation in the MineCare connector saves data to the following Canonical Model Classes

Equipment.Equipment
Equipment.EquipmentCategory
Equipment.EquipmentModel
HWMonitoring.OEMEvent
HWMonitoring.OEMEventType
HWMonitoring.OEMInterface
HWMonitoring.OEMInterfaceMap

2.2 PowerView Connector

2.2.1 External System Connection

The External System connection of this connector if done using a JDBC connection to the PowerView database which runs on SQL Server (v2019+), the connector uses a standard IRIS SQL Inbound Adapter to perform this connection.



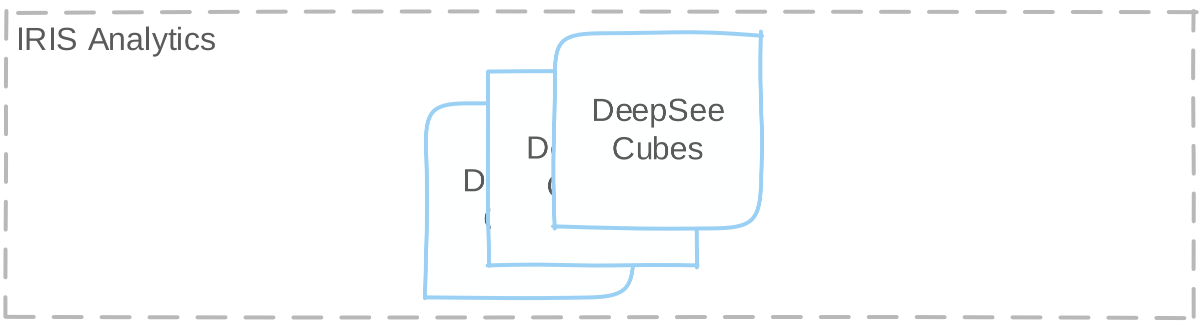
Source Table	Data obtained	Data Usage
Hist_eqmtlist	Equipment metadata (capacity, category, model)	Equipment Information
Hist_exproot	Shifts information	Shift Type and Start Time
Hist_reasontable	Reasons for Status Event changes	Details about events
Hist_statusevents	Status events history for every equipment	Events Information
Hist_dumps	History of material Dumps	
Hist_loads	History of material Loads	

2.3 Canonical Model

The canonical model details can be found in the Canonical Data Model.pdf file.

3 IRIS Analytics: DeepSee Cubes

The DeepSee cubes consolidate raw data and processed data from the Canonical Model, making it available to be accessed from the FrontEnd to the end users. These cubes are updated continuously by Scheduled Tasks.



The cubes provided by the Starter Pack are:

Cube Name	Contents	Usage
Equipment Cube	Equipment Information	General Information
OEMEvents Cube	OEM Events	Hardware Maintenance KPIs
Production Dump Events Cube	Material Dump Events	Production KPIs
Production Load Events Cube	Material Load Events	Production KPIs
Status Event Cube	Equipment State Changes only	State changes trazability
Status Events Sliced Cube	Equipmente State changes with interpolation over time	State changes KPIs (daily analysis)
Unified Events Cube	Production Events combined with Status Events	OEE and OEE related KPIs: Utilization, Capacity Performance, Time Performance

<Explain Unified Events cube in detail>

3.1 OEE Calculation

The Overall Equipment Efficiency KPI is a very known KPI used in many industries, since it indicates how efficiently the process equipment is being.

Calculating the OEE form a mine in the site side of the mine has been a challenge for many decades, not only for the information available but also for the way the standard mining systems have been designed. Being able to provide this dodgy KPI showcases 2 values of IRIS:

1. Simplicity to integrate an existing system to the data platform (e.g: connection to PowerView/MineCare)
2. Model oriented design that simplifies the KPI and value extraction from the data (e.g: being able to unify the time events in the UnifiedEventsCube)
3. Performance benefits that enables to calculate these new KPIs in realtime

For the ASP Mining starterpack, a different approach has been taking to calculate the OEE of the Mine like:

$$OEE = Utilization \ x \ Capacity \ Performance \ x \ Cycle \ Time \ Performance$$

Where:

- Utilization: Percentage of time that the equipment was operative
- Capacity Performance: How many Tons was the equipment loaded with vs its nominal capacity.
- Cycle Time Performance: How fast the Load/Dump cycle is being completed for a given source/destination location vs previous same trips.

These 3 KPIs are conveniently precalculated in the UnifiedEventsCube to make it easier for the frontend to access these results.

FASE IV: Generación Indicadores: OEE

A partir de los tres indicadores anteriores (Utilización, Performance Capacidad y Performance Ciclo Productivo), es posible obtener el indicador OEE a nivel individual para cada equipo, multiplicando los indicadores mencionados.

$$OEE_i = Util_i \ x \ Perf_{\cdot cap} \ x \ Perf_{\cdot ciclo}$$

donde,

OEE_i: OEE del equipo i

$Util_i$: Utilización del equipo i

$Perf_{\cdot cap}$: Performance Capacidad del equipo i

$Perf_{\cdot ciclo}$: Performance Ciclo Productivo del equipo i

Equipo	Utilización	Performance Capacidad	Performance Ciclo	OEE Individual	Capacidad Ponderada
CA100	0,00%	0,00%	0,00%	0,00%	0,94%
CA101	79,31%	98,05%	93,16%	72,44%	0,94%
CA102	70,74%	102,26%	98,00%	70,89%	0,94%
CA103	90,22%	98,72%	95,30%	84,89%	0,94%
CA104	84,47%	97,10%	87,13%	71,47%	1,17%
CA105	0,00%	0,00%	0,00%	0,00%	1,17%
CA106	0,00%	0,00%	0,00%	0,00%	1,17%
CA107	77,98%	97,10%	82,83%	62,72%	1,17%
CA108	0,00%	0,00%	0,00%	0,00%	0,94%
CA109	76,05%	104,70%	77,25%	61,51%	0,94%
CA110	64,88%	100,20%	86,28%	56,09%	0,94%
CA111	0,00%	0,00%	0,00%	0,00%	0,94%
CA112	90,92%	96,35%	93,64%	82,02%	0,94%
CA113	82,51%	81,88%	88,56%	59,83%	0,94%
CA114	79,44%	98,12%	99,08%	77,22%	0,94%
CA115	81,39%	95,87%	86,99%	67,88%	0,94%

A para la Flota

OEE Flota
54,18%

$$OEE_{flota} = \sum OEE_i \ x \ Cap_i$$

donde,

OEE_i: OEE del equipo i

Cap_i: Capacidad Ponderada del equipo i

3.1.1 Utilization

The equipment Utilization is calculated based on the time the equipment stays in state Operative vs other states. This state is defined in the StatusType Class of the canonical model. To calculate the total utilization, the StatusEventsSlicedCube and the UnifiedEventsCube can be used.

For more detail in the analysis the StatusEventsSlicedCube is preferred, since this cube provides 5 minute windows with all the details related to StatusEvents, where the time of all states inside this window (Operative, Delay, etc.) is calculated as PartialTime, allowing fast calculation and comparison of time durations for any given time range.

<math equation>

<equation using cube parameters>

FASE IV: Generación Indicadores en camino al OEE – 1º factor de eficiencia: Utilización

Como primer indicador de interés a definir, se encuentra el Indicador de Utilización, el cual representa el porcentaje de tiempo en el cual el equipo se encuentra en estado operativo dentro del intervalo total de tiempo en análisis.

La siguiente tabla muestra un ejemplo del cálculo de este indicador para algunos camiones en un determinado turno de trabajo.

Equipo	Operativo	Demora	Panne	Reserva	Total general	Utilización
CA100			12,00		12,00	**0,00%**
CA101	9,52	2,46		0,03	12,00	**79,31%**
CA102	8,49	2,59	0,92		12,00	**70,74%**
CA103	10,83	1,17			12,00	**90,22%**
CA104	10,14	1,86			12,00	**84,47%**
CA105			12,00		12,00	**0,00%**
CA106			12,00		12,00	**0,00%**
CA107	9,36	2,14	0,29	0,22	12,00	**77,98%**
CA108			12,00		12,00	**0,00%**
CA109	9,13	2,01		0,86	12,00	**76,05%**
CA110	7,79	1,86	1,59	0,77	12,00	**64,88%**
CA111		0,00	9,42	2,58	12,00	**0,00%**
CA112	10,91	1,09			12,00	**90,92%**

Muestra de equipos en período de análisis de 1 turno

$$Utilización = \frac{\sum T_{op}}{T_{total}}$$

donde,

T_{op}: Tiempo Operativo

T_{total}: Tiempo total del período

3.1.2 Capacity Performance

<math equation><equation using cube parameters>

FASE IV: Generación Indicadores en camino al OEE – 2º factor de eficiencia: Performance Capacidad

Otro indicador fundamental dentro de la construcción del OEE, corresponde al Indicador de Performance por Capacidad, el cual representa el porcentaje de la capacidad que posee el equipo y que se aprovechó realmente en el período de análisis.

Para el cálculo de este indicador, es necesario obtener las toneladas totales cargadas durante el período en análisis y la cantidad de veces que el equipo fue cargado. De la división de dichos valores se obtiene la carga promedio que tuvo el equipo y este valor al compararlo con la capacidad nominal del mismo (representa la cantidad de toneladas que se esperan cargar cada vez), se obtiene el Indicador de Performance por Capacidad. A su vez, es posible calcular la capacidad ponderada de cada equipo que representa el aporte de cada camión a la flota total considerando su capacidad total y la capacidad de toda la flota.

Equipo	TM Cargadas	N° Operaciones Carga	TM Descargadas	N° Operaciones Descarga	TM Carga promedio	TM Descarga promedio	Capacidad Nominal	Capacidad ponderada	Performance Capacidad
CA100					0,0	0,0	300,0	**0,94%**	**0,00%**
CA101	4.706,5	16	4.405,2	15	294,2	293,7	300,0	**0,94%**	**98,05%**
CA102	4.908,7	16	4.908,7	16	306,8	306,8	300,0	**0,94%**	**102,26%**
CA103	5.923,5	20	5.923,5	20	296,2	296,2	300,0	**0,94%**	**98,72%**
CA104	7.606,0	21	7.606,0	21	362,2	362,2	373,0	**1,17%**	**97,10%**
CA105					0,0	0,0	373,0	**1,17%**	**0,00%**
CA106					0,0	0,0	373,0	**1,17%**	**0,00%**
CA107	6.519,4	18	6.519,4	18	362,2	362,2	373,0	**1,17%**	**97,10%**
CA108					0,0	0,0	300,0	**0,94%**	**0,00%**
CA109	4.711,6	15	5.014,1	16	314,1	313,4	300,0	**0,94%**	**104,70%**

Muestra de equipos en período de análisis de 1 turno

$$Perf.Cap. = \frac{\frac{\sum TM_{carga}}{N°_{op.carga}}}{Cap._{nominal}}$$

donde,

$Perf.Cap.$: Performance Capacidad

TM_{carga}: Toneladas Cargadas

$N°_{op.carga}$: Número de operaciones de carga

$Cap._{nominal}$: Capacidad nominal del equipo

$$Capacidad\ ponderada = \frac{Cap_i}{Cap_{total}}$$

donde,

Cap_i: Capacidad Equipo i

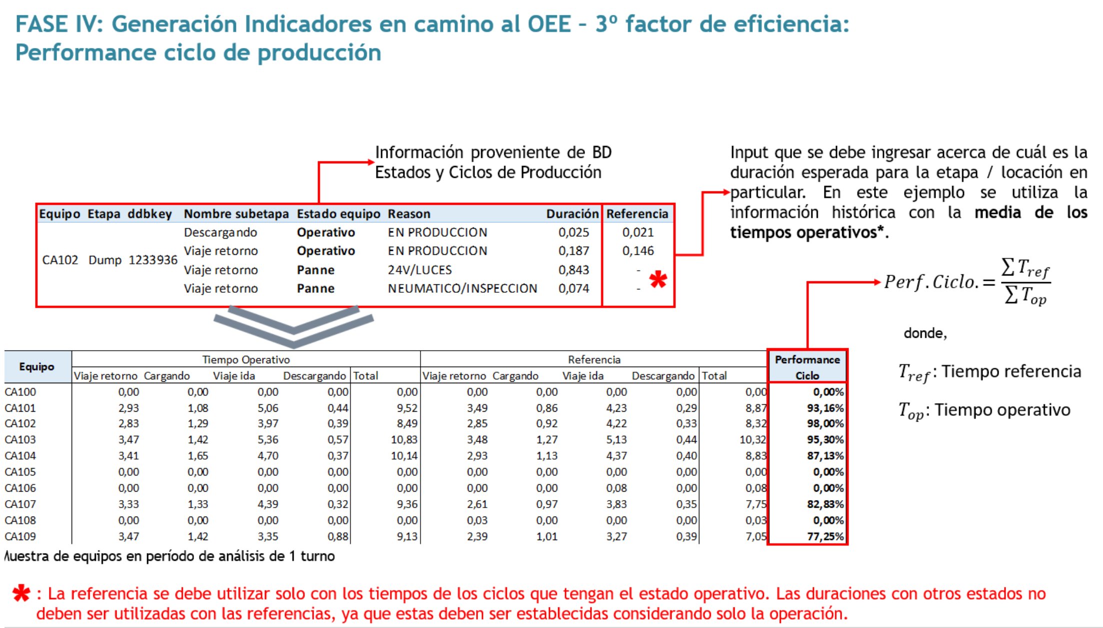
Cap_{total}:Sumatoria capacidades flota

3.1.3 Cycle Time Performance

<math equation>

<equation using cube parameters>

The cycle time performance is calculated for each trip, comparing the last trip time vs its expected time, and the result is stored in the **UnifiedEventsCube** in the Calculated Dimension: Time Performance.



FASE IV: Generación Indicadores en camino al OEE - 3° factor de eficiencia: Performance ciclo de producción

Información proveniente de BD Estados y Ciclos de Producción

Equipo	Etapa	ddbkey	Nombre subetapa	Estado equipo	Reason	Duración	Referencia
CA102	Dump	1233936	Descargando	**Operativo**	EN PRODUCCION	0,025	0,021
			Viaje retorno	**Operativo**	EN PRODUCCION	0,187	0,146
			Viaje retorno	**Panne**	24V/LUCES	0,843	- *
			Viaje retorno	**Panne**	NEUMATICO/INSPECCION	0,074	-

Input que se debe ingresar acerca de cuál es la duración esperada para la etapa / locación en particular. En este ejemplo se utiliza la información histórica con la **media de los tiempos operativos***.

$$Perf.Ciclo. = \frac{\sum T_{ref}}{\sum T_{op}}$$

donde,

T_{ref}: Tiempo referencia

T_{op}: Tiempo operativo

Equipo	Tiempo Operativo					Referencia					Performance Ciclo
	Viaje retorno	Cargando	Viaje ida	Descargando	Total	Viaje retorno	Cargando	Viaje ida	Descargando	Total	
CA100	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00%**
CA101	2,93	1,08	5,06	0,44	9,52	3,49	0,86	4,23	0,29	8,87	**93,16%**
CA102	2,83	1,29	3,97	0,39	8,49	2,85	0,92	4,22	0,33	8,32	**98,00%**
CA103	3,47	1,42	5,36	0,57	10,83	3,48	1,27	5,13	0,44	10,32	**95,30%**
CA104	3,41	1,65	4,70	0,37	10,14	2,93	1,13	4,37	0,40	8,83	**87,13%**
CA105	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00%**
CA106	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,08	0,00	0,08	**0,00%**
CA107	3,33	1,33	4,39	0,32	9,36	2,61	0,97	3,83	0,35	7,75	**82,83%**
CA108	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,00	0,03	**0,00%**
CA109	3,47	1,42	3,35	0,88	9,13	2,39	1,01	3,27	0,39	7,05	**77,25%**

/uestra de equipos en período de análisis de 1 turno

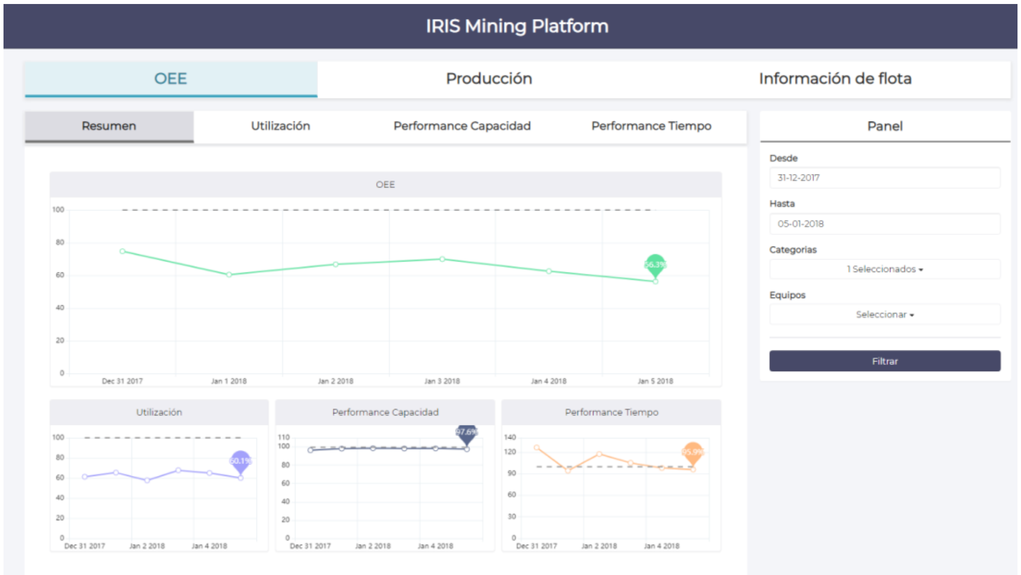
*: La referencia se debe utilizar solo con los tiempos de los ciclos que tengan el estado operativo. Las duraciones con otros estados no deben ser utilizadas con las referencias, ya que estas deben ser establecidas considerando solo la operación.

4 VISUALIZATION: WEB APP

The Visualization frontend is an application based on AngularJS, currently using 2 libraries for graphics: Chart.js and ECharts.js.

The JavaScript code performs queries to the IRIS cubes using MDX queries through the MDX2JSON libraries.

Example of the visualizations made on JavaScript showing the resulting graphics of the OEE.



<Example of generation of 1 graphic>

<Project Structure>