

*2016 Anylogic Conference*

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# Maintenance Scheduling Tool in the Oil & Gas Industry

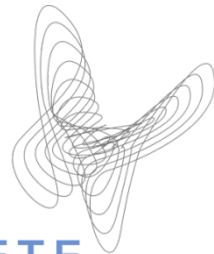
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*Jonatan Casiet; J.Pablo Rodriguez Varela;  
Patricio Pipp; Marina Pérez Gaido*



## Who we are

*YPF S.A.* is the largest oil & gas company in Argentina and the third in South America.



CONTINENTE **SIETE**





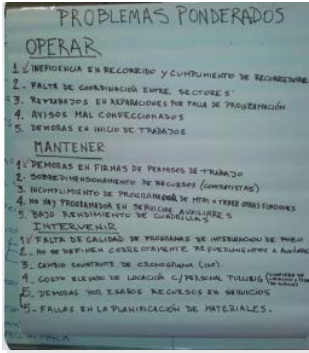

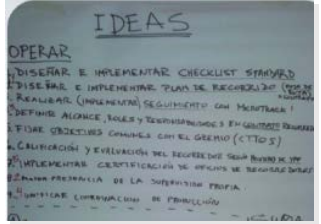

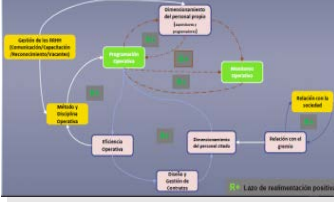
*Continente Siete (C7 S.A.)* is an algorithm workshop, where mathematical models are constantly being developed to address complex business problems.

*Simcastia* is C7's Simulation and Optimization division.





# Once upon a time...

Critical business Process selection	Process mapping	Identification of Improvement opportunities	Root cause analysis	Clustering of Improvement opportunities	Prioritization of Improvement opportunities
<p>Business processes analyzed:</p> <ul style="list-style-type: none"> <li>Wells and facilities operation</li> <li>Wells and facilities maintenance</li> <li>Well services with pulling rig</li> </ul>	<p>Value stream mapping methodology:</p>  	<p>Identification and prioritization of issues for each process:</p> 	<p>Ishikawa diagram for identification of root causes:</p> 	<p>Brainstorming for improvement opportunities:</p>  <p>Clustering:</p> 	<p>Mess mapping; inter relationships between clusters of improvement opportunities</p> 



## Pilot location

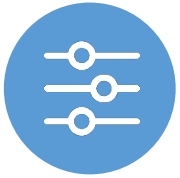


- “Rincón de los Sauces” is an oil field located in Neuquén, Argentina.
- Aprox. **700 wells** (among water injection and oil wells)
- About **100 working crews**.
- More than **100 weekly maintenance orders**.



# Proposed solution

# KRON



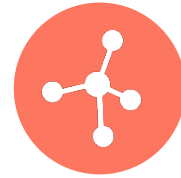
## Flexibility

Is needed to develop a fully customized tool



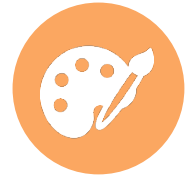
## Optimization

Is core to the solution in order to drive objective efficiency



## Multi-paradigm Simulation

Allows the tool to be better accepted



## Eye-catching Interfaces

Help the tool to be better accepted



# Cost function

$$\text{Cost} = \text{Resources Utilization} + \text{Wells' Prod Loss} + \text{Dist covered}$$

*$f_{\text{prod}} \times (\text{Unplanned} + \text{Programmed}) \text{ Interruptions}$*

*$f_{\text{nonOperativeHours}} \times \text{CostRegular Hours} + f_{\text{extraHours}} \times \text{CostExtra Hours}$*

*$f_{\text{dist}} \times \text{MovingCosts}$*



# Agent-based focus



Resources



Positions



Tasks

- *Skills*: type of tasks for each resource.
- *Parameters*: Working hours, maximum extra hours.
- *Georeferenced map*: distances in between each point.
- *Status*: conditions in the point to be maintained.
- *Preventive & predictive*: they can be planned.
- *Corrective*: after fail detection.



# Work order complexity

## Tasks



- 1. Preparation (30')
- 2. Functional Verification (60')
- 3. Maintenance (90')
- 4. Sign off (30')

## Position



## Resources





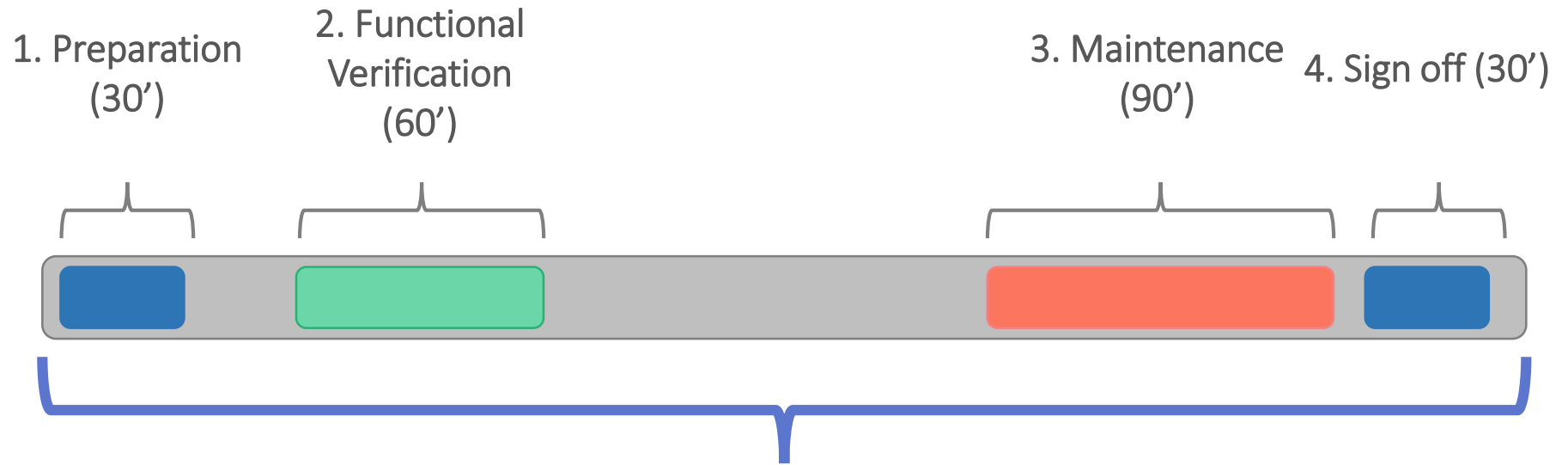


# Work order complexity

## Tasks



## Position



**NEW AGENT REQUIRED: WORK ORDER**



# Scheduling Methodology

*Priority*  
*Location*  
*Aging*

**Work Order  
Characteristics**



**Task  
Characteristics**

*Sequence*  
*Simultaneity*  
*Duration*



**Optimization Process**

- 
1. *Order priority*: lists the work order according to characteristics.
  2. *Greedy*: Analyzes possible day/time for each operation.
  3. *Final iteration per Work Order*: Adjusts tasks to minimize work order duration.

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# KRON Screens

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Rincon de los Sauces

Simulación & Optimización del programa de tareas



Configuración de la Herramienta



Priorización de órdenes:

- Considerar Ley
- Considerar Seguridad
- Priorizar Preventivos

Fecha

28/10/2016

Ponderación de pesos en la función objetivo:

- Por producción: **1.0** x el precio unitario [\$/m3]
- Por movilidad: **1.0** x el precio unitario [\$/km]
- Por lucro: **1.0** x el precio unitario [\$/h]
- Por hora extra: **1.0** x el precio unitario [\$/h]

Correr el optimizador



Rincon de los Sauces

Simulación & Optimización del programa de tareas



Configuración de la Herramienta



Calendario

Días	28 OCT	29 OCT	30 OCT	31 OCT	01 NOV	02 NOV	03 NOV	04 NOV	05 NOV
Lluvia	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Viento	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Correr el optimizador



Rincon de los Sauces

Simulación & Optimización del programa de tareas



Configuración de la Herramienta



Turnistica

Mant

Días	28 OCT	29 OCT	30 OCT	31 OCT	01 NOV	02 NOV	03 NOV	04 NOV	05 NOV
MINSTRU1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MINSTRU2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MINSTRU6	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MMASICO	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MSISTEM1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MSISTEM2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CRCHI	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CRL0M	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Correr el optimizador >



Rincón de los Sauces  
Simulación & Optimización  
del programa de tareas



Fecha: Sun Nov 06 2016  
Tiempo: 00:00:00



Vista general / Resumen general



Función objetivo / pérdidas



Total Función  
Objetivo  
**548.1 kUSD**

Total  
Pérdidas  
**97.0m3**

Función objetivo

● Pérdidas por correctivo	35.6 kUSD
● Pérdidas por preventivo	12.4 kUSD
● Tiempo improductivo por traslados	9496 USD
● Tiempo improductivo sin tareas asignadas	489.7 kUSD
● Tiempo de horas extras	896 USD

Pérdidas

● Pérdidas por correctivo	72 m3
● Pérdidas por preventivo	25.0 m3

Ver todas las divisiones

División

Mant

143 / 156



Utilización de  
las cuadrillas

SSAA

84 / 118



Utilización de  
las cuadrillas

Pulling

19 / 24



Utilización de  
las cuadrillas

otros

0 / 0



Utilización de  
las cuadrillas

● Esperando ● Trabajando ● Trabajando extra ● Transportándose



Rincón de los Sauces  
Simulación & Optimización  
del programa de tareas



Fecha: Sun Nov 06 2016  
Tiempo: 00:00:00

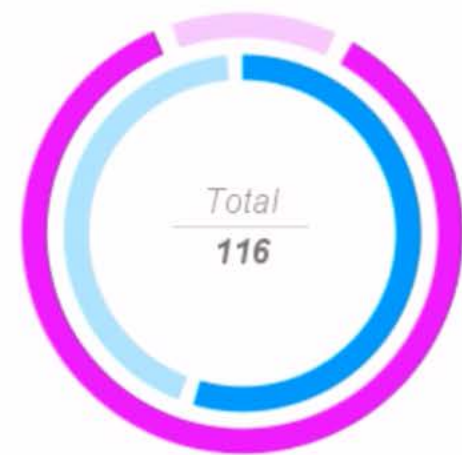


Vista general / Órdenes & Transporte

Indicadores



Programación de las Órdenes



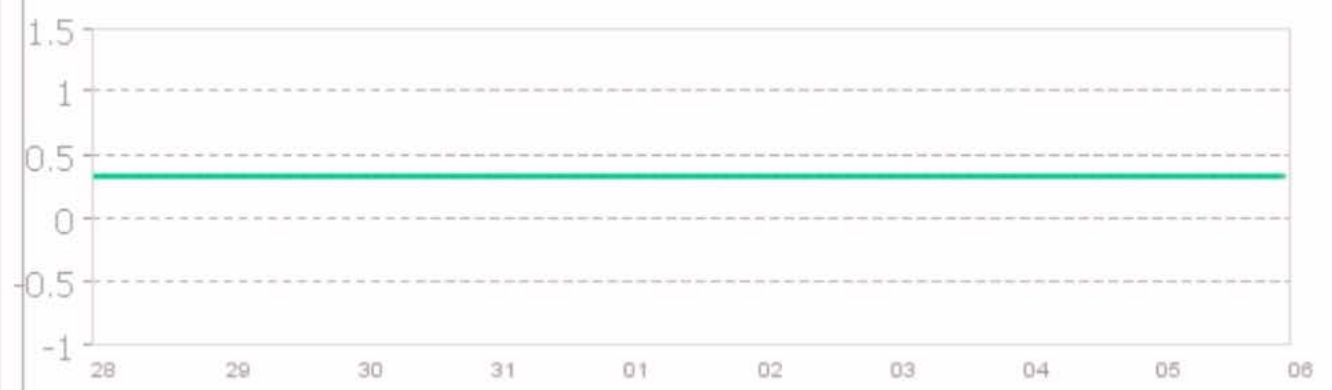
	Total	Programadas	Sin Programar
Plan:	16	14	2
Backlog:	100	56	44

Distancias recorridas

- Distancia de/hacia las bases: 976 km.
- Distancia entre nodos y de/hacia almuerzos: 1621 km.
- Distancia Total: 2597 km.



Pérdida de Producción [m3 por día]







Rincón de los Sauces  
Simulación & Optimización  
del programa de tareas



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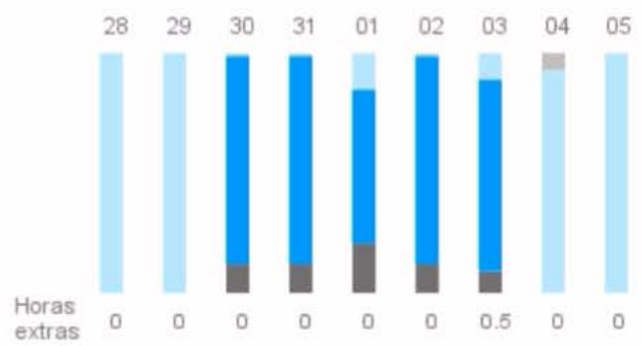


Vista general / Cuadrillas

Indicadores



Distribución de tiempos



Divisiones

Familias

Contratistas

**Cuadrillas**



MINSTRU1



Distancia recorrida [km]: 119



Operaciones por realizar: 0



Operaciones realizadas: 18

	Horas	Porcentaje
Esperando	31.66	46.9 %
Trabajando	30.3	44.9 %
Trabajando extra	0.53	0.8 %
Transportándose	4.99	7.4 %

Cuadrillas

- MINSTRU1 - QIPCELEC
- MINSTRU2 - QIPCELEC
- MINSTRU6 - QICOELEC
- MMASICO - QIPCELEC
- MOTOCOMP - MRLCOMPR
- MSISTEM1 - QIPCTELE
- MSISTEM2 - QIPCTELE
- PTN-311 - Pulling
- PTN-718 - Pulling
- SAI-256 - Pulling
- 101105 - MMSMOTON
- 101108 - MMSMOTON



Rincón de los Sauces  
Simulación & Optimización del programa de tareas



Fecha: Sun Nov 06 2016  
Tiempo: 00:00:00



Vista general / Mix de Órdenes



Órdenes [u]



	Correctivo	Preventivo	Pulling
Plan:	-	14	0
Backlog:	24	24	8

	Abordados	Sin abordar	Total activos
Orden:	60	10	70
Operaciones:	246	52	298

Inicio
Día 9
Día 20
Mes

Tipo de Orden:

<span style="color: green;">●</span> Pulling:	0	0	100%
<span style="color: gray;">●</span> Correctivo:	31	1	97%
<span style="color: black;">●</span> Preventivo:	29	9	76%

Criticidad de Orden:

<span style="color: green;">●</span> ALTA:	31	1	96%
<span style="color: black;">●</span> MEDIA:	23	9	72%
<span style="color: gray;">●</span> BAJA:	6	0	100%

Ley / Seguridad:

<span style="color: green;">●</span> LEY:	4	0	100%
<span style="color: gray;">●</span> CVS:	0	0	100%
<span style="color: black;">●</span> ZEN:	56	10	85%
<span style="color: blue;">●</span> Otros:	0	0	100%

Familia:

<span style="color: green;">●</span> Mant - Instrumentos:	30	0	100%
<span style="color: black;">●</span> SSAA - MOTOCOMPRESOR ~:	0	0	100%
<span style="color: green;">●</span> Mant - Telemetría:	10	0	100%
<span style="color: black;">●</span> Pulling - Pulling:	7	1	88%
<span style="color: green;">●</span> SSAA - MOTONIVELADORA~:	0	0	100%
<span style="color: black;">●</span> SSAA - MOTONIVELADORA~:	2	0	100%
<span style="color: green;">●</span> Mant - Energia baja t~:	0	0	100%
<span style="color: black;">●</span> SSAA - CUADRILLA SOLD~:	0	0	100%
<span style="color: green;">●</span> otros - Equipo PH:	0	0	100%
<span style="color: black;">●</span> SSAA - GRUA (H):	0	0	100%
<span style="color: green;">●</span> otros - Integridad YPF:	0	0	100%
<span style="color: black;">●</span> SSAA - Tracción ancla~:	0	0	100%



Rincón de los Sauces  
 Simulación & Optimización  
 del programa de tareas



Fecha: Sun Nov 06 2016  
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Vista de las cuadrillas

Cuadrilla [kms recorridos]	Sun Oct 30 2016	Mon Oct 31 2016	Tue Nov 01 2016
MINSTRU1 <span>📍</span> 135			
MINSTRU2 <span>📍</span> 215			
MINSTRU6 <span>📍</span> 32			
MMASICO <span>📍</span> 233			
MOTOCOMP <span>📍</span> 0			
MSISTEM1 <span>📍</span> 112			
MSISTEM2 <span>📍</span> 64			
PTN-311 <span>📍</span> 25			
PTN-718 <span>📍</span> 0			
SAI-256 <span>📍</span> 11			
101105 <span>📍</span> 48			
101108 <span>📍</span> 48			
101111 <span>📍</span> 80			



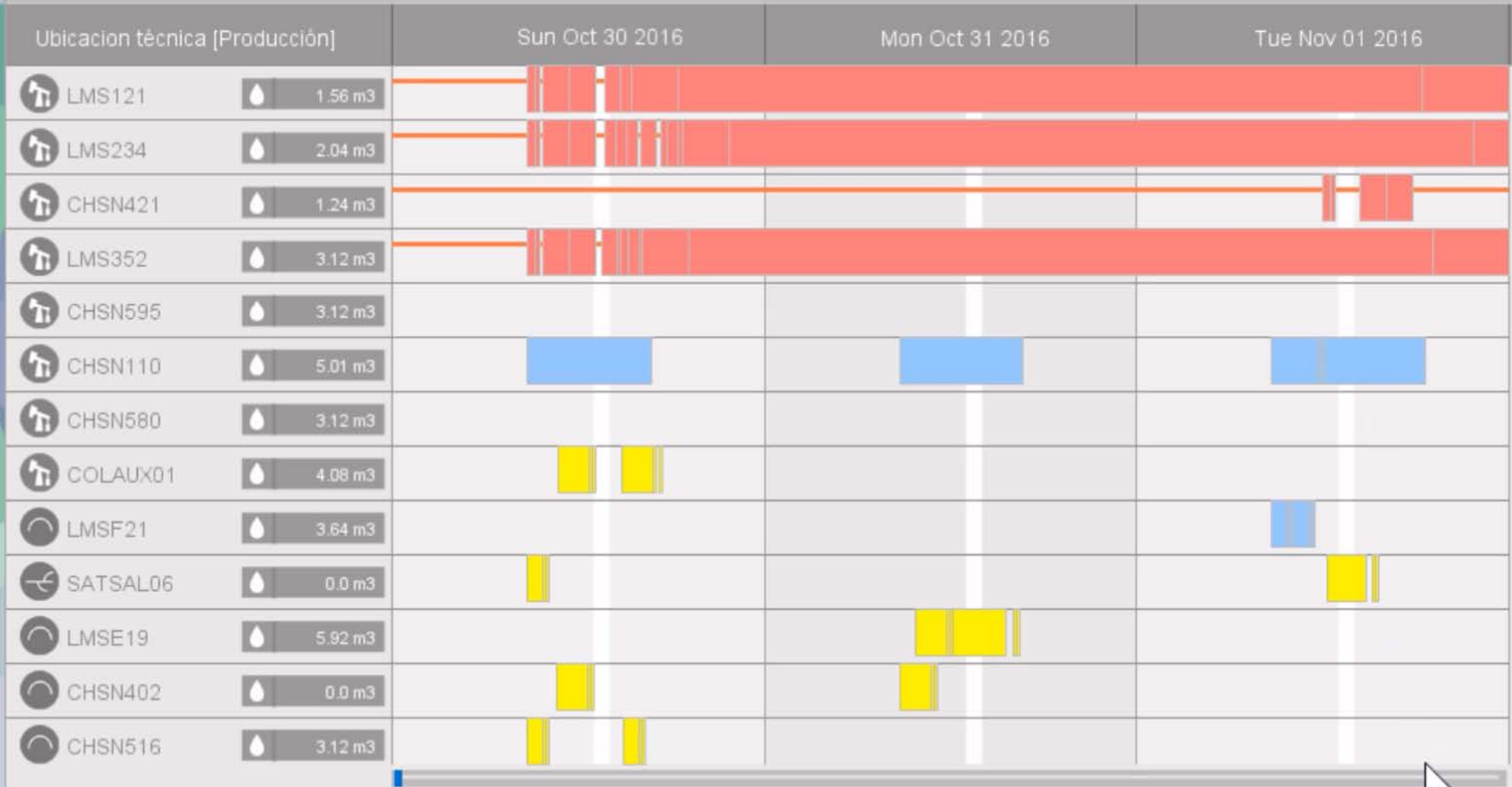
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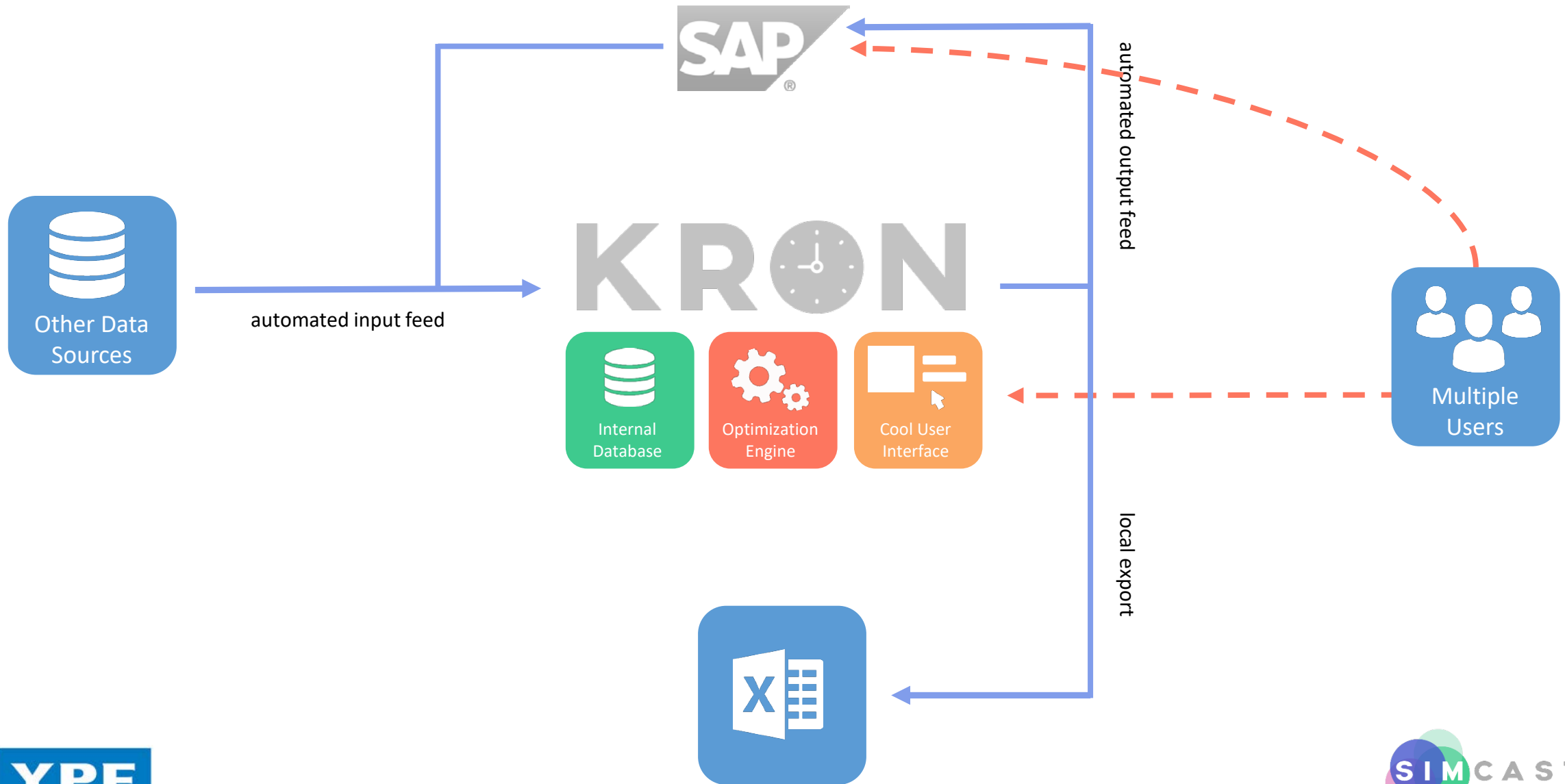


Vista de los Nodos





# Scheduler integration



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# KRON Results

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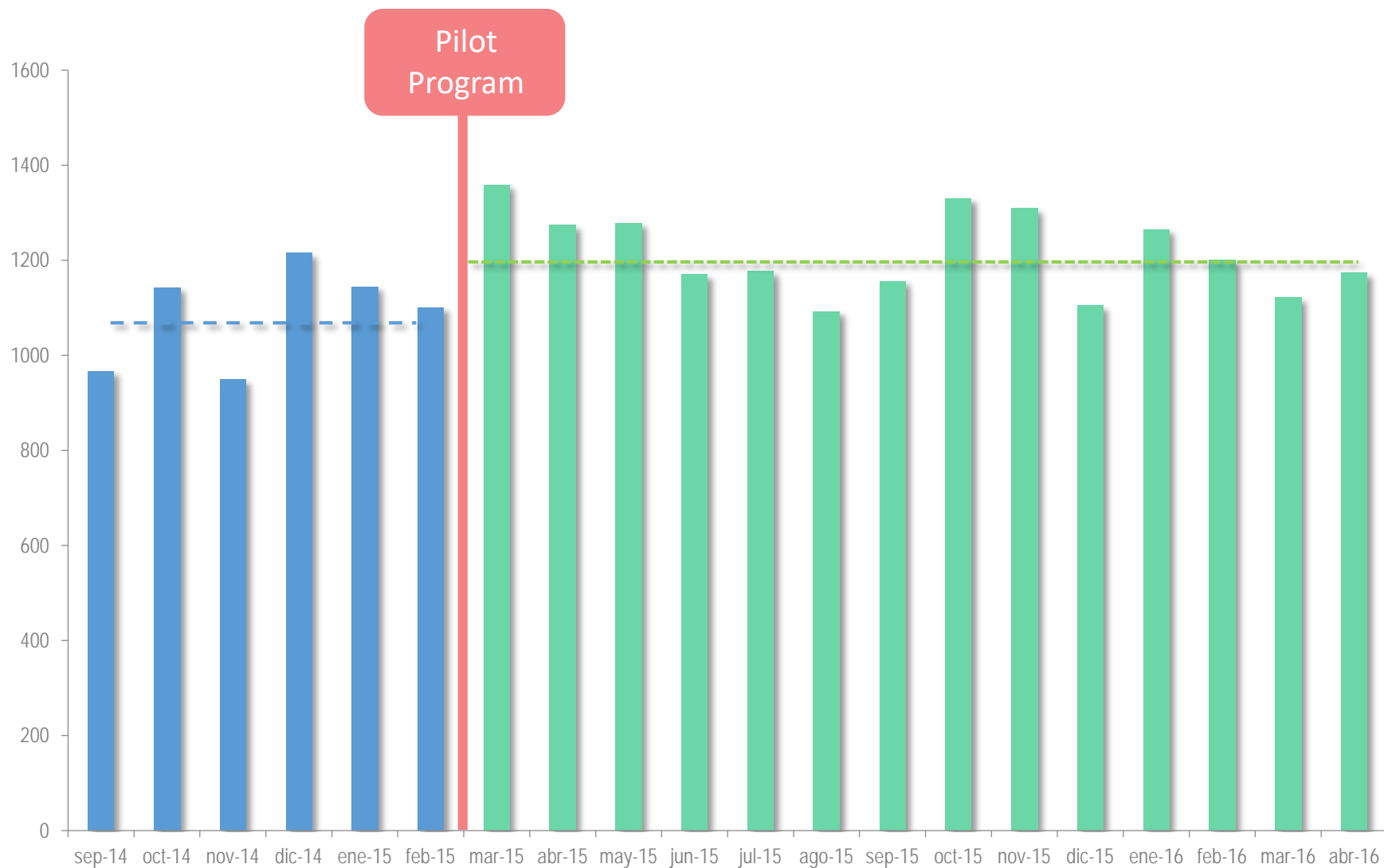


# Work order execution increased 11%

Work order execution

**+11%**

After pilot program was initiated.





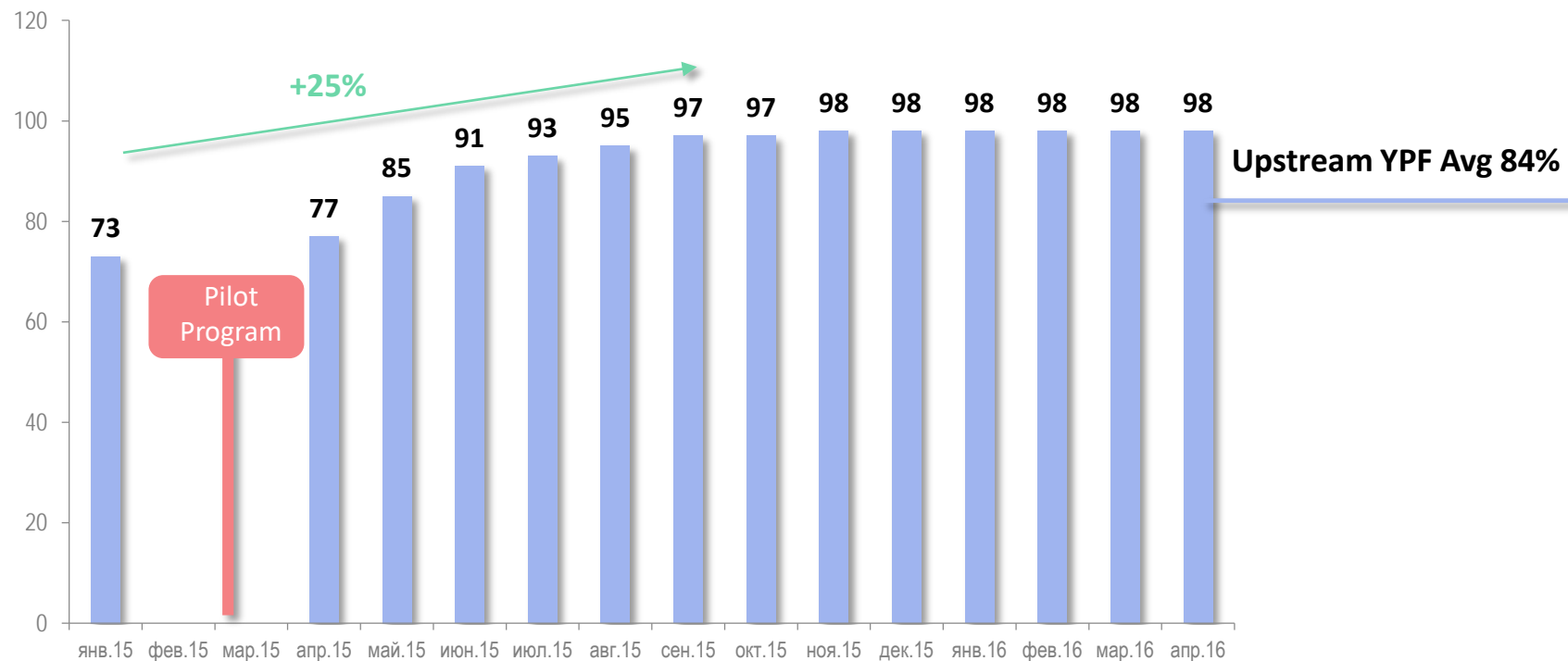
# Preventive maintenance improvement

**Preventive maintenance Improved 25%**

In just six months...

With just one scheduler...

With just one tool





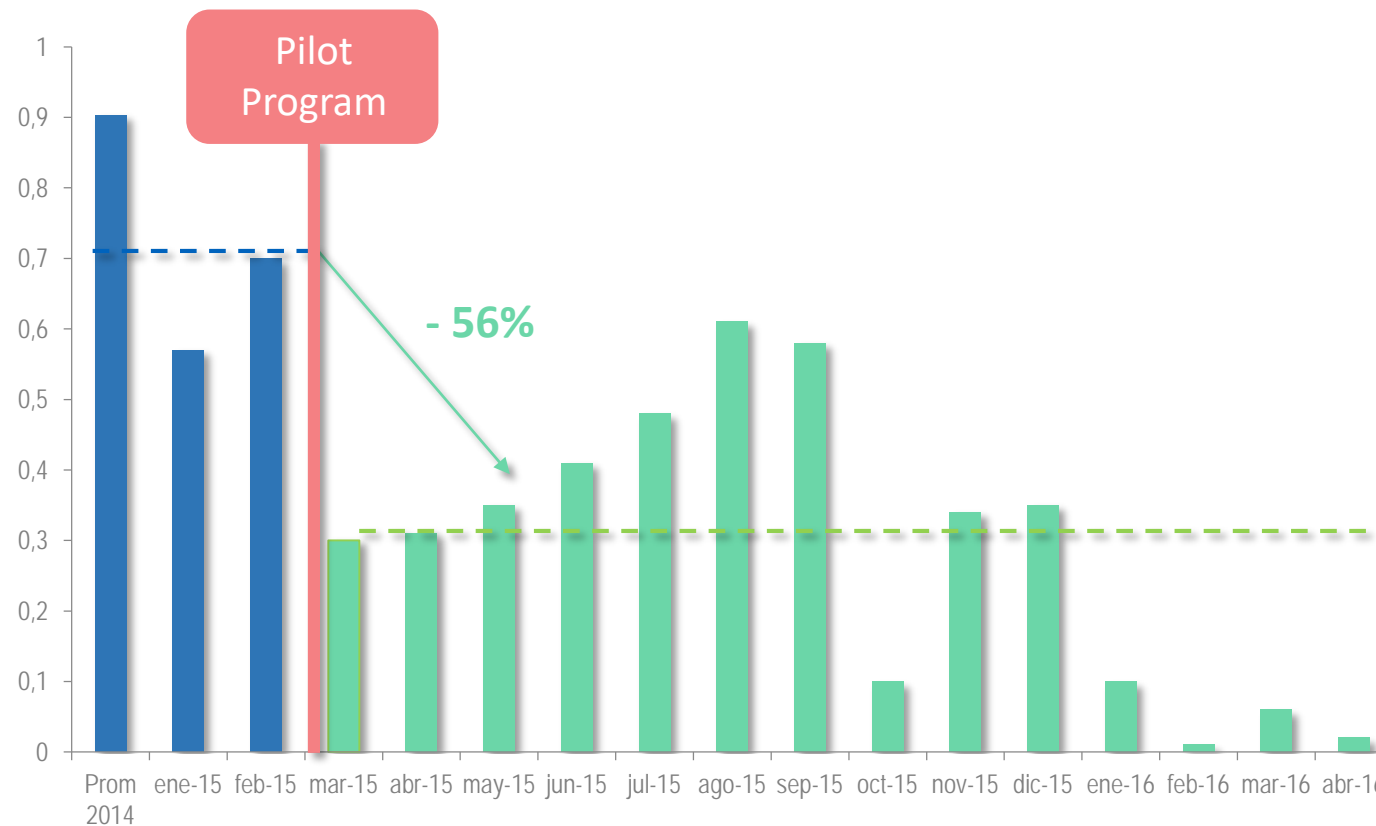


# Backlog reduction

Corrective  
Maintenance  
backlog

# -56%

Reduction from avg  
2014



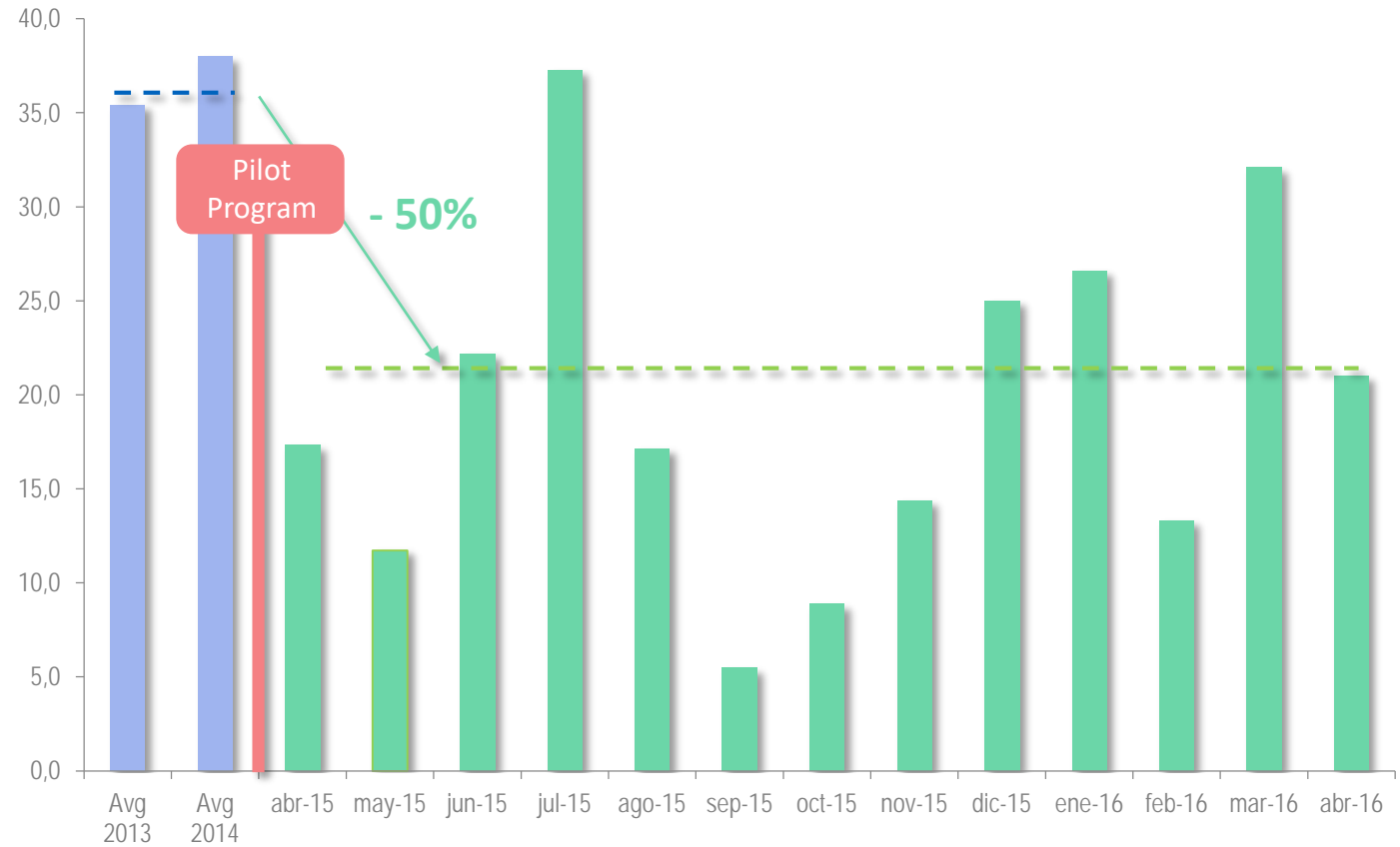


# Downtime due to mechanical failures was improved

Oil production  
Losses due to  
mechanical  
failures

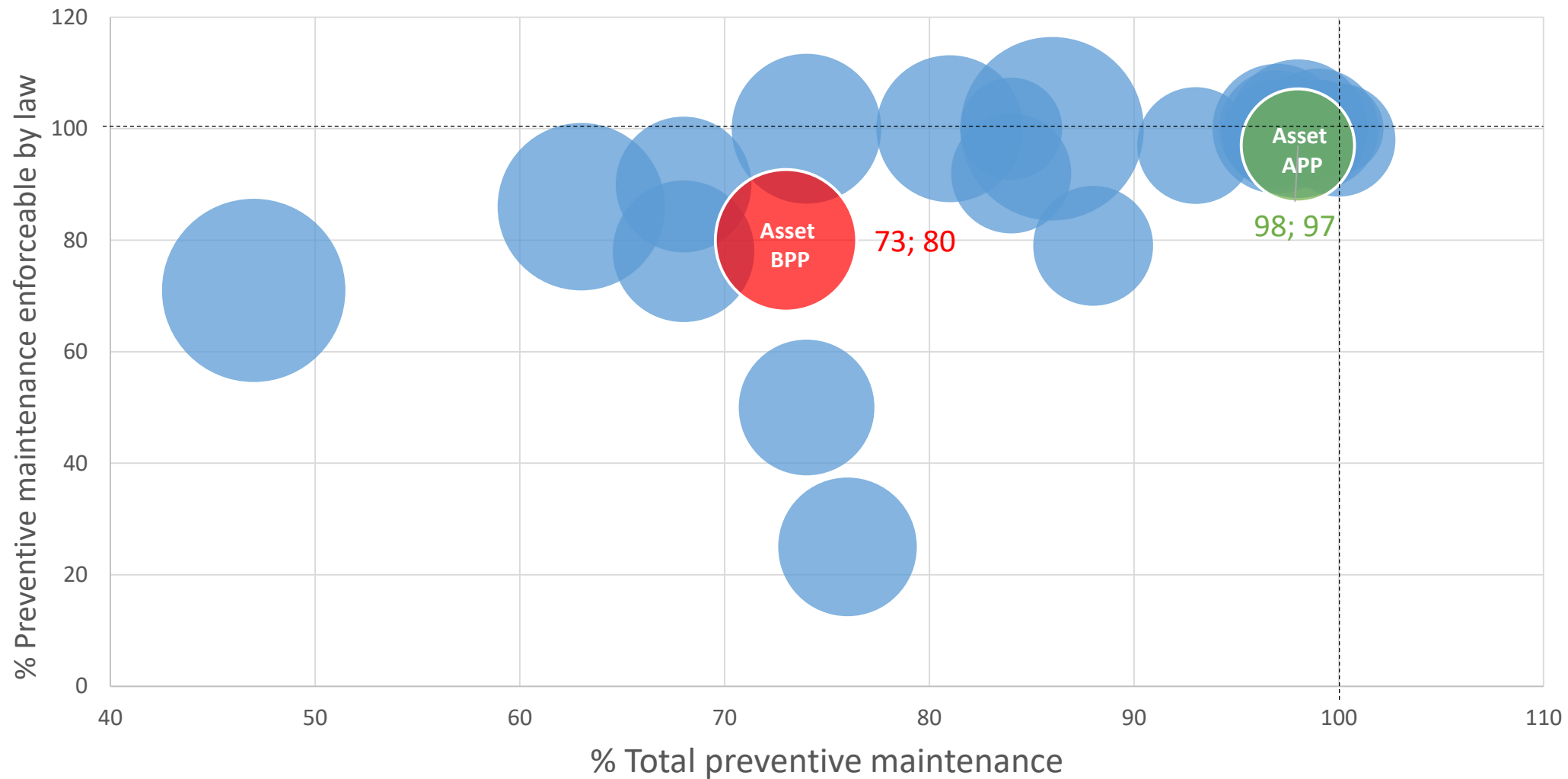
**-50%**

Reduction from avg  
2013 and 2014





# Rincón de los sauces asset before and after the pilot program





Economical impact

**18 MMUSD per year**

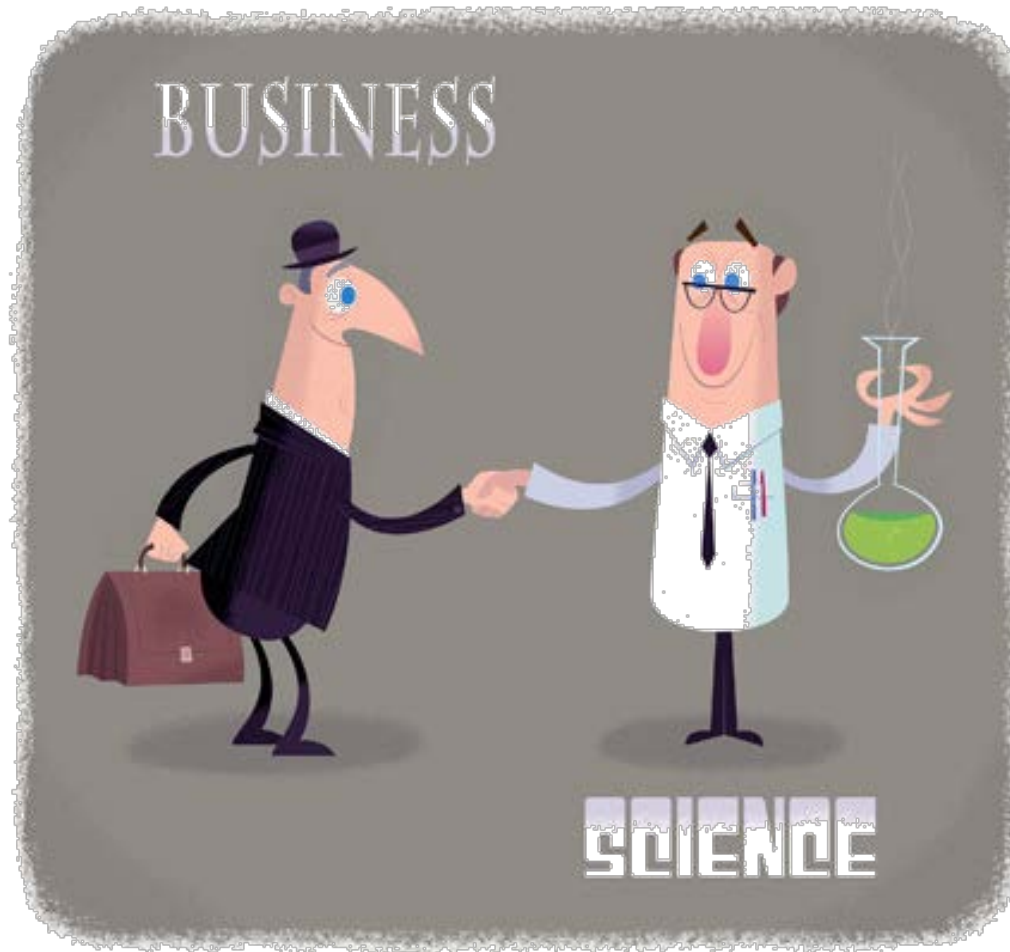
At Rincón de los Sauces Asset

**NPV@12%: 234 MMUSD**

With this project implemented in all the YPF assets



# Final words



*Suggestions? Questions?*

**Thanks for your time!**

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*Jonatan Casiet; J.Pablo Rodriguez Varela  
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## Lessons learned

- Start with a pen and paper
- Do not animate just because you can
- Validation at each turn
- *Optimal* is great, but *better* is good enough