GRTMPS Migration and Modeling at Pemex

"We have the energy to do it"

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Gerencia de Modelos de Optimización Integral, GMOI

MUG 2016

Alexandria, VA

Agenda

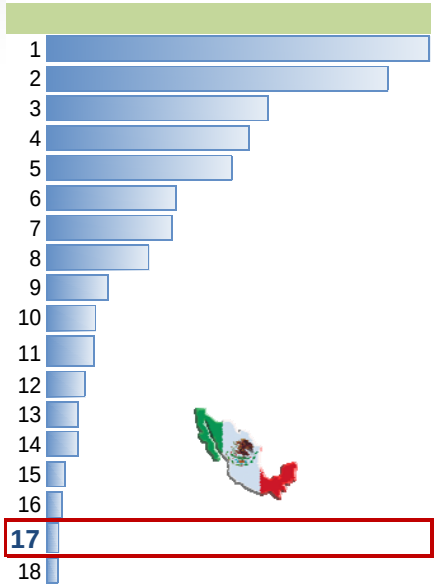
I. **Decision making**

II. Migration Process

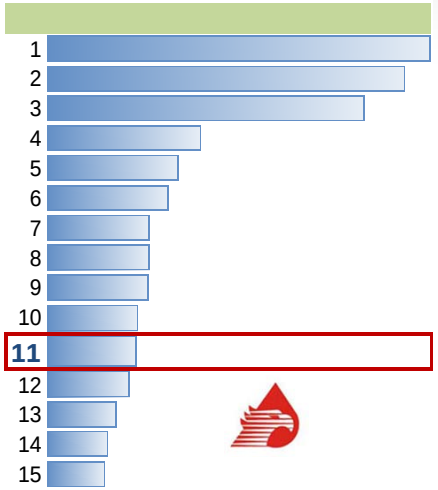
III. Next steps

Who is Pemex?

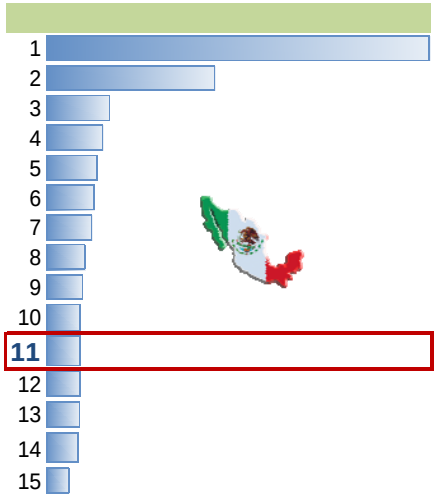
Proved Oil Reserves



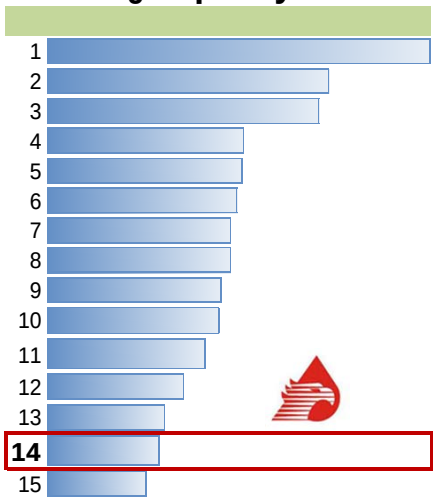
Oil Production



Distillates Market



Refining Capacity



Mexico

- *120 million people*
- *13th largest economy in the world*
- *17th largest oil reserves globally*
- *6th largest shale reserves globally*
- *11th largest distillate products market*

Pemex

- *11th largest oil producer globally*
- *14th largest refining capacity globally*

Pemex Divisions

Main activities

PEP (Upstream)
PTRI (Downstream)

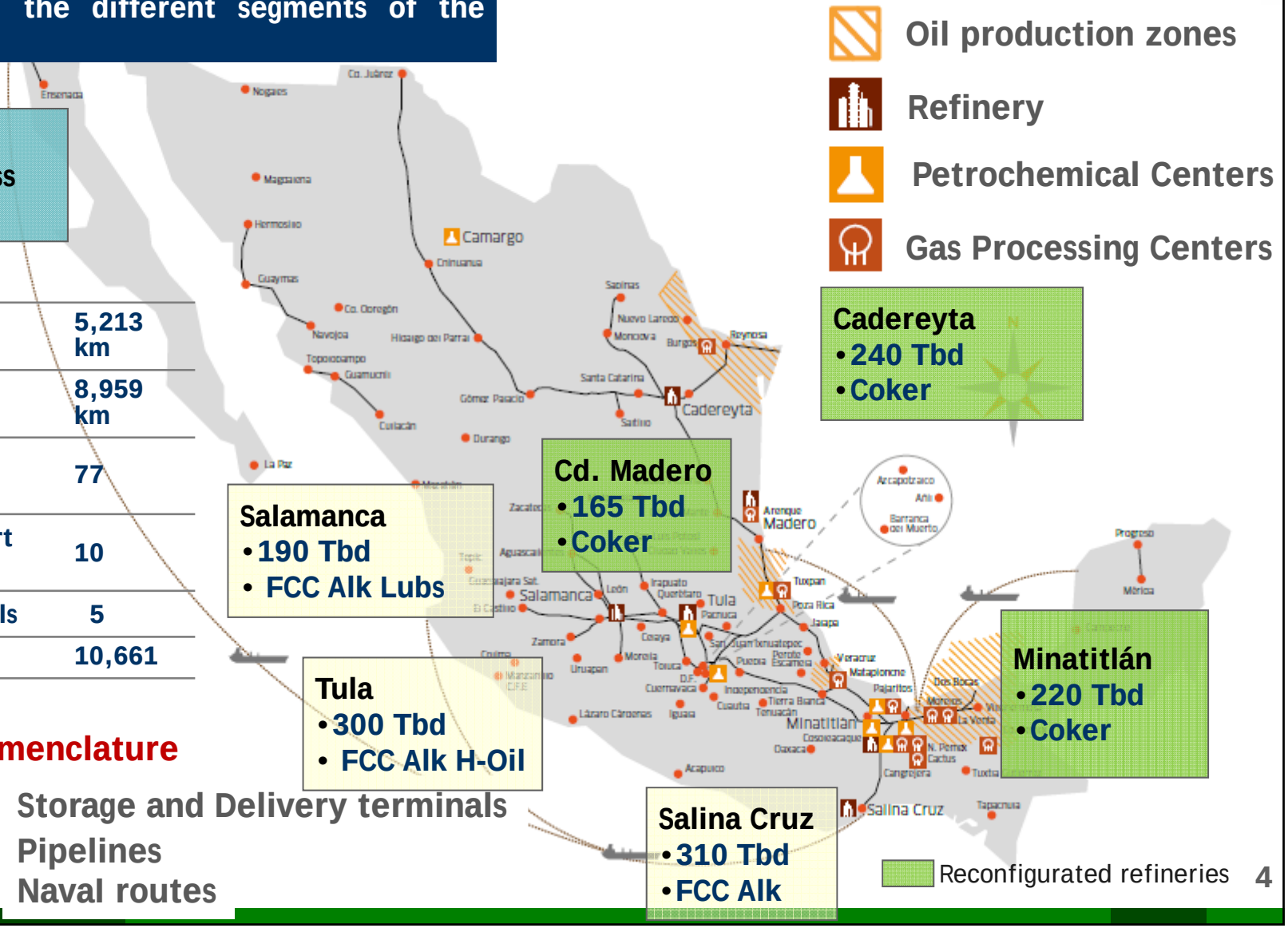
Secondary activities

PL (Logistics)
PMI (trading)
PPS (Drilling)
PE (Ethilene)
PF (Fertilizers)
PC (Cogeneration)

Pemex's National Refining Sytem

In order to maintain as the market leader in the downstream, Pemex has the infraestructure to partipate in all the different segments of the industry chain.

Refinery Maximum process Configuration	
Oil Pipelines	5,213 km
Product pipelines	8,959 km
Land storage terminals	77
Residences of port operations	10
Maritime terminals	5
Service stations	10,661



Some history

Milestone:

- **6 Refineries models in GRTMPS**
- **Less than 4 months**
- **Haverly's support**
- **Mutual achievement**

Migration process:

New business relationship between PEMEX and Haverly

Paradigm shift:

Reliable supplier of optimization solutions (*Multi-criteria evaluation*).

Migration challenge

Long term contract expires:

☹ customer service + ☹ negotiations + $

Pemex refused to sign a new contract

Optimization in Pemex:

Refining/Gas/Petrochemicals Models + Local/Global Models + Distribution network

Planning, Programming and Investments evaluation.

Initial Steps:

1987 + 25 years + Corporate License + unlimited users

Company A acquired software rights.

Pemex's learning curve started

Decision making process

2014	2015	2016		
Technical workshops	**Sample modeling**	**Economic evaluation**	**Optimizer crisis**	**Pemex-Haverly partnership**
Alternatives for optimization and simulation ✓ 6 companies ✓ 18 Pemex users	Model conversion ✓ 3 companies ✓ Pemex experts	✓ Contract extension (1y) ✓ Long term license ✓ Support ✓ Model conversion ✓ Training	✓ Contract expires ✓ Crude oil price decrease ✓ Budget restrictions	✓ April 2016 new contract ✓ This adventure began…

Who knows how to use a hammer, everything looks like a clove head

Questions that we faced internally were:

- Why do we have to change?
- We have all tools with Optimizer "A"
- We don't have enough personnel to do it
- The learning curve will be too expensive to afford it
- I have already done my training with Option "A"!
- The company is changing, this is not the time to do it.

Multiple Criteria Matrix

Main characteristics		Optimizer A	Optomizer S	GRTMPS Haverly
Technical evaluation	Modeling	😐	☺	😐
	Performance	☺	☺	☺
	Migration	☺	☺	😐
	Optimizer	😐	😐	☺
	Link to Simulators	☺	☹	☺
Licensing and architecture	Perpetual	☹	☺	☺
	Server	☹	😐	☺
	Availability	☹	☺	☺
	Management	☺	☺	☺
	Connectivity	😐	☺	☺
Total Ownership Cost	Conversion	☺	😐	☹
	License	☹	☹	☺
	Maintenance		😐	☺

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What to expect of the migration process?

- The principal targets of the migration process were:

- Matrix Analysis and nomenclature
- Ensure stability
- Reduce local optima.
- Robust building
- Case stacking

Goals already achieved!

- Customized reporting tools
- Database interaction
- Link to process simulators
- Global model integration

Still in our queue list.

How we did it?
- 2016 Migration Timeline -

Crisis

J

- No license
- Difficult & tense negotiations
- No partnership
- **BUDGET RESTRICTIONS**

1

F

Back to the basics

- Development of Model Calculators per refinery

2

A

Getting used to the new tool

- Contract signature
- Study & understanding sample models
- **Deep analysis of the matrix**
- First trials with GRTMPS (Pinino model)
- **Pemex's Dream Team**

3

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Organizing our minds

- Three webinars given by Haverly
- Homogeneous nomenclature
- **Tula draft model**
- Periodic internal meetings

4

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Official Kickoff

- Training course at Pemex's HQ
- **Tula audit model by GRTMPS' expert**

GRTMPS BETA MODELS

- Complete models of the 6 refineries
- Includes ULSG structure
- On time
- Customized development of tools starts

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The importance of talent

Leadership & Coordination

Rafael García Jolly
Optimization Model Manager

James Mena de la Rosa
Gas Model

Víctor Bonilla
Transport Model

Raúl Rosillo
Salina Cruz Model

Mónica Corvera
Crudes and Salamanca Model

Fernando Jiménez
Tula & Cadereyta Models

Félix Betancourt
Minatitlán and Madero Models

Salvador de Lira
Customized reporting

- **It is important to highlight that we had the support of a multidisciplinary team inside PEMEX, and many expectations were put over this team.**

Definition of nomenclature

Nomenclatura para unidades de proceso

	Código de 3 letras	Código de 2 letras*	
Primaria	CRi	Primaria	Pj / Qj
Vacío	VUi	Vacío	Vj / Wj
HDS Naftas	HNi	Naftas	Nj
HDS Destilados	HDi	Destilados	Dj / Ej
HDS Gasóleos	HGi	Gasóleos	Gj
Reformadora	RFi	Reformadora	Rj / Sj
Isomerizadora	InY	Ysómero	Yj
FCC	FCi	Fcc	Fj
MTBE	MTi	mtBe	Bj
TAME	TAM	Tame	Tj
Alquilación	AKi	Alquilación	Aj
CD-Tech (GUBA)	CDi	Uba	Uj
Reductora Visc.	VBR	Cope	Cj
H-Oil	HOL	H-oil	Hj
Coquizadora	DCK	coKe	Kj
Azufre	SRU	aZufre	Zj
Propano	P3i	Propano3	-3
Splitter de propileno	PPS	Propileno 3	3j
Splitter de crudo	SPL	Splitter de crudo	Sj
Fraccionadora	MC1	MC	Mj
Isomerizadora de butanos	I4Y	Isomerizadora C4	4j
Fraccionadora de gas	THi	Fraccionadora gas C1	1j
Fraccionadora de H2	HMP	Fraccionadora de H2	Hj

Nomenclatura para propiedades

PROPIEDADES:			
COD	DESCRIPCIÓN	BASE	HCAMS
API	API Gravity	WT	
ARW	Aromáticos, peso%	WT	ARW
ARO	Aromáticos %vol	VL	ARO
BEN	Benceno	VL	BEN
BNT	Nitrogeno básico % peso	WT	BNT
BPI	Index BEN	VL	BZI
C3=	Propileno, peso%	WT	
C3P		WT	
C4=	Butilenos, peso%	WT	
C5M	Contenido de C5	WT	
CON	CARBON	WT	CON
DEN	Density	VL	DEN
DBI	IND. DIESEL	WT	DBI
DNX	DENSIDAD	VL	
FON	Formula Octane	VL	
I4=	Isobutilenos, peso%	WT	
I5=	Isoamileno, peso %	WT	
iC4	Isobutano, peso%	WT	iC4
MN1	% C7+	WT	
MON	Motor Octane	VL	MON
NAW	Naftenos, peso%	WT	NAW
NAP	Naftenos, peso%	VL	NAP
NC1	Metano, peso%	WT	
NC2	Etano, peso%	WT	
nC3	Propano, peso%	WT	nC3
nC4	Butano normal, peso%	WT	nC4
N2A	N+2A	WT	N2A
NIK	NIKEL	WT	NIK
OLF	Olefinas, vol%	VL	

Customized reporting

PEMEX

DCPCD

GERENCIA DE MODELOS DE OPTIMIZACIÓN INTEGRAL

13 de septiembre de 2016

REPORTE DE MODELO DE OPTIMIZACION
DE MEZCLADO DE PRODUCTOS PETROLIFEROS

CASO: Base

CONCEPTO

Mezcla Coke

COMF

	Componentes	Descriptor	Vol (Mbd)	%	SUL	DON
Tula						
Pemex Magna	Total		**35.6**	**100%**		
	BM1	FONDOS TAME	4.1	11.6%		
	CGf	GASOLINA FCC2	8.5	24.0%		
	NC4	BUTANO NORMAL	1.4	3.9%		
	RF1	REFORMATE	16.5	46.3%		
	RIF	RAFINADO TAME	4.0	11.3%		
	SFJ	GASOLINA UBA	1.0	2.8%		
Pemex Magna Ox.	Total		**78.6**	**100%**		
	AL1	ALKILADO	5.3	6.7%		
	CGf	GASOLINA FCC2	16.5	20.9%		
	IX5	C5 ISOMERO	8.0	10.2%		
	MTB	MTBE IMP	4.8	6.1%		
	NTQ	GASOLINA A MEZCLA	3.4	4.3%		
	RF1	REFORMATE	5.0	6.3%		
	RF2	REFORMADO REF 2	24.7	31.5%		
	RIF	RAFINADO TAME	0.3	0.4%		
	SFJ	GASOLINA UBA	4.3	5.5%		
	TAM	TAME	1.7	2.2%		
	UPI	PREMIUM COMP	4.6	5.9%		
Gasolina Premium RP	Total		**11.6**	**100%**		
	AL1	ALKILADO	1.2	10%		
	MT1	MTBE	1.7	15%		
	MTB	MTBE IMP	0.2	2%		
	RF1	REFORMATE	3.6	31%		
	RIF	RAFINADO TAME	1.0	8%		
	SFJ	GASOLINA UBA	3.5	30%		
	UPI	PREMIUM COMP	0.4	3%		
Gasolina Premium ZMMTY	Total		**80.1**	**100%**		
	CSF	RESIDUO FCC1	2.2	3%		
	CSf	RESIDUO FCC2	0.4	0%		
	LD#	POOL DESTILADO PRIMARIO	4.1	5%		
	PVB	PITCH VISBREAKER	38.0	47%		
	V2#	POOL RESIDUO 2	23.2	29%		
	Z1#	POOL DESTILADO PRIMARIO 1	12.2	15%		
S. Cruz						

Producción | Mezclas | Economico

PEMEX

DCPCD

GERENCIA DE MODELOS DE OPTIMIZACIÓN INTEGRAL

13 de septiembre de 2016

REPORTE DE MODELO DE OPTIMIZACION
DE INSUMOS Y PRODUCTOS PETROLIFEROS

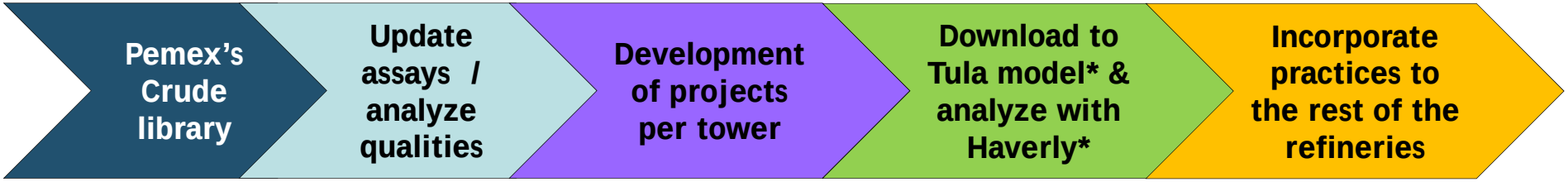
CASO: Base

CONCEPTO

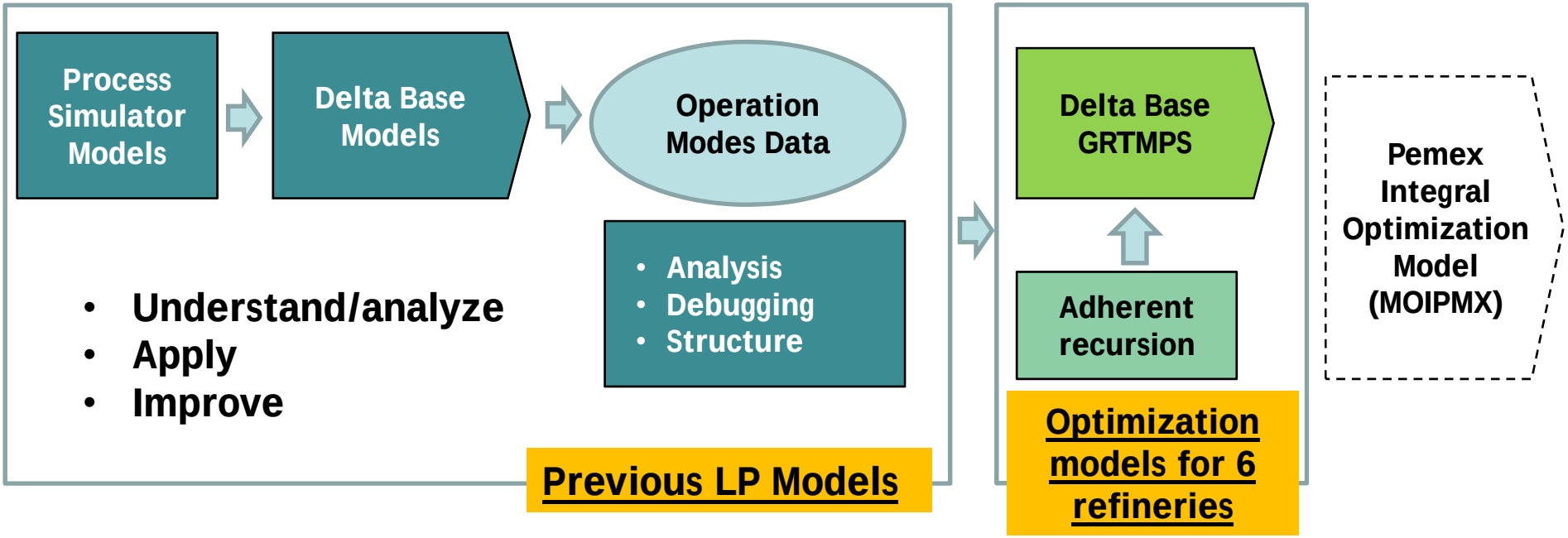
	REFINERIAS						
	CADEREYTA	MADERO	MINATITLAN	SALAMANCA	S. CRUZ	TULA	SNR
TOTAL DE INSUMOS (MBD)	**168.0**				**332.1**	**305.4**	**805.6**
Crudo	**167.2**				**307.0**	**294.6**	**768.8**
Arenque	5.3						
Gasolina natural al crudo							
Pentanos al crudo							
Istmo	44.7				214.9	231.3	491.0
Marfo							
Papaloapan							
Pozóleo							
Alamo							
Cacalilao							
Horcón							
Maya	117.2				92.1	53.0	262.3
Muro							
Naranjos							
Perdiz Pesado	0.0				0.0	0.1	0
Perdiz Gasífero	0.0				0.0	0.1	0
Tamaulipas							
Importado	0.0				0.0	0.0	0.0
Xcanda	0.0				0.0	10.0	10.0
Maya (%)	*70%*				*30%*	*18%*	*34%*
Pesados (%)	*70%*				*30%*	*18%*	*34%*
API de la mezcla							
Otros					**9.6**	**0.0**	**9.6**
Butano-butileno	0.0				0.0	0.0	0.0
Isobutano Imp./ de Mina	0.0				0.5	0.0	0.5
Mezcla de butanos							
Hidrocarburo Alto Octano	0.0				0.0	0.0	0.0
Nafta carga hidros	0.0				0.0	0.0	0.0
Alquilado							
Nafta a Tanques	0.0						
MTBE							
TAME							
Otras gasolinas / Pentanos							
Turbosina carga hidros	0.0				0.0	0.0	0.0

Model Building Strategy

H/CAMS:



GRTMPS:



**Tula model has been in review by Haverly.*

And the final products were:

Refining:

Complete beta models of the 6 refineries with information based on the models of Optimizer "A"

Includes Clean Fuels Project structure for gasolines

Gas:

GMOI counts with the operational programming model

Logistics:

- Complete current refined logistics model and with infrastructure investment in
- Models in development: Natural gas and LPG marketing

Agenda

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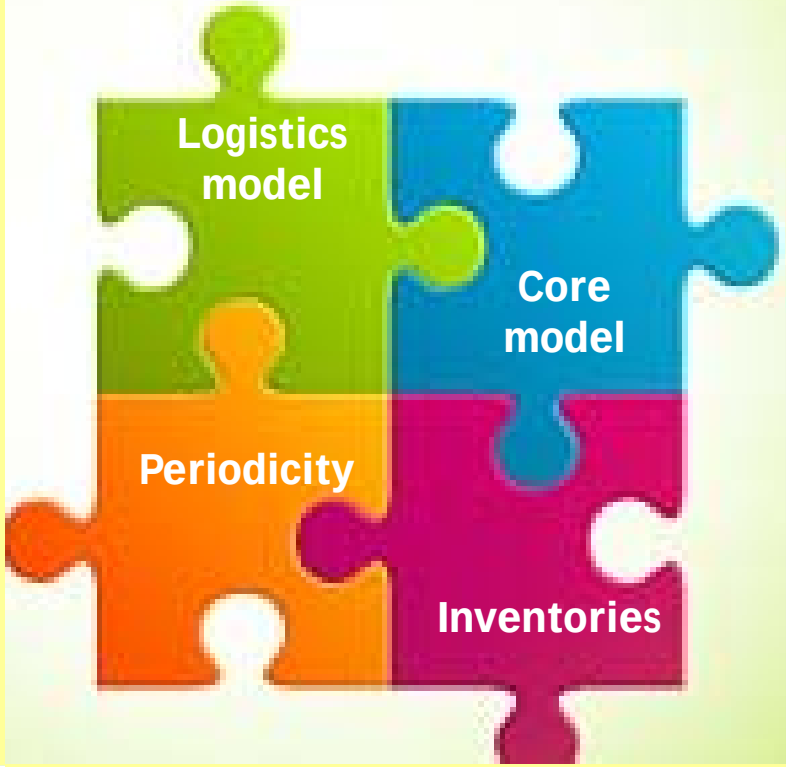
What have we achieved so far?

Multi-refineries Model

Logistics Model



Local Models

Multi periods local models

- First phase:
  - Objective: Obtain Interlocking models
  - Ensure homogeneity among them.
- Continuous improvements

- Second phase:
  - Inventory Management
  - Periodicity
  - Process adjustment factors
  - Integration of new plants

- Third Phase:
  - Cut Point Optimization
  - Migrate to databases
  - Adherent recursion
  - Process Simulator Interface (PSI)

Next steps for the Optimization Modeling Deparment

Activity	%	Notes
Refining Models:		
Local model calibration considering refinery balances and process simulators.	20%	Still pending. Only Tula has been updated.
Review of mathematical structure to avoid multipaths in the solution.	70%	In progress, Tula, Salina Cruz, Cadereyta and Madero have been reviewed
Customized reports for Corporate Offices and Transformación Industrial	40%	In progress.
Addition of structure for multi-period programming	70%	In progress
Global Refining Model	60%	In progress
Logistics model with multi-period programming	20%	Still pending.
Long term models considering adddional plants and investments associated with ULSD and ULSG	30%	It is done jointly with the long term department of Transformación Industrial.
Case stacking	80%	In progress
Gas Models:		
MOGAS	80%	Structural behaviour under review and long term requirements are being detected.
Natural Gas Logistics Model	35%	In progress
LPG Logistics model	50%	In progress. Multiperiod handling structure is under review.
Crude oil Models		
Income Distribution Model for Pemex Exploration and Production	20%	In progress

And finally…..

What we like about GRTMPS?

- Robust mathematical structure.
- Provides a logical sequence during the building of submodels with a friendly interphase.
- Swift update of crude properties, therefore its evaluation is easier.
- Facilitates a better understanding of the operating parameters and its effects in the refinery yields and economic results.

What we'll like to have in GRTMPS?

- Block diagram including mass or volume flows with associated properties, identifying those that are obtained through recursion.
- Friendly building of customized reports, without the need of programming, it might be done through drag & drop.

Our assessment about Haverly and GRTMPS is...

Main characteristics		Optimizer	Optomizer S	GRTMPS Haverly
Technical evaluation	Mod			😐
	Per			☺
				😐
				☺
	Li			☺
Licensing and architecture				☺
				☺
				☺
	M			☺
	Con			☺
Total Ownership Cost	Convers		😐	☹
	License		☹	☺
	Maintenance		😐	☺

Thank you for your time