



**Simulation and optimisation technologies supporting
Refinery operation Planning and Scheduling**

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WHERE DO WE COME FROM ?



DR. ALBERTO FERRUCCI



- Genoa ERG Refinery (late 60'): as shift operator improves CDU train with 50°C Furnace Inlet increase.
- Priolo ISAB Refinery
 - ✓ (1972-1976) feasibility, project planning, engineering, procurement, construction, start-up, management.
 - ✓ (1977) appointed CEO of ISAB.
 - ✓ (1979) oil crisis, crude price skyrockets: “wrong refinery in the wrong place in the wrong moment”
 - ✓ (1981) 1st Mild Hydro Cracker of the world
 - ✓ (1983) 1st Real Vacuum Pitch Visbreaking
- Genoa Refinery: (1980) saves it from Bankruptcy
- 1985 with ISAB profits buys Chevron's Italian Assets and becomes the first Italian private downstream operator.
- 1985 appointed ERG Group VP and ISAOIL (ex Chevron Italy) President
- 1986 Starts Prometheus

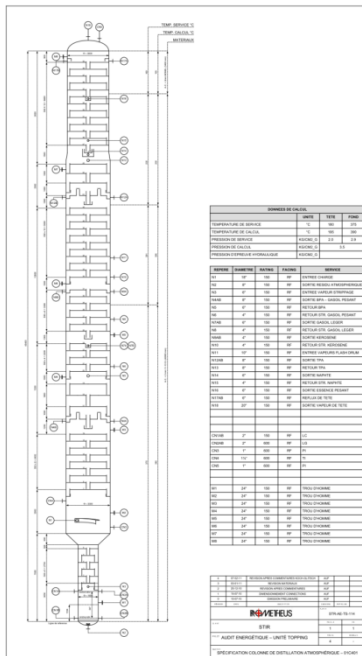
2011: Lukoil buys ISAB refinery for 2.0 Billions USD

PROMETHEUS



- We help various operators worldwide
 - ✓ Italy (IPLOM, IES, API)
 - ✓ Former Soviet Union (UFA and Odessa Refineries)
 - ✓ Mediterranean Area (Egypt, Libya, Tunisia)
 - ✓ India (HMEL)
- Providing Consulting Services
 - ✓ Strategic consulting, feasibility studies
 - ✓ Technical assistance
 - ✓ Process design studies
- and Software solutions: Prometheus DSS
 - ✓ Crude oil characterisation
 - ✓ LP Refinery Optimisation
 - ✓ Blending Optimisation
 - ✓ Operation Scheduling
 - ✓ Plant simulation / monitoring

SPECIALISED CONSULTING



- **Surveys**

assess current Performance and highlight minor modifications permitting to overcome production bottlenecks and to improve global profitability

- **Feasibility Studies**

highlight solutions to cope with operational changes or evaluate process modifications

- **Conceptual Engineering**

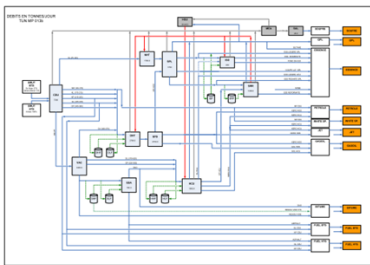
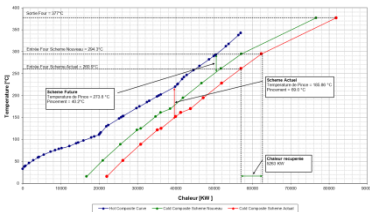
process design of modifications of existing units aimed to reach new operational targets (heat & material balances, thermodynamic calculations, equipment sizing, issue of datasheets, PFDs & P&IDs)

- **Energy Audits**

improve Energy Performance Fuels optimisation, heat transfer and heaters efficiency, utilities and fuels balances, emissions control

- **LP Audits**

assess the reliability of the existing LP model, verify its capability to model in a satisfactory way the specific operative flexibilities



DECISION SUPPORT SYSTEM TOOLS

Designed specifically for refinery professionals trigger the diffusion of a common “techno-economic mentality” in refinery services.

A framework of integrated technologies to support Supply Chain Management tasks.

... Oil Characterisation

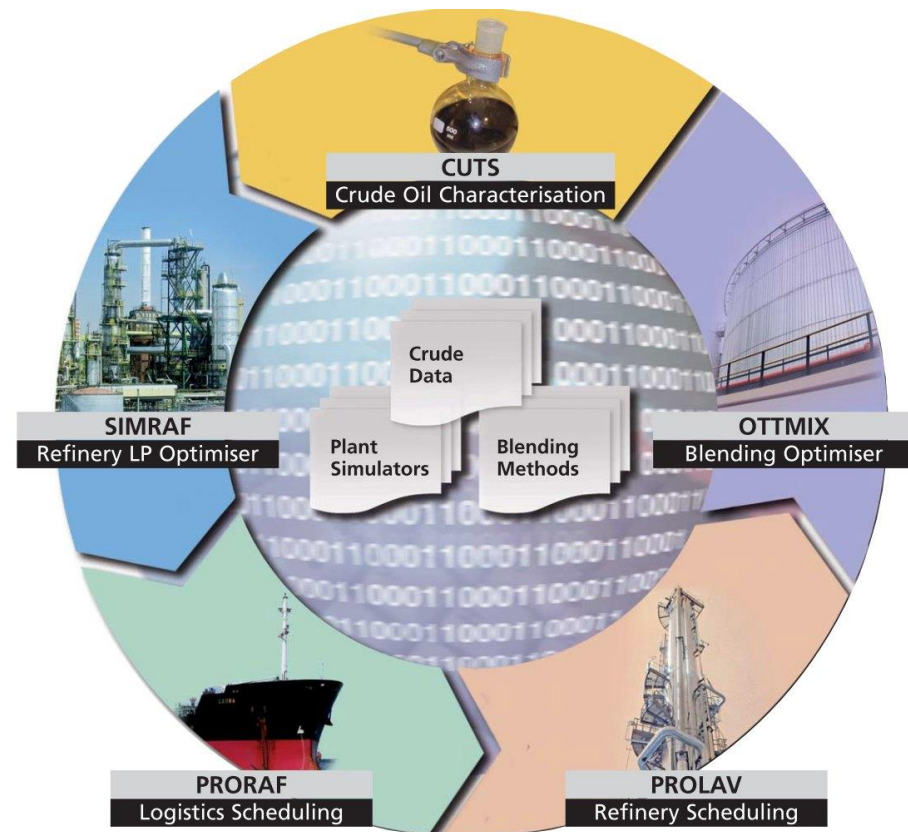
... LP Optimisation

... Scheduling

... Logistics

... Processing

... Blending

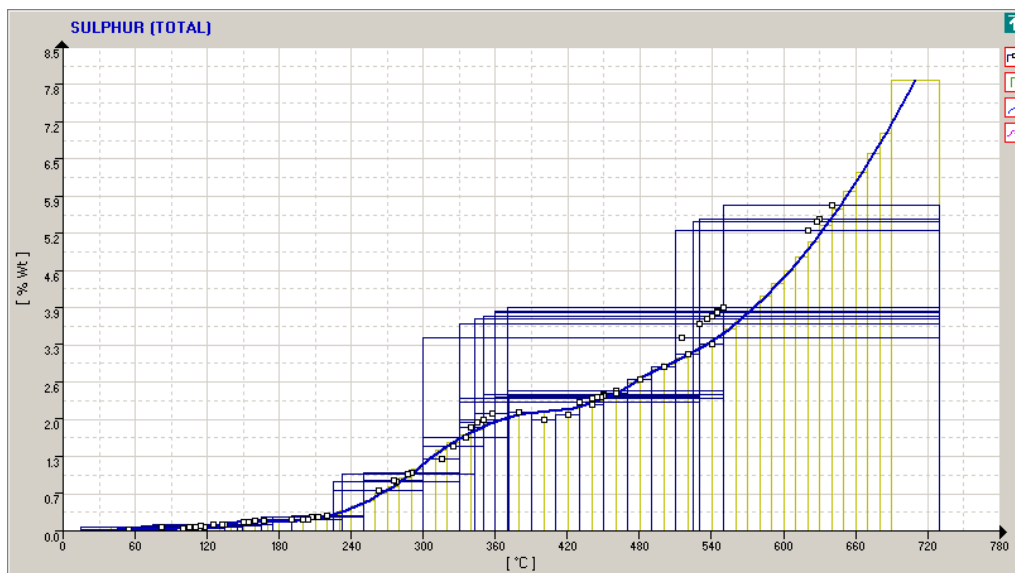


CUTS™: CRUDE ASSAY DATA REGRESSION

“Multi-dimensional regression” characterises crude oils by pseudo - components (narrow cuts) generating information required by processing simulation.

Crude Assay data are not independent: the regression considers at the same time fractions quality balances and distribution shapes.

The system predicts well all characterisation data required for operation Planning and Scheduling activities (~30 fundamental properties plus derived).

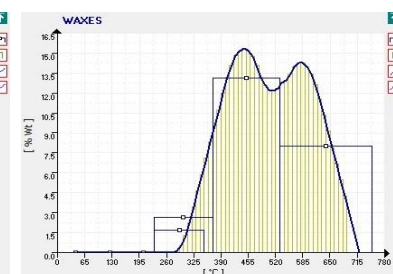
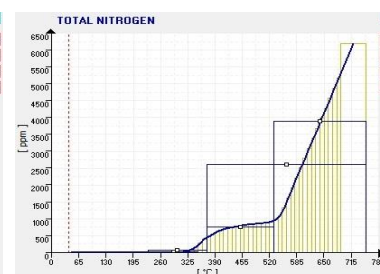
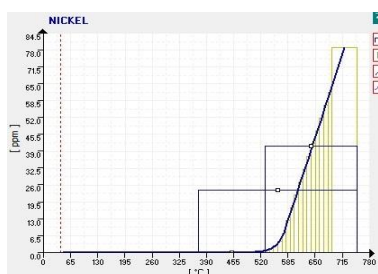
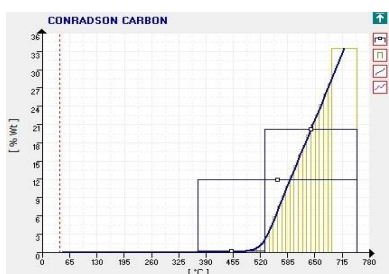
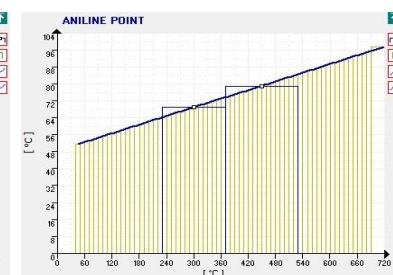
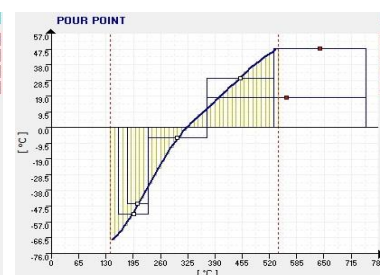
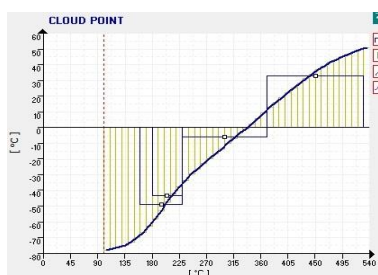
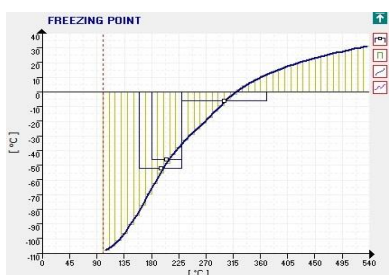
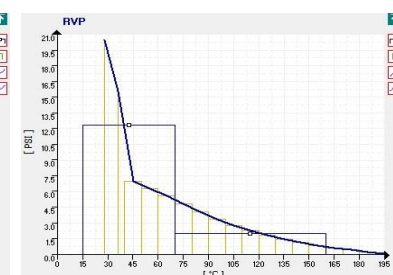
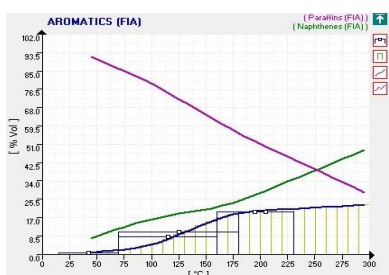
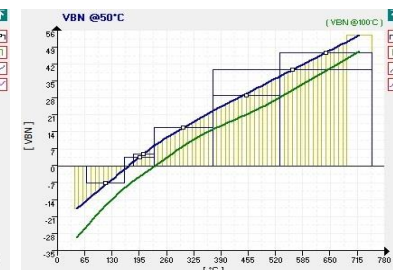
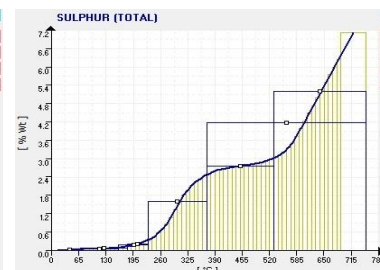
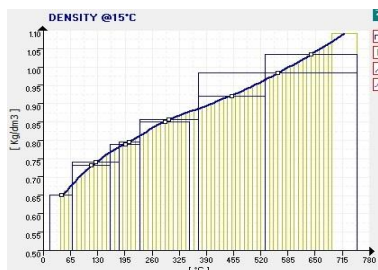
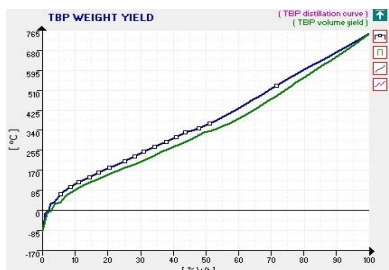


| Results Data Check | | | | | | |
|--------------------------------------|--------------------|------------------|--------------|-------------------|------------------------|----------------|
| Check for property : SULPHUR (TOTAL) | | | | | | |
| CUTS | Initial Temp. [°C] | Final Temp. [°C] | Input [% wt] | Calculated [% wt] | Difference Input-Calc. | Difference [%] |
| BULK | -88.6 | 730.0 | 1.880 | 1.892 | -0.012 | -0.64 % |
| C01 | 15.0 | 95.0 | 0.023 | 0.023 | 0.000 | 0.00 % |
| C06 | 15.0 | 149.0 | 0.056 | 0.056 | 0.000 | 0.00 % |
| C02 | 65.0 | 135.0 | 0.050 | 0.050 | 0.000 | 0.00 % |
| C03 | 65.0 | 145.0 | 0.062 | 0.062 | 0.000 | 0.00 % |
| C04 | 75.0 | 145.0 | 0.069 | 0.067 | 0.002 | 2.90 % |
| C07 | 65.0 | 165.0 | 0.085 | 0.086 | -0.001 | -1.18 % |
| C05 | 90.0 | 145.0 | 0.073 | 0.073 | 0.000 | 0.00 % |
| C09 | 75.0 | 175.0 | 0.106 | 0.104 | 0.002 | 1.89 % |
| C10 | 90.0 | 175.0 | 0.111 | 0.111 | 0.000 | 0.00 % |
| C11 | 95.0 | 175.0 | 0.120 | 0.119 | 0.001 | 0.83 % |
| C08 | 135.0 | 165.0 | 0.150 | 0.150 | 0.000 | 0.00 % |
| C12 | 135.0 | 175.0 | 0.160 | 0.162 | -0.002 | -1.25 % |
| C13 | 145.0 | 175.0 | 0.175 | 0.175 | 0.000 | 0.00 % |
| C14 | 145.0 | 190.0 | 0.180 | 0.180 | 0.000 | 0.00 % |
| C16 | 149.0 | 232.0 | 0.190 | 0.194 | -0.004 | -2.11 % |
| C15 | 175.0 | 225.0 | 0.195 | 0.192 | 0.003 | 1.54 % |
| C17 | 175.0 | 232.0 | 0.200 | 0.200 | 0.000 | 0.00 % |
| C18 | 165.0 | 250.0 | 0.240 | 0.239 | 0.001 | 0.42 % |
| C19 | 175.0 | 250.0 | 0.245 | 0.246 | -0.001 | -0.41 % |
| C20 | 190.0 | 250.0 | 0.260 | 0.260 | 0.000 | 0.00 % |
| C21 | 225.0 | 300.0 | 0.710 | 0.695 | 0.015 | 2.11 % |
| C22 | 250.0 | 300.0 | 0.880 | 0.858 | 0.022 | 2.50 % |
| C23 | 225.0 | 320.0 | 0.870 | 0.870 | 0.000 | 0.00 % |

CUTS™: PROPERTIES

Properties

- TBP weight yield
- Density @15°C
- Sulphur (Total)
- Sulphur (Mercaptans)
- Viscosity @50°C
- Viscosity @100°C
- Viscosity Index
- Acidity
- Aromatics (FIA)
- Naphthenes (FIA)
- Paraffins (FIA)
- Aromatics (GC)
- Naphthenes (GC)
- Paraffins (GC)
- Clear MON
- Clear RON
- TEL 0.5 RON
- TML 0.5 RON
- RVP
- Freezing Point
- Cloud Point
- Pour Point
- Refraction Index @20°C
- Refraction Index @70°C
- Aniline Point
- Total Nitrogen
- Basic Nitrogen
- Ash
- Asphaltenes
- Conradson Carbon
- Nickel
- Vanadium
- Waxes
- Cyclopentane content
- C6 Isoparaffins content
- N-hexane content
- Methylcyclopentane content
- Benzene content
- Cyclohexane content



CUTS™: SOURCE DATA

Tab. 1b: ASTM D2892

| TBP CUT POINT | DISTILLATE % ON CRUDE | CU % |
|---------------|-----------------------|------|
| °C | wt/m | |
| Gas+Gpl | 0.4 | |
| 80 | 3.5 | |
| 100 | 3.6 | |
| 120 | 3.9 | |
| 140 | 4.0 | |
| 160 | 2.4 | |
| 180 | 2.1 | |
| 200 | 4.4 | |
| 210 | 5.2 | |
| 230 | 4.5 | |
| 250 | 4.1 | |
| 270 | 4.2 | |
| 290 | 3.8 | |
| 320 | 5.1 | |
| 350 | 5.7 | |
| 370 | 4.2 | |
| 400 | 4.5 | |
| 400+ | 34.2 | |

Tab. 4: GASOILS

| TBP RANGE | °C | 230-320 | 320-370 | 370-400 | |
|---------------------------------------|----------|---------|---------|---------|-------------|
| YIELD % ON CRUDE | % m/m | 21.63 | 9.21 | 4.66 | ASTM D 2892 |
| | % v/v | 21.41 | 8.66 | 4.29 | ✓ |
| DENSITY @ 15°C | kg/l | 0.8397 | 0.8843 | 0.9024 | ASTM D 4052 |
| SPECIFIC GRAVITY @ 60/60°F | | 0.8401 | 0.8848 | 0.9029 | ** |
| API GRAVITY @ 60/60°F | | 36.9 | 28.4 | 25.2 | ** |
| ✓ SULPHUR (Total) | %m/m | 0.04 | 0.18 | 0.21 | ASTM D 4294 |
| ✓ NITROGEN (Total) | ppm | | 970 | | ASTM D 4629 |
| ✓ BASIC NITROGEN | | | 384 | | UOP 313 |
| ✓ ACIDITY (Total) | mg KOH/g | 0.04 | 0.18 | 0.30 | ASTM D 974 |
| ✓ WAX | %m/m | | 7.29 | | BP 237 |
| ✓ CLOUD POINT | °C | -24 | +3 | -21 | ASTM D 2500 |
| ✓ POUR POINT | °C | -24 | +3 | +18 | ASTM D 97 |
| ✓ CETANE INDEX by four var. equations | | 53.6 | 55.6 | 58.4 | ASTM D 4737 |
| ✓ ANILINE POINT | °C | 77.0 | 81.6 | 84.4 | ASTM D 611 |
| ✓ AROMATICS | | | | | IP 391 |
| Monocyclic | %v/v | 16.6 | 19.3 | 20.3 | |
| Bicyclic | %v/v | 5.3 | 10.0 | 11.3 | ** |
| Tri + Tetracyclic | %v/v | 0.1 | 0.4 | 0.5 | ** |
| Total | %v/v | 21.9 | 29.6 | 32.1 | ** |
| ✓ REFRACTIVITY INDEX @ 70°C | | 1.4464 | 1.4700 | 1.4809 | ASTM D 1747 |
| ✓ CARBON RESIDUE (Connorsen) | %m/m | | | | ASTM D 4530 |
| ✓ KINEMATIC VISCOSITY @ 40 °C | mm²/s | 4.383 | | | ASTM D 445 |
| ✓ " " " " 50 °C | mm²/s | 3.956 | 3.97 | 15.78 | ** |
| ✓ " " " " 50 °C | VBN | 16.60 | 16.60 | 25.98 | ASTM D 341 |
| ✓ " " " " 60 °C | mm³/s | 3.960 | 11.320 | | ASTM D 445 |

STANDARD CRUDE ASSAY



| TEST RUN RESULTS | | | | | | |
|------------------|--------------------|----------------|----------|--------------|--------------|---------|
| | Stabilised Naphtha | Light Kerosene | Kerosene | Light Gasoil | Heavy Gasoil | Residue |
| Density | Kg/m3 | 711.30 | 787.60 | 812.60 | 840.00 | 866.60 |
| Yield | % m/m | 24.30 | 15.47 | 7.50 | 16.22 | 5.31 |
| Distillation | | D86 | D86 | D86 | D86 | D1160 |
| IBP | | 36.5 | 150.9 | 156.9 | 225.5 | 252.0 |
| 10 %w | °C | 62.7 | 167.3 | 212.8 | 280 | 354 |
| 30 %w | °C | 81.6 | 180 | 236.1 | 293 | 400 |
| 50 %w | °C | 99.5 | 190.5 | 248.2 | 313 | 425 |
| 70 %w | °C | 116 | 203 | 257 | 330 | 450 |
| 90 %w | °C | 137 | 212 | 269 | 360 | 475 |
| EBP | | 160 | 238 | 286 | >371.0 | 504 |

FIELD DATA



Crude oil database



| Crude Oils to blend | |
|-----------------------|----------------|
| Crudes List | Percentage [%] |
| Russia | |
| ● KALG KALININGRAD | 8.00 |
| ● SIB5 SIBERIAN LIGHT | 31.50 |
| ● URA9 URALS | 48.50 |
| ● URAV URA4 Vac. Dist | 12.00 |
| TOTAL | 100.00 |

Blend composition

STANDARD BLEND



Crude oil database



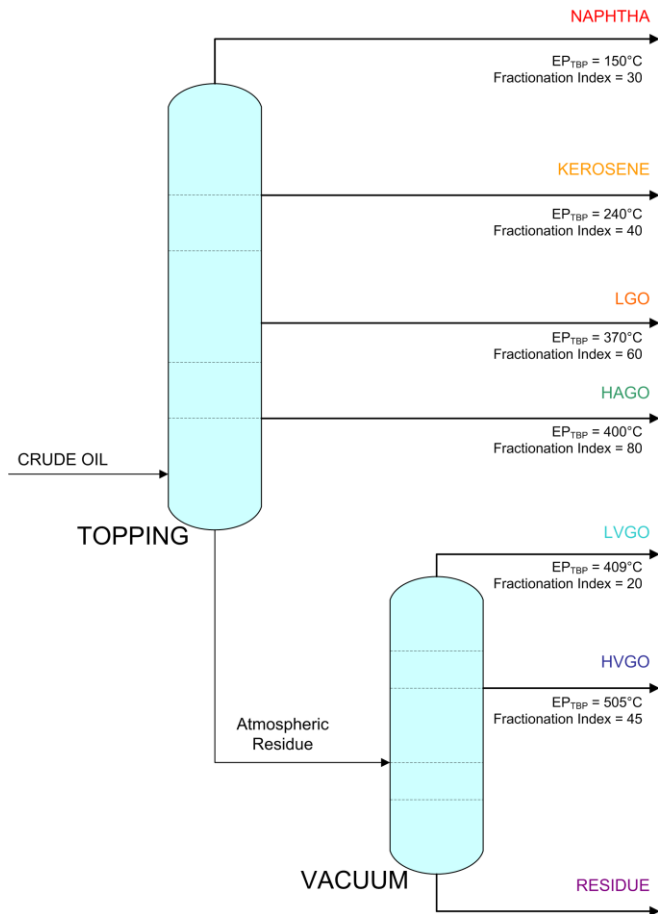
| Type | Property | Temperature [°C] | Unit | Initial temperature [°C] | Final temperature [°C] | Specified Value | Calculated Value |
|------|----------------------|------------------|--------|--------------------------|------------------------|-----------------|------------------|
| Bulk | Density @15°C | | Kg/dm3 | | | 0.8580 | 0.8610 |
| Bulk | Pure Component Yield | | % wt | 88.6 | -0.5 | 1.200 | 1.162 |
| Bulk | Sulphur (Total) | | % wt | | | 1.770 | 1.814 |
| Bulk | TBP Recovered@ | 70.0 | % wt | | | 3.90 | 4.60 |
| Bulk | TBP Recovered@ | 190.0 | % wt | | | 21.90 | 22.07 |
| Bulk | TBP Recovered@ | 225.0 | % wt | | | 30.00 | 29.97 |
| Bulk | TBP Recovered@ | 280.0 | % wt | | | 38.20 | 38.10 |
| Bulk | TBP Recovered@ | 343.0 | % wt | | | 49.30 | 49.20 |
| Bulk | TBP Recovered@ | 565.0 | % wt | | | 81.30 | 81.40 |
| Cut | Viscosity @100°C | | Cst | 343.0 | + | 25.00 | 25.72 |

Target Specifications

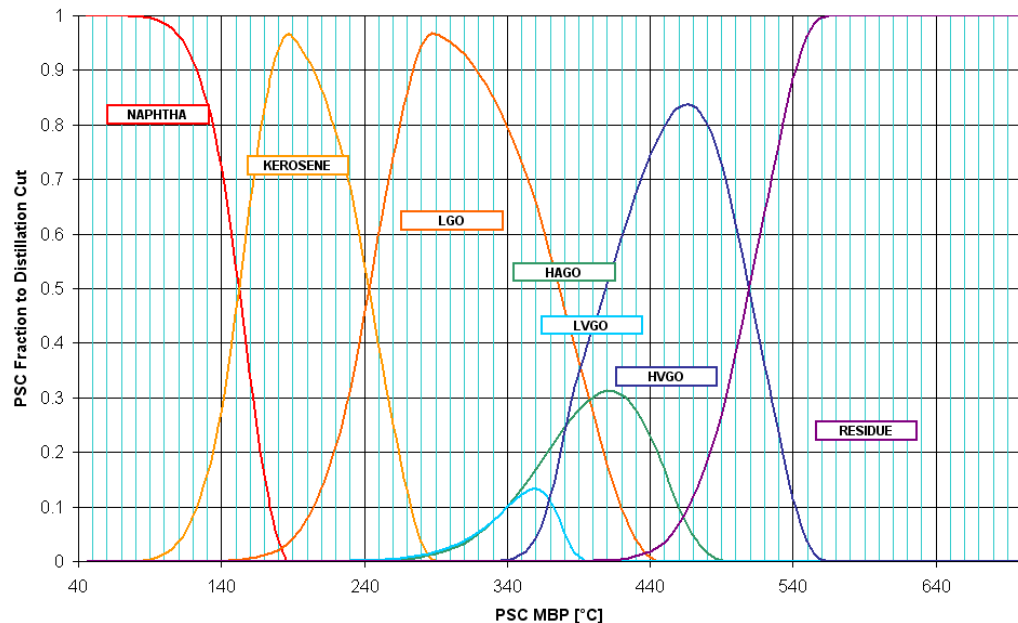
OPTIMIZED BLEND (DATA MINING)

ACCOUNTING FOR REAL FRACTIONATION

Detailed crude characterisation permits to embed directly in the LP model processes and activities usually realised externally like:



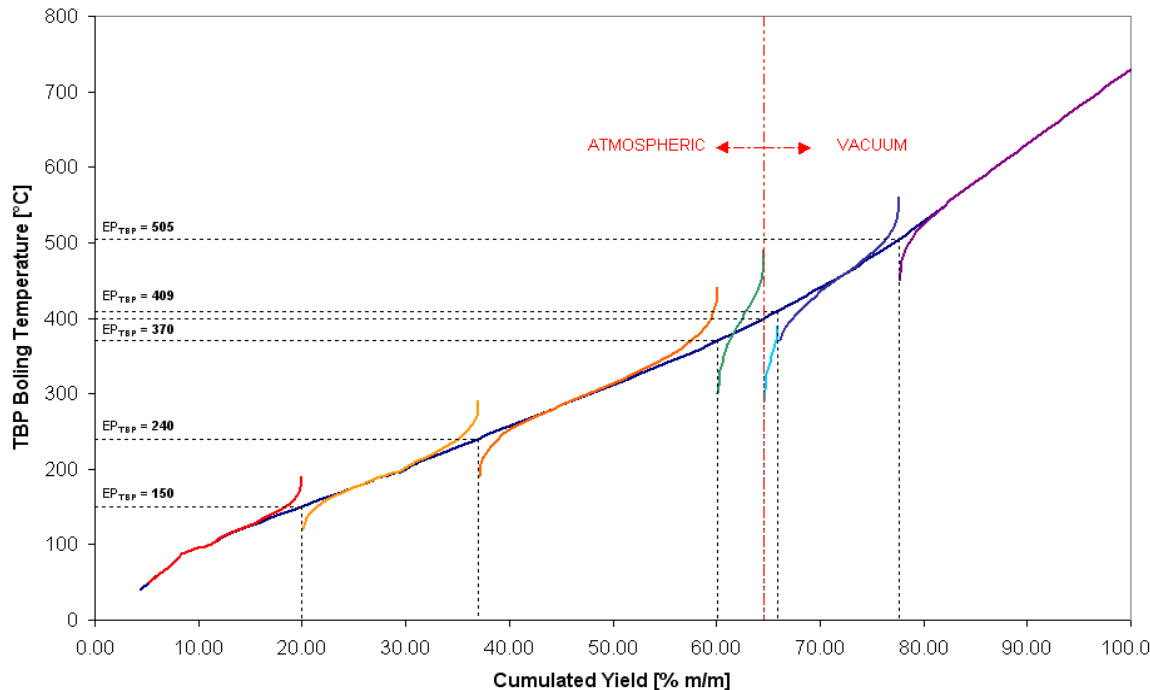
- Calculate oil mixes and fractions
- Simulate distillation units (with efficiency)
- Characterise Process units feedstock and effluents.



ACTUAL DISTILLATION RESULTS

Ignoring this effect introduces quality estimations errors affecting the optimal solution (overestimating refinery result).

The bigger impact is on viscosity, cold properties and distillation values.



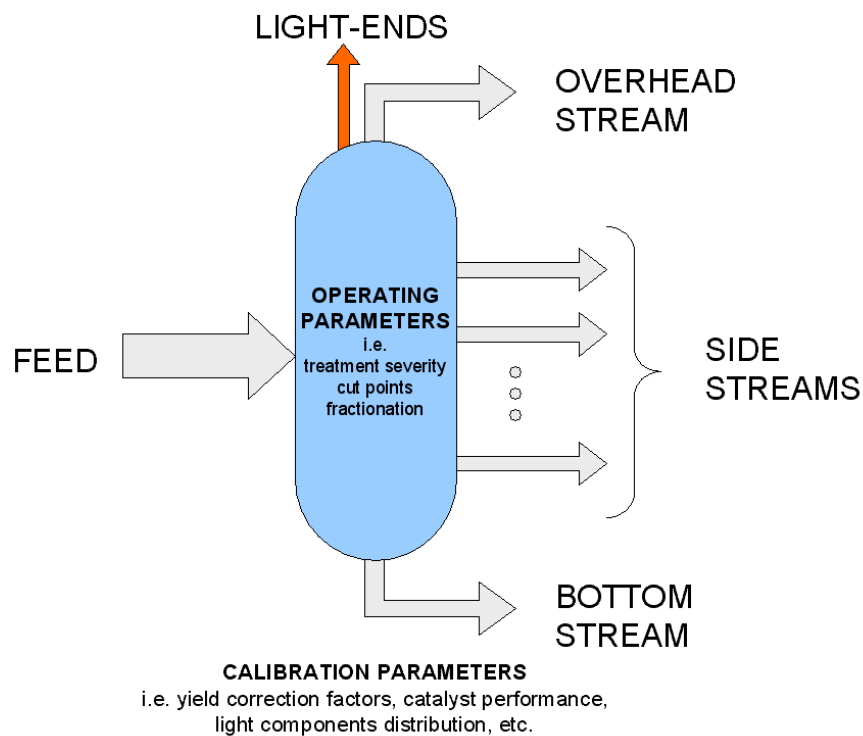
| RECUTTING WITHOUT FRACTIONATION INDEXES | | | | | | | | |
|---|--------------------|---------|-------|-------|-------|-------|-------|---------|
| | | NAPHTHA | KERO | LGO | HAGO | LVGO | HVGO | RESIDUE |
| Yield | % m/m | 19.55 | 17.12 | 23.05 | 4.53 | 1.30 | 11.72 | 22.37 |
| Density 15/4 | Kg/dm ³ | 0.695 | 0.792 | 0.850 | 0.892 | 0.899 | 0.917 | 1.013 |
| Sulphur | % m/m | 0.053 | 0.208 | 1.244 | 2.057 | 1.982 | 2.371 | 5.189 |
| Viscosity@50°C | cst | 0.41 | 1.04 | 3.33 | 10.2 | 14.6 | 35.6 | 33229 |
| Freezing | °C | | -51.9 | -8.1 | | | | |
| Cloud | °C | | -49.1 | -3.6 | 21.2 | 25.8 | 34.2 | |
| Pour | °C | | -51 | -6.4 | 16.5 | 20.4 | 32 | |
| Rec.@100 | % v/v | 56 | | | | | | |
| Rec.@250 | % v/v | | 100 | 0 | 0 | 0 | | |
| Rec.@360 | % v/v | | | 100 | 0 | 0 | | |

| RECUTTING WITH FRACTIONATION INDEXES | | | | | | | | |
|--------------------------------------|--------------------|---------|-------|-------|-------|-------|-------|---------|
| | | NAPHTHA | KERO | LGO | HAGO | LVGO | HVGO | RESIDUE |
| Yield | % m/m | 19.55 | 17.12 | 23.05 | 4.53 | 1.30 | 11.72 | 22.37 |
| Density 15/4 | Kg/dm ³ | 0.696 | 0.792 | 0.851 | 0.893 | 0.872 | 0.916 | 1.012 |
| Sulphur | % m/m | 0.059 | 0.242 | 1.247 | 2.005 | 1.746 | 2.395 | 5.166 |
| Viscosity@50°C | cst | 0.41 | 1.05 | 3.4 | 11.8 | 5.5 | 32.6 | 29931 |
| Freezing | °C | | -48 | -7.2 | | | | |
| Cloud | °C | | -45.1 | -0.6 | 23.7 | 8.2 | 33.8 | |
| Pour | °C | | -48.6 | -5.3 | 18.8 | 6.6 | 31.4 | |
| Rec.@100 | % v/v | 52 | | | | | | |
| Rec.@250 | % v/v | | 99 | 4 | 0 | 0 | | |
| Rec.@360 | % v/v | | | 93 | 21 | 96 | | |

Changes in the range 10-20 %
Changes beyond 20 %

PLANT SIMULATION MODELS

Plant simulation models are integrated in the models and calculate **effluents yields and quality** as function of feedstock and of meaningful operating variables.



- Fine-tuneable to predict **actual performance**.
- Need for **few** input data
- Available processes are:
 - ✓ Distillation (primary and successive)
 - ✓ Hydrogenation and Desulphurisation.
 - ✓ Thermal Conversions (Coking, VB, THC)
 - ✓ Catalytic Conversions (Reforming, FCC, Hydrocracking)
 - ✓ Lubricant (Solvent Dearomatisation and Dewaxing, Catalytic Dewaxing).
- The same algorithms are applied both in **SIMRAF** and in **PROLAV**

SIMULATION MODELS – CATALYTIC PROCESSES

| PROCESS | VARIABLE | DESCRIPTION |
|--------------------------|---|--|
| CATALYTIC REFORMING | Feedstock Severity Pressure Fractionation Cycle advancement Model tuning | Density, Distillation, PNA, RVP Reformate C5 PLUS RON Average reactor Pressure Light Ends Distribution H2 and Reformate EOR Yield Correction Hydrogen and Reformate Yield Correction |
| FLUID CATALYTIC CRACKING | Feedstock Severity Feed Type Fractionation Model tuning | Characterisation Factor (VABP, Sulphur, AP, SG) Gasoline 204°C Vol Conversion Hydrotreated or not Light Ends Distribution, TBP Cuts and Fractionation Efficiency Catalyst performance, C3-204 and Coke yield correction |
| MILD HYDROCRACKING | Feedstock Conversion Severity HDS Severity H2 Consumption Fractionation | Density, Sulphur, Nitrogen, Bromine, Viscosity, Distillation Wt. Conversion of 375°C Plus fraction % of Feedstock sulphur removed Detailed HDS, HDN, HDBr, Conversion, Downgrade Light Ends Distribution, TBP Cuts and Fractionation Efficiency |
| HYDROTREATMENT | Feedstock HDS Severity HDN Severity HDBr Severity Yields H2 Consumption | Density, Sulphur, Nitrogen, Bromine, Distillation, Cold Properties % of Feedstock Sulphur removed or ppm Sulphur out % of Feedstock Nitrogen removed % of Feedstock Bromine number removed Fuel Gas and Wild Naphtha Detailed HDS, HDN, HDBr, Conversion, Downgrade |

SIMULATION MODELS – THERMAL PROCESSES

| PROCESS | VARIABLE | DESCRIPTION |
|------------------|-------------------------------|--|
| VISBREAKING | Feedstock | Density, Sulphur, Nitrogen, Cold Properties, Viscosity, Conradson, Metals, Asphaltenes, Distillation |
| | Severity | Wt. Conversion of 371°C Plus fraction |
| | Feed Type | Atmospheric / Vacuum Residue |
| | Fractionation Model tuning | Light Ends Distribution, TBP Cuts and Fractionation Efficiency Residue Viscosity Calculation parameters |
| THERMAL CRACKING | Feedstock | Density, Sulphur, Nitrogen, Cold Properties, Viscosity, Conradson, Metals, Asphaltenes, Distillation |
| | Severity | Wt. Conversion of 371°C Plus fraction |
| | Feed Type | Percentage of Recycled VGO |
| | Fractionation Model tuning | Light Ends Distribution, TBP Cuts and Fractionation Efficiency Residue Viscosity Calculation parameters |
| COKING | Feedstock | Density, Sulphur, Nitrogen, Cold Properties, Viscosity, Conradson, Metals, Asphaltenes, Distillation |
| | Feed Type | Atmospheric / Vacuum Residue |
| | Fractionation | Light Ends Distribution, TBP Cuts and Fractionation Efficiency |
| | Model tuning | Coke yield correction |

SIMULATION MODELS – LUBRICANTS

| PROCESS | VARIABLE | DESCRIPTION |
|----------------------------|-------------------------------|---|
| SOLVENT DEAROMATISATION | Feedstock | Density, Sulphur, Cold Properties, Viscosity, Viscosity Index Refraction Index, Wax Content, Distillation |
| | Solvent | Solvent Feed Ratio |
| | Temperature Model tuning | Extraction Temperature PNA distribution over products for max/min operating variables values (fine tuning for actual unit performance) |
| SOLVENT DEWAXING | Feedstock | Density, Sulphur, Cold Properties, Viscosity, Viscosity Index Refraction Index, Wax Content, Distillation |
| | Separation Model tuning | Hard / Soft wax ratio Hard wax oil content / soft wax oil content |
| CATALYTIC DEWAXING | Feedstock | Density, Sulphur, Cold Properties, Viscosity, Viscosity Index Refraction Index, Wax Content, Distillation |
| | Severity | Product Pour Point |
| | HDS Severity | % of Feedstock sulphur removed |
| | Cycle | Cycle advancement |
| | Fractionation Model tuning | Light Ends Distribution. SOR/EOR Light Ends and Naphtha Yields, Min/Max/Design LHSV, SOR/Min/Max Reactor Temperature, Hydrogen consumption (Detailed HDS, HDN, HDBr, Conversion, Downgrade) |

SIMRAF – LP PLANNING TOOL: APPLICATIONS

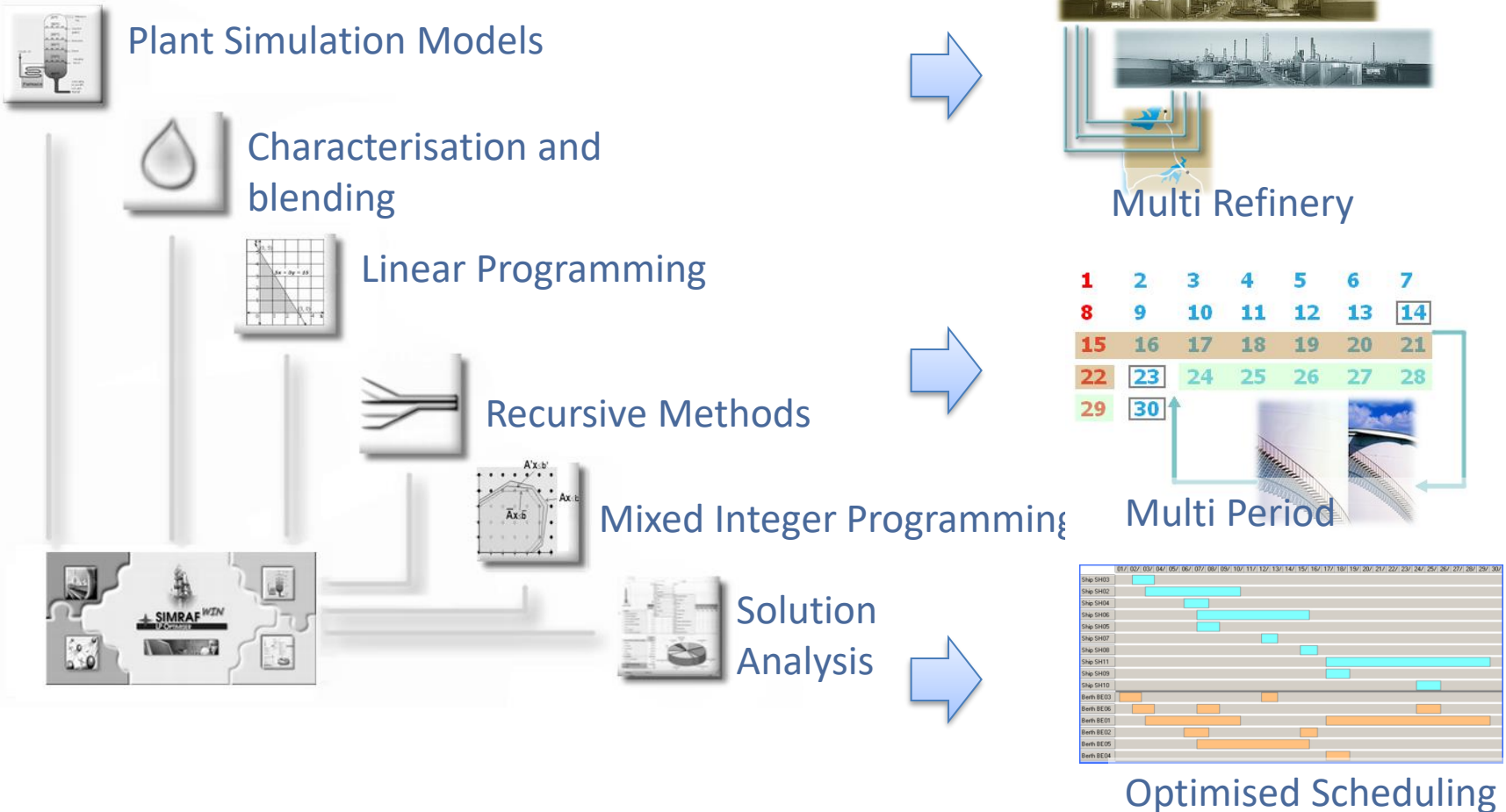
Conceived by refinery experts it an “industry oriented” LP tool.

Intuitive for oil downstream professionals supports the addressing of strategic and ordinary planning problems:



SIMRAF TECHNOLOGIES

The competitive advantage results from the availability in the same environment of simulation and optimisation technologies:



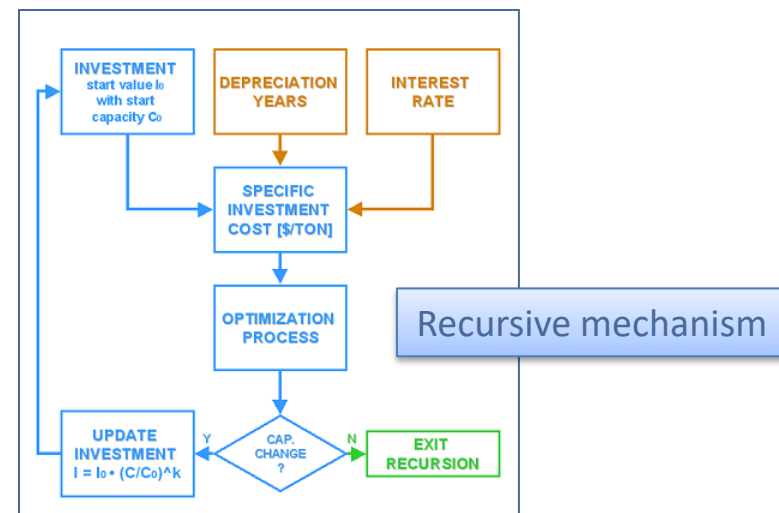
STRATEGIC PLANNING STUDIES

SIMRAF disposes of particular features useful in case of strategic Planning studies for new investments.

INVESTMENTS 01 => 1 - COMPLEX REFINERY => Economics => Investments

| Plants | Handlings | Tanks | Investment Templates | | | |
|----------------------|-----------|------------|----------------------|-------------|-------------|--------------|
| Type | Unit | VA | MH | CC | DC | SU |
| Description | | DI | CO | CO | CO | FY |
| Template | | Vacuum | Mild Hydrocr. | FCC | Coker | Sulfur Plant |
| Recursion | | YES | YES | YES | YES | YES |
| Capacity | ton/day | 5600 | 3000 | 1700 | 2000 | 70 |
| Stream days per year | days | 330 | 330 | 330 | 330 | 330 |
| Capital cost | \$ | 58314670.0 | 226020300.0 | 116313300.0 | 105866800.0 | 11849110.0 |
| Interest rate | % | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Amortization period | year | 10 | 10 | 10 | 10 | 10 |
| Scale factor | | 0.7 | 0.65 | 0.6 | 0.6 | 0.6 |
| Specific cost | \$/ton | 4.7 | 34.0 | 30.9 | 2 | |

Capital costs



| ECONOMIC RESULTS | UNIT | VALUE |
|------------------------------|------|---------------|
| Sales | \$ | 3,426,333,174 |
| Purchases | \$ | 2,767,892,727 |
| Variable Costs | \$ | 11,698,200 |
| Personnel | \$ | 52,058,822 |
| Maintenance | \$ | 62,470,586 |
| Insurance + Property Taxes | \$ | 26,029,411 |
| Overheads | \$ | 29,152,940 |
| Total Production Costs | \$ | 2,949,302,686 |
| Interest on Investments Debt | \$ | 27,560,640 |
| Interest on working capital | \$ | 18,741,176 |
| Fixed Depreciation | | 673,528 |
| Valued Depreciation | | 471,322 |
| Total Costs | | 749,352 |
| Taxable income | \$ | 349,583,821 |
| Income Tax | \$ | 87,395,955 |
| Net Income | \$ | 262,187,866 |
| Capital Costs | \$ | 494,357,343 |
| Cash Flow | \$ | 329,754,597 |
| Pay Out Period | year | 1.50 |
| DCFRR - IRR | % | 66.7 |

Financial result

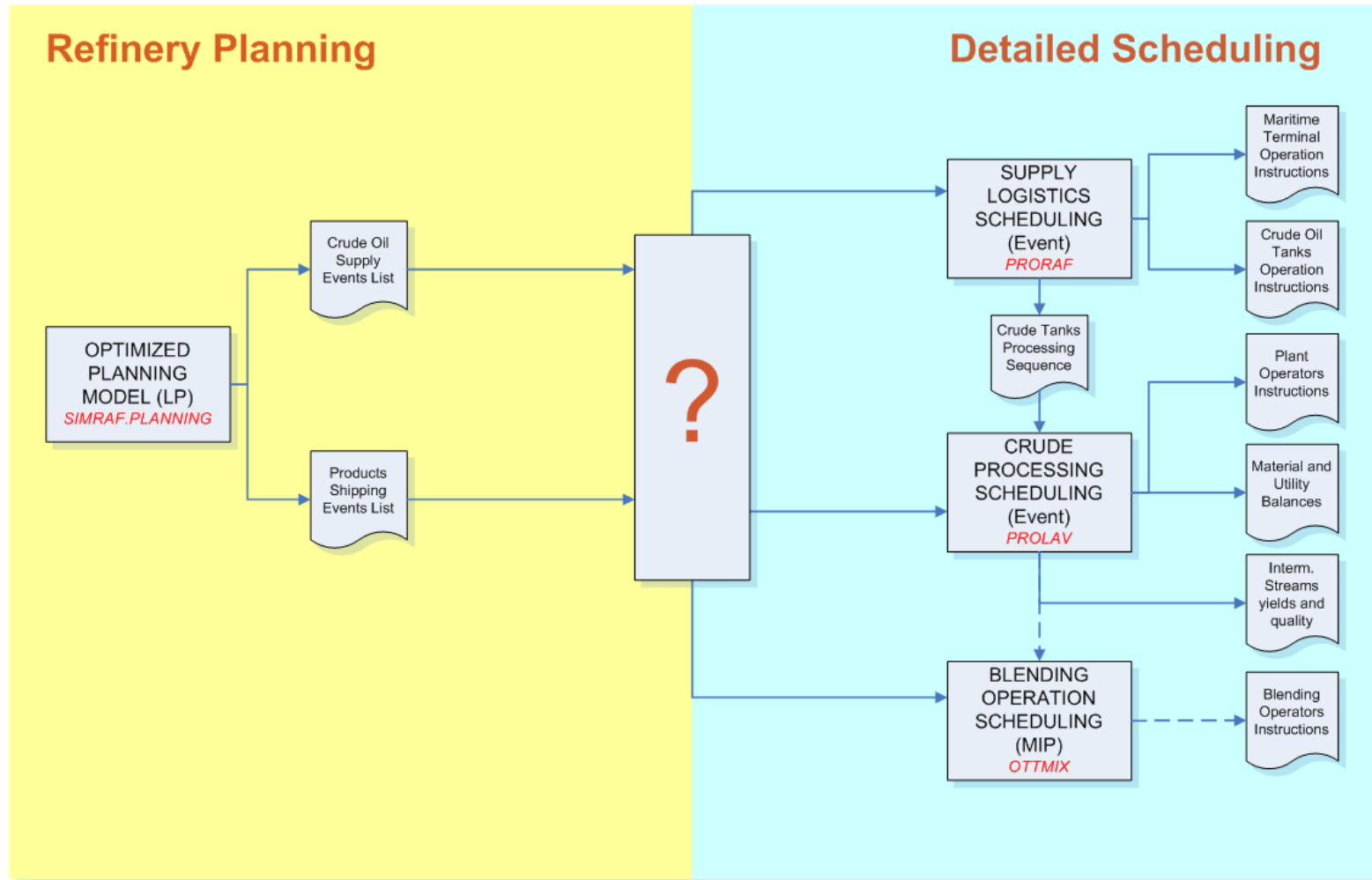


INVESTMENTS 01 => 1 - COMPLEX REFINERY => Economics => Fixed Costs

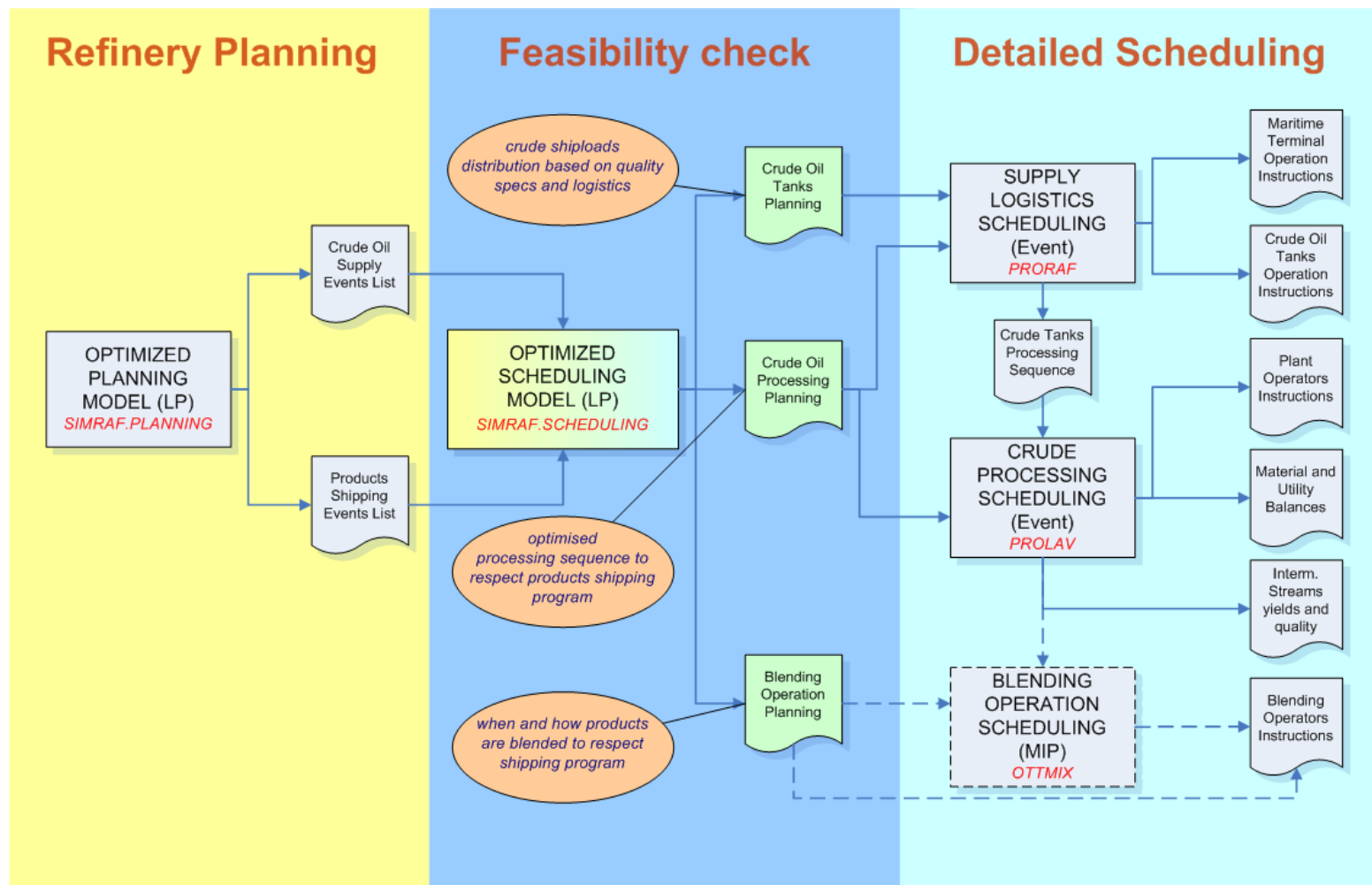
| Annual Fixed Costs | | |
|---------------------------------|------|------------|
| Description | Unit | Value |
| Personnel | \$ | 50,000,000 |
| Maintenance | \$ | 60,000,000 |
| Insurance + Property Taxes | \$ | 25,000,000 |
| Overheads | \$ | 28,000,000 |
| Past Depreciation | \$ | 28,500,000 |
| Working Capital Financial Cost | \$ | 18,000,000 |
| Income Tax on Gross Profit | % | 25.0 |
| Working Days | - | 340.0 |
| NPV/DCFRR/IRR Period | year | 20.00 |
| Net Present Value Interest Rate | % | 15.0 |

Fixed costs

TURNING PLANNING INTO REALITY...

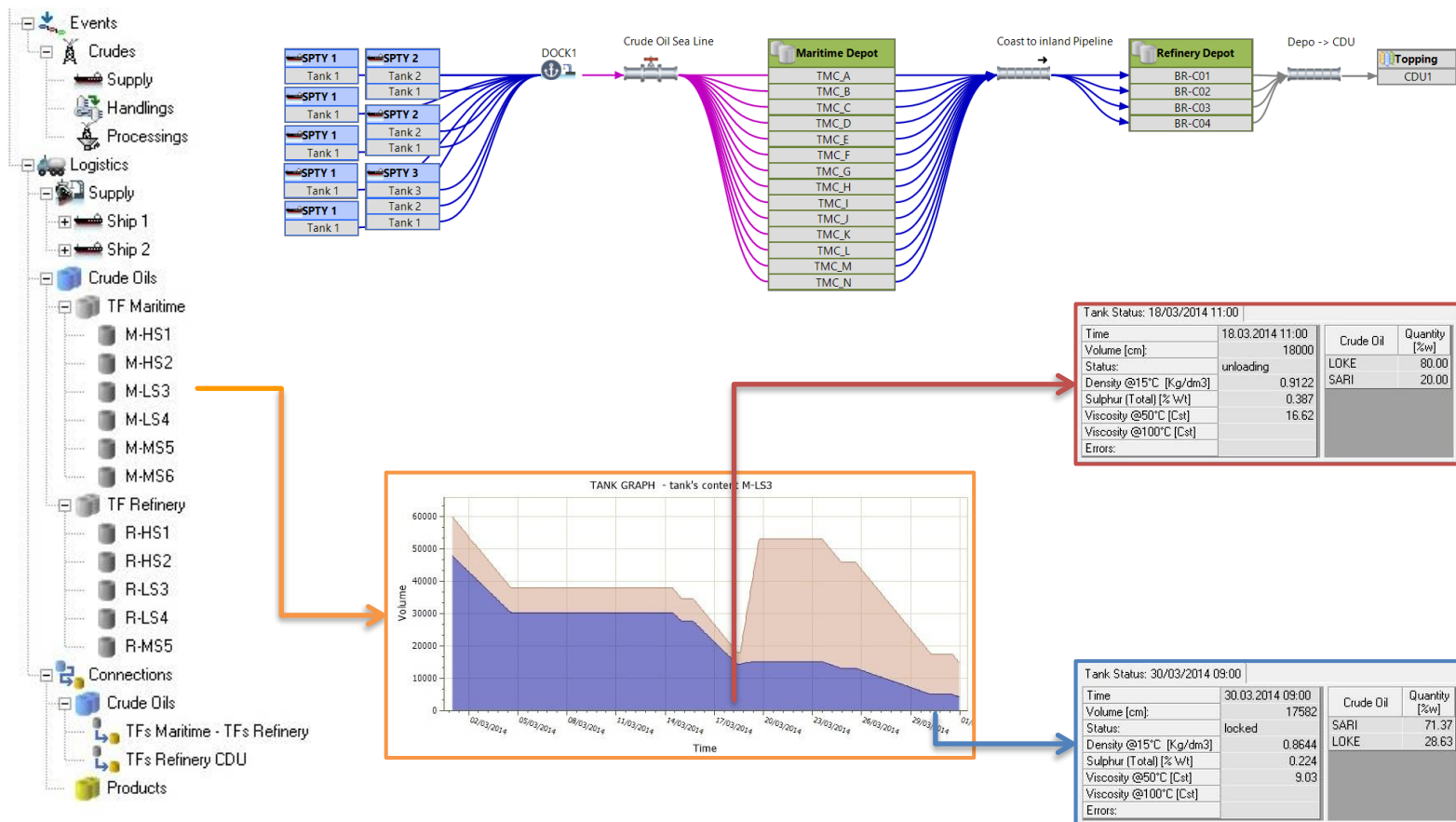


PLANNING FEASIBILITY CHECK



PRORAF: LOGISTICS SIMULATION

Considering supply, handling and processing events calculates the hourly evolution of each tank status, returning volume and composition for each tank to be processed.



PRORAF: EVENTS EDITOR

This environment enables the definition of transfer events and the setting of related parameters (type, calculation mode, origin, destination, volume, flow rate and quality constraints).

The screenshot displays the PRORAF Events Editor interface. The main window shows a timeline from day 23 to 25. The left sidebar lists various event categories: Supply Carriers (Olympic Spirita, Nordic Mistral, Jag Lakshita, Nordic Hunter, Sinopa, Jag Lateef), Supply Continuous, Transfers (To Refinery, OI, OO, DI, DO), and Processings (CDU Processing 1, OI, OO, DI, DO). The central timeline area shows a sequence of events: Tank 1 and Tank 2 (blue), Maritime Depot (red), TMC_J, TMC_D, and TMC_E (green), followed by BR-C04, BR-C01, BR-C02, BR-C01, BR-C03, BR-C02, BR-C01, BR-C03, and CDU1 (green).

The right sidebar contains configuration panels:

- Event Generalities:** Description, Calendar (To Refinery), Ignore Tank, Quantity [m3], Flow Rate [m3/d] (Auto, 39240).
- Sequence Generalities:** Type (Parallel), Mode (Auto/Quantity), Loop.
- Sequence Element:** General Data (Sequence Type: Parallel, Sequence Mode: Auto/Quantity, Element Type: Set), Calculate (Start Date: 23/04/2018 18:00:00, End Date: 25/04/2018 18:00:00, Quantity [m3]: 78480, Flow Rate [m3/d]: 39239.98, Lot Limit [m3]).
- Group Data:** Table showing data for Maritime Depot, TMC_G, TMC_N, TMC_F, and TMC_L.
- Qualities:** Panel for quality constraints.

At the bottom, the status bar shows "9TRA|To Refinery|OO|9", the date "24/04/2018", and the location "SCA|Nordic Hunter".

| + | Tank Farm | Tank | Quantity [%] | Quantity [m3] | Flow Rate Max [m3/d] | Crude Type |
|---|----------------|-------|--------------|---------------|----------------------|------------|
| | Maritime Depot | TMC_G | 46.43 | 36438 | 18219 | HACO |
| | Maritime Depot | TMC_N | 23.26 | 18251 | 9126 | LACO |
| | Maritime Depot | TMC_F | 21.37 | 16771 | 8385 | HACO |
| | Maritime Depot | TMC_L | 8.94 | 7019 | 3510 | HTCO |

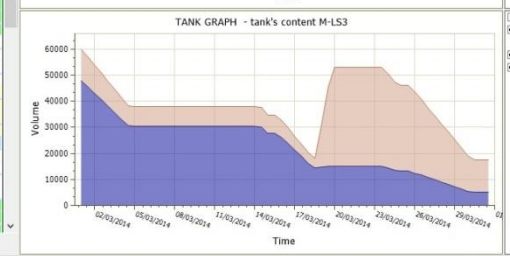
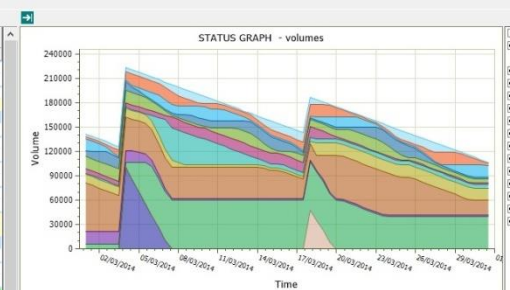
PRORAF: CALCULATION ENGINE

Manages the service requests for supply, handling and processing events to produce an operative plan considering:

- Volume and pumping (Load/Unload) constraints
- Status (volume and content) and availability
- Handling operations (Drainage, Measurements)
- Quality specifications
- Pipeline quality tracking
- Tank selection logics

| EdtTank | Tank's Operations | Quality Specifications | Tank Status | Tank Report |
|------------------|-------------------|------------------------|-------------|----------------------------------|
| 01.03.2014 00:00 | 04.03.2014 16:00 | Unloading | -22000 | Frequency [Hours]: 24 |
| 04.03.2014 16:00 | 04.03.2014 19:00 | Locked | 0 | Samplings |
| 04.03.2014 19:00 | 14.03.2014 12:00 | Stop | 0 | Volume [m3] |
| 14.03.2014 12:00 | 15.03.2014 01:00 | Unloading | -3343 | Status |
| 15.03.2014 01:00 | 15.03.2014 04:00 | Locked | 0 | 02.03.2014 00:00 53800 Unloading |
| 15.03.2014 04:00 | 15.03.2014 18:00 | Stop | 0 | 03.03.2014 00:00 47702 |
| 15.03.2014 18:00 | 18.03.2014 12:00 | Unloading | -16657 | 04.03.2014 00:00 41902 |
| 18.03.2014 12:00 | 18.03.2014 15:00 | Locked | 0 | 05.03.2014 00:00 38000 Stop |
| 18.03.2014 15:00 | 19.03.2014 20:00 | Loading | 35077 | 06.03.2014 00:00 38000 |
| 19.03.2014 20:00 | 19.03.2014 23:00 | Locked | 0 | 07.03.2014 00:00 38000 |
| 19.03.2014 23:00 | 23.03.2014 15:00 | Stop | 0 | 08.03.2014 00:00 38000 |
| 23.03.2014 15:00 | 24.03.2014 19:00 | Unloading | -7108 | 09.03.2014 00:00 38000 |
| 24.03.2014 19:00 | 24.03.2014 22:00 | Locked | 0 | 10.03.2014 00:00 38000 |
| 24.03.2014 22:00 | 25.03.2014 16:00 | Stop | 0 | 11.03.2014 00:00 38000 |
| 25.03.2014 16:00 | 30.03.2014 07:00 | Unloading | -28386 | 12.03.2014 00:00 38000 |
| 30.03.2014 07:00 | 30.03.2014 10:00 | Locked | 0 | 13.03.2014 00:00 38000 |
| 30.03.2014 10:00 | 31.03.2014 14:00 | Stop | 0 | 14.03.2014 00:00 38000 |
| 31.03.2014 14:00 | 01.04.2014 00:00 | Unloading | -2842 | 15.03.2014 00:00 34657 Unloading |
| | | | | 16.03.2014 00:00 32849 |
| | | | | 17.03.2014 00:00 26649 |
| | | | | 18.03.2014 00:00 20449 |
| | | | | 19.03.2014 00:00 30500 Loading |
| | | | | 20.03.2014 00:00 53077 Stop |
| | | | | 21.03.2014 00:00 53077 |
| | | | | 22.03.2014 00:00 53077 |
| | | | | 23.03.2014 00:00 53077 |
| | | | | 24.03.2014 00:00 50494 Unloading |
| | | | | 25.03.2014 00:00 45969 Stop |
| | | | | 26.03.2014 00:00 43644 Unloading |
| | | | | 27.03.2014 00:00 37444 |
| | | | | 28.03.2014 00:00 31244 |
| | | | | 29.03.2014 00:00 25202 |
| | | | | 30.03.2014 00:00 19002 |
| | | | | 31.03.2014 00:00 17592 Stop |
| | | | | 01.04.2014 00:00 14741 Unloading |

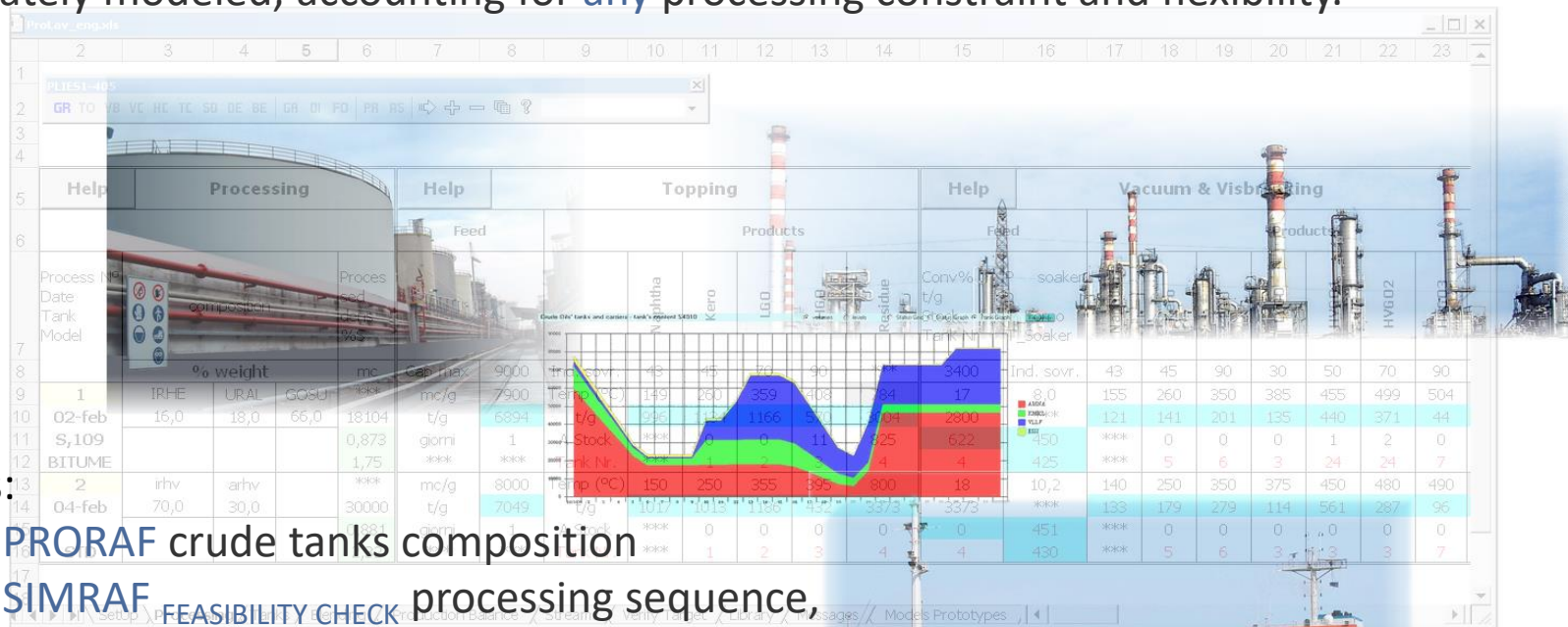
| Date | Hours | Ship 1 | Ship 2 | TF Maritime | TF Refinery |
|------------|-------|--------|--------|--|------------------------------|
| 01.03.2014 | 00:00 | 6000 I | 15000 | 6000 I 10677 1250 5600 | 15000 6835 15000 N 2500 3000 |
| 01.03.2014 | 12:00 | 6000 I | 15000 | 6000 I 96900 10677 1250 5600 | 15000 9677 12000 2758 3000 |
| 02.03.2014 | 00:00 | 6000 I | 15000 | 6000 I 53800 10677 1250 5600 | 15000 12777 3000 2758 3000 |
| 02.03.2014 | 12:00 | 6000 I | 15000 | 6000 I 50802 10677 1250 5600 | 15000 6000 2758 3775 |
| 03.03.2014 | 00:00 | 6000 I | 15000 | 6000 I 47702 10677 1250 5600 | 15000 15000 3000 5342 4282 |
| 03.03.2014 | 12:00 | 6000 I | 15000 | 6000 I 44602 10677 1250 5600 | 15000 13500 1697 8442 4282 |
| 04.03.2014 | 00:00 | 6000 I | 15000 | 6000 I 41502 10677 1250 5600 | 15000 10500 1697 11542 4282 |
| 04.03.2014 | 12:00 | 100000 | 21000 | 15000 38402 10677 1250 5600 | 15000 7500 1697 14642 4282 |
| 05.03.2014 | 00:00 | 70000 | 36000 | 13125 38000 10677 1250 5600 | 15000 4500 3615 15000 4282 |
| 05.03.2014 | 12:00 | 55000 | 51000 | 10625 38000 10677 1250 5600 | 14900 2200 6115 15000 4282 |
| 06.03.2014 | 00:00 | 41000 | 60000 | 8125 38000 10677 6250 5600 | 11500 2200 8615 15000 4282 |
| 06.03.2014 | 12:00 | 26000 | 60000 | 5625 38000 10677 21250 5600 | 8500 2200 11115 15000 4282 |
| 07.03.2014 | 00:00 | 11000 | 60000 | 3125 38000 10677 36250 5600 | 6500 2200 11324 15000 5663 |
| 07.03.2014 | 12:00 | 60000 | 2000 | 38000 9127 40000 12850 2500 2200 | 11324 15000 9258 |
| 08.03.2014 | 00:00 | 60000 | 2000 | 38000 6084 40000 12850 2500 3432 | 11324 12000 11000 |
| 08.03.2014 | 12:00 | 60000 | 2000 | 38000 3077 40000 12850 2500 6508 | 11324 9000 11000 |
| 09.03.2014 | 00:00 | 60000 | 2000 | 38000 3077 38900 12850 2500 8575 | 12257 6000 11000 |
| 09.03.2014 | 12:00 | 60000 | 2000 | 38000 3077 34257 12850 2500 8575 | 15000 3000 11000 |
| 10.03.2014 | 00:00 | 60000 | 2000 | 38000 3077 32449 12850 2500 8575 | 15000 4308 8500 |
| 10.03.2014 | 12:00 | 60000 | 2000 | 38000 3077 29349 12850 3533 8575 | 15000 6375 5500 |
| 11.03.2014 | 00:00 | 60000 | 2000 | 38000 3077 26249 12850 6633 8575 | 15000 6375 2500 |
| 11.03.2014 | 12:00 | 60000 | 2000 | 38000 3077 20049 12850 12833 8575 | 10500 6375 1200 |
| 12.03.2014 | 00:00 | 60000 | 2000 | 38000 3077 17107 12850 15000 9350 7500 | 6375 1200 |
| 12.03.2014 | 12:00 | 60000 | 2000 | 38000 3077 14007 12850 15000 12450 4500 | 6375 1200 |
| 13.03.2014 | 00:00 | 60000 | 2000 | 38000 3077 10940 12850 15000 1697 6375 | 1777 |
| 13.03.2014 | 12:00 | 60000 | 2000 | 38000 3077 78940 12850 15000 1637 6375 | 4617 |
| 14.03.2014 | 00:00 | 60000 | 2000 | 37742 3077 5000 12850 3000 15000 1697 6375 | 7915 |
| 14.03.2014 | 12:00 | 60000 | 2000 | 34657 3077 5000 12850 6000 15000 1697 6375 | 11000 |
| 15.03.2014 | 00:00 | 60000 | 2000 | 32849 3077 5000 12850 3000 15000 1697 6375 | 11000 |
| 15.03.2014 | 12:00 | 60000 | 2000 | 29749 3077 5000 12850 4308 12850 1697 6375 | 11000 |
| 16.03.2014 | 00:00 | 60000 | 2000 | 26649 3077 5000 12850 7408 9500 1697 6375 | 11000 |
| 16.03.2014 | 12:00 | 60000 | 2000 | 23549 3077 5000 12850 8700 6500 1697 6375 | 11000 |
| 17.03.2014 | 00:00 | 60000 | 2000 | 20449 3077 5000 12850 8700 3500 1697 11283 | 11000 |
| 17.03.2014 | 12:00 | 47000 | 60000 | 2000 20449 3077 5000 12850 8700 2200 1697 | 14383 9500 |
| 18.03.2014 | 00:00 | 35077 | 60000 | 2000 18000 15000 5000 12850 8700 2200 2767 | 15000 8500 |
| 18.03.2014 | 12:00 | 22677 | 60000 | 2000 16000 15000 5000 9482 8700 2200 6887 | 15000 9600 |



PROLAV: WIDE REFINERY MODEL

PROLAV finds the best scheduling program considering supply, logistics and processing constraints:

- Simulates the processing of a sequence of crude tanks. Refinery operation is accurately modeled, accounting for any processing constraint and flexibility.



- Links:
 - ✓ PRORAF crude tanks composition
 - ✓ SIMRAF FEASIBILITY CHECK processing sequence, conditions, recipes
 - ✓ OTTMIX blending recipes
 - ✓ LIMS and DCS (inventory status)



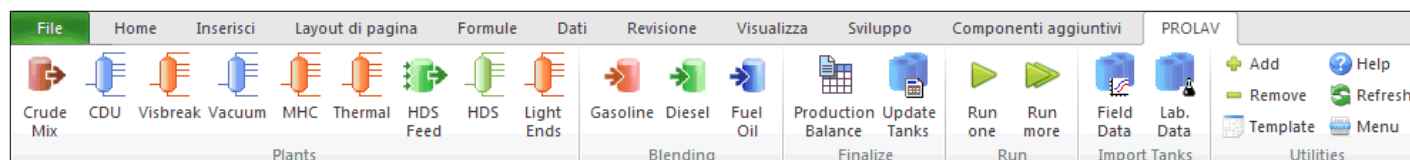
PROLAV: FEATURES

PROLAV applies crude characterization database and plant simulation models to simulate refinery daily operation calculating:

- Yields and refinery material balance
- Fuels and utilities
- Hydrogen balance
- Inventories
- Operative instructions
- KPIs
- Production control
- Energy performance
- Blending

| 5 | Help | Processing | | | Help | Topping | | | | | Help | | | | |
|----|---|-------------|------|------|-----------------|---------|------|------------|------|------|------|---------|----------------------------------|---------------|----|
| 6 | | | | | | Feed | | Products | | | | | Feed | | |
| 7 | Process N° Date Tank Model | composition | | | Process dens %S | | | Naphtha | Kero | LGO | HGO | Residue | Conv% t/g Stock Tank Nr | P T. T. | |
| 8 | | % weight | | | mc | Cap max | 9000 | Ind. sovr. | 43 | 45 | 70 | 90 | *** | 3400 | jr |
| 9 | 1 | IRHE | URAL | GOSU | *** | mc/g | 7900 | Temp (°C) | 149 | 260 | 359 | 408 | 784 | 17 | |
| 10 | 02-feb | 16,0 | 18,0 | 66,0 | 18104 | t/g | 6894 | t/g | 996 | 1134 | 1166 | 570 | 3004 | 2800 | |
| 11 | S,109 | | | | 0,873 | days | 1 | A Stock | *** | 0 | 0 | 11 | 825 | 622 | |
| 12 | BITUME | | | | 1,75 | *** | *** | Tank Nr. | *** | 1 | 2 | 3 | 4 | 4 | |
| 13 | 2 | rhv | arhv | | *** | mc/g | 8000 | Temp (°C) | 150 | 250 | 355 | 395 | 800 | 18 | |
| 14 | 04-feb | 70,0 | 30,0 | | 30000 | t/g | 7049 | t/g | 1017 | 1013 | 1186 | 432 | 3373 | 3373 | |
| 15 | | | | | 0,881 | days | 1 | A Stock | *** | 0 | 0 | 0 | 0 | 0 | |
| 16 | STD | | | | 2,32 | *** | *** | Tank Nr. | *** | 1 | 2 | 3 | 4 | 4 | |
| 17 | Process Runs | | | | | | | | | | | | | | |
| 18 | SetUp \ Processing \ Tanks \ Blending \ Production Balance \ Streams \ Verify Target \ Library \ Messages \ Models Prototypes | | | | | | | | | | | | | | |

The model is built to follow and reproduce client's consolidated operative flexibilities and is operated through an Excel interface.



THANK YOU!

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