Near-Real Time Flow Assurance Monitoring

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New Issues are often identified that must be addressed

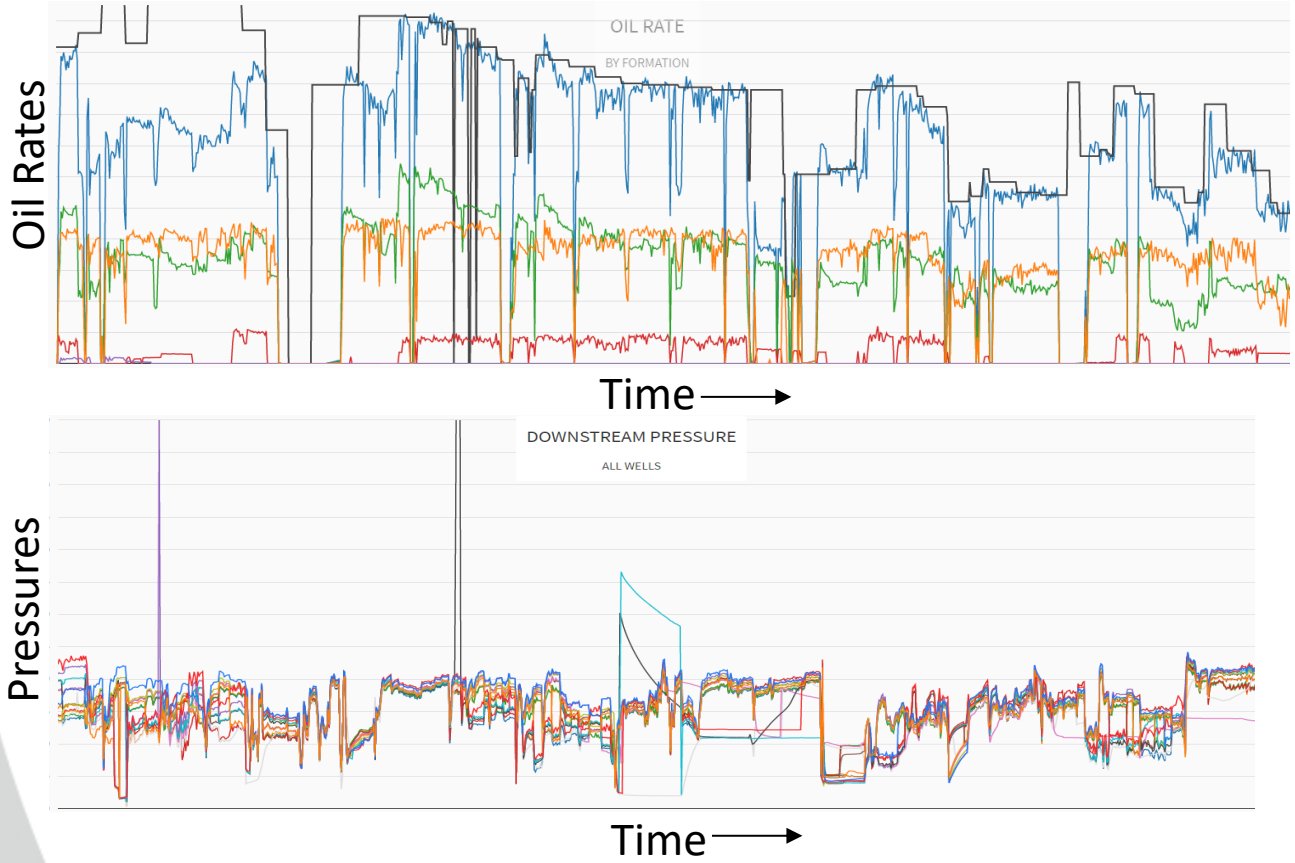
- *Case Study: Wax Monitoring in an Oil Field*

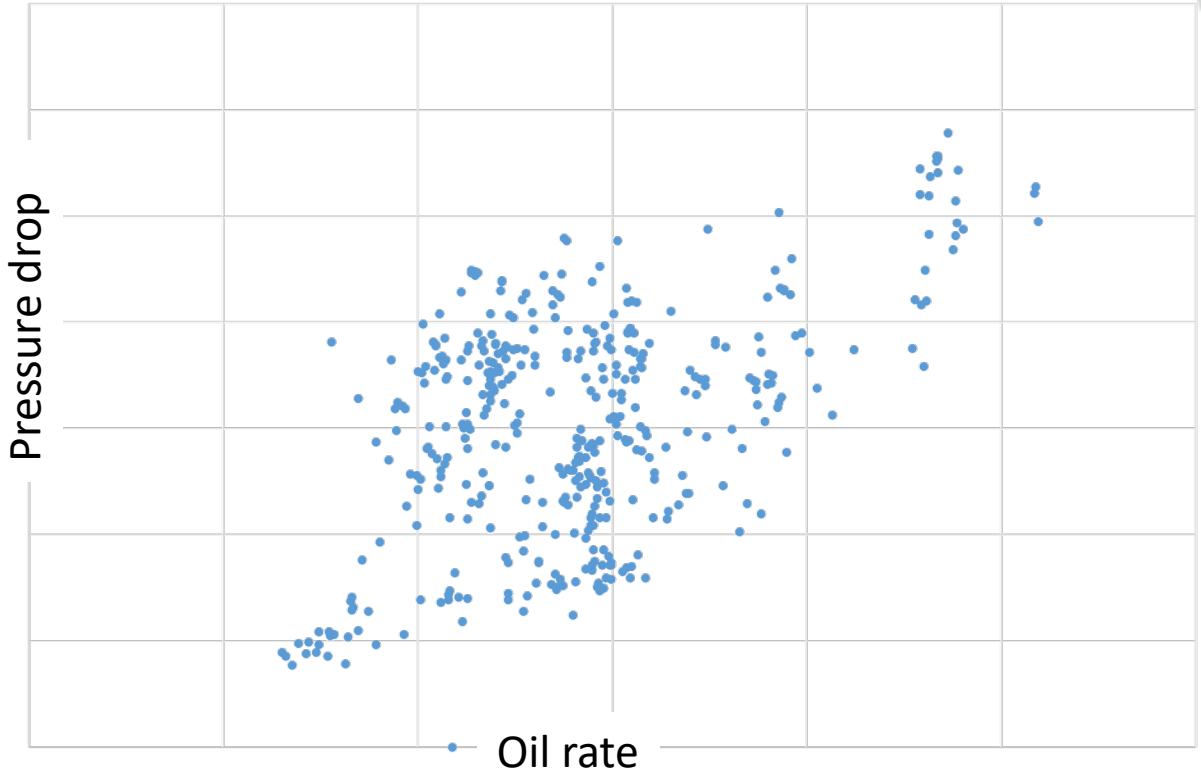
  - Field in production for over three years
  - Temperatures decreasing in production pipeline, arriving near/below the Wax Appearance Temperature
  - Before major intervention (e.g., pigging), an assessment was required using historic data and modeling

Starting Concept:

- Compare ΔP vs. Q along time → If increasing, wax deposition is likely occuring
- If occuring, match ΔP and estimate the amount of wax

Typical Trends followed in Control Room during Production

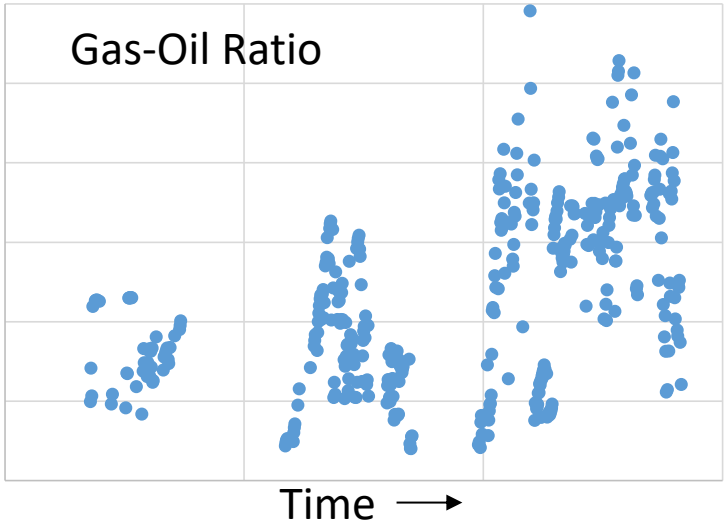


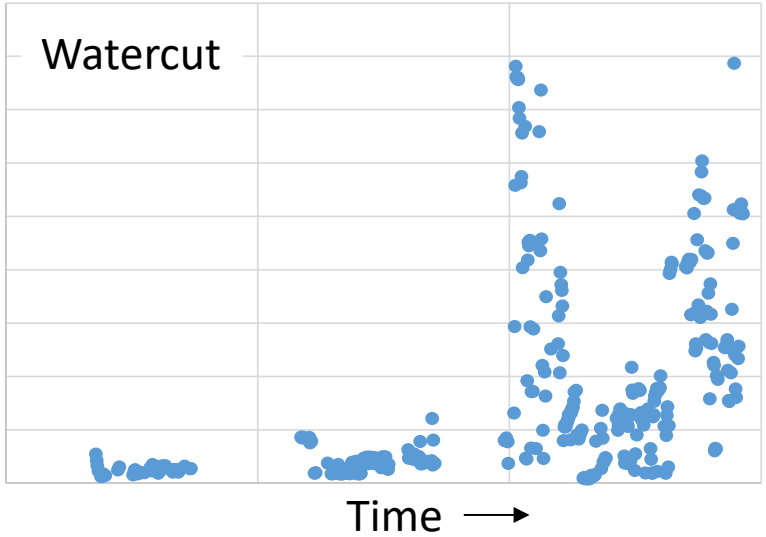


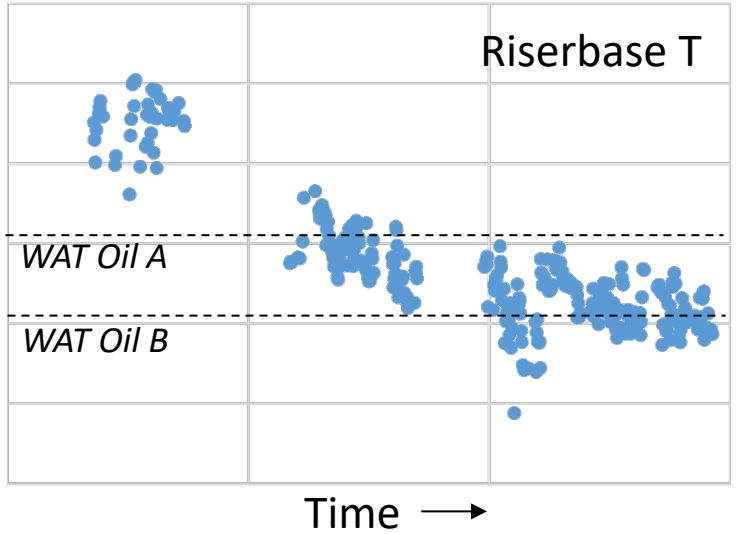
- *High level of scattering*
- *Changing ΔP can be a function of many variables*
  - *Deposits, watercut, oil blend, GOR…….*

Changing Conditions Required Modeling to Understand Pressure Drops

- *Over field life, continual variation in operating conditions (rates, GOR, temperature)*
  - Model comparison required to un-tangle these multiple effects







Extensive historic comparison required a number of steps

- Multiple years of field data (flowrates, P, T)
- Simulation of daily conditions
- Systematic comparison between model and simulation

1000s of input values – Not feasible to perform by hand

How can this be done?

Flexibility to Confront New Issues Identified over Time

- *Ability to both go back in time and to schedule regular tasks with focused models*

  - Continuously changing conditions

  - **Typical online** approach
    - Model follows trends over time
    - Model developed before start-up and largely fixed

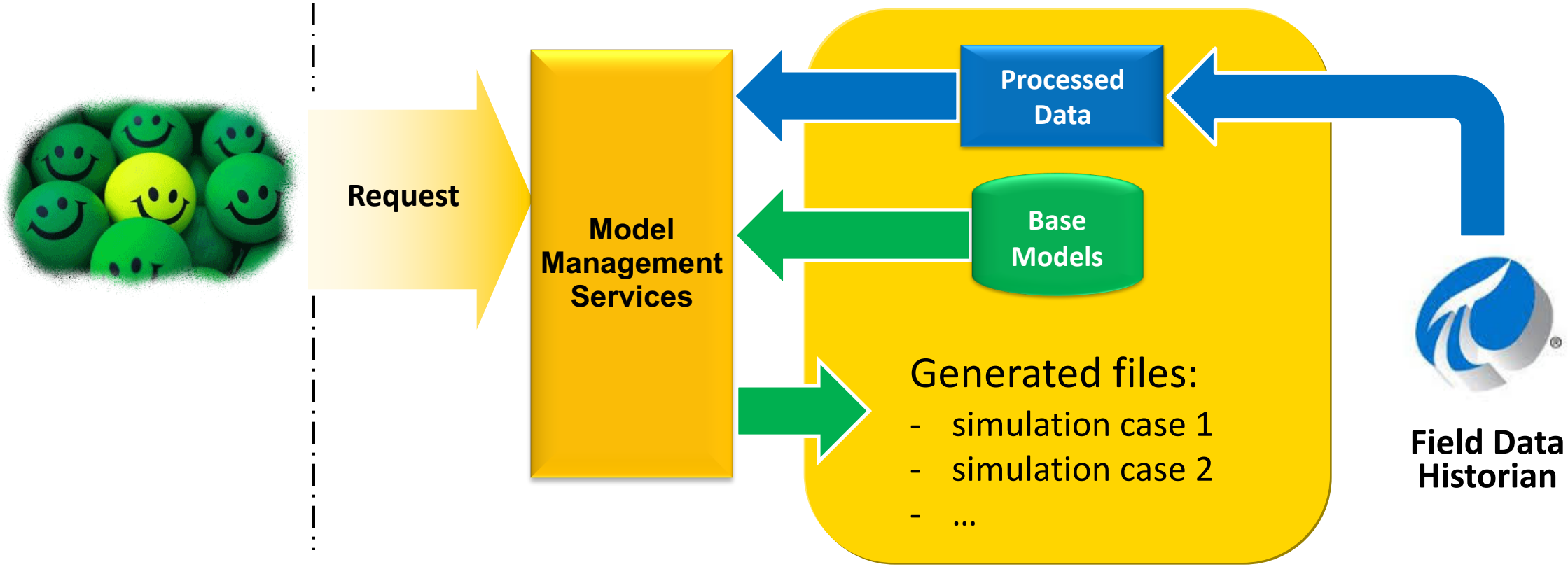
  - **But** many analyses require flexibility to investigate
    - Development of new models
    - Modification of internal parameters
    - Return in time and re-apply new hypotheses to historic data

"Near-online" paradigm

The following **concepts** have been adopted:

- All field data continuously transferred to a global **historian**
  - Mirrored or located in the HQ
- Proprietary **design tool e-fast™ is directly connected to the historian**
- **Data series** directly extracted from the historian using scripting
  - Preprocessed to make them suitable for desired simulation
  - **Fed into any simulation file**

Near-Online Model Management Service

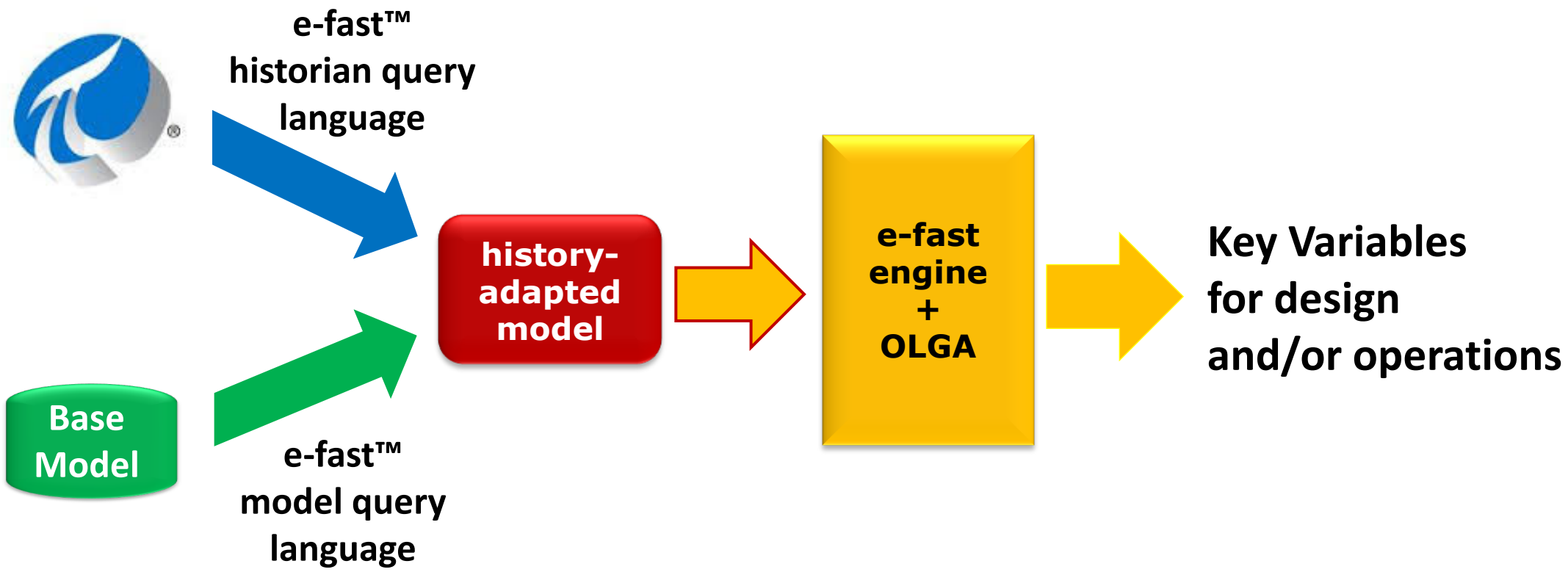


The Near-Online Model Management Service

creates new simulation files by "injecting" processed field data into base models

to be run and analyzed within e-fast™

Near-Online Model Management Service



Tools to generate history-adapted input models,
run simulations and analyze results within e-fast™

Example of data extraction and process

The e-fast™ historian query language has been defined in order to:

- Create reusable analysis and data extraction procedures
- Load data streams from the historian, possibly time-shifted
- Create new series through specific computations

  either time-series or arbitrary XY series
- Carry out mathematical processing, such as:

  filtering, smoothing, fitting, interpolation, series alignment, derivatives, integrations, statistics, etc.

The language is very synthetic and has a functional “flavor” :

```
PI  =        QUADRATIC_FIT @
                 SMOOTH(3) @   DERIVATIVE @   SMOOTH(3) @
                    SORT_X @    TRIM_Y(10, INF) @    PQ_data
```

Example model generation based on field data

The proprietary **e-fast™ model query language** allows to **isolate any part of an Olga input file and to change it** imposing specified values or time series.

In this way, the **input file does not need any "manual" change** or adaptation to comply to the Near-Online methodology.

The same language is used for data extraction
(from simulation outputs: trends, profiles, …)
and for the computation of **Key Engineering Variables**.

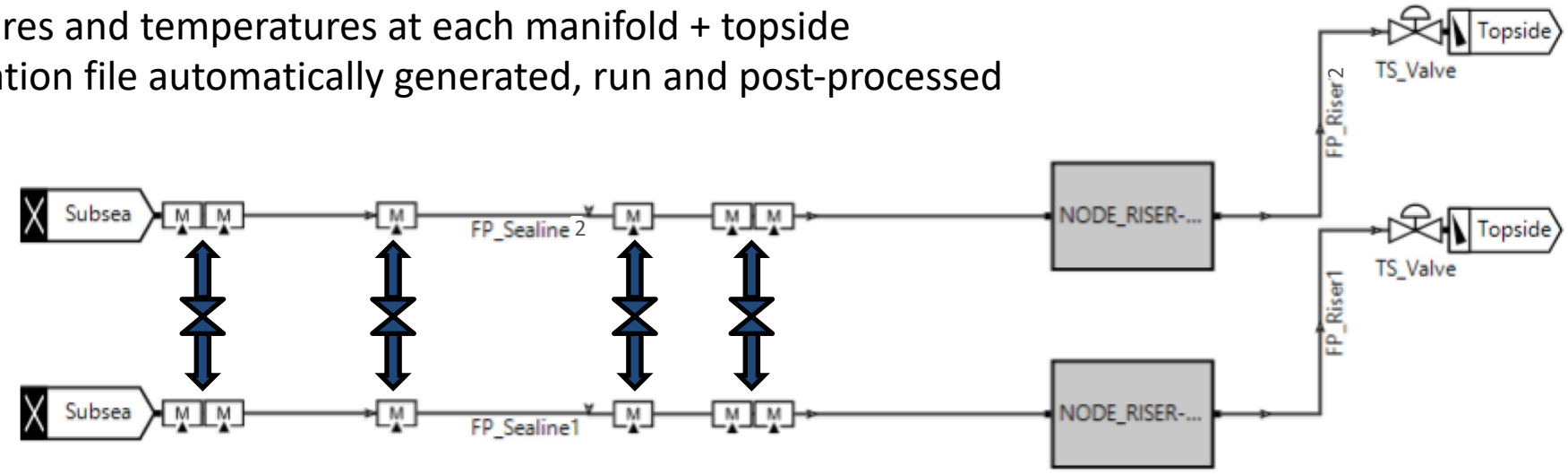
```
// set flowrates and line diameter
SET    'FLOWLINE_A'  AND  'SOURCE'  AND  'STDFLOWRATE'    Qoil.V
SET    'FLOWLINE_A'  AND  'SOURCE'  AND  'TIME'           Qoil.T : 'h'
SET    'FLOWLINE_A'  AND  'DIAMETER'                      '123': 'mm'
SET    'FLOWLINE_A'  AND  'DIAMETER'                      '=V+2*25.4' : 'mm'
```

Near-online modeling allowed for >3 years field data to be analyzed

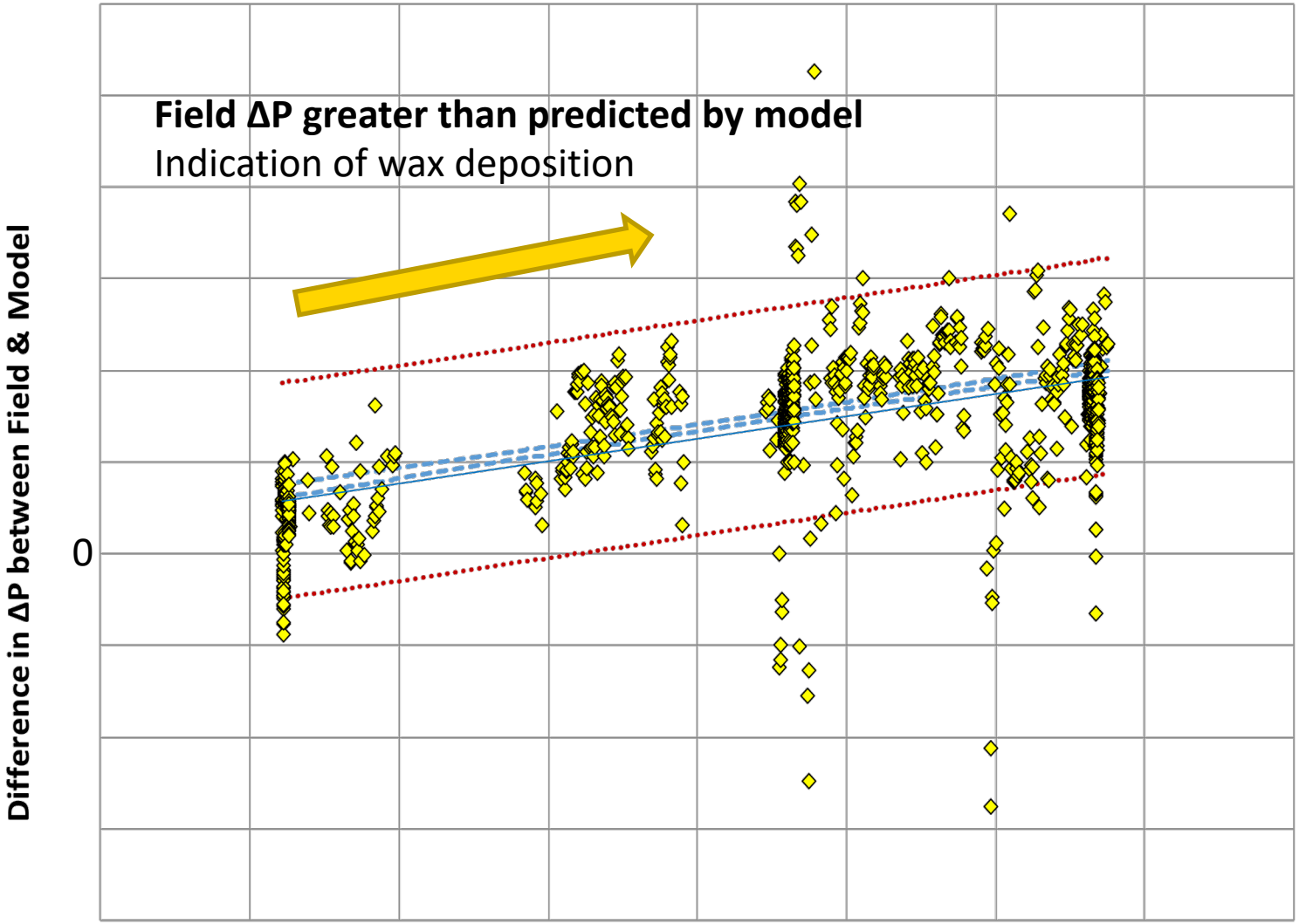
- *“Template” model to simulate production pipeline*
- *Historic data fed into the template adapted to the instantaneous conditions*
- *Model ran directly on cloud-based nodes*
- *Simulation data post-processed along with field data to obtained desired output*

For each time interval sampled (400 data points for 80+ variables every day for three years):

- Valve openings checked to determine well routing into the sealines
- Oil, gas, and water mass rates for each well + T/P for over 12 wells
- Pressures and temperatures at each manifold + topside
- Simulation file automatically generated, run and post-processed

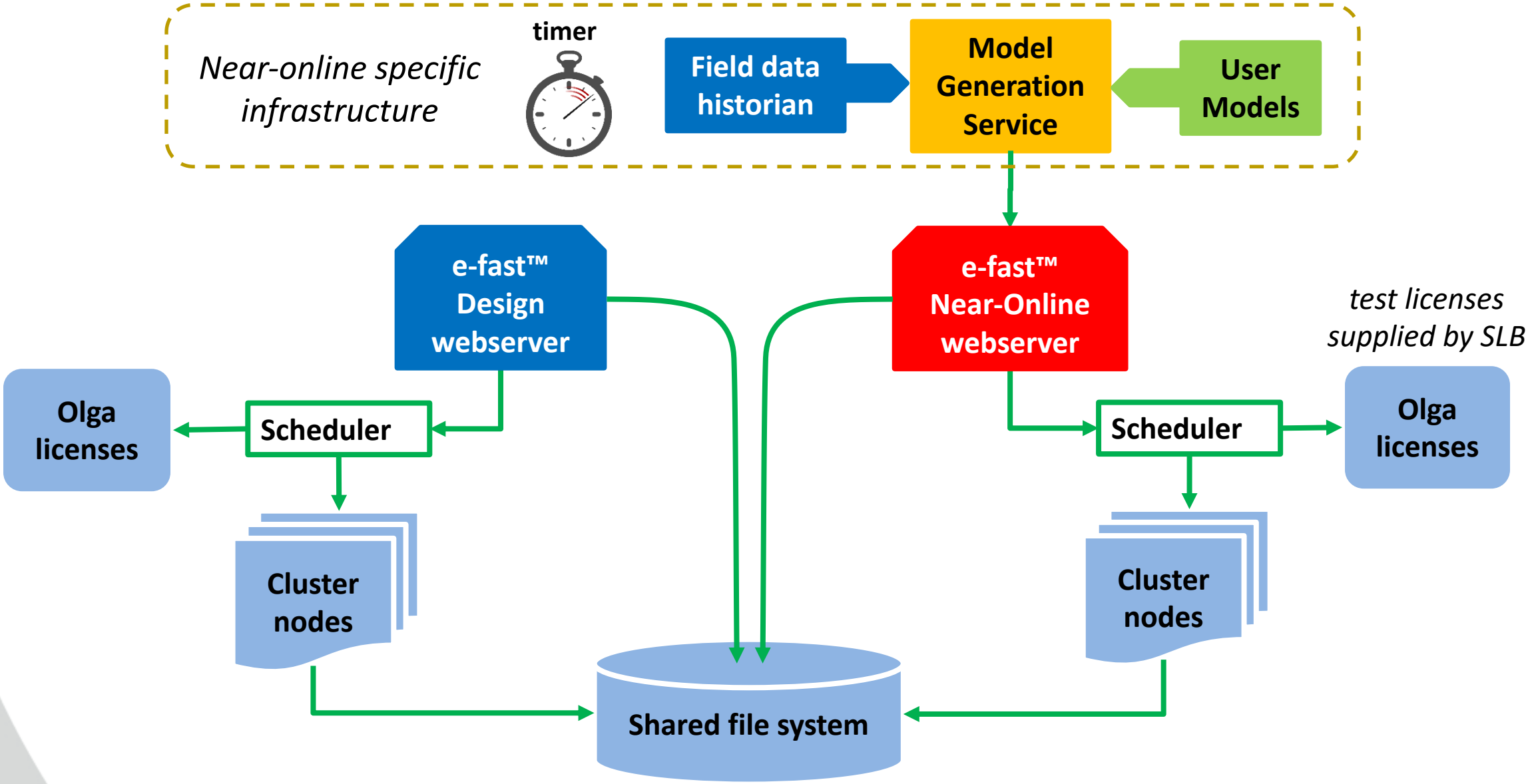


Pressure Drops with Statistical Significance Evaluated



- Increasing difference in ΔP indicated potential wax deposition
- Further steps taken to estimate thickness of wax accumulated
- Valuable information obtained to guide operations on steps required
  - i.e., are chemicals working correctly?
  - is pigging required?

e-fast™ Integrated Design and Near-Realtime Architectures



Conclusions

- Near-online paradigm has been effective in addressing flow assurance issues
- Allows for advanced data analysis, to extract KPIs and understand performance
- Gives the ability to monitor current situation, understand historic behavior and use the acquired information for designing tie-ins and new fields
  - Issues identified with production experience with often not envisioned before start-up
  - Adaptability to create targeted models and analyze the entire production history