TACHYUS

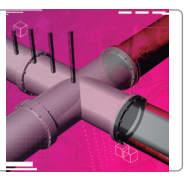
www.tachyus.com

Optimizing energy production for the oil and gas industry

Our Solutions

Back Allocation

Fully automated physics based hydrocarbon back allocation integrating well test, pressure and temperature data of your surface network.

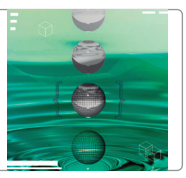


Subsurface Back Allocation

Understand layer-level production and injection allocation for every well across the whole history of the field simultaneously.

Waterflood Management

Make all key waterflood management decisions quickly and easily with Data Physics driven fast simulation models that matches all your historical data and honors reservoir physics.



Waterflood Optimization

Maximize production by discovering the optimal configuration of producers and injectors. Reduce costs by reducing water injection while maintaining production.

Probabillistic Decline Curve Analysis

Fully automated probabilistic DCA leveraging state-of-the-art machine learning and data assimilation approaches.

Cyclic Steam Optimization

Maximize production or minimize steam costs by focusing on only the best cyclic steam opportunities. Reduce steam costs by reducing steam injection while maintaining production.

Steamflood Optimization

Maximize production by discovering the optimal configuration of producers and injectors. Reduce steam costs by reducing steam injection while maintaining production.

CO_2-flood Optimization

Predict production response and redistribute CO2 accordingly. Reduce costs by reducing CO2 injection while maintaining production.

Shale Optimization

Optimize completion design to minimize frac cost and maximize initial production rates.

Uses well known physical models and state-of-the-art machine learning techniques

Very fast and independent of interpretation bias, full field allocations can be done in hours

Can run locally or on Tachyus Cloud, with no infrastructure footprint

Data can be exported easily to other visualization and analysis tools

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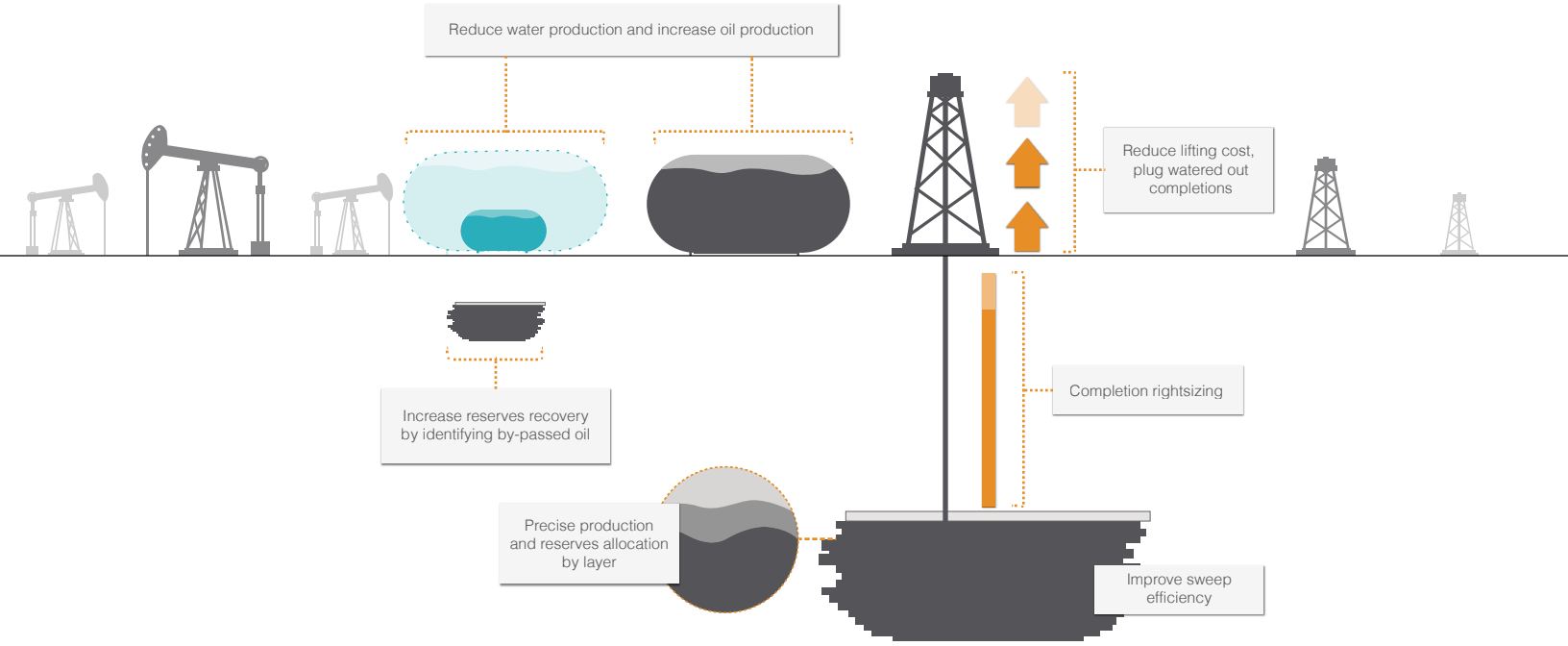
Subsurface Back Allocation

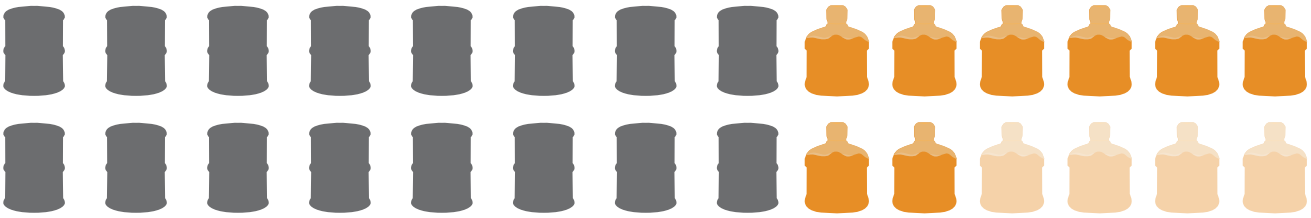
Fully Automated Layer Level Flow Profiles and Injection Allocation

Applications.

- Estimate oil and water production per layer over time
- Estimate allocation of injection to connected producers per layer
- Estimate recovery factor and remaining reserves per layer
- Identify candidates for workover, re-completion and in-fill drilling
- Understand injection conformance and sweep efficiency

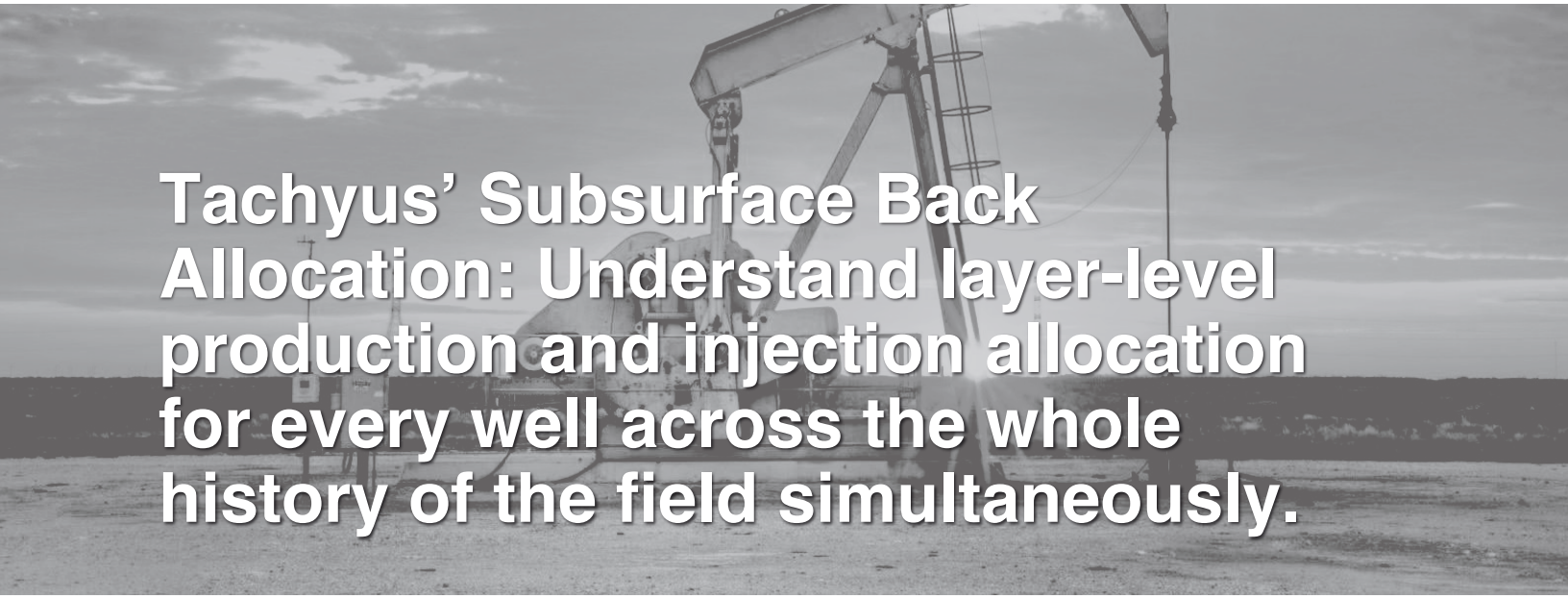
Benefits.





Increase oil production

Decrease water production



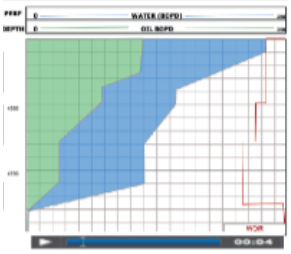
Tachyus' Subsurface Back Allocation: Understand layer-level production and injection allocation for every well across the whole history of the field simultaneously.

Reservoir and production engineers value accurate, timely data on layer-level production and injection. In practice however, production is usually measured only at the well level due to difficulty, expense, and production disruption of running flowmeters, and layer-level injection allocation is currently measured using expensive tracers or other inaccurate and time consuming processes. *Injection rates, production rates, and connectivity are dynamic and need to be estimated continuously, otherwise leading to out-of-date analysis and results.*

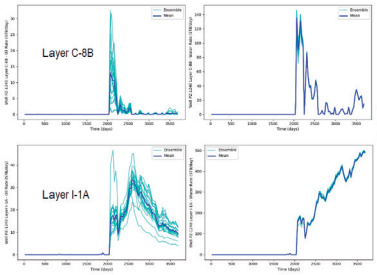
Using state-of-the-art machine learning and data assimilation approaches with well-known physical models, Tachyus' Subsurface Back Allocation continuously calculates layer-level production rates and dynamic injection allocations that match all measured historical injection and production data. The workflow runs very fast and can be powered by the cloud or local computing. *Tachyus' Subsurface Back Allocation is the equivalent of running tracers and flowmeters in every well during the whole history of the field.*

1

Estimate oil and water production per layer over time



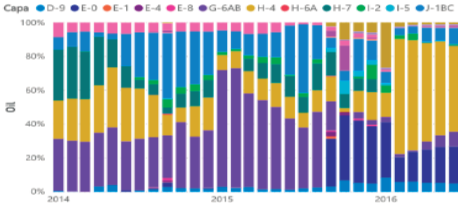
Synthetic dynamic production Log



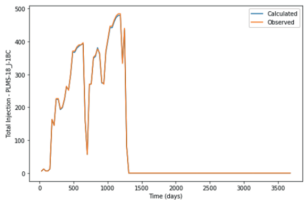
Oil (left) and gross (right) ensemble for one specific layer

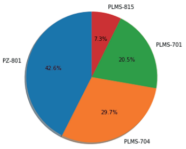
2

Estimate allocation of injection to connected producers per layer



Visualize allocation factors changes as injection and production vary with time.



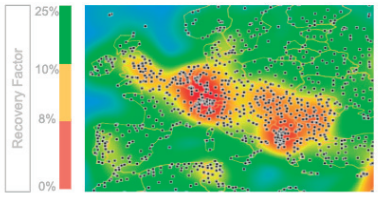


Display of Water to Oil Ratio (WOR) per layer during the whole history of each well

3

Estimate recovery factor and remaining reserves per layer

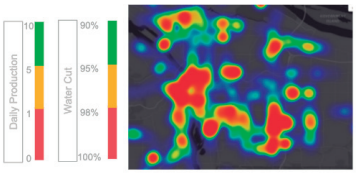
Reserves reporting and certification is one of the key workflows of Oil Companies; to the point that companies are valued by their remaining producible reserves. The process usually takes months as several manual calculations are involved. Combining the OOIP and the GIIP together with the cumulative production of each layer, remaining reserves per layer can be estimated. Subsurface Back Allocation also allows automatic calculation of these factors and their variation over time.



4

Identify candidates for workover, re-completion and in-fill drilling

Zones which fall below minimum oil production or above maximum water production thresholds should be plugged for being uneconomic. With Tachyus' Subsurface Back Allocation tool the user can quickly identify candidate layers for workover effectively reducing water production and improving lifting cost. Similarly, the tool can be used to identify zones that show good performance in one well as candidates for opening in nearby wells.



5

Understand injection conformance and sweep efficiency

Tachyus' Subsurface Back Allocation tool allows users to understand injection conformance and sweep efficiency by estimating connection strengths and injector efficiency.

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Features.

- Subsurface Back Allocation provides precise, continuous dynamic fluid allocation per layer
- Uses well known physical models and state-of-the-art machine learning techniques
- Very fast and independent of interpretation bias, full field allocations can be done in hours
- Can run locally or on Tachyus Cloud, with no infrastructure footprint
- Data can be exported easily to other visualization and analysis tools

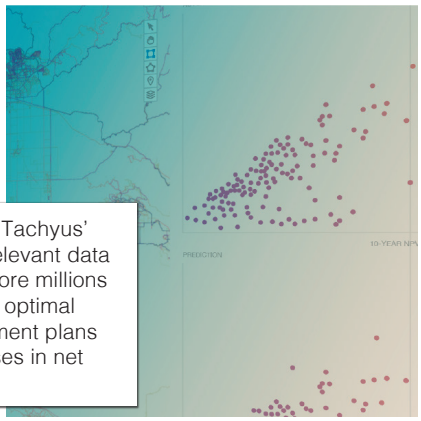
TACHYUS

Operators of varying sizes have leveraged Tachyus across 25,000 wells to achieve up to a 20% increase in production and up to a 40% decrease in injection cost.

Measure, Analyze, Produce

Tachyus' platform helps producers to optimize production across the most challenging production environments including secondary and tertiary oil recovery in complex reservoirs.

Quantitative Optimization



Petroleum engineers use Tachyus' platform to integrate all relevant data sources in real-time, explore millions of scenarios, and identify optimal operational and development plans resulting in 10%+ increases in net present value of assets.

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Aqueon

Waterflood Management & Optimization

Tachyus' *Data Physics*™ platform powers the Aqueon web application that **producers leverage to cut costs and increase oil production in waterflood operations.**

VALUE PROPOSITION

Minimize Opex: cut processing costs by reducing water injection and production while maintaining oil production.

Increase Oil Production: predict production response and redistribute water accordingly.

Maximize Recovery Factor: optimize vertical and areal sweep.

Increase Efficiency: empower engineers to accomplish more in less time.

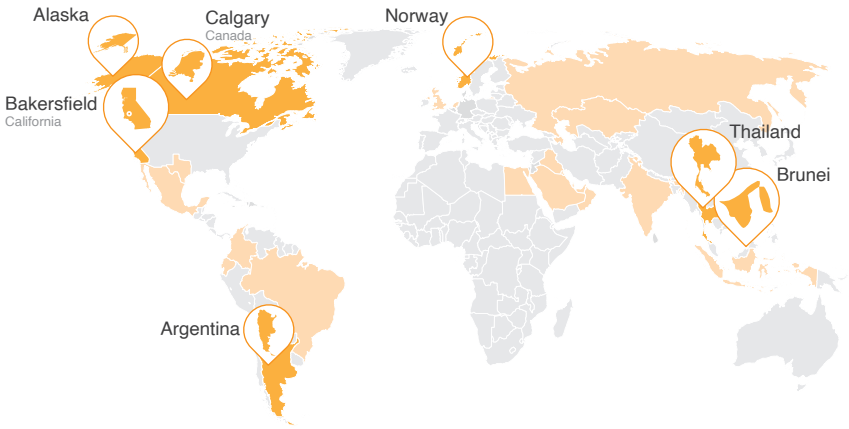
Quantify Financial Impact: visualize the effect of modifications on field-wide performance.

Streamline Surveillance: smart algorithms drive data exploration and decision-making.

EXTENSIVE VALIDATION

Aqueon has been used to model thousands of injection rate modifications and infill drilling opportunities. Predicted financial impact has been validated across more than a dozen fields.

On average, producers can leverage Aqueon to cut the Water Oil Ratio (WOR) by 10%. Aqueon users save tens of millions of dollars on water cycling each year while achieving 10%+ increases in oil production.



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INDUSTRY VALIDATION

Dr. Jeff Spath
Former SPE President,
Head Chair at Texas A&M

Dr. Jeff Spath is a Professor and holder of the Stephen A. Holditch '69 department Head Chair at the Texas A&M University.
He has over three decades of operational and technical experience in reservoir characterization and simulation, productivity improvement and is recognized as a world expert in production and EOR.

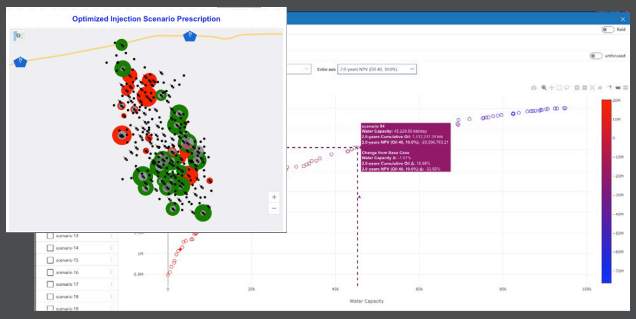
He served as President of the Reservoir Management Group in Schlumberger and also as the CEO of the Texas Oil & Gas Institute. In 2014 he was elected as President of the Society of Petroleum engineers, a position he held until 2015.

"The Tachyus technology is revolutionary for the petroleum industry in how it combines the robustness of the known physics and the speed of modern data science."

HOW AQUEON WORKS

Prescriptive Analytics

Aqueon users leverage fast optimization algorithms to mitigate risk while determining the best possible use of capital. The Tachyus platform enables engineers to explore millions of scenarios rapidly so that instead of manually sifting through vast quantities of data, engineers can focus on managing trade-offs between cutting costs, increasing oil production and maximizing recovery across a range of operational and development plans for waterfloods.

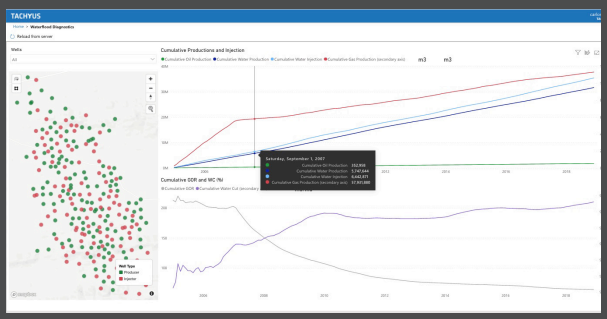


Predictive Analytics

Tachyus' *Data Physics* integrates the same fundamental physical principles found in traditional reservoir simulators with data science techniques such as machine learning to create predictive models in weeks and run operational scenarios in minutes. Engineers use Aqueon Waterflood Management module to evaluate in minutes, operational decisions supported by a predictive model of the field.

Descriptive Analytics

Engineers can explore a wide range of visualizations of past pattern performance, potential water redistribution plans and expected drilling response. Aqueon reports are accessible on command center displays, workstations, and tablets in the field. It has never been easier for engineers to keep track of waterflood operations and to share reports and analysis with colleagues.



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Probabilistic Decline Curve Analysis

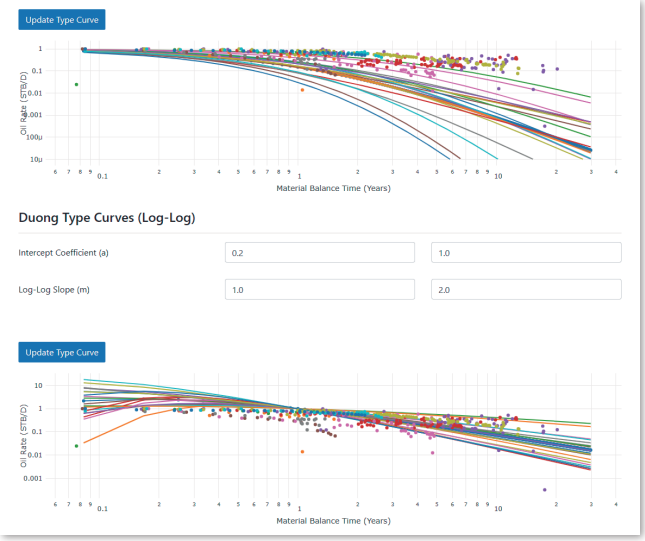
Fully automated probabilistic DCA leveraging state-of-the-art machine learning and data assimilation approaches.

Features.

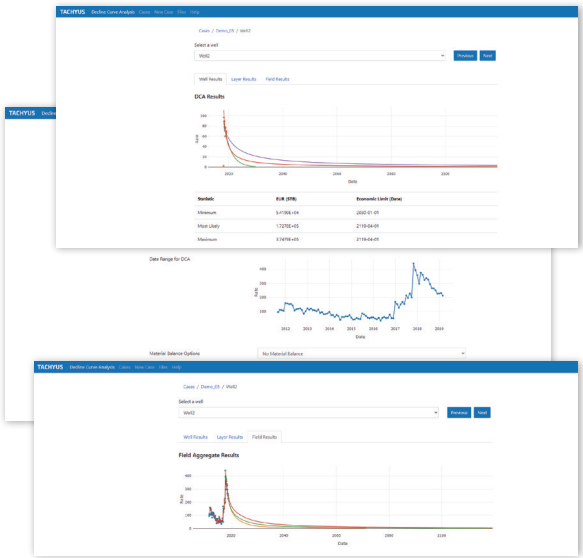
- Estimate P10-P50-P90 decline curves accounting for data noise and uncertainty
- Automatically remove outliers for more robust and reliable decline curve analysis
- Use traditional Arp's decline models or more advanced combined models
- Use waterflood specific models and workflows such as WOR vs Np models
- Use unconventional specific models such as Duong model and Fractional DCA model

Decline curve analysis (DCA) is one of the oldest methodologies used by production and reservoir engineers to predict future production, calculate reserves and estimate ultimate recovery, and it is fundamental to economic valuation of oil and gas assets. In practice, DCA is usually performed using deterministic tools that provide a unique solution ignoring the probabilistic nature of the production data due to measurement and back allocation errors.

Leveraging state-of-the-art machine learning and data assimilation approaches with traditional and advanced decline models , Tachyus' Probabilistic Decline Curve Analysis (pDCA) creates an ensemble of models to automatically fit the historical data and estimate future production and reserves in a probabilistic manner providing P10-P50-P90 estimates of these entities. Additionally, Tachyus pDCA automatically identifies and removes outliers, improving the accuracy of the models, can also correct for BHP variations and results can be aggregated to arbitrary groups of wells.



- Fully automated model fitting, hundreds of wells can be fit in minutes
- Correct decline curve analysis for changing bottom hole pressures
- Perform DCA at well level, layer level or on arbitrary aggregations
- Can run locally or on Tachyus Cloud, with no infrastructure footprint
- Data can be exported easily to other visualization and analysis tools



Tachyus' Probabilistic Decline Curve Analysis leverages state-of-the-art machine learning and data assimilation approaches for faster, more accurate and reliable production and reserves forecasting.

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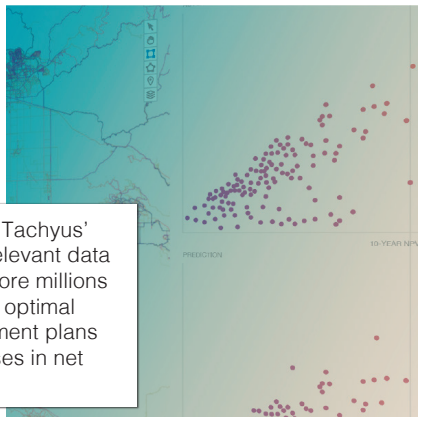
Quantitative Optimization



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Data Physics Cloud (DPCloud™)

Integrated *Data Physics*™ APIs to support your workflow

Integrate the industry leading data-driven simulation optimization toolkit into your home-grown software solutions to bring powerful new workflows to your Reservoir Production Engineering teams.

VALUE PROPOSITION

Integrated workflow: API driven access mean inputs and outputs are integrated to existing tools.

Rapid Insight: Gain valuable insight via the speed of data science with the robust predictivity of physics-based reservoir simulation.

Increase Production: Predict production response and redistribute injection accordingly.

Optimize Injection Pressure: Identify the optimal injection volume pattern-by-pattern.

Increase Efficiency: Empower engineers to accomplish more in less time using distributed cloud computing technology.

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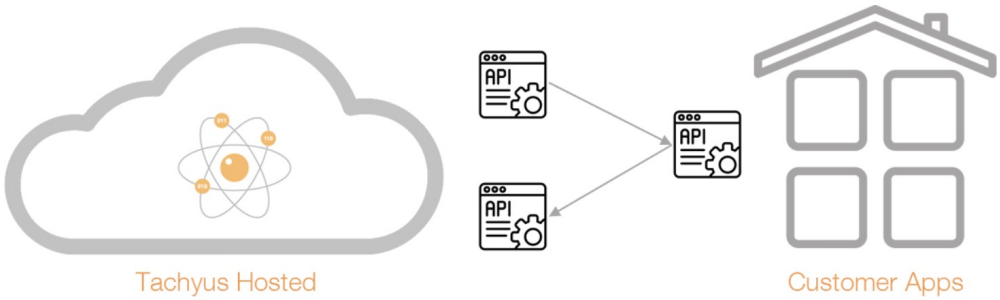
HOW DOES IT WORK?

APIs allow the *Data Physics*™ content to be easily embedded with any customer/3rd party application. A full library of tools is available and fully customizable to allow customers to build and model a digital representation of their field, integrate a variety of supported field data and access intermediate calculations. The end results can be applied in a wide variety of industry-standard decision-making workflows.



TACHYUS *DATA PHYSICS*™ TECHNOLOGY

Tachyus' technology integrates the same fundamental principles with data science techniques such as machine learning to rapidly predict and optimize well response. Traditional reservoir physics equations (e.g., partial differential equations (PDEs) for mass balance, heat balance, Darcy's law) are solved via data-driven neural networks to provide fast and accurate predictions of reservoir performance that can be optimized to achieve business goals.

The DPCloud™ puts this technology directly in your hands via a customer integrated API connection without a dedicated web application to view the modeled results.

Physics and Simulations

$$Q = \frac{-kA}{\mu}\frac{(p_b - p_a)}{L}$$

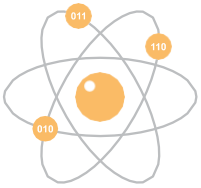
Darcy's Law

$$\frac{\partial}{\partial t}\left[(1-\phi)\rho_M U_M + \phi\sum_{k=1}^{p}\rho^k U^k S^k\right] \ldots = 0$$

Conservation of Energy

$$\frac{\partial}{\partial t}\left(\phi\sum_{k=1}^{p}\rho^k x_i^k S^k\right) - \sum_{k=1}^{p}(\rho^k x_i^k V^k + S^k J_i^k) - Q = 0$$

Conservation of Mass



TACHYUS
Data Physics

Data Science and Machine Learning

Neural Networks

Fuzzy Logic

Machine Learning