The inverse problems associated with data measured to characterize systems and processes are frequently ill-posed, and, consequently, small errors in the measured quantities may transfer into large errors in the desired estimates. Better accuracy may be obtained by improving the experimental design. This paper deals with experimental design and its importance in the field of petroleum engineering.

The experimental design studies described in this paper are based on a linearized covariance analysis. We utilize measures such as confidence intervals, contribution of information, and optimal design as ways of ranking different competing measurement strategies (or designs). In many cases, it is not a goal in itself to have an accurate estimate, rather that one knows with which accuracy the estimate may be found, and that the accuracy may be controlled in regions (in state or space) where an accurate estimate is needed to characterize the process. The methodology is selected to achieve this.

Among a series of inverse problem applications within petroleum engineering, we consider two cases: The first application deals with estimation of properties defined within a set of partial differential equations, namely those describing flow of fluids through porous media. We show how experimental design can be utilized to select flow experiments (both flow rates, types of data and when and where to measure) to obtain accurate estimates in regions important for reservoir exploitation. The second example deals with identification of the inflow profile of oil, water, and gas, in a horizontal oil-producing well drilled into an underground reservoir (identification of a source term in the model for fluid flow in the well). Measurements may be taken in the well or at the well-head (at surface). We show what data would provide the most valuable information, and we rank different instrumentation options with respect to providing most accurate estimates.