The thesis concerns the development of tools and methods for on-line dynamic security assessment (DSA). In a future power system with low-dependence or even independence of fossil fuels, generation will be based to a large extent on noncontrollable renewable energy sources (RES), such as wind and solar radiation. Moreover, ongoing research suggests that demand response will be introduced to maintain power balance between generation and consumption at all times. Due to these changes the operating point of the power system will be less predictable and today's stability and security assessment tools may no longer be feasible, since they are generally based on extensive off-line studies. A core component of an efficient on-line dynamic security assessment is a fast and reliable contingency screening. As part of this thesis a contingency screening method is developed and its performance is assessed on a set of test cases. The developed method reliably assesses first-swing transient angular stability of a power system in its current state with respect to a given set of contingencies. In order to ensure fast performance of the screening method, first a review of existing transient stability assessment (TSA) methods was carried out and their computational complexity was investigated. This allowed to identify the single machine equivalent (SIME) method as the potentially fastest assessment method and, hence, well suited for on-line DSA. Means for further performance improvement of the SIME method are investigated such as the reduction of the degree of model detail used in time-domain simulation, which results in a recommendation for the required model detail for synchronous generators. A challenging task when using the SIME method is to early and reliably determine the critical machine cluster, which is the group of generators likely to lose synchronism. Therefore, a novel approach to identify the critical machine cluster is proposed in the thesis. This approach uses a new coupling coefficient, which is a measure of the coupling strength of a pair of generators, and a simple clustering algorithm to identify the critical group of generators. In order to determine a system to be transient secure, it is not sufficient to solely assess if all synchronous generators remain in synchronism, it is also required that the bus voltages remain within acceptable limits. A transient disturbance and the following angular divergence of a group of generators can cause critical voltage sags at certain buses in the system. In this thesis assessment of such voltage sags using two types of sensitivities, which are derived from the algebraic network equations, is proposed. These sensitivities are derived after an in-depth study of the mechanism causing the voltage sags. The first sensitivity type is called load voltage \( i/x \) sensitivity and allows identifying which bus voltages are affected by a change in rotor angle of a particular generator. The second proposed type is called generator power sensitivity, which provides information on the effect of load variation on the generator's power injection. It is shown that the derived sensitivities can give valuable information to identify critical generator-load pairs as well as locations for applying preventive or remedial control measures. Furthermore, the development of a method for early prediction of critical voltage sags is described. The method's performance is compared to other prediction approaches. The results show that the proposed method succeeds in early, accurately and consistently predicting critically low voltage sags. An efficient on-line DSA not only identifies unstable or insecure operation, but also proposes preventive or remedial control actions to restore stability and security in the system. In this thesis a further development of a method for determining real-time remedial action against aperiodic small signal rotor angle instability is described. A real-time aperiodic small signal rotor angle stability assessment method is employed to monitor the respective stability boundary and to compute the respective stability margin of each generator in the system. In case that the stability margin of a particular generator falls below a pre-defined security threshold, the proposed method analytically determines power generation re-dispatch solutions, which restore stable and secure operation in the system. The effectiveness of the method is presented on two test cases in two different test systems.