SUMMARY

In order to face the challenges faced by the European aviation industry, the Cleansky initiative was launched in 2008 and one of the initiatives within the programme is an increased collaboration between aircraft manufacturers, research institutes and universities. One technology that is investigated within this framework is the effect of relaxed static stability on the preliminary design of business jet aircraft. RSS aircraft have a neutral point located closer to or even in front of the aircraft's centre of gravity. As a consequence, the required trim force is reduced and thus the tail size may be reduced as well. Due to the infamous snowball-effect, it is anticipated that RSS can lead to significant weight loss and fuel savings. On the downside however, it is expected that RSS requires complex stability augmentation systems and reduces the elevator effectiveness. In this research it is quantified how RSS affects the mass of key aircraft components, as well as how RSS influences the handling qualities, by investigating its effect on the inertia tensor and stability & control derivatives.

For this research a preliminary design tool called the Initiator has been used. This tool is developed at the FPP-department at Delft University of Technology and was initially set-up for large conventional commercial aircraft. As part of this research, the capabilities of the Initiator were extended such that the tool can also be used to analyse the preliminary design of business jet aircraft. First, the class 2 weight estimation was overhauled by implementing the methods of Torenbeek and General Dynamics. Furthermore, an iteration loop was implemented, such that the Initiator now produces a converged weight estimate for the given aircraft configuration. Moreover, a correction factor to account for the use of composites in modern aircraft was implemented. The weight estimates obtained with the new methods and those obtained with the already implemented Raymer's method were then compared to weight data. As such, it was shown that within the Initiator, Torenbeek's method provides the most accurate weight estimate for business and commercial aircraft with a mean error of 1% and a maximum error of 11%.

Secondly the method for estimating the stability and control derivatives was updated based on the approach described by J. Roskam and it was shown that this module does a reasonable well job at predicting the longitudinal stability derivatives as well as the control derivatives. For example, a mean error of 3% in C_{L_α} was obtained for business jet aircraft over a range of three conditions. The directional and lateral control derivatives however, were estimated with larger errors. The main reason this error is believed to be caused by the fact that the module was validated by separating it from the Initiator. As a consequence no accurate estimate for the centre of gravity's x and y-position is available, which highly affects those derivatives.

Furthermore, the inertia estimation was updated such that it would also account for the contributions of the payload and fuel. The updated module was validated for the Fokker 100 and it was observed that although the module estimates the inertia tensor for the fully loaded aircraft reasonably well with a mean error of 3% and a maximum error of 13%, it has the tendency to underestimate the tensor of the empty aircraft by a considerably larger margin. This error is compensated for the fully loaded aircraft due to an over-estimation of the cargo's contribution to the inertia tensor. Based on the validation of the aforementioned modules it was concluded that these could be used to estimate the extend of the effects of relaxed static stability on the preliminary aircraft design and its handling qualities.

To assess the effect of RSS on business jet aircraft, a baseline aircraft based on the requirements of the Cessna Citation II was created. By shifting the wing forward, thus decreasing the static margin, it was observed that a decrease of 5% of MTOM could be achieved. Furthermore it was observed that although the MTOM decreased, the weight of the fuselage actually increased by 7%. This is a consequence of shifting the wing forward, and thus increasing the tail arm, which results in a heavier fuselage. Furthermore as anticipated, it was observed that the increased tail arm resulted in a smaller horizontal (14%) and vertical tail (16%). The most noticeable effect on the stability derivatives, was the change in C_{m_α} from -0.518 for the reference aircraft to -0.036 and a steady decrease in the pitch rate derivatives. Finally, it was rather surprisingly observed that although the elevator's size decreases, the elevator control power is almost unaffected by RSS. This is caused by the fact that in the chosen approach to obtain RSS, the horizontal tail volume remains constant.