Executive summary

European Space industry demand for lighter and cheaper launcher transport systems. The project DESICOS contributed to these aims by a new design approach for imperfection sensitive composite launcher structures, exploiting the worst imperfection idea efficiently: the Single Perturbation Load Approach. Currently, imperfection sensitive shell structures prone to buckling are designed according the NASA SP 8007 guideline using the conservative lower bound curve. The guideline dates from 1968, and the structural behaviour of composite material is not considered appropriately, in particular since the imperfection sensitivity of shells made from such materials depends on the lay-up design. The buckling loads of CFRP structures may vary by a factor of about 3 just by changing the lay-up. This is not considered in the NASA SP 8007, which allows designing only so called "black metal" structures. Here is a high need for a new precise and fast design approach for imperfection sensitive composite structures which allows significant reduction of structural weight and design cost. For most relevant architectures of cylindrical and conical launcher structures (monolithic, sandwich - without and with holes) DESICOS investigated a combined methodology from the Single Perturbation Load approach and a specific stochastic approach which guarantees an effective and robust design. Investigations demonstrated, that an axially loaded unstiffened cylinder, which is disturbed by a large enough single perturbation load, is leading directly to the design buckling load 45% higher compared with the respective NASA SP 8007 design. All results and experience is summarized in a handbook for the design of imperfection sensitive composite launcher structures. The potential is demonstrated within 2 industrially driven use cases.

By getting the objectives DESICOS contributes to reduce launcher weight, development time, design and manufacturing costs, and to increase launcher capacity.
The main DESICOS results can be summarised as following:

1) Benchmarking results:
    a. Collection of all worldwide existing papers to buckling experiments
    b. Imperfection data base with existing measurements
    c. ABQUS plug-in for improved modelling and evaluation of cylindrical and conical structures with different loads, boundary conditions, cut-outs, imperfections, …
2) Experimental data base on:
    a. Material properties of different materials used in the project
    b. Manufacturing of structures
    c. Buckling experiments
3) New design approaches:
    a. Modelling and analyses
    b. New design approaches
    c. Validation and application of the design approaches
4) Design and analysis handbook
    a. Design and analysis handbook
    b. Industrial validation

The main results were published in 30 peer-reviewed papers (see www.desicos.eu). All the results generated are used by the industrial partners. One can summarize that the application of analysis based design methods, using different approaches to represent the imperfections, seems to lead to less conservative KDFs than those obtained by the NASA SP. However, additional studies are needed to collect imperfection data of the real structures, and how these imperfections should be represented in an efficient way.