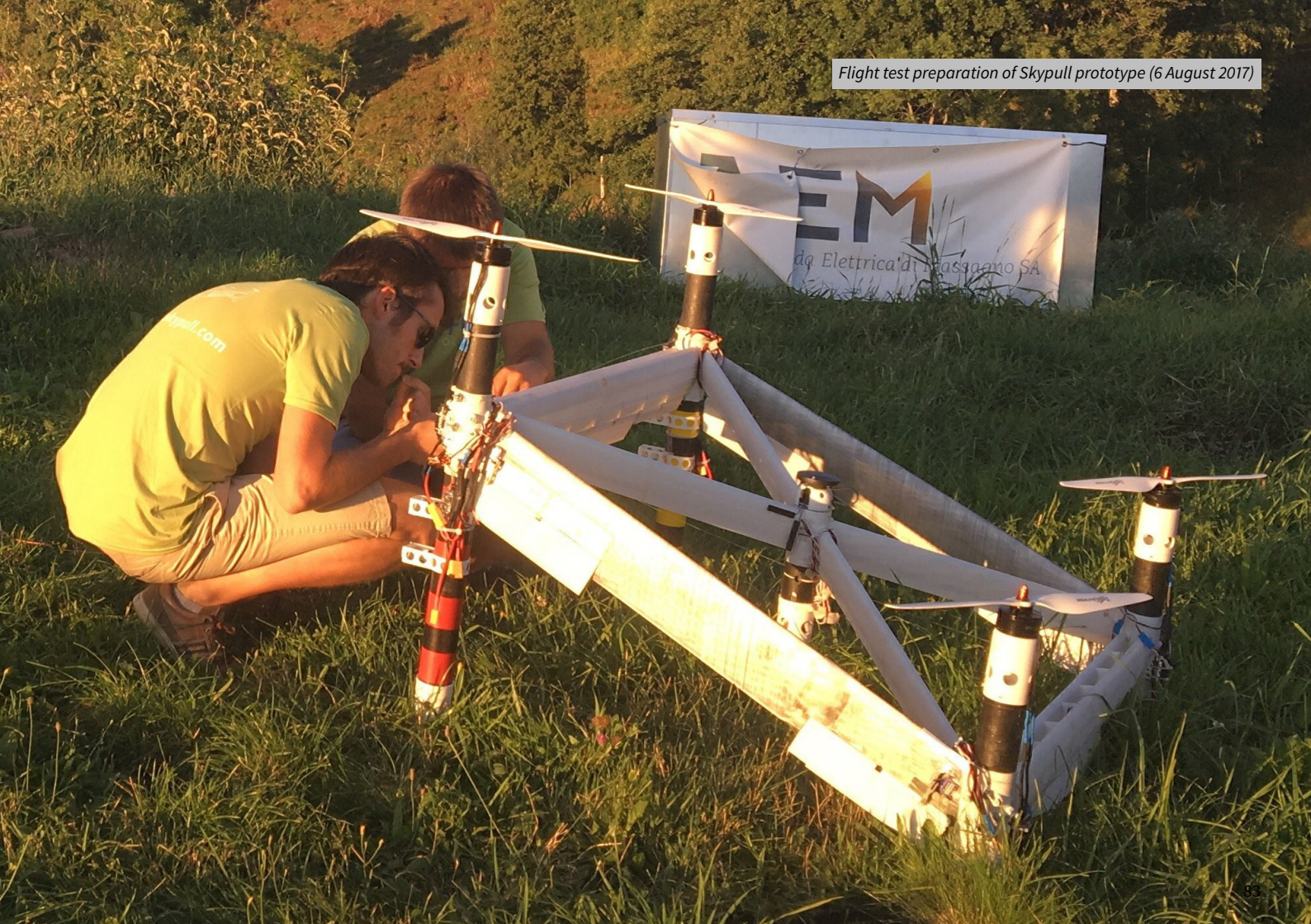
Skypull prototype SP1 125a, 1 kW power system drone (2 March 2016)



Flight test preparation of Skypull prototype (6 August 2017)

Flight testing of Skypull prototype (6 August 2017)

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Nonlinear Model Predictive Control of a Large-Scale Quadrotor

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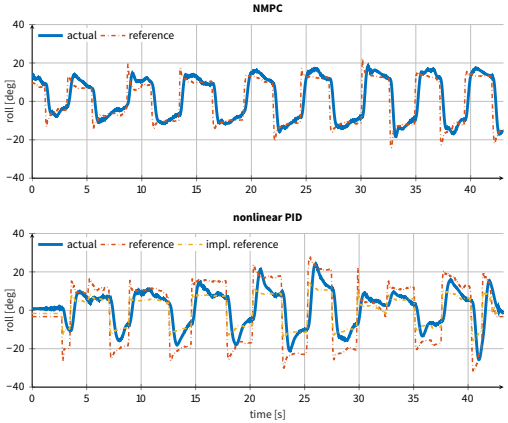
Several concepts in airborne wind energy (AWE) that emerged in the last few years exploit quadrotor-like systems to leverage the advantages of vertical take-off and landing strategies. Although the dynamics can be rather different after transitioning into a power generating phase, during take-off and landing, the system can be expected to share some similarities with a "pure" quadrotor system.

In this talk, the problem of controlling a large-scale quadrotor is addressed with nonlinear model predictive control (NMPC). NMPC is an optimization-based control technique that allows one to directly take into account nonlinearities of the model and physical constraints by formulating a nonlinear nonconvex optimization problem. In order to be able to solve such problems online, as the state of the system changes, efficient numerical algorithms and software implementations are required.

In the application described, NMPC is used to stabilize the attitude of the quadrotor. In order to achieve the required sampling time, inexact schemes are used such as the Real-Time Iteration (RTI) scheme and the so-called partially tightened formulation [2]. Moreover, the solver `HPMPC` [1] is used that exploits a cache efficient data format and vectorized instructions to improve execution time. Experimental results are presented that show real-time feasibility of the proposed approach and a large improvement of the control performance over classical control solutions.



Tracking of roll steps on the physical system: comparison of an NMPC and a nonlinear PID controller. The NMPC controller, with a sample rate of 10ms, was deployed on an embedded platform with an ARM Cortex A9 processor running at 800MHz.

References:

[1] G. Frison, H. B. Sorensen, B. Dammann, and J. B. Jørgensen. High-performance small-scale solvers for linear model predictive control. In Proceedings of the European Control Conference (ECC), pages 128-133, June 2014.

[2] A. Zanelli, R. Quirynen, G. Frison, and M. Diehl. A stabilizing partially tightened real-time iteration scheme for nonlinear model predictive control. In Proceedings of 56th IEEE Conference on Decision and Control, Melbourne, Australia, December 2017. (accepted).