

---

# Contents

---

<b>Abstract</b>	<b>vii</b>
<b>Resumen</b>	<b>ix</b>
<b>Resum</b>	<b>xi</b>
<b>Acknowledgements</b>	<b>xiii</b>
<b>I Thesis report</b>	<b>1</b>
<b>1 Introduction</b>	<b>3</b>
1.1 Motivation . . . . .	3
1.2 Description of a high-speed catenary . . . . .	5
1.3 Objective . . . . .	6
1.4 Thesis layout . . . . .	7
<b>2 State of the art</b>	<b>9</b>
2.1 Catenary modelling . . . . .	10
2.2 Pantograph modelling . . . . .	11
2.3 Coupling modelling and numerical integration . . . . .	11
2.4 Initial configuration problem . . . . .	12
2.5 Real-time simulations . . . . .	13
2.6 Parametric analyses and optimisations . . . . .	13
2.7 Simulation of irregularities and uncertainties . . . . .	14
2.8 Other related topics . . . . .	15

<b>3</b>	<b>Pantograph–catenary dynamic interaction simulation</b>	<b>17</b>
3.1	Mathematical models . . . . .	17
3.1.1	Catenary . . . . .	18
3.1.2	Pantograph . . . . .	19
3.1.3	Interaction . . . . .	21
3.2	Static equilibrium and initial configuration problems . . . . .	22
3.3	Dynamic interaction problem . . . . .	24
<b>4</b>	<b>Contributions</b>	<b>29</b>
4.1	Parametric model . . . . .	30
4.2	Fast simulation algorithm . . . . .	35
4.2.1	<i>Offline</i> stage . . . . .	35
4.2.2	<i>Online</i> stage . . . . .	37
4.3	Catenary optimisation . . . . .	40
4.4	Stochastic simulations . . . . .	45
<b>5</b>	<b>Closure</b>	<b>51</b>
5.1	Summary and conclusions . . . . .	51
5.2	Open research lines . . . . .	52
	<b>Bibliography</b>	<b>55</b>
<b>II</b>	<b>Articles</b>	<b>67</b>
	<b>Paper A: Parametric model for the simulations of the railway catenary system static equilibrium problem</b>	<b>69</b>
	<b>Paper B: Fast simulation of the pantograph–catenary dynamic interaction</b>	<b>105</b>
	<b>Paper C: An approach to geometric optimisation of railway catenaries</b>	<b>141</b>
	<b>Paper D: Stochastic Monte Carlo simluations of the pantograph– catenary dynamic interaction to allow for uncertainties introduced during catenary installation</b>	<b>175</b>