CURRICULUM: SCIENCES AND TECHNOLOGIES FOR AERONAUTICS AND SATELLITE APPLICATIONS (STASA)

MODELLING SPRAY DYNAMICS FOR EVAPORATION AND COMBUSTION

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SUPERVISOR: **Prof. Francesco Picano**

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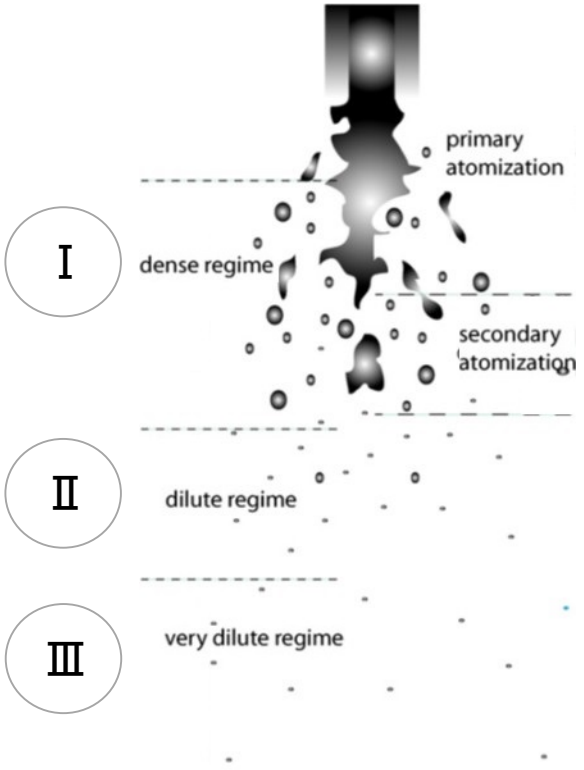
OUTLINE OF THE PRESENTATION

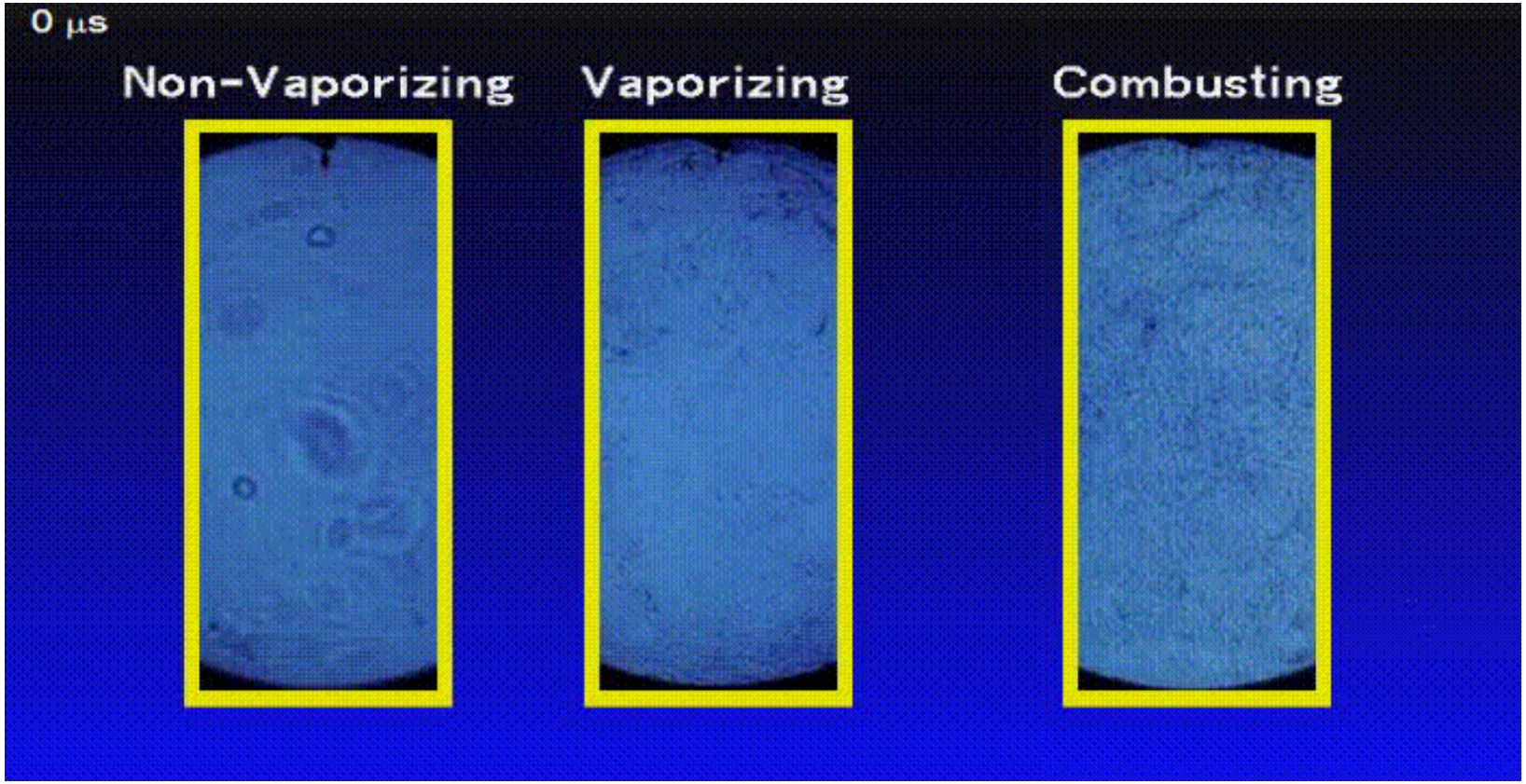
- Introduction Part
- What's New
- Summary of The Research Activity

Introduction – What Is The Spray Evaporation & Combustion?



- A turbulent spray is a chaotic multiphase flow where chemical reactions occur together with phase exchange during combustion.
- The different physical phenomena involved range from submicron-scale, e.g. reactions, to meter size turbulent motions.

Introduction – How It Looks Like in Practical Applications?



High-Speed Schlieren Movies of Diesel Sprays (Sandia National Lab)

- Similar phenomena happen in car engines, ship engines, airplane engines and liquid rocket engines.

Introduction – Why Is It Important to Study The Phenomena?

- Improving combustion efficiency
  - More chemical energy transfer into works available
  - Less fuel consumption

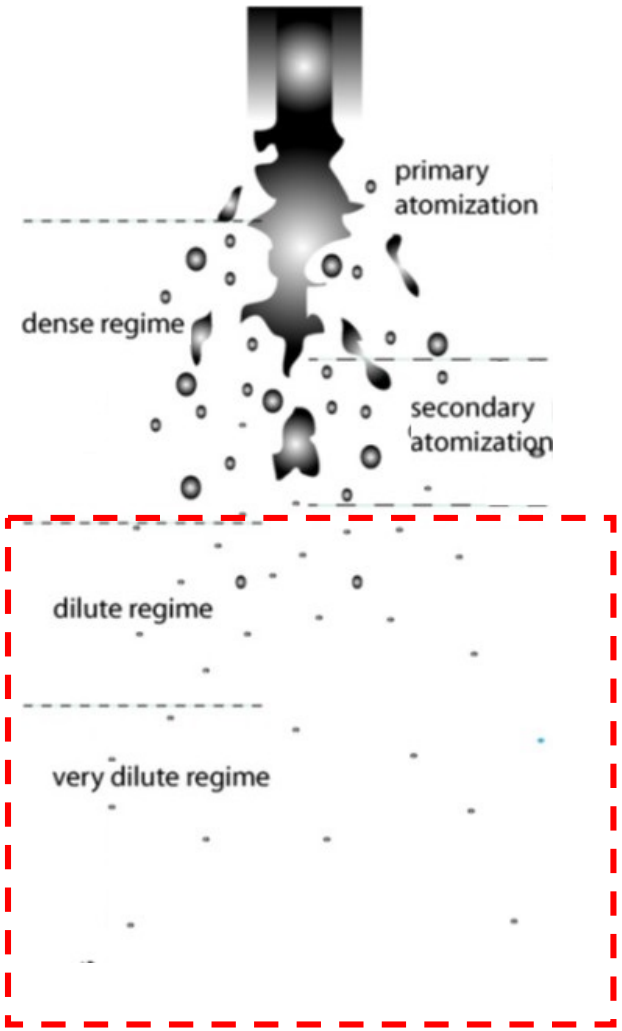
- Reducing pollutant emission levels
  - Particular Matter (PM)
  - NOx
  - CO
  - Greenhouse Gas
  - ……

Introduction – State of The Art

Flow	Combustion	
Direct Numerical Simulation (DNS)	Detailed Chemical Mechanism (Hundred of Species with Thousands of Reaction Steps)	Not available
Large Eddy Simulation (LES)	Reduced Chemical Mechanism (Species Below 100)	
Reynolds-average Navier-Strokes (RANS)	Various Combustion Model (e.g. Shell-CTC, G-Equition, ECFM……)	Main method used in industry

- LES coupled with Reduced Chemical Mechanism / Combustion Model is a promising method to analyzing the turbulent spray phenomena.

What's New? – Our Focus



Dilute regime & very dilute regime:

- Dispersed droplets
- **No Break-up** : surface tension >> aer. forces (We ≪ 1)
- **No collision / coalescence** : low volume fraction (Φ <10-4)
- Main region occurring combustion

What's New? – Our Goal

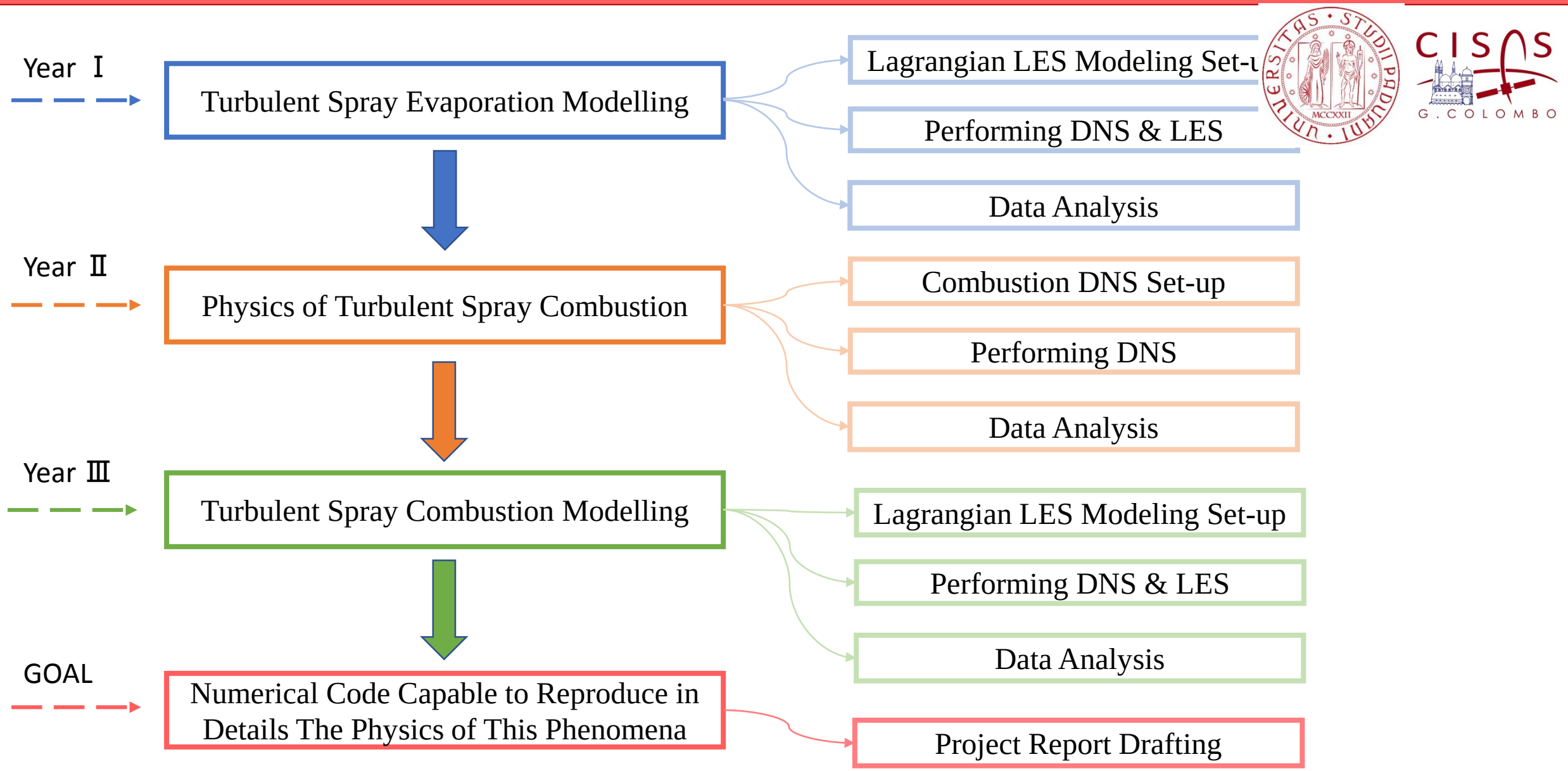
- Move forward the physical and technological understanding of multiphase turbulent spray evaporation and combustion phenomena

- Satisfactory code will de updated to perform 3D simulations of turbulent, evaporating and reacting sprays

- Prof. Francesco Picano has reliable codes in multiphase flows

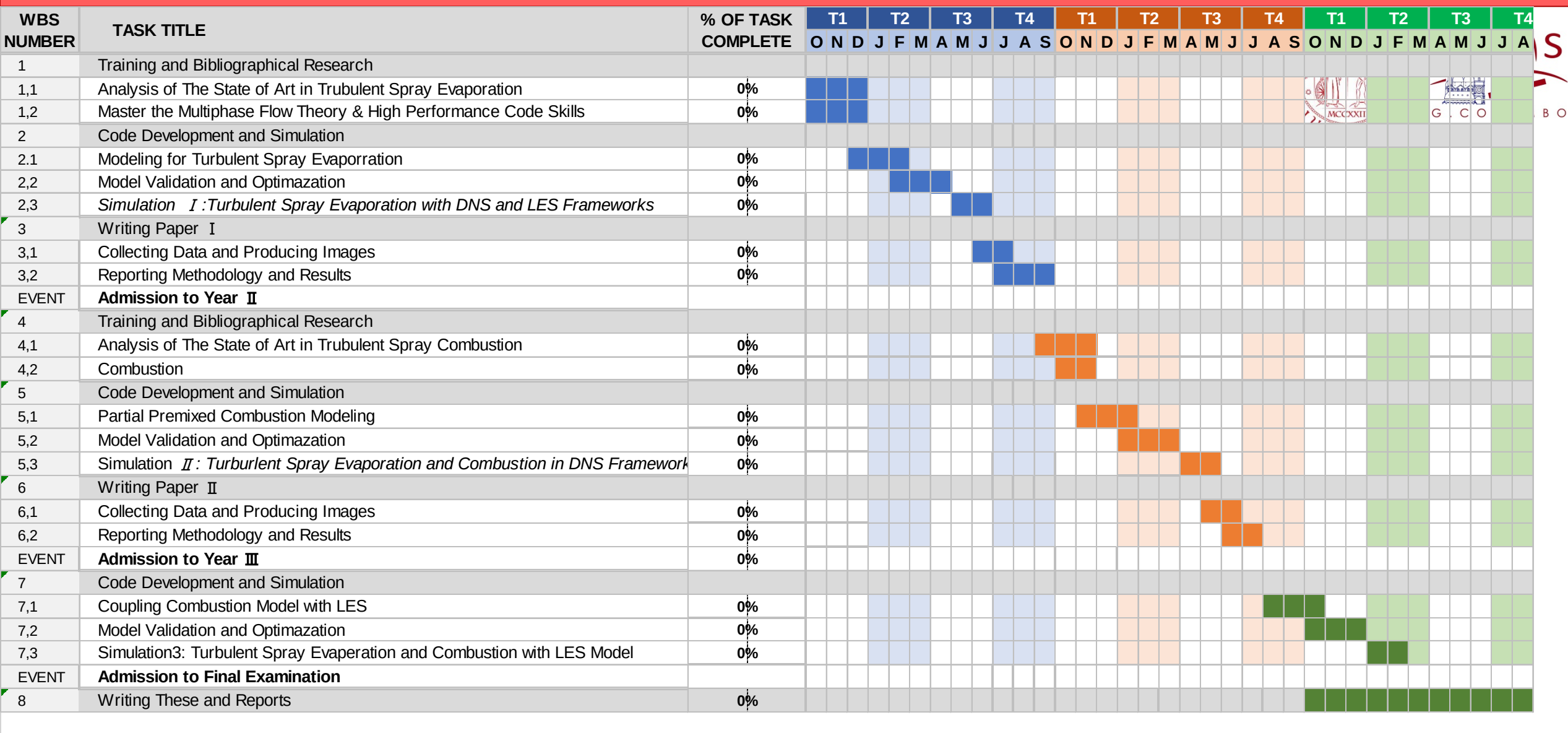
- The applicant has focused on analyzing combustion characteristics in internal combustion engines during his Master period

Summary of Research Activity – Three Years



Summary of Research Activity - GANNT

WBS NUMBER	TASK TITLE	% OF TASK COMPLETE
1	Training and Bibliographical Research	
1,1	Analysis of The State of Art in Trubulent Spray Evaporation	0%
1,2	Master the Multiphase Flow Theory & High Performance Code Skills	0%
2	Code Development and Simulation	
2.1	Modeling for Turbulent Spray Evaporration	0%
2,2	Model Validation and Optimazation	0%
2,3	*Simulation Ⅰ:Turbulent Spray Evaporation with DNS and LES Frameworks*	0%
3	Writing Paper Ⅰ	
3,1	Collecting Data and Producing Images	0%
3,2	Reporting Methodology and Results	0%
EVENT	**Admission to Year Ⅱ**	
4	Training and Bibliographical Research	
4,1	Analysis of The State of Art in Trubulent Spray Combustion	0%
4,2	Combustion	0%
5	Code Development and Simulation	
5,1	Partial Premixed Combustion Modeling	0%
5,2	Model Validation and Optimazation	0%
5,3	Simulation *Ⅱ: Turburlent Spray Evaporation and Combustion in DNS Framework*	0%
6	Writing Paper Ⅱ	
6,1	Collecting Data and Producing Images	0%
6,2	Reporting Methodology and Results	0%
EVENT	**Admission to Year Ⅲ**	0%
7	Code Development and Simulation	
7,1	Coupling Combustion Model with LES	0%
7,2	Model Validation and Optimazation	0%
7,3	Simulation3: Turbulent Spray Evaperation and Combustion with LES Model	0%
EVENT	**Admission to Final Examination**	
8	Writing These and Reports	0%



Thank you for your attention!