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B in Large-Scale Projects:
The Canarsie Line CBTC Experience

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B in Large-Scale Projects

- What is a CBTC ?
- The Canarsie Line
- Metrics: a comparison of Meteor and the Canarsie Line
- Developing in B

Communications Based Train Control

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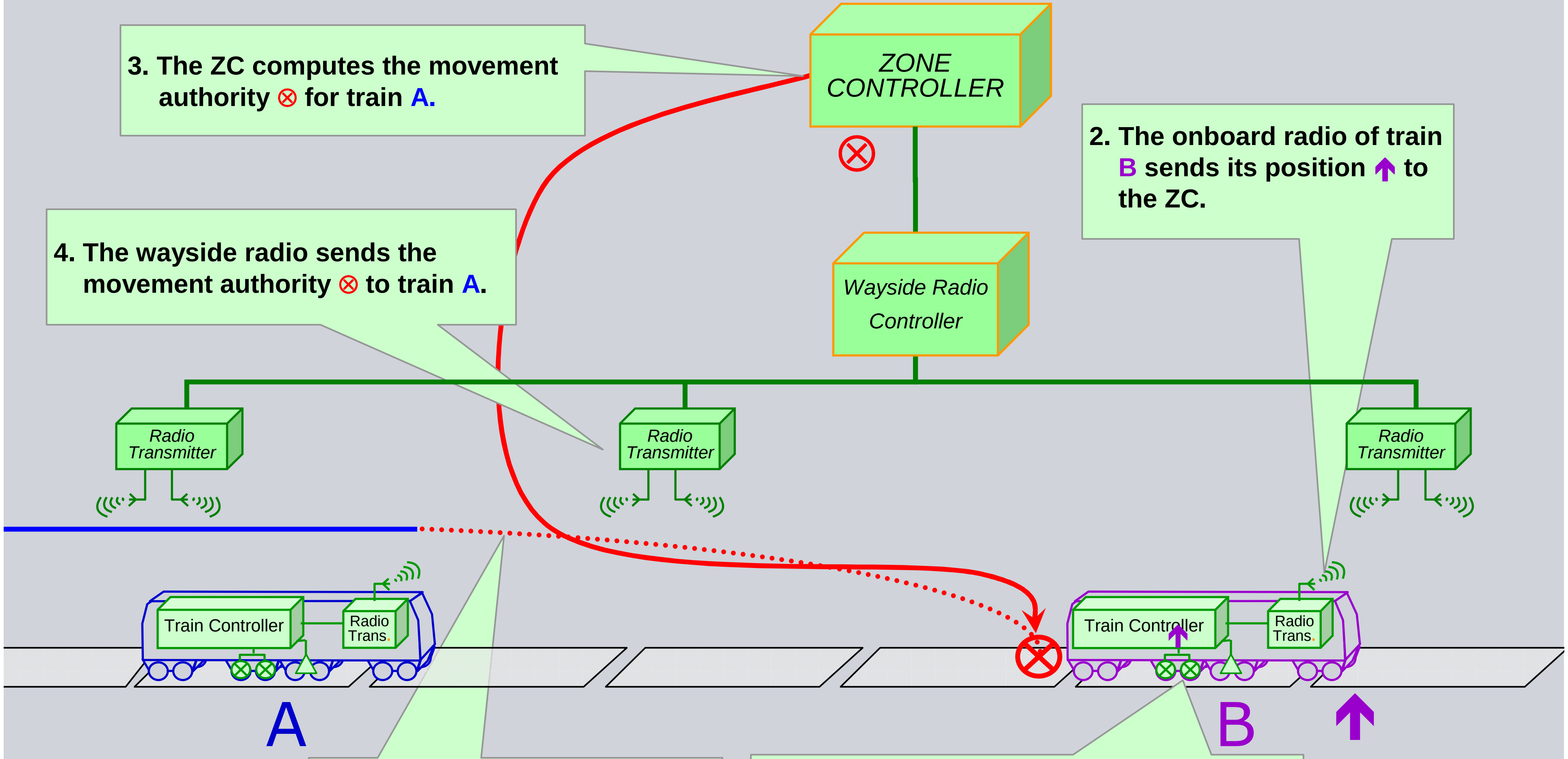

1. Using its odometry sensors, train B continuously computes its position: ↑.

2. The onboard radio of train B sends its position ↑ to the ZC.

3. The ZC computes the movement authority ⊗ for train A.

4. The wayside radio sends the movement authority ⊗ to train A.

5. Train A computes a speed profile that complies with the movement authority ⊗.

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The B in CBTC: where is it?

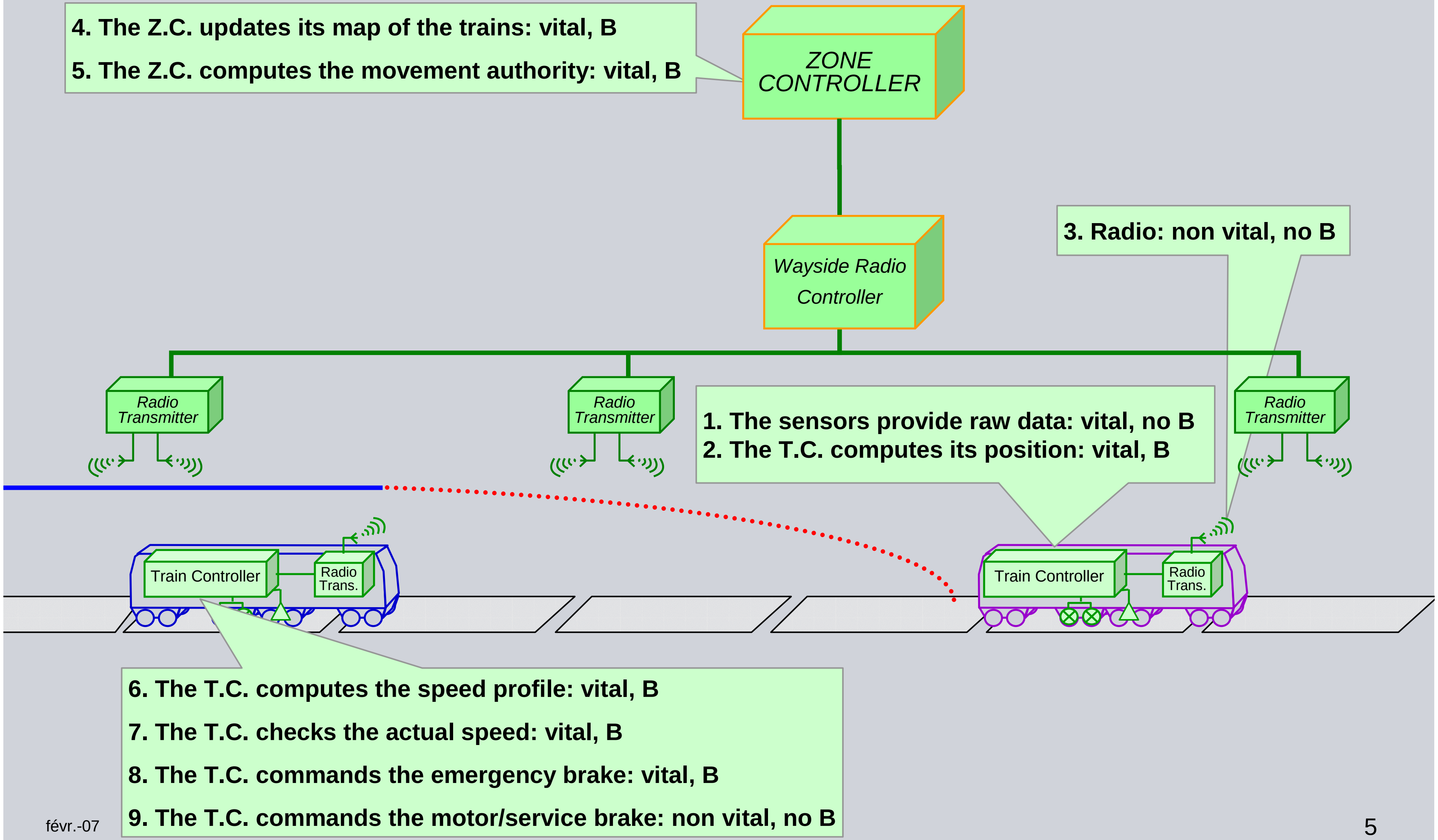
Early in the design the vital and non vital functions are split.

Every vital function is developed in B.

Exceptions:

- low level input/output
- configuration files of the vital software
- the main (infinite) loop

The B in CBTC: where is it?



4. The Z.C. updates its map of the trains: vital, B

5. The Z.C. computes the movement authority: vital, B

3. Radio: non vital, no B

1. The sensors provide raw data: vital, no B
2. The T.C. computes its position: vital, B

6. The T.C. computes the speed profile: vital, B

7. The T.C. checks the actual speed: vital, B

8. The T.C. commands the emergency brake: vital, B

9. The T.C. commands the motor/service brake: non vital, no B

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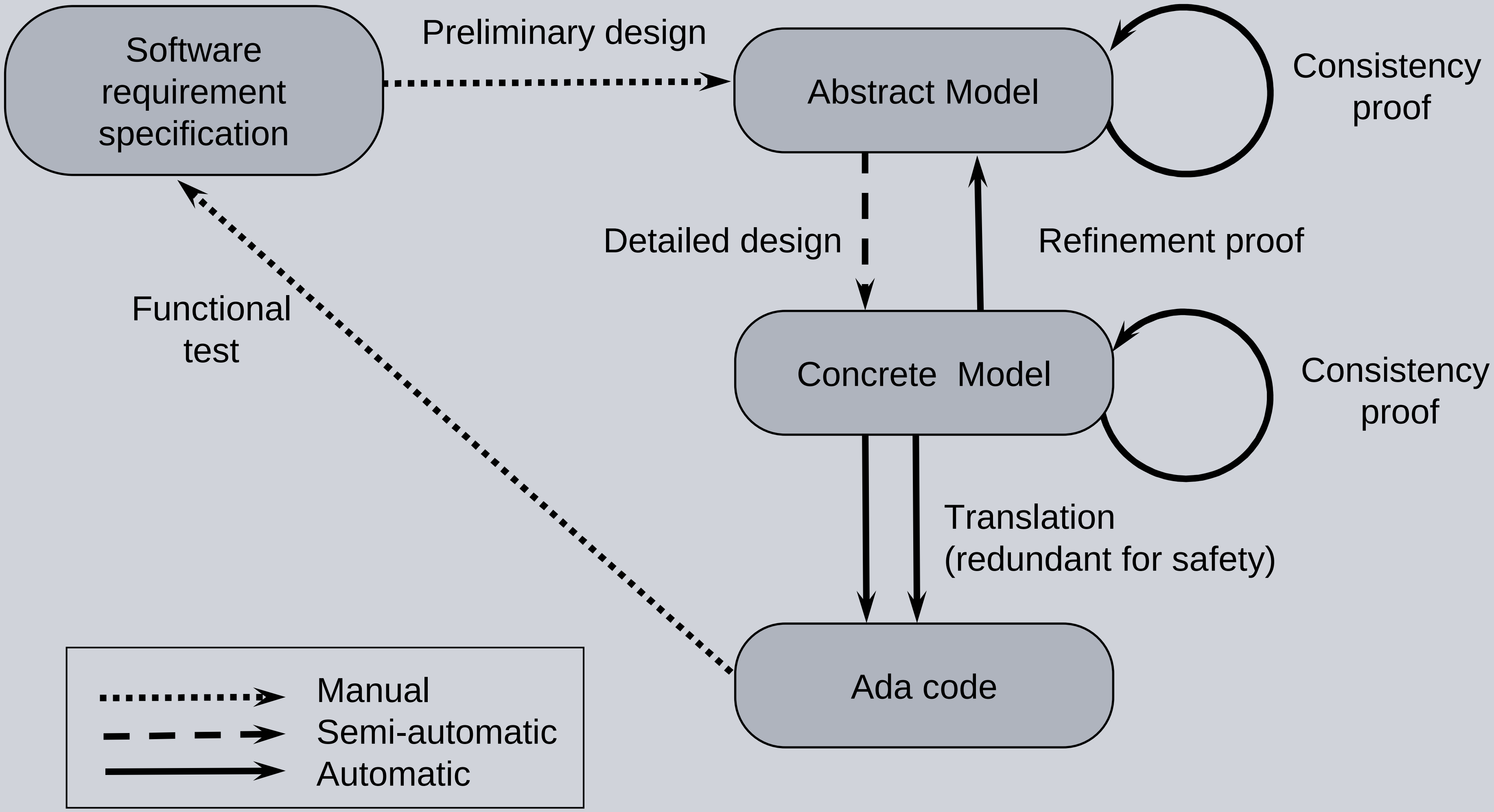
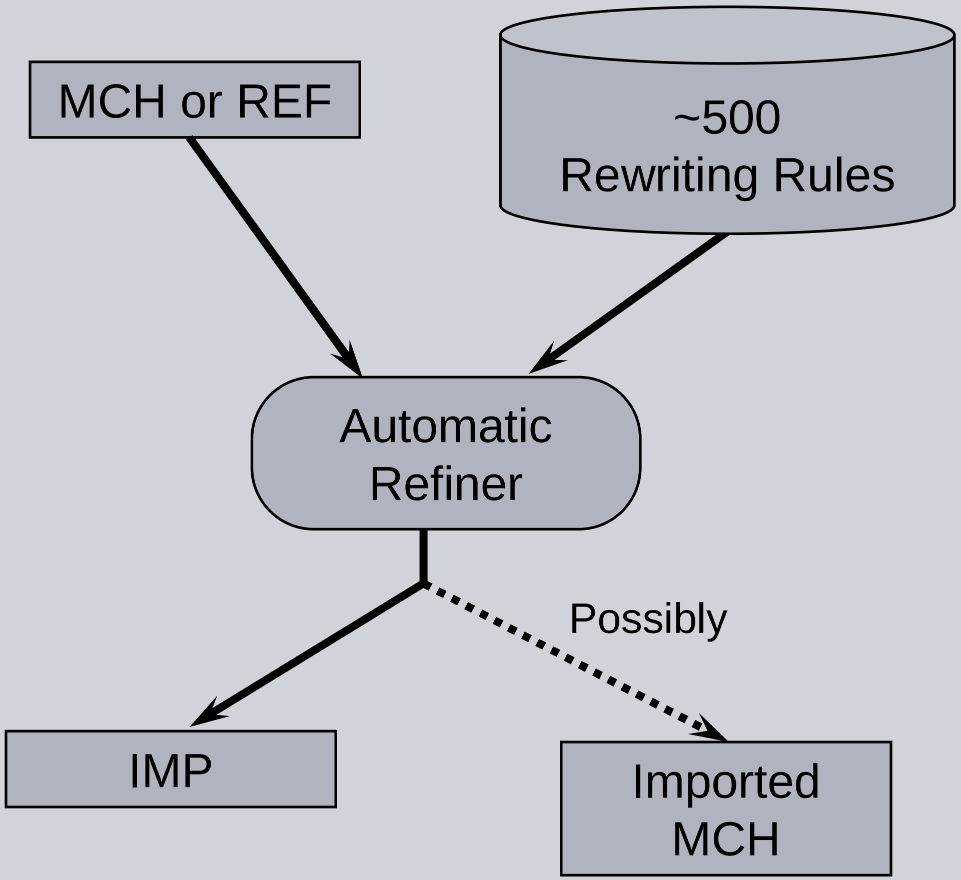
The B in CBTC: what is it?



A word about automatic refinement

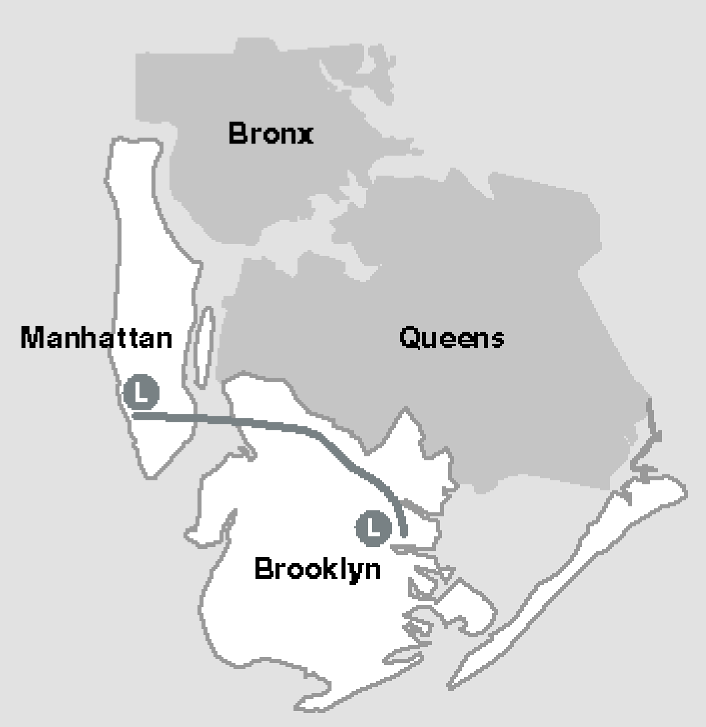
How does it work?



Why does it work?

- Constructive specifications
  x := e ~~x:(P)~~
- The “system” properties disappear during refinement
- Few (< 10) data refinement schemes

New York: Canarsie Line



Length of the line: 17 km

Number of Stations: 24

Number of trains: 53

Operating times: 24h/day, 7 days/week

Mixed fleet: equipped / unequipped trains

Interoperability between lines and between suppliers

Revenue service: Jan. to Nov. 2006

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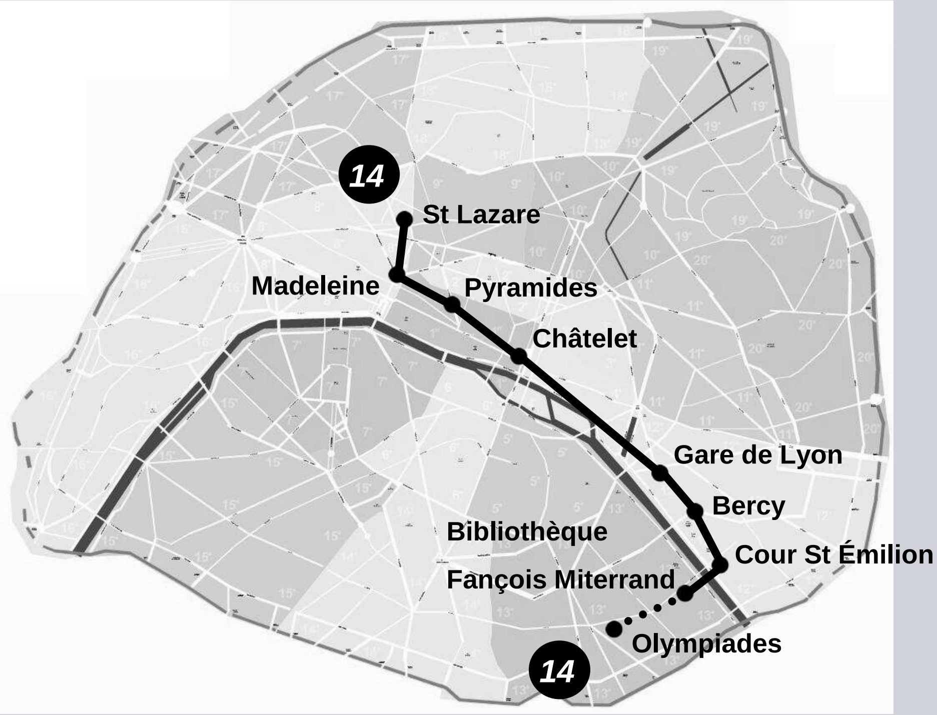
Paris: Meteor



Driverless

Length of the line: 8,5 km

Number of Stations: 8

Number of trains: 19

Revenue service: Oct. 1998

Passengers/day: 350000

Canarsie Line vs. Meteor: a complexity step

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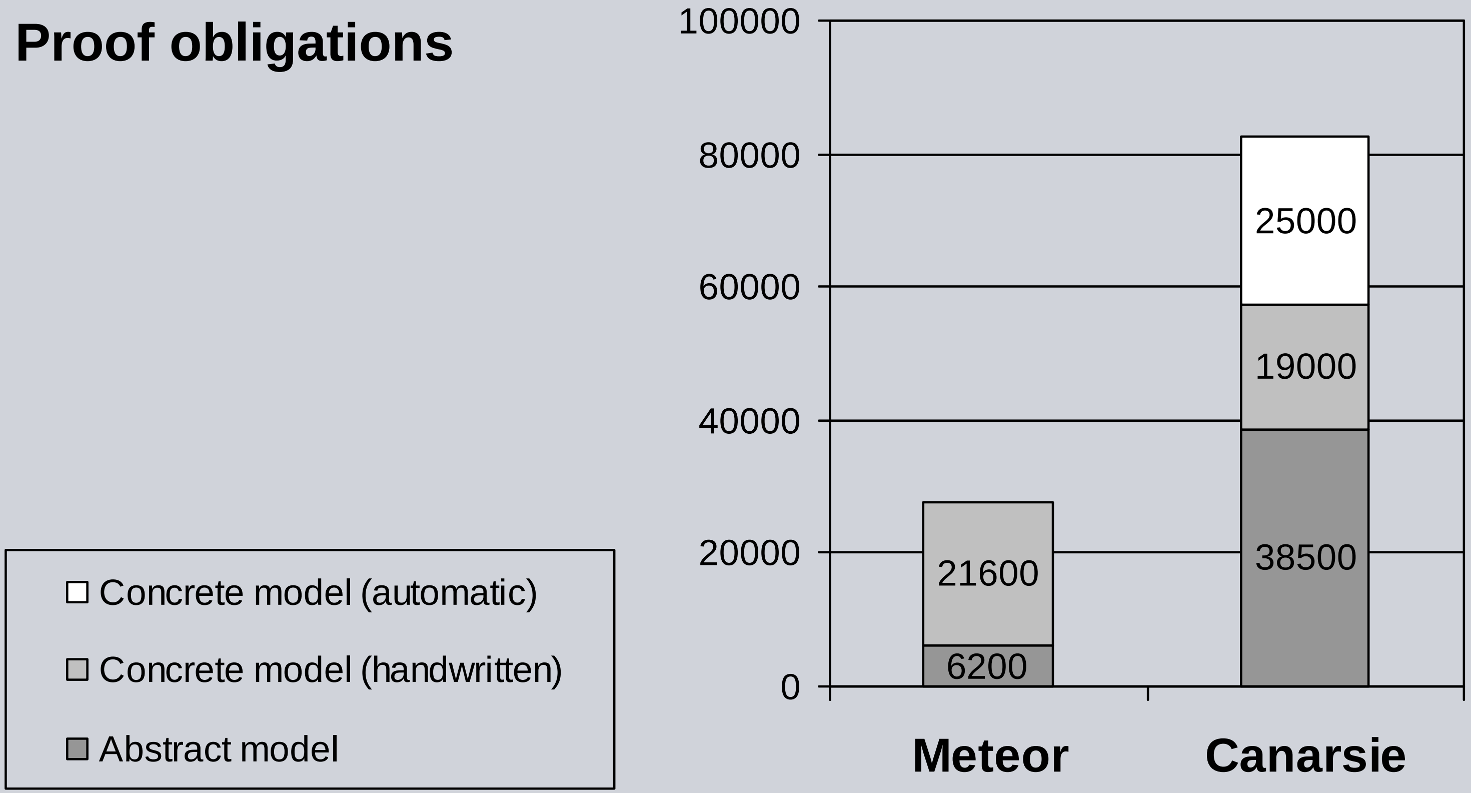
Meteor is driverless but ... the Canarsie Line CBTC is more complex

Canarsie Line	**Meteor**
Refurbishment Radio	New line Induction loop in the track
Continuous speed/energy computation Dynamically loaded configuration files	Pre-computed tables Statically linked configuration data
Automatic refinement Use of more B constructs (lists, generalized union)	Hand written B model Use of less B constructs

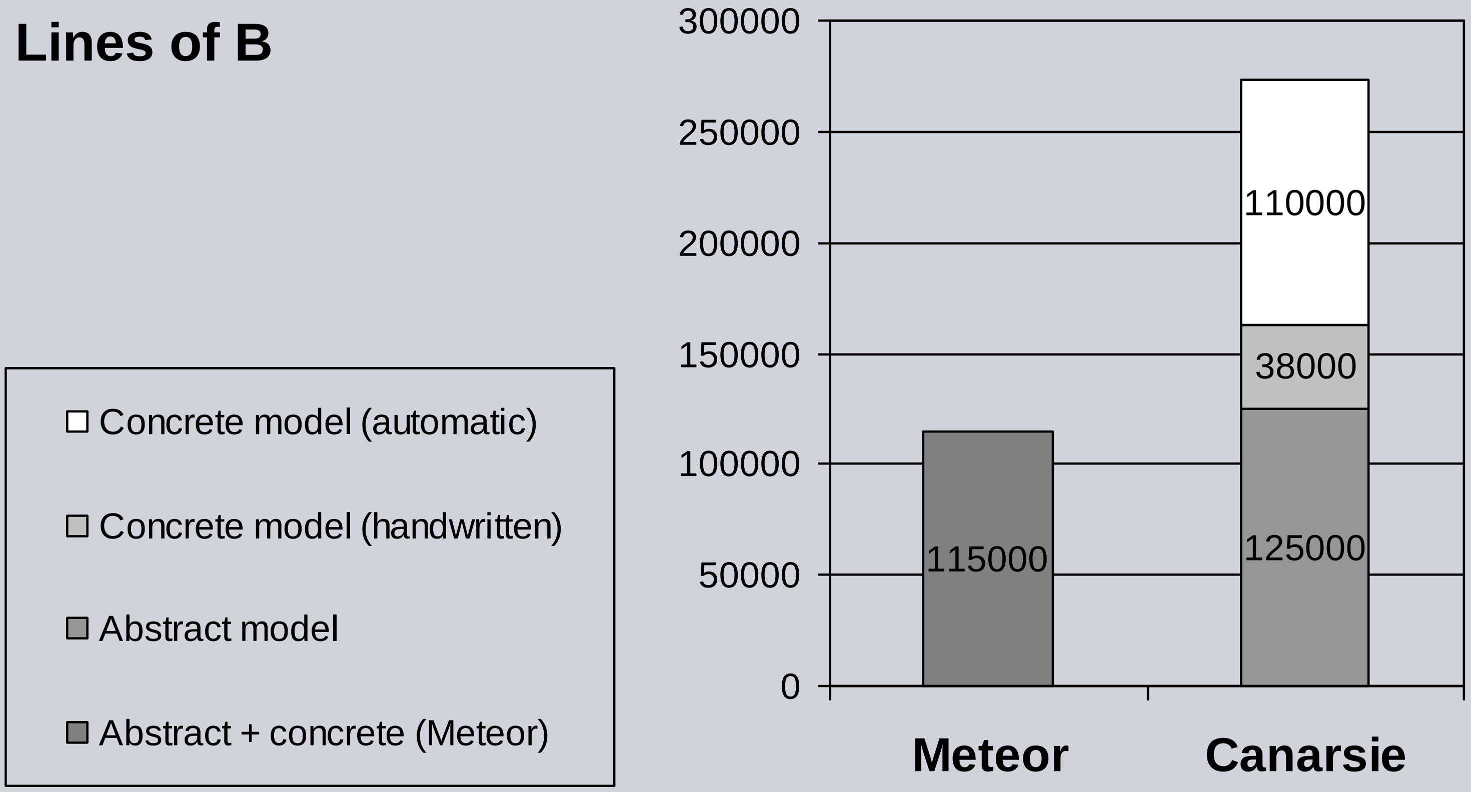
Canarsie Line vs. Meteor: metrics

Proof obligations

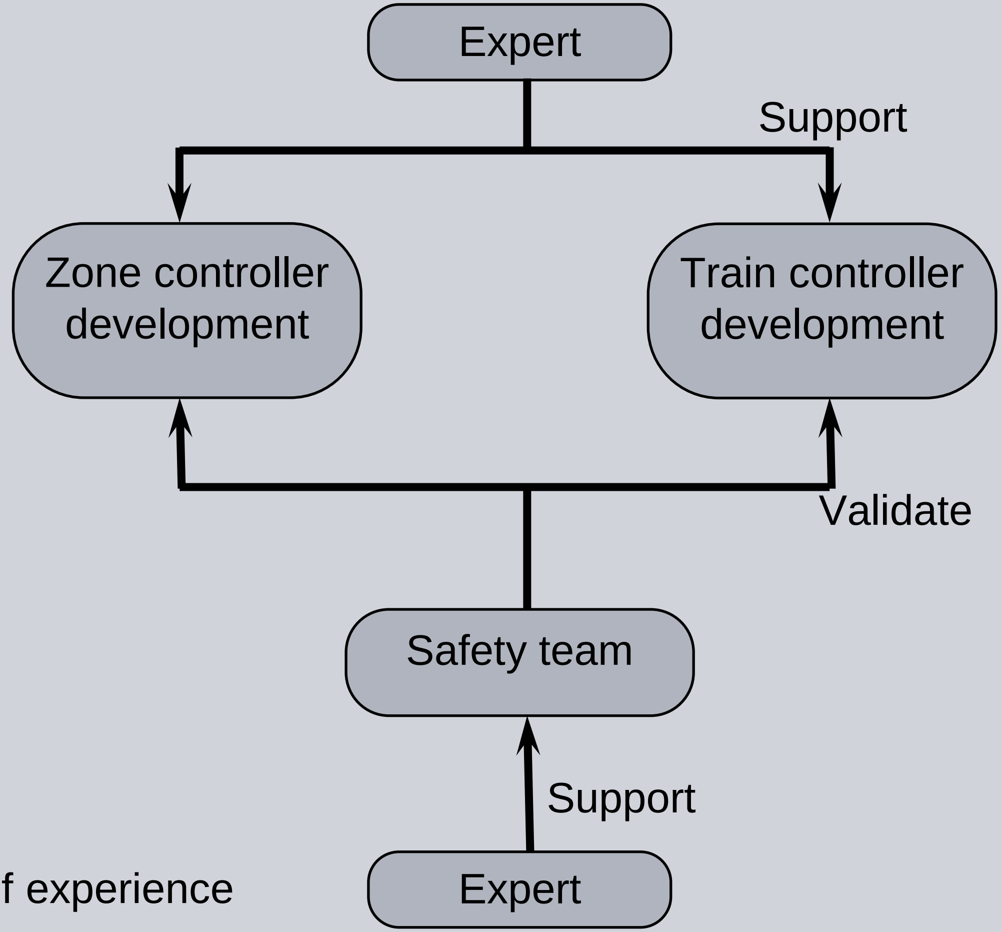


Canarsie Line vs. Meteor: metrics

Lines of B



Organizing a B development



Expert: 1 year of experience

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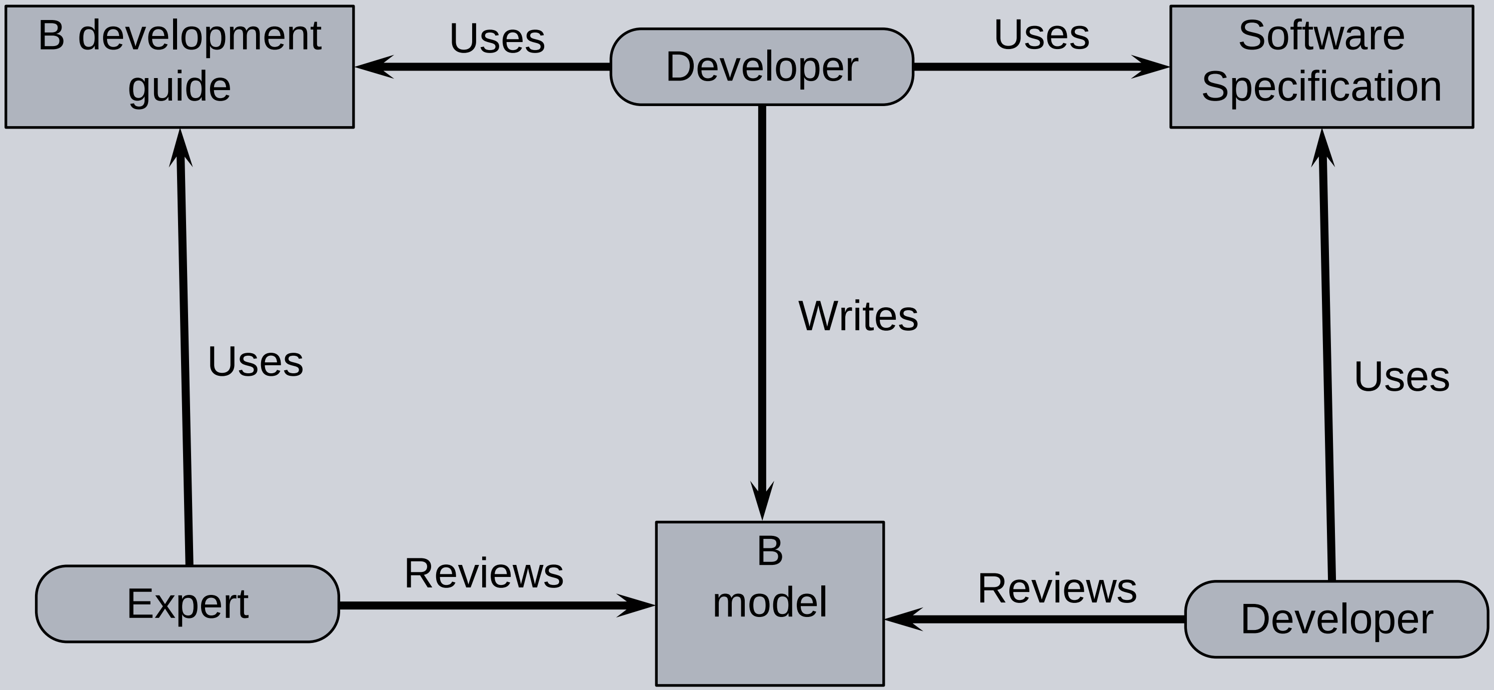
Review process during development



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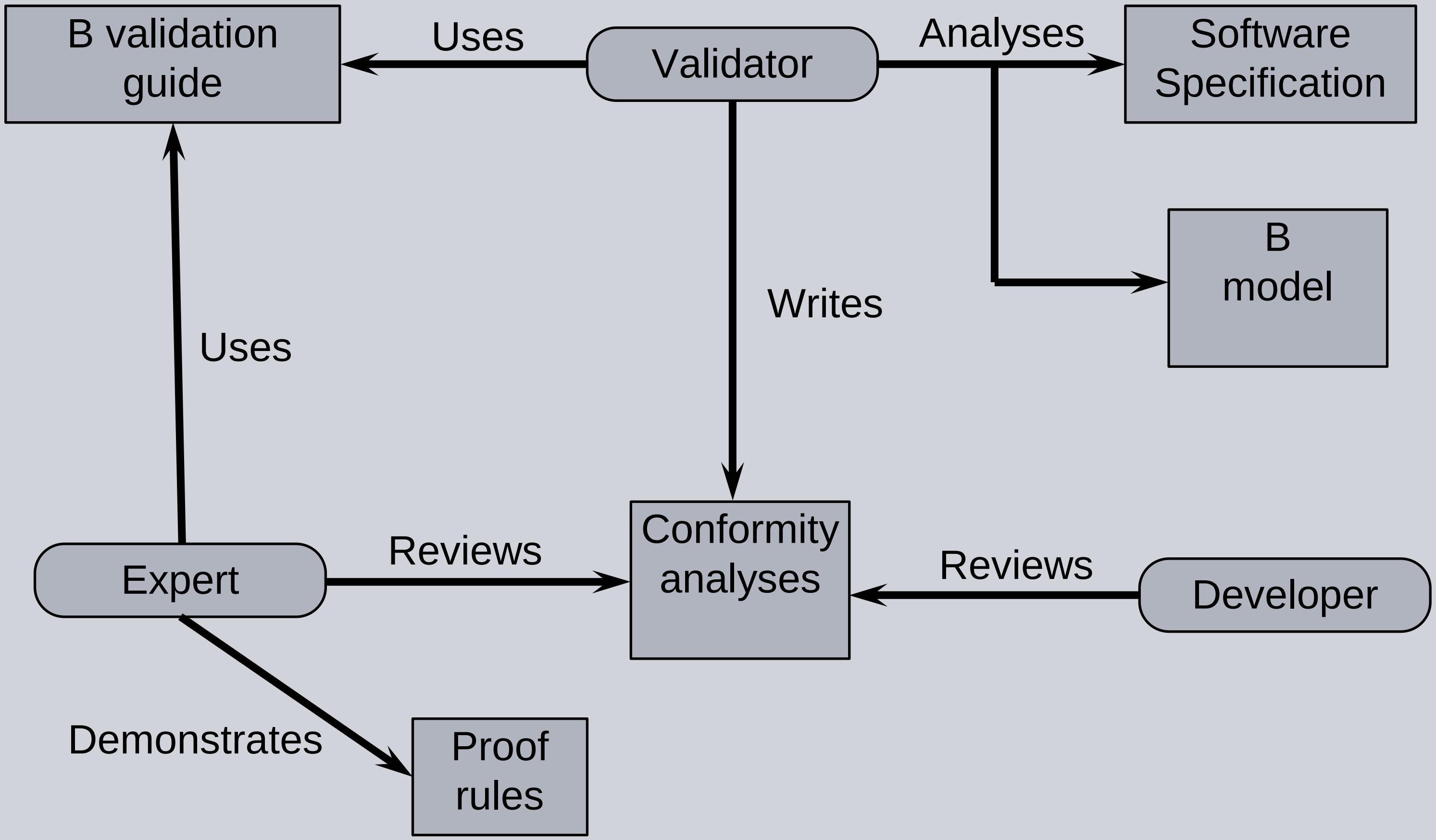
Review process during validation



B: a world of train control systems

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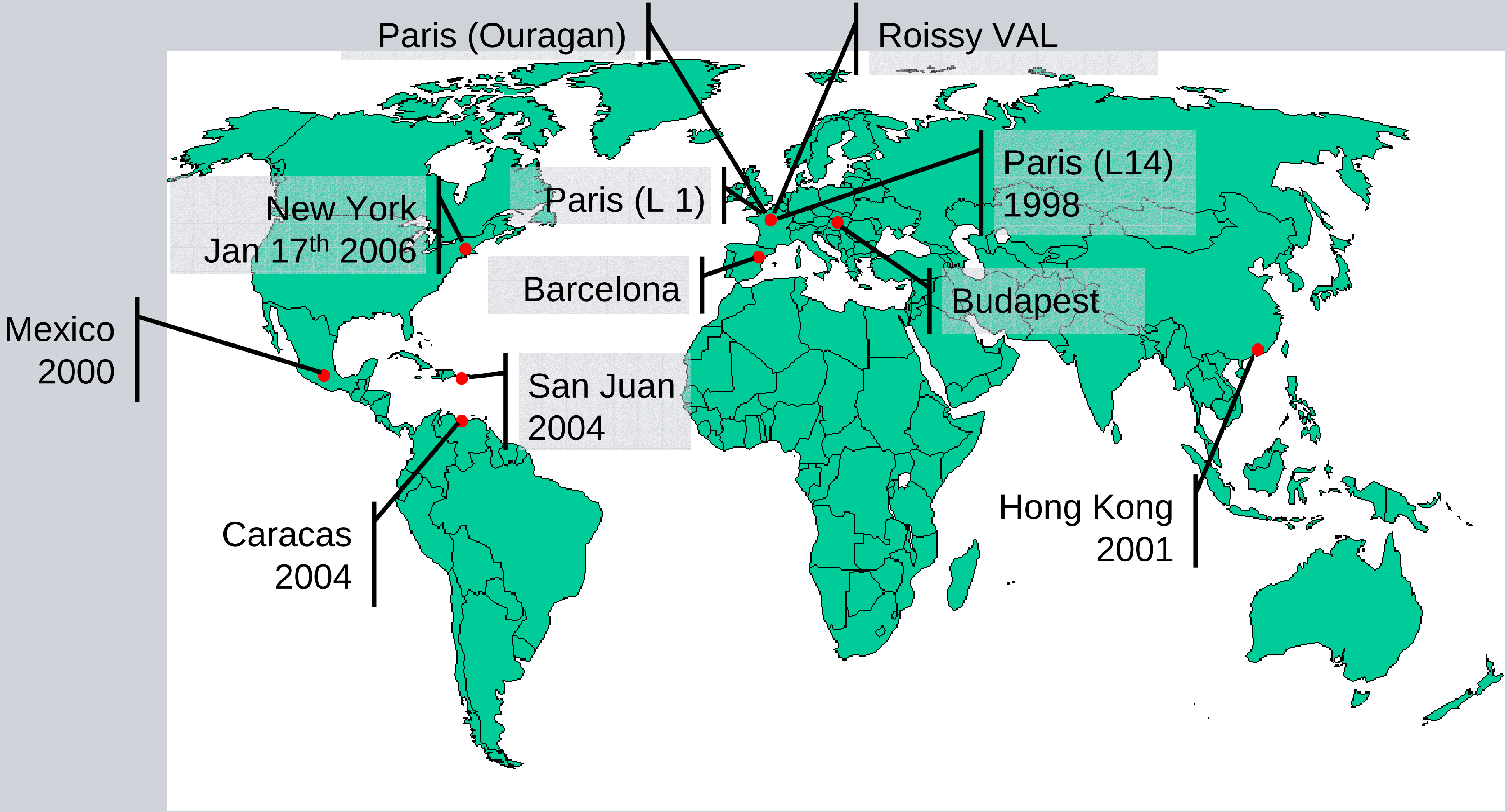

B in large scale projects

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Thank you for your attention

Any questions?