

IT15-rail

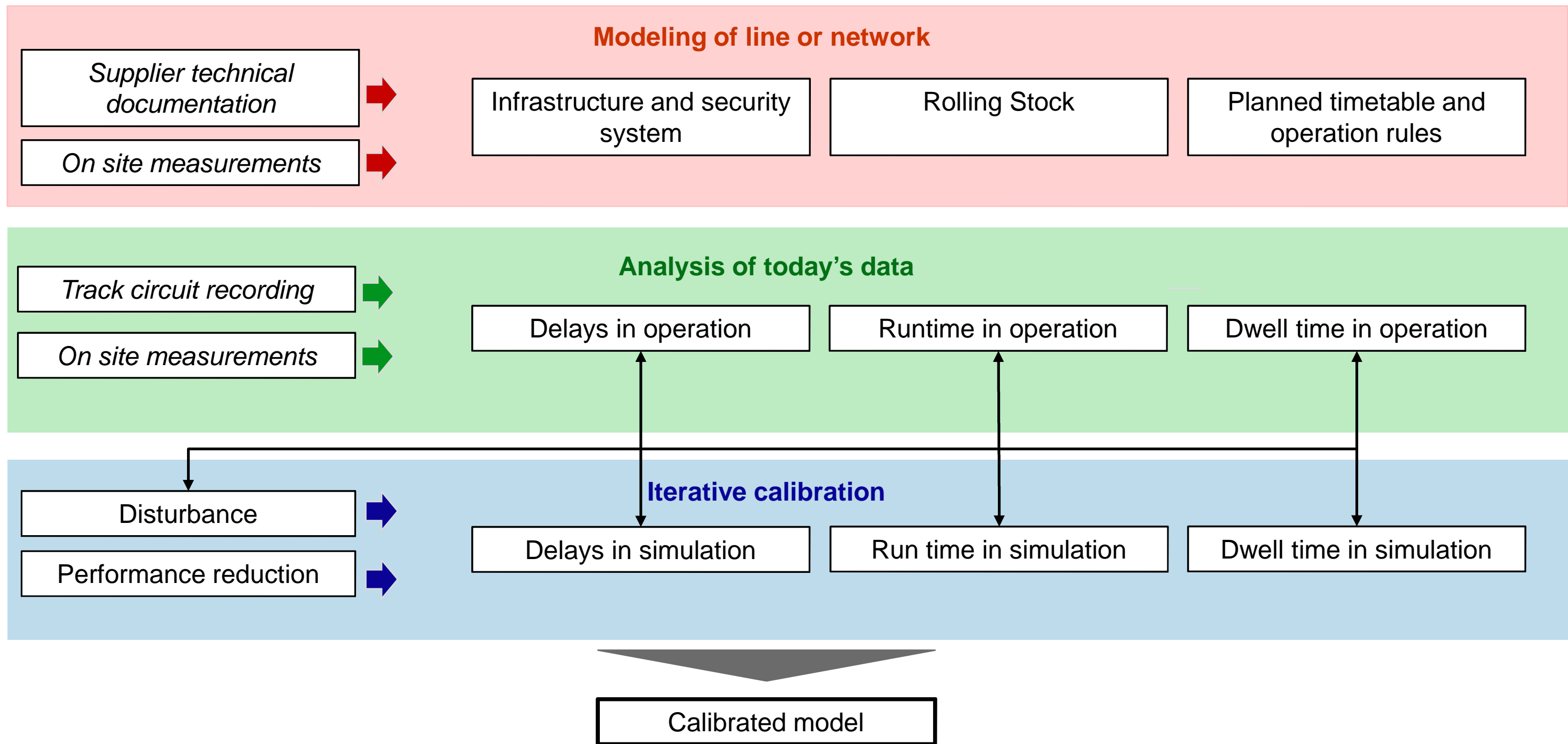
Simulation of a Commuter Network - Methodology and practical implementation

Program

1. Methodology
2. Practical implementation
 - TWL – MTR



Calibration of a line or network





Calibration of Line TWL (Hong-Kong)

Line characteristics:

Length: 16 km

Stations: 16

Safety system: Automatic Train Protection (ATP)

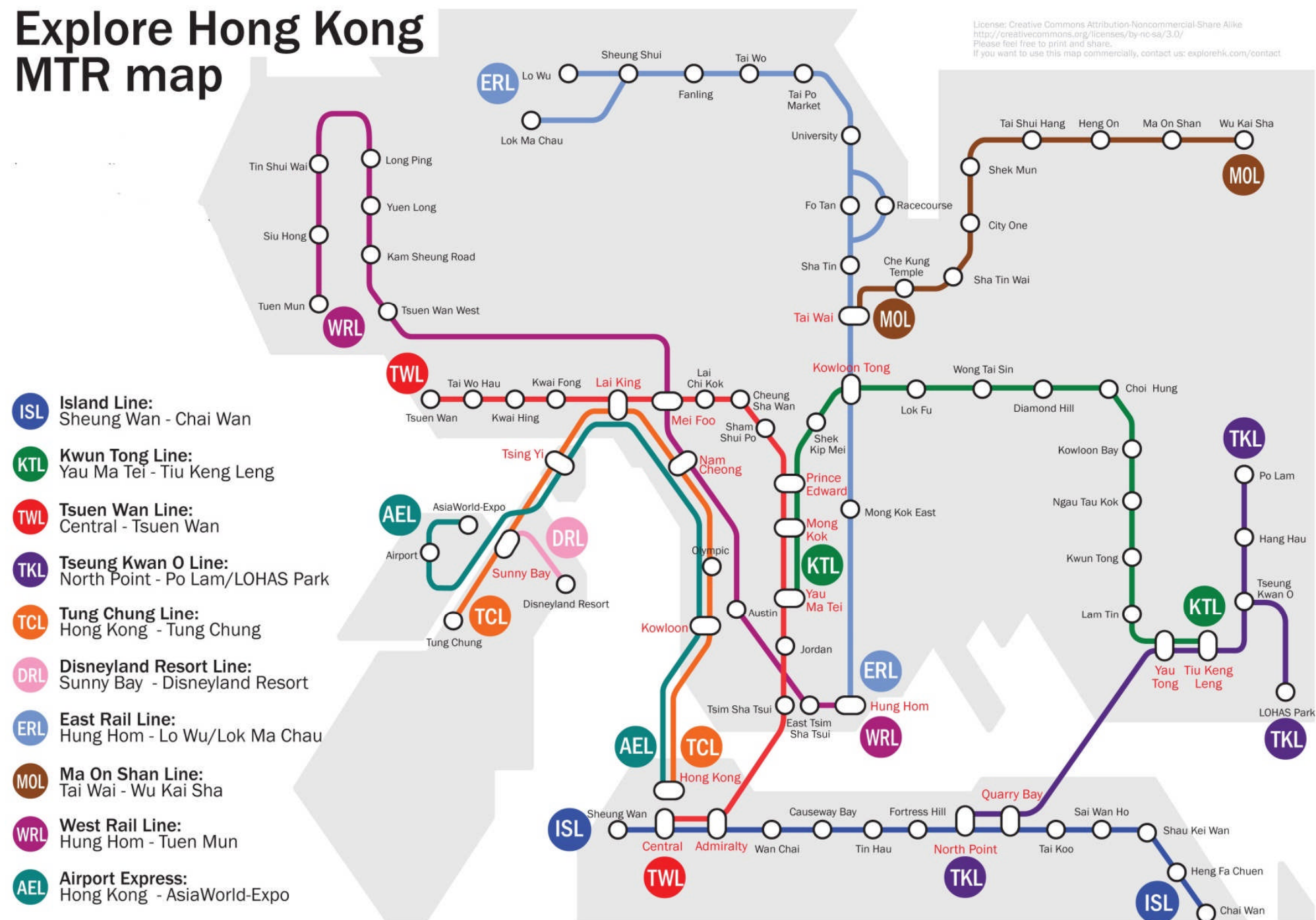
Operation system: Automatic Train Operation with driver (responsible for departing tops and backup in case of failure)

Rolling Stock: 180 m, 2100 passengers/train

Ridership: 1,06 M⁶ on weekdays

Train Interval in PH: 2 min

Explore Hong Kong MTR map





Modelling of the line - Infrastructure

Signaling plans



Infraspeed import file



OpenTrack documents

Transposition of supplier technical data to an excel file and import into OT:

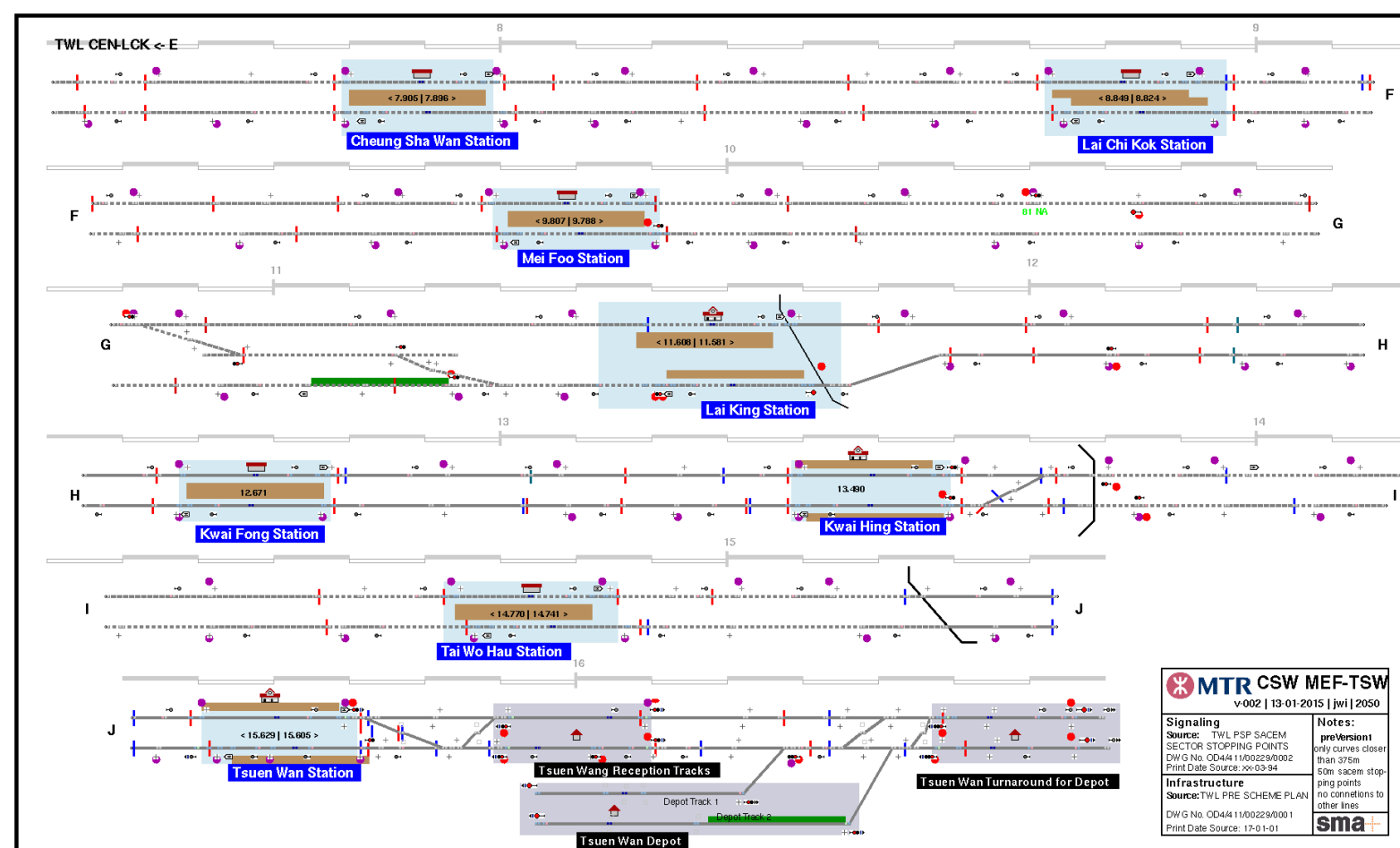
- Km of characteristic points (vertex)
- Coordinate of the vertex
- Station name
- Curves
- Gradients
- Speed
- Stopping points
- Signal
- Tunnel type

Advantage of Infraspeed format:

Flexibility of vertex placement (Use of coordinates)

Advantage over manual modelling:

- Time gained 20%
- Risk of errors: -50%





Modelling of the line - Courses

Course data



Course Treno import



OpenTrack course model

Description of course and import in OT:

- Course ID
- Delayed / on Time Performances
- Speed profile
- Rolling stock
- Itineraries (main and alternative)

Reason for choosing Treno format (xml):

- Easy adjustments with excel (after reprocessing in xml format)

Advantage over manual modelling:

- Quick adjustments of course performance for calibration
- Quick attribution of train types

 A screenshot of the 'Courses / Services' window in OpenTrack. The window has a list of courses on the left and a detailed view of the selected course on the right.

Use	ID
<input checked="" type="checkbox"/>	AA 001
<input checked="" type="checkbox"/>	RA 002
<input checked="" type="checkbox"/>	AA 003
<input checked="" type="checkbox"/>	RA 004
<input checked="" type="checkbox"/>	AA 005
<input checked="" type="checkbox"/>	SA 006
<input checked="" type="checkbox"/>	AA 007
<input checked="" type="checkbox"/>	RA 008
<input checked="" type="checkbox"/>	AA 009
<input checked="" type="checkbox"/>	RA 010
<input checked="" type="checkbox"/>	AA 011
<input checked="" type="checkbox"/>	RA 012
<input checked="" type="checkbox"/>	AA 013
<input checked="" type="checkbox"/>	RA 014
<input checked="" type="checkbox"/>	AA 015
<input checked="" type="checkbox"/>	RA 016
<input checked="" type="checkbox"/>	AA 017
<input checked="" type="checkbox"/>	RA 018
<input checked="" type="checkbox"/>	AA 019
<input checked="" type="checkbox"/>	RA 020
<input checked="" type="checkbox"/>	AA 021
<input checked="" type="checkbox"/>	RA 022
<input checked="" type="checkbox"/>	AA 023
<input checked="" type="checkbox"/>	RA 024
<input checked="" type="checkbox"/>	AA 025
<input checked="" type="checkbox"/>	RA 026
<input checked="" type="checkbox"/>	AA 027
<input checked="" type="checkbox"/>	RA 028
<input checked="" type="checkbox"/>	AA 029
<input checked="" type="checkbox"/>	RA 030
<input checked="" type="checkbox"/>	AA 031

Used: 739

Sort by ID Num.

Inv. Unuse Use

Sel. used Sel. active

Search

Perf. (on Time) [%]: 82

Perf. (delayed) [%]: 90

Entry Speed [km/h]: 0.0

Output Offset [m]: 0

Delete Update Analyze Duplicate Edit New

Itineraries

Itineraries		
<input checked="" type="checkbox"/> A-TWD2-TSWTRTdown-	1	Show
<input checked="" type="checkbox"/> alt exit TWD	2	Define
<input checked="" type="checkbox"/> alt ADM-CENdn	3	Create T. D.

Description: TWD

Comment:

Kind: A extra

Train:

TWL A extra Show

Train Category:

TWL A Central for Reversing special Show

Train Speedtype:

CBTC

Route Reservation / Release:

Discrete

Timetable: First Departure:

06:12:15 at TWD New Show



Modelling of the line - Timetable

Timetable data (Excel)



Opentrack-Track import format



OpenTrack timetable model

Transposition of planned timetable and operation characteristics and import into OT:

- Planned arrival and departure time on station
- Minimum dwell time
- Mean delay or delay distribution
- Rostering (connections)

Reason for choosing Open-Track .txt Format:

- Possible definition of connections
- Possible definition of all timetable information

Advantage towards manual modelling:

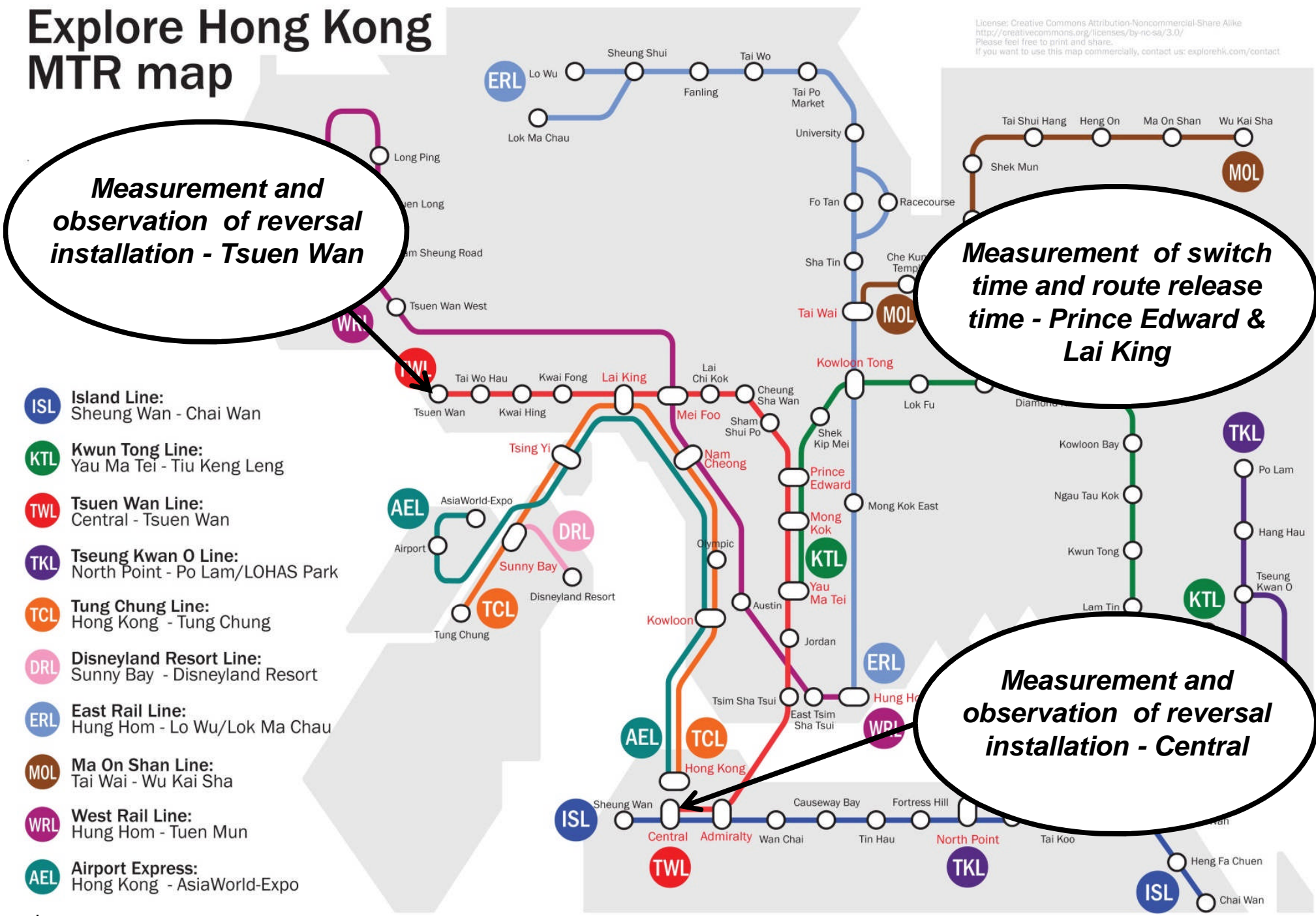
- Quick adjustments of delays for calibration
- Risk of errors: -70%

Course ID	Station	Arrival	Departure	Use	Dwell	Stop	Delta Load	Distr.	M. Del.
AA 001	Tsuen W	HH:MM:SS	06:12:15	✓	0	✓	0.000		0
AA 001	Tsuen W	06:08:45	06:18:45	✓	240	✓	0.000		0
AA 001	Tsuen W	HH:MM:SS	HH:MM:SS	✓	0	✓	0.000		0
AA 001	Tsuen W	06:21:15	06:21:40	✓	36	✓	0.000		20
AA 001	Tai Wo H	06:23:04	06:23:24	✓	26	✓	0.000		2
AA 001	Kwai Hin	06:25:05	06:25:25	✓	26	✓	0.000		4
AA 001	Kwai For	06:26:54	06:27:17	✓	28	✓	0.000		2
AA 001	Lai King	06:28:59	06:29:26	✓	29	✓	0.000		3
AA 001	Mei Foo	06:31:41	06:32:01	✓	28	✓	0.000		0
AA 001	Lai Chi K	06:33:34	06:33:54	✓	28	✓	0.000		0
AA 001	Cheung	06:35:26	06:35:48	✓	27	✓	0.000		0
AA 001	Sham Sh	06:37:13	06:37:37	✓	30	✓	0.000		1
AA 001	Prince E	06:39:09	06:39:37	✓	32	✓	0.000		3
AA 001	Mong Ko	06:40:51	06:41:20	✓	30	✓	0.000		2
AA 001	Yau Ma	06:42:40	06:43:02	✓	27	✓	0.000		1
AA 001	Jordan S	06:44:34	06:44:59	✓	26	✓	0.000		1
AA 001	Tsim Sha	06:46:24	06:46:52	✓	28	✓	0.000		1
AA 001	Admiralty	06:49:57	06:50:25	✓	31	✓	0.000		1
AA 001	Central S	06:52:02	HH:MM:SS	✓	240	✓	0.000		0
AA 003	Tsuen W	HH:MM:SS	07:30:31	✓	0	✓	0.000		0
AA 003	Tsuen W	07:32:25	07:33:00	✓	36	✓	0.000		20
AA 003	Tai Wo H	07:34:24	07:34:44	✓	26	✓	0.000		3
AA 003	Kwai Hin	07:36:34	07:36:54	✓	26	✓	0.000		3
AA 003	Kwai For	07:38:23	07:38:46	✓	29	✓	0.000		1
AA 003	Lai King	07:40:34	07:41:01	✓	32	✓	0.000		4
AA 003	Mei Foo	07:43:24	07:43:44	✓	29	✓	0.000		1
AA 003	Lai Chi K	07:45:22	07:45:42	✓	28	✓	0.000		1
AA 003	Cheung	07:47:23	07:47:45	✓	29	✓	0.000		2
AA 003	Sham Sh	07:49:21	07:49:45	✓	32	✓	0.000		3
AA 003	Prince E	07:51:31	07:51:59	✓	37	✓	0.000		2
AA 003	Mong Ko	07:53:23	07:53:52	✓	34	✓	0.000		5



On site measurements

Explore Hong Kong MTR map





Analysis of today's data

Analysis:

Distribution of dwell time (track circuit occupation over 3 months)

Distribution of run time (track circuit occupation over 3 months)



Calibration runs (1)

Iterative adjustments of the following parameters:

- General delay at origin (Simulation inspector)
- Minimum Dwell-time at station (in Timetable import/export file)
- Mean delay at all stations (in Timetable import/export file)
- Performance factor (in Course import/export)
- Braking Curve (in train window)
- Maximum acceleration (in train window)



Calibration runs (2)

Run of **multiple simulation**

- 10 runs each multiple simulation
- 1 multiple simulation = 3 hours
- Calibration of TWL: > 40 multiple simulations
- Detail of calibration: for each 1h window:
 $|\text{real journey time} - \text{simulated journey time}| < 1,5\%$



Iterative adjustments of calibration parameters

Evaluation file of a simulation, after processing with some VBA macros

1+2		file	50%	6 h	7 h	8 h	9 h	10 h	11 h	12 h	13 h	14 h	15 h	16 h	17 h	18 h	19 h	20 h	21 h	22 h	23 h
Up	ADM			-17"	-16"	-14"	-14"	-06"	-05"	-05"	-05"	-05"	-05"	-04"	-08"	-05"	-08"	-10"	-04"	-05"	-06"
	TST			-02"	-03"	-02"	-02"	-01"	-01"	-02"	-01"	-01"	-00"	-00"	-05"	-03"	-05"	-05"	-00"	-00"	-00"
	JOR			-01"	-02"	-04"	-04"	-03"	-08"	-09"	-04"	-02"	-01"	-01"	-08"	-05"	-09"	-08"	-01"	-00"	-01"
	YMT			-05"	-03"	-06"	-05"	-04"	-04"	-05"	-04"	-04"	-02"	-01"	-11"	-10"	-12"	-11"	-02"	-01"	-04"
	MOK			-01"	-02"	-01"	-01"	00"	00"	00"	00"	00"	00"	00"	-01"	01"	-01"	-01"	00"	00"	00"
	PRE			-02"	-02"	-02"	-03"	-01"	-09"	-09"	-09"	-05"	-04"	01"	-05"	02"	-01"	-06"	-09"	-08"	-05"
	SSP			-00"	-01"	-00"	-00"	01"	04"	04"	04"	05"	-00"	07"	01"	03"	03"	-02"	-01"	-01"	-00"
	CSW			-01"	-02"	-02"	-02"	-00"	01"	01"	01"	02"	-02"	06"	-01"	03"	02"	-04"	-01"	-02"	-02"
	LCK			32"	31"	31"	30"	26"	25"	23"	26"	25"	22"	36"	29"	35"	33"	23"	25"	24"	22"
	MEF			-43"	-43"	-44"	-42"	-39"	-38"	-38"	-38"	-38"	-42"	-38"	-40"	-40"	-43"	-39"	-39"	-43"	-42"
	LAK			-04"	-04"	-03"	05"	-01"	05"	05"	05"	06"	05"	06"	05"	05"	04"	04"	04"	01"	-01"
	KWF			03"	02"	06"	08"	06"	-01"	01"	-03"	-02"	-03"	-00"	06"	06"	06"	06"	05"	06"	01"
	KWH			02"	-01"	06"	08"	05"	07"	07"	07"	07"	07"	08"	07"	07"	06"	07"	05"	02"	01"
	TWH			-00"	-01"	04"	-08"	-11"	04"	04"	03"	03"	03"	03"	-04"	-08"	-14"	-02"	01"	01"	01"
	ADM			-18"	-18"	05"	-03"	02"	-06"	-09"	-10"	-08"	-08"	-12"	-18"	-16"	-17"	-21"	-18"	-18"	-18"
Down	TST			03"	-02"	02"	-00"	-00"	09"	08"	09"	09"	08"	08"	-00"	02"	02"	-03"	-10"	-21"	-22"
	JOR			01"	-02"	-02"	-02"	02"	06"	05"	06"	06"	05"	02"	-01"	-00"	-00"	-03"	-04"	-04"	-04"
	YMT			-05"	-09"	-03"	-09"	-07"	06"	06"	07"	06"	06"	04"	-00"	03"	03"	-01"	-00"	-05"	-04"
	MOK			-01"	-03"	-02"	-03"	00"	01"	01"	02"	01"	01"	01"	-02"	-02"	-01"	-02"	-05"	-05"	-05"
	PRE			-06"	-07"	-06"	-07"	-05"	-01"	00"	00"	00"	00"	-01"	-05"	-04"	-03"	-06"	-05"	-07"	-04"
	SSP			-05"	-05"	-09"	-06"	-01"	-00"	-01"	03"	03"	03"	-00"	-03"	01"	02"	-06"	-02"	-09"	-08"
	CSW			-00"	-02"	-03"	-02"	01"	02"	03"	03"	02"	02"	01"	-03"	-07"	-03"	-06"	-01"	-02"	-02"
	LCK			-05"	-06"	-05"	-04"	-02"	-02"	-02"	-02"	-02"	-02"	-02"	-11"	-07"	-05"	-11"	-08"	-09"	-08"
	MEF			-02"	-02"	01"	02"	-07"	-07"	-07"	-06"	-07"	-07"	-06"	-07"	-04"	-02"	-07"	-03"	-04"	-04"
	LAK			-01"	-06"	-05"	-03"	-09"	-08"	-08"	-07"	-09"	-09"	-03"	-02"	-02"	-02"	-07"	-06"	-05"	-09"
	KWF			-05"	-13"	-13"	-09"	-07"	-05"	-07"	-07"	-07"	-08"	-09"	-08"	-08"	-03"	-07"	-05"	-07"	-07"
	KWH			-08"	-10"	-08"	-03"	-06"	-10"	-10"	-11"	-11"	-11"	-12"	-07"	-04"	-03"	-09"	-07"	-09"	-07"
	TWH			05"	-04"	-07"	-02"	-03"	-03"	-03"	-03"	-03"	-03"	-03"	-04"	-02"	-02"	-05"	-03"	-03"	-03"



Calibration : synthesis

- A finely tuned simulation like the calibration of TWL line requires many iterations
- For that reason It is essential to optimise the workflow:
 - Automation of adaptation of calibration parameters > work with the import and export files for courses and timetable
 - Automation of evaluation of simulation outputs > process with VBA macro
- It is essential to have a detailed understanding of the functioning and sensitivity of the line
- The quality of real operations data has to match the desired accuracy of the calibration
- The needed calibration level depends of the future use of the model