EMFAC-HK Training

Application of EMFAC-HK at the Project Level

Overview

- Understand how EMFAC-HK works at the project level

- Discuss how highways, intersections, and off-network areas can be characterized as links

- Discuss how EMFAC-HK can incorporate activity information for each link

Overview (cont.)

- Determine the number of EMFAC-HK runs needed for an analysis

- Set up, execute and review an EMFAC-HK run for a simple example (highway link).

Key References

- EMFAC-HK supporting documentation
  - EPD's website (April, 2012):
    - http://www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/emfac.html

- Project Level Training for Quantitative PM Hot-Spot Analyses: USEPA (Sept, 2011)
    - http://www.epa.gov/otaq/stateresources/transconf/training3day.htm

# How does EMFAC-HK work at the project level?

What Does EMFAC-HK Calculate?

- Emissions for
  - All relevant processes
    - running exhaust
    - starting exhaust
    - evaporative emissions (VOC only)
  - All vehicle types
    - Vehicle classes redefined from EMFAC-HK Version 1.2
  - Each defined link

How Does EMFAC-HK Calculate Emissions?

- Vehicle Fleet / Vehicle Class – Varies per year

- Fuel – petrol, diesel, LPG

- Vehicle Activity – kilometers per vehicle or number of trips or total number of vehicles

- Vehicle Population- based on registration data (i.e., 2010)

# Running EMFAC-HK at the Project Scale
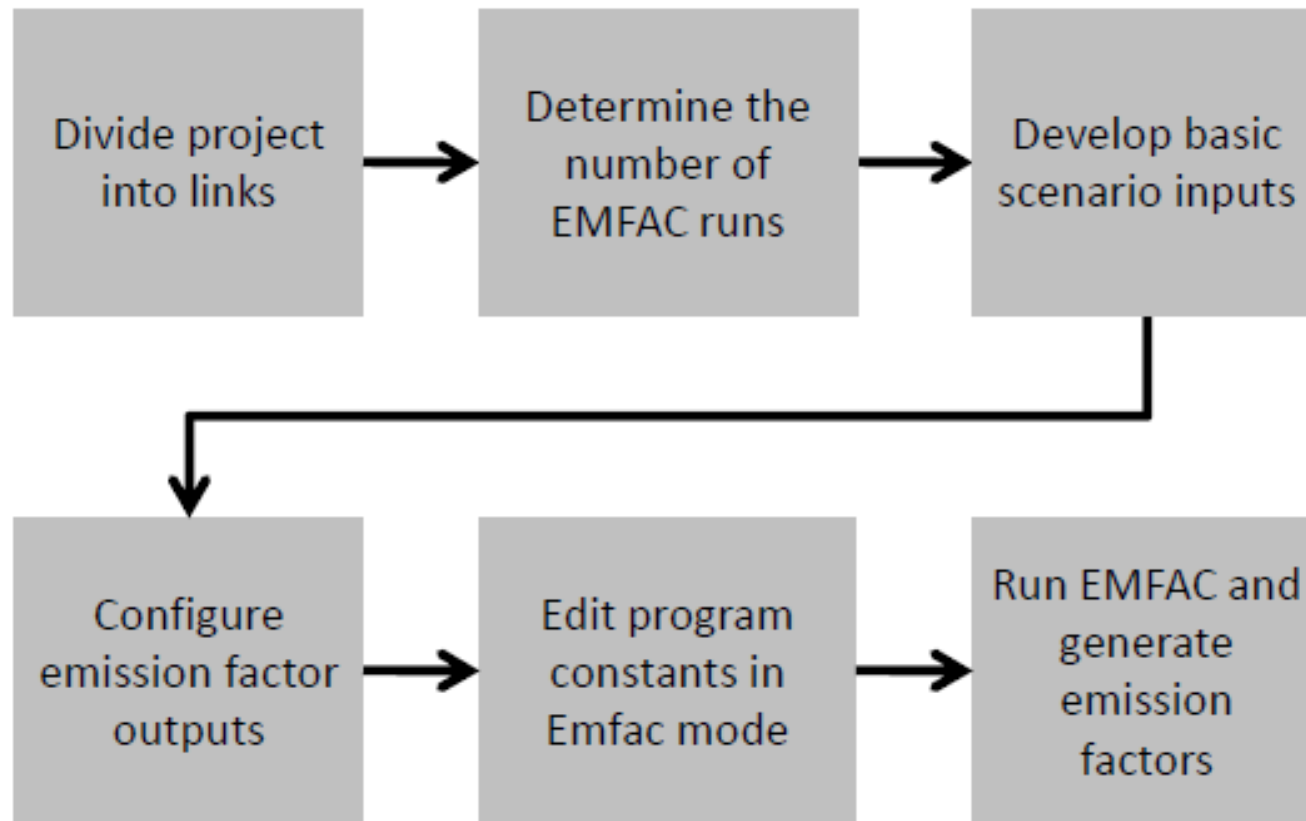
"Emfac" Emission Rate Mode

- Useful for project-level analyses since it provides a lookup table by average speed

- In most cases:
  - The fleet aggregate emission rate (i.e., "All" column) can be selected for the appropriate link speed
  - Combined with the corresponding period traffic volume
  - Used in air quality modeling

Data Requirements

- Traffic Data
  - Review data to define links
  - Determine link average speeds and volumes
- Project-Specific Data
  - Geographic area
  - Fleet mix
  - Age distribution
  - Off-Network activity (e.g., starts)

Running EMFAC-HK at the Project Scale
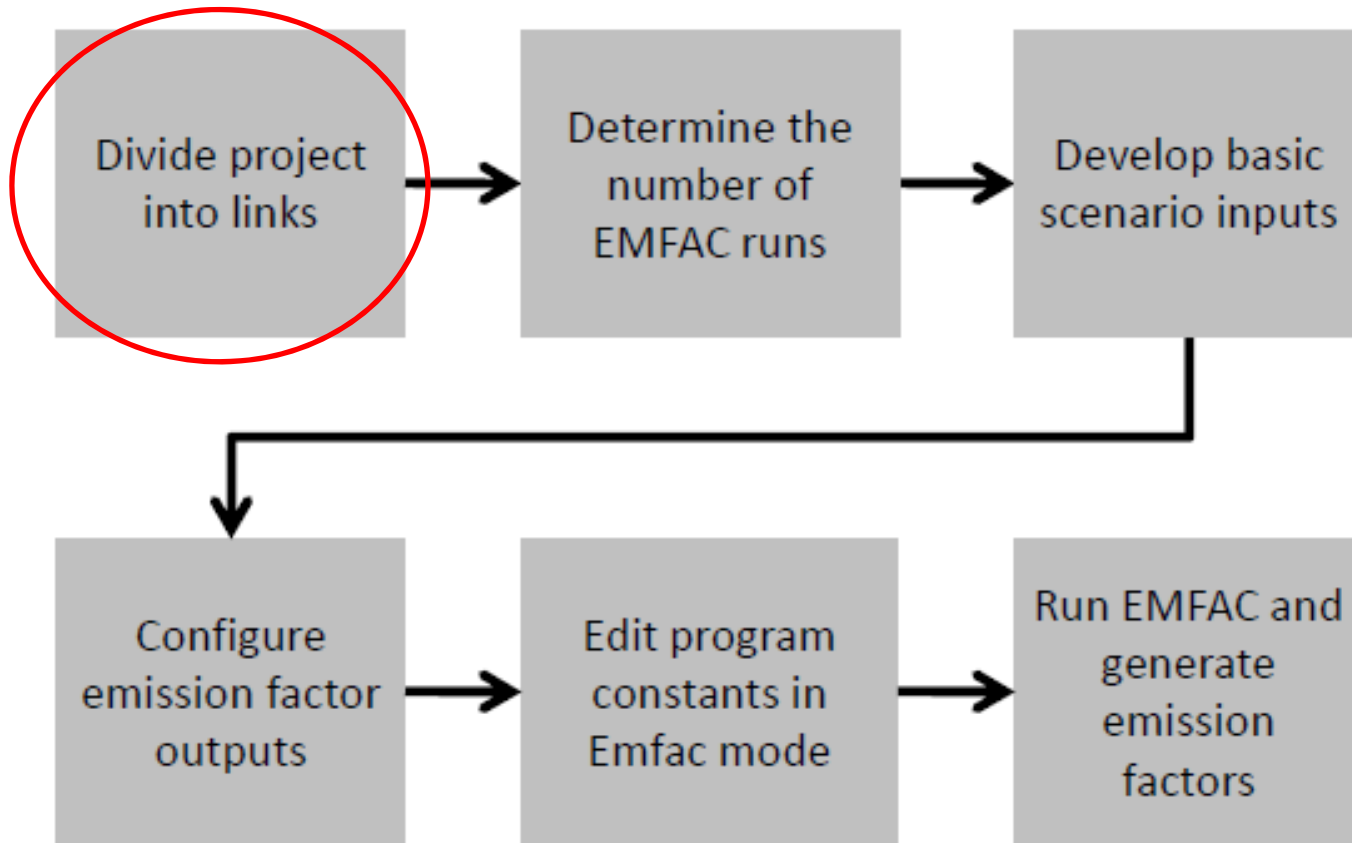
What is a Link?

- A segment of road or an "off-network" location where a similar type of activity occurs
- Types of links include
  - Running Links
    - Expressways, trunk roads, primary distributors and local distributors
    - intersection (cruise, deceleration, acceleration)
  - Off-network Links
    - Start and idling (idle not presently implemented in Hong Kong)

What is an EMFAC Link?

Handling Link Activity in EMFAC

- Highway and Intersection links
  - » Running exhaust, brake wear, and tire wear
  - » Activity modeled using:
    - Average speed
    - Traffic volumes

[1] Tire wear and brake wear not currently used in Hong Kong at this time.

- Off-network links
  - » Start and idle emissions as well as exhaust for running links
  - » Activity modeled using:
    - Starts per hour, and
    - Number of vehicles idling

Defining Links for Projects

- Goal of defining a project's links in EMFAC-HK is to accurately capture emissions where they occur

- Should include segments with similar traffic/activity conditions and characteristics

- In general, links will be defined based on how much vehicle activity changes over the length of the roadway, data availability, and the modeling approach used

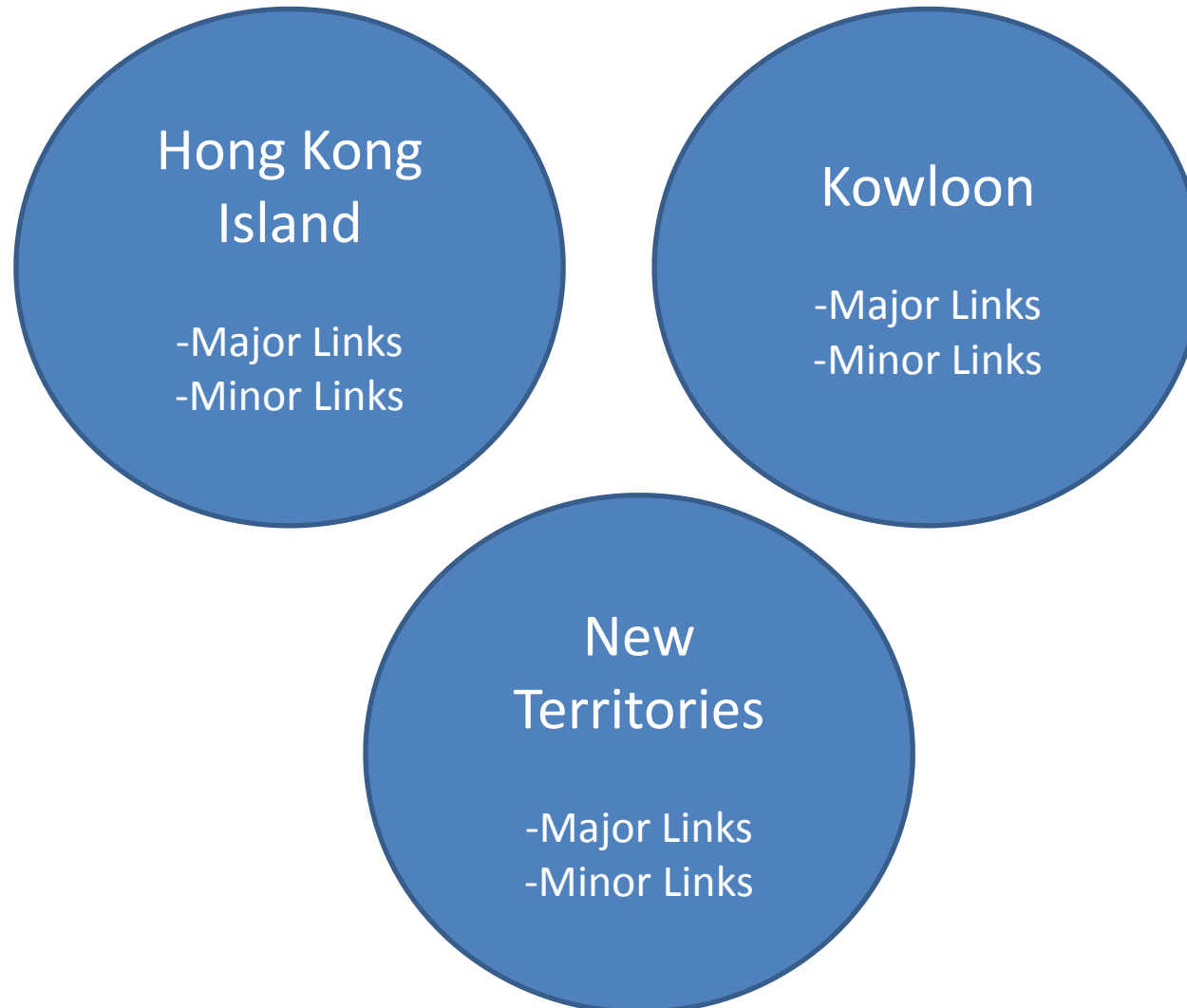- In general, density of links depends on project type

Examples

- New links could be defined when
  - Speeds change (i.e., changes in activity over highway ramps)
  - Volumes change
  - Fleets change (bus-only lane vs all-purpose)
  - Facility purpose changes (turn lane vs through lane)

Typical Traffic Data

- What traffic data might be available for a project?
  - Network Schematics with segment data: (ATC)
    - Annual average daily traffic (AADT)
    - Peak-hour traffic volume (% of AADT)
  - Discussion of local data later in training.

- What additional data might be needed?
  - Volumes, fleet mix, and speeds for additional time periods

Examples of Hong Kong Road Types

Hong Kong
Island

-Major Links
-Minor Links

Kowloon

-Major Links
-Minor Links

New
Territories

-Major Links
-Minor Links

Road Networks

- **Major Road Network**
  - includes all the roads contained in the Comprehensive Transport Study (CTS) simplified road network with modifications to exclude those road links generated by imaginary nodes connected to CTS zone centroids or produced for depicting turning movements at most road junctions.

- **Minor Road Network**
  - includes all trafficable roads that are outside the major road network, with the exception of roads assigned for special use, all types of restricted roads and local access roads leading to a few premises.

- **Road Types**
  - Applicable to both Major and Minor Networks, as shown below

Road Types

Classification	Function	Standard	Traffic Management
Expressway and Urban / Rural Trunk Road (EX, UT, RT)	Connects the main centres of Population	High capacity roads with no frontage access or development, pedestrians segregated, widely spaced grade-separated junctions.	24 hour stopping restrictions.
Primary Distributor (PD)	Forms the major network of the urban area	Roads having high capacity junction, normally grade separated, segregated pedestrian facilities and limited frontage access.	Usually 24 hour stopping restrictions.
District Distributor (DD)	Links districts to the Primary Distributor	Roads having high capacity at-grade junction.	Usually peak hour stopping restrictions and parking restrictions throughout the day.
Local Distributor (LD)	Roads within districts linking developments to the District Distributor		
Rural Road (RR)	Connects the smaller centres of population or popular recreation areas with majorroad networks	Roads having high capacity junction and limited frontage access.	

Road Network Link/VKT Summaries

- Hong Kong Island

Road Network	Road Type	Road Link	Trafficable Length (km)
Major	Expressway (EX)	10	7.78
	Urban Trunk Road (UT)	25	18.43
	Primary Distributor (PD)	130	55.14
	District Distributor (DD)	133	77.82
	Local Distributor (LD)	30	18.03
		Sub-total	177.20
Minor	District Distributor (DD)	2	1.56
	Local Distributor (LD)	706	209.61
		Sub-total	211.17
Total Covered by Census			**388.37**

Road Network Link/VKT Summaries

- Kowloon

Road Network	Road Type	Road Link	Trafficable Length (km)
Major	Expressway (EX)	5	10.66
	Urban Trunk Road (UT)	56	37.91
	Primary Distributor (PD)	189	61.83
	District Distributor (DD)	248	92.82
	Local Distributor (LD)	53	18.01
	Sub-total		221.23
Minor	Local Distributor (LD)	738	185.28
	District Distributor (DD)	2	0.10
	Sub-total		185.38
Total Covered by Census			406.61

Road Network Link/VKT Summaries

- ## New Territories

Road Network	Road Type	Road Link	Trafficable Length (km)
Major	Expressway (EX)	58	137.35
	Urban Trunk Road (UT)	27	29.05
	Primary Distributor (PD)	139	82.12
	District Distributor (DD)	248	120.82
	Local Distributor (LD)	76	49.12
	Rural Trunk Road (RT)	9	14.46
	Rural Road (RR)	48	178.32
	Sub-total		611.24
Minor	Local Distributor (LD)	869	372.53
	Rural Road (RR)	29	25.47
	Sub-total		398.00
Total Covered by Census			**1009.24**

Road Types (1)

- Expressway (EX) and Urban (UT) / Rural (RT) Trunk Road

- Primary Distributor (PD)
  - form urban area's major network

- District Distributor (DD)
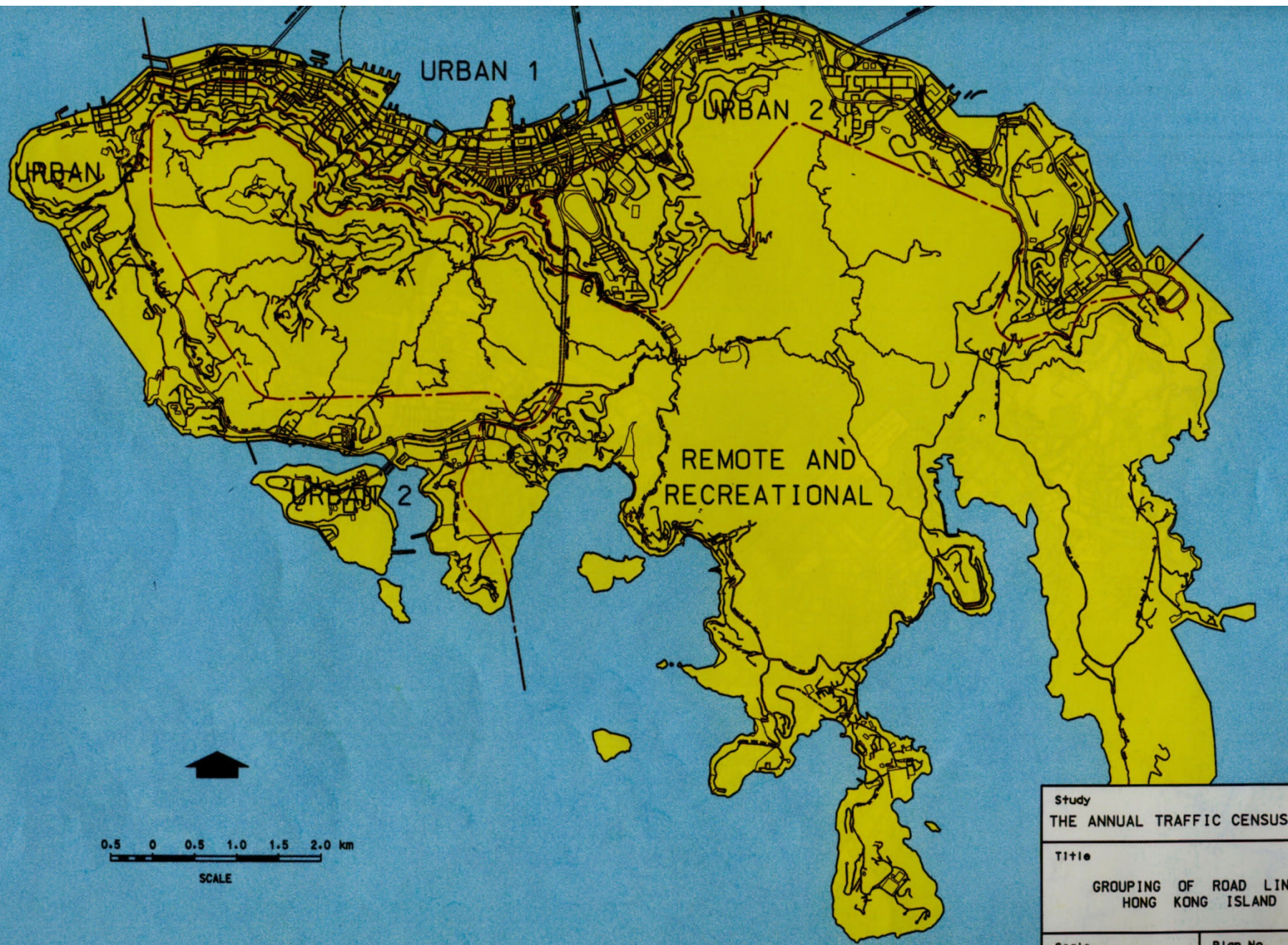 - links districts to the PD

Road Types (2)

- Local Distributor (LD)
  - Roads within districts linking developments to DD

- Rural Road
  - Connects the smaller population centres/recreation areas with major road networks

Road Link Groups (1)

- For coverage stations, AADT estimated by making use of the available information for the core stations.

- The core stations are clustered into groups based on the daily traffic pattern exhibited at each counting stations, called **road link groups**.

Road Link Groups (2)

Region	Road Link Group
Hong Kong	Urban 1
	Urban 2 (Major Road Network)
	Urban 2 (Minor Road Network)
Kowloon	Urban 1
	Urban 2 (Trunk Roads and Primary Distributors)
	Urban 2 (District Distributors and Local Distributors)

URBAN 1

URBAN 2

URBAN

URBAN 2

REMOTE AND
RECREATIONAL

0.5   0   0.5   1.0   1.5   2.0 km

SCALE

URBAN 2

URBAN 1

URBAN 2

URBAN 1

URBAN

0.5   0   0.5   1.0   1.5   2.0 km

SCALE

Inputs per Road Type

- Free-flow Speed Distribution
- Vehicle Kilometers Traveled (VKT)
- Vehicle Type Distribution
- Vehicle Population
- Vehicle Throughput

Aggregation of Road Types into Scenario

- For Each Region
  - Road Type 1
  - Road Type 2
  - Road Type 3
  - Etc. as needed
- Calculation of mass emissions
- Conversion to emission factor using aggregated emissions and VKT

Link Speed Flow Curves
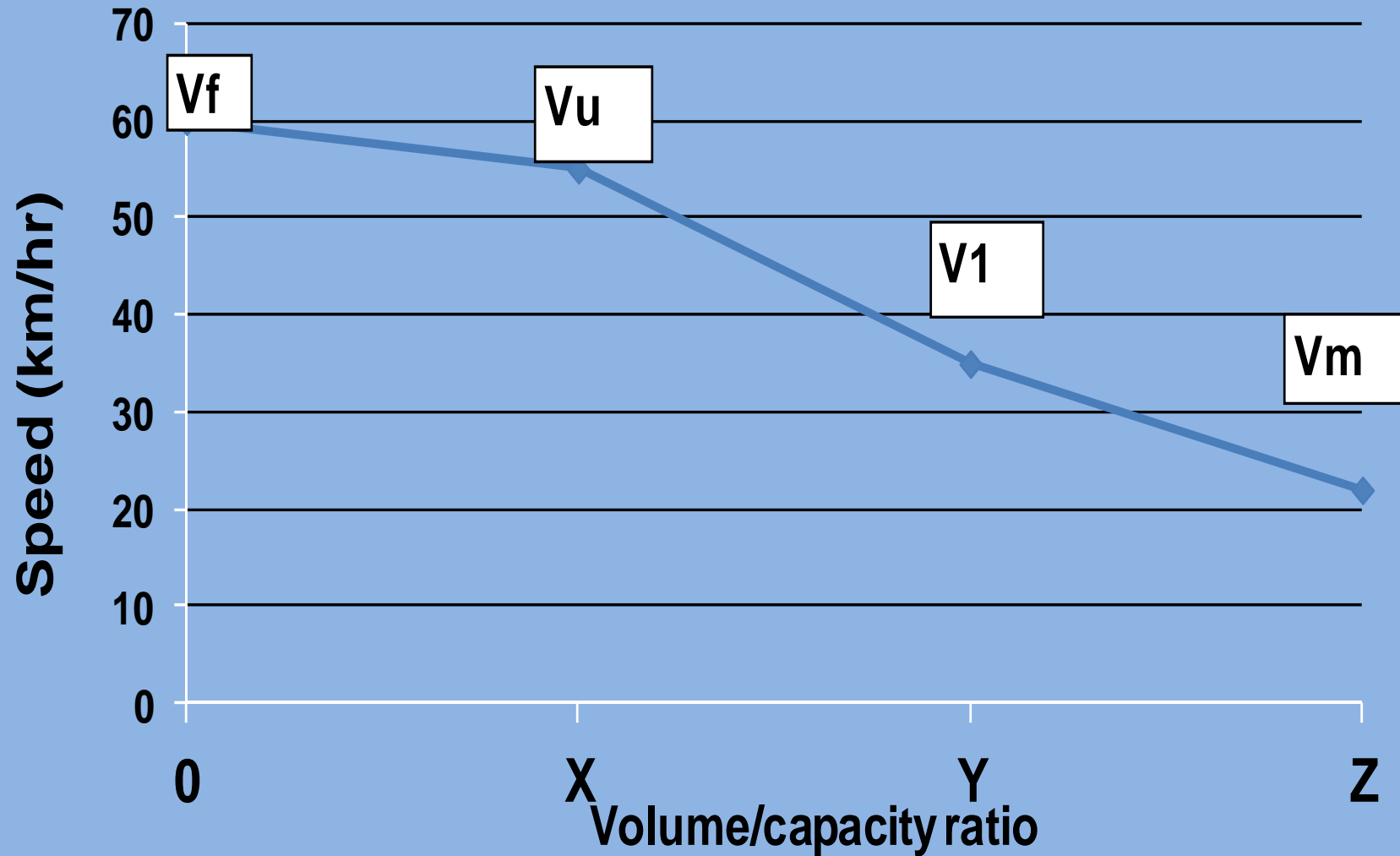
Link Speed Flow Curves (CTS-3)

| Road Type	Vf	Vu	V1	Vm	X	Y	Z
Rural Road A	60	55	35	22	0.4	1.0	1.2
Rural Trunk Road	75	70	45	30	0.4	1.0	1.2
Urban Local Distributor	30	30	12	5	0.1	1.0	1.2
Urban District Distributor	40	40	22	11	0.1	1.0	1.2
Urban Primary Distributor	50	50	27	16	0.2	1.0	1.2
Urban Trunk Road	70	70	45	30	0.4	1.0	1.2
Expressway	90	85	65	40	0.4	1.0	1.2

Running EMFAC-HK at the Project Scale
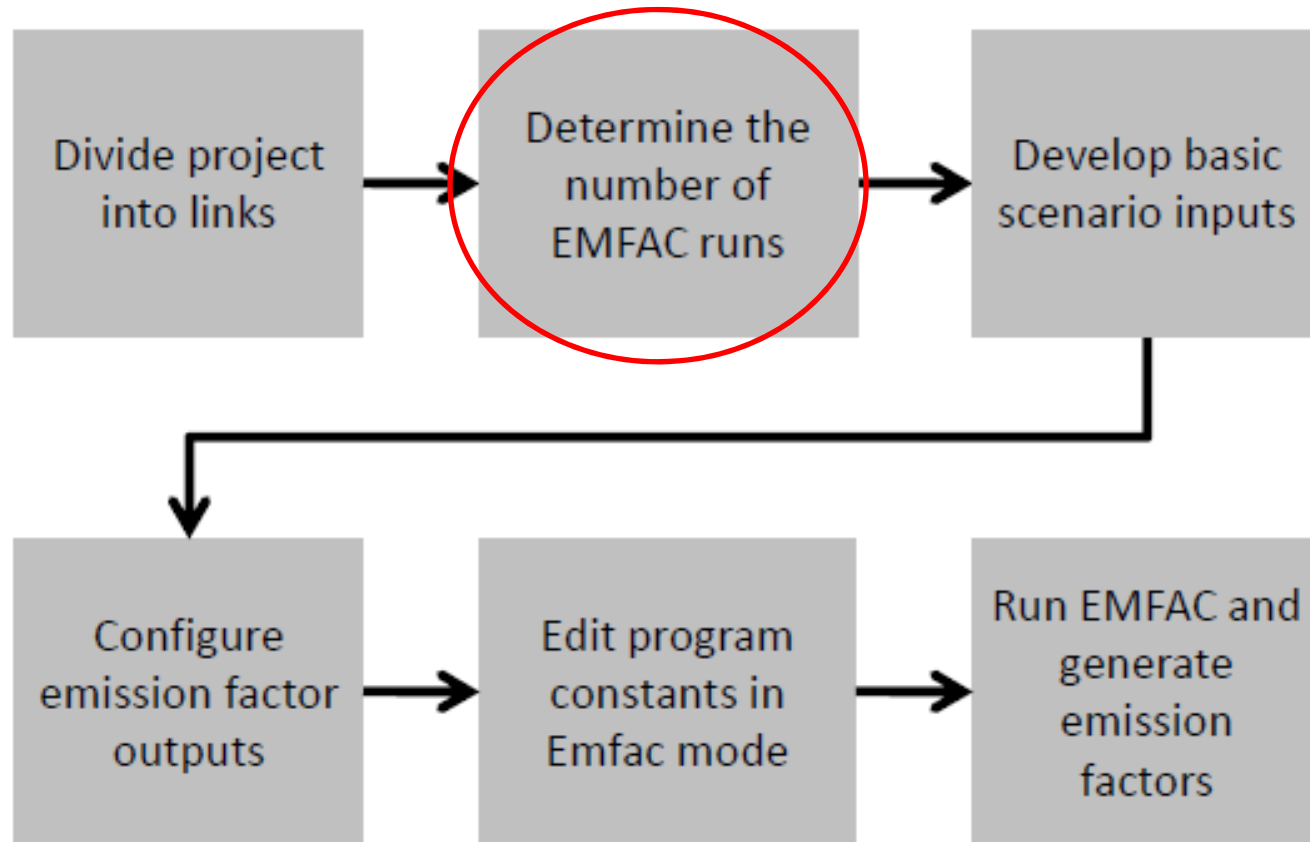
Number of EMFAC-HK Runs

- Number of runs depends on the variation in fleet mix across links and/or time periods (i.e., scenario years)
  - e.g., fleet mix differs for urban trunk roads vs local distributors; therefore aggregate emission rate will be different.
  - Technology fractions change by calendar year
- If there is no variation in fleet mix – only one run is necessary
  - No temperature sensitivity in PM rates means that additional runs are unnecessary if fleet mix is constant
- Note: Each scenario must be run twice if both PM_{10} and $PM_{2.5}$ are needed

Running EMFAC-HK at the Project Scale
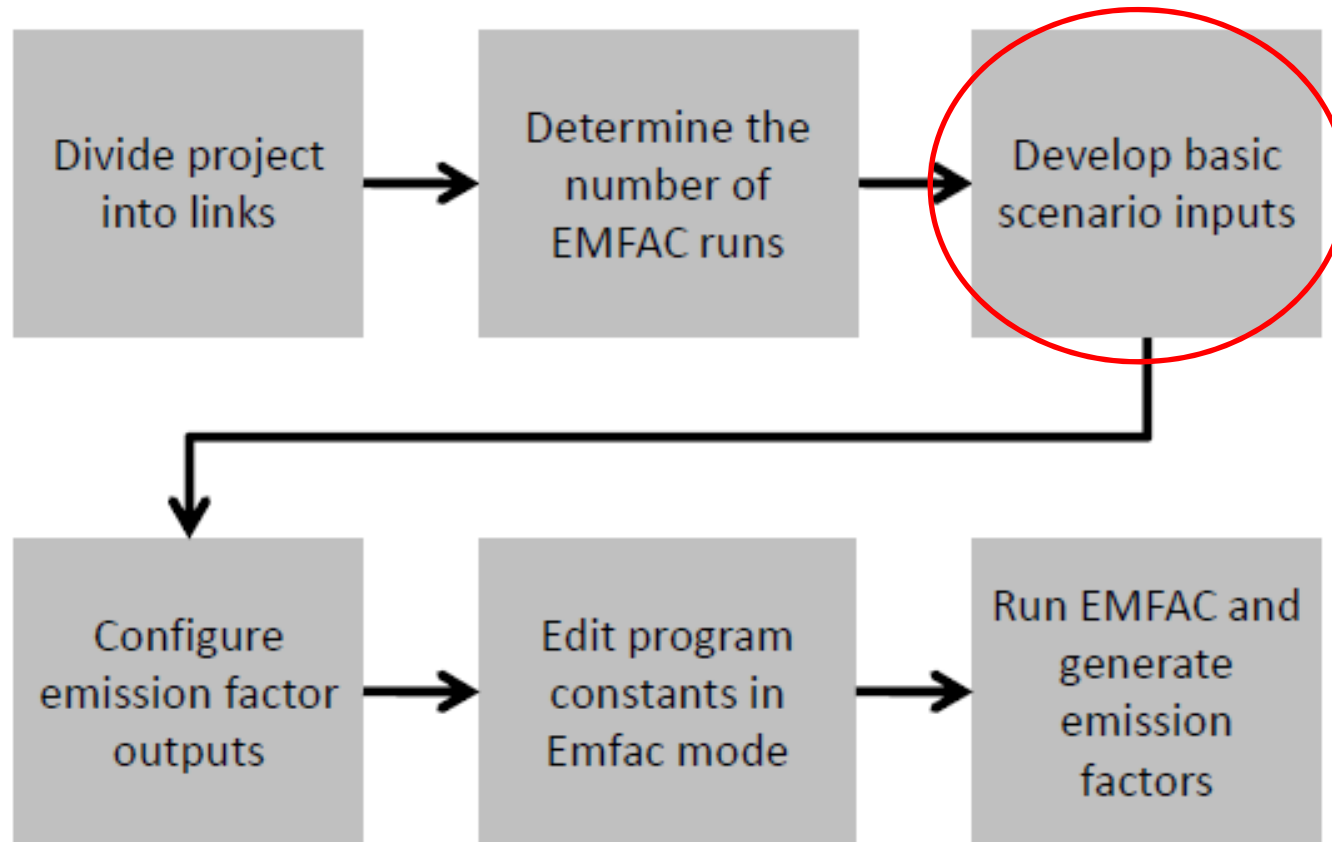
Develop Basic Scenario Inputs

- Input Tab 1
  - Geographic Area
  - Calendar Year
  - Season or Month
- Input Tab 2
  - Scenario Title
  - Model Years
  - Vehicle Classes
- Program constants
  - Population, accrual, trips
- Modeling Mode: EMFAC or Burden
  - Burden: speed fractions, temperatures, RH
  - EMFAC mode:

Running EMFAC-HK at the Project Scale
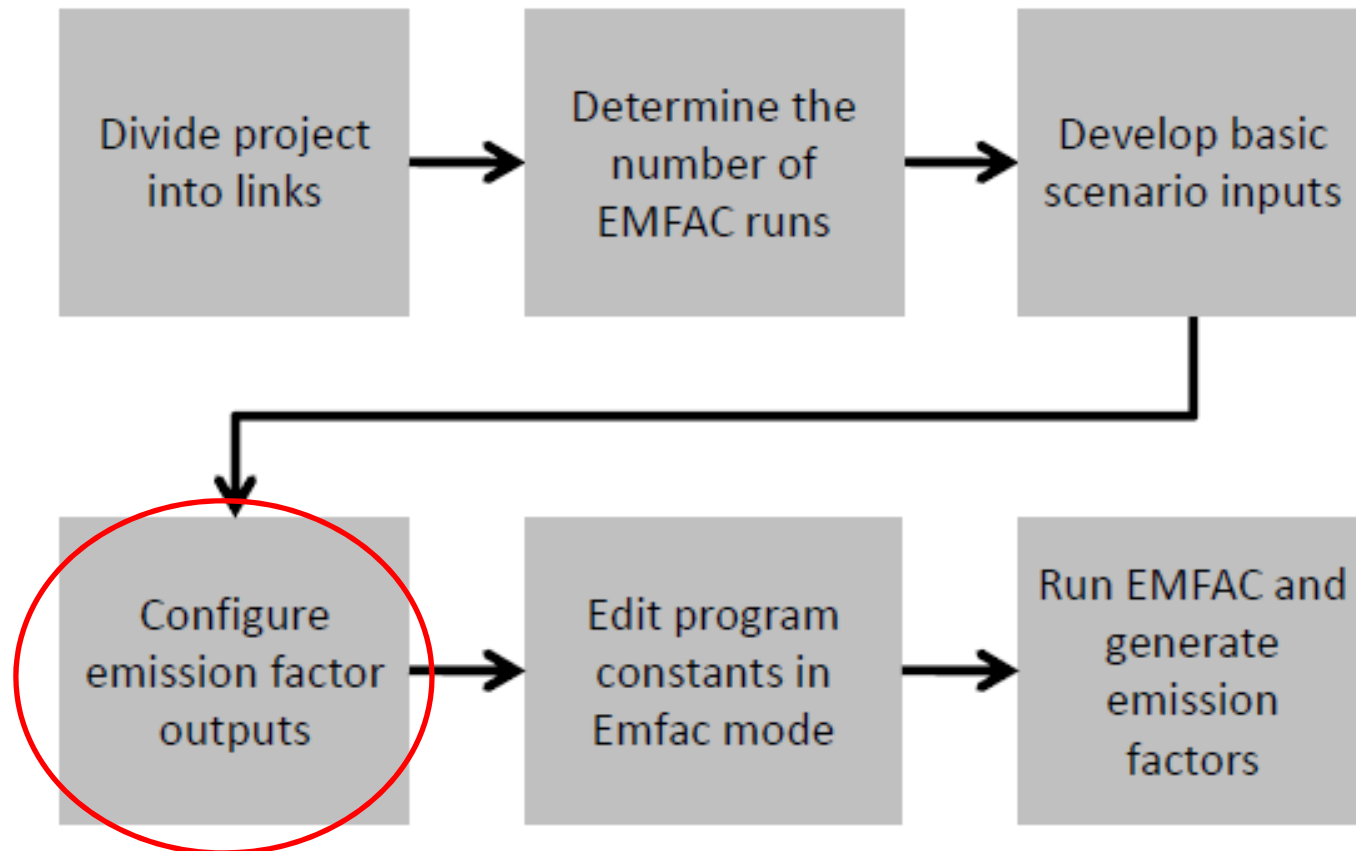
Emission Factor Output

- EMFAC mode approach
  - Set up EMFAC-HK runs using Emfac mode
  - Simplify settings for the following, depending on sensitivity
    - ambient temperature;
    - relative humidity; and,
    - Speeds
  - Look up emission factors by vehicle class for average speed in RTL file
  - May use "All" if project-specific fleet-mix and average speed accurately entered in to EMFAC-HK run; otherwise,
  - Compute "composite" (i.e., fleet-average) emission factor for link by weighting the emission factors for each vehicle class and speed by vehicle-specific VKT.

Emission Factor Output

- Burden approach
  - Obtain/apply temperature, relative humidity and speed fractions by vehicle type directly into EMFAC-HK
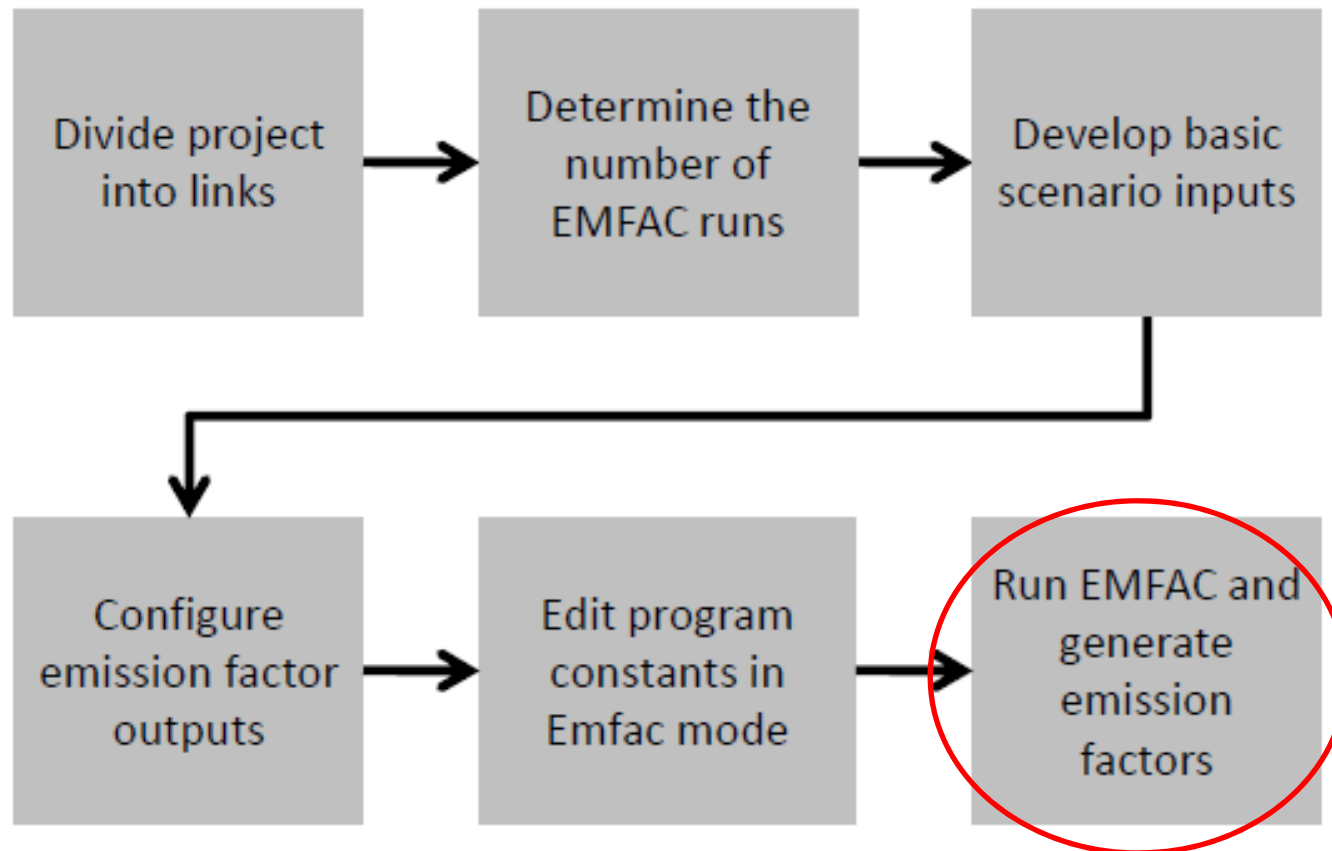 - Obtain emission factors by dividing total tonnes by VKT.

Running EMFAC-HK at the Project Scale
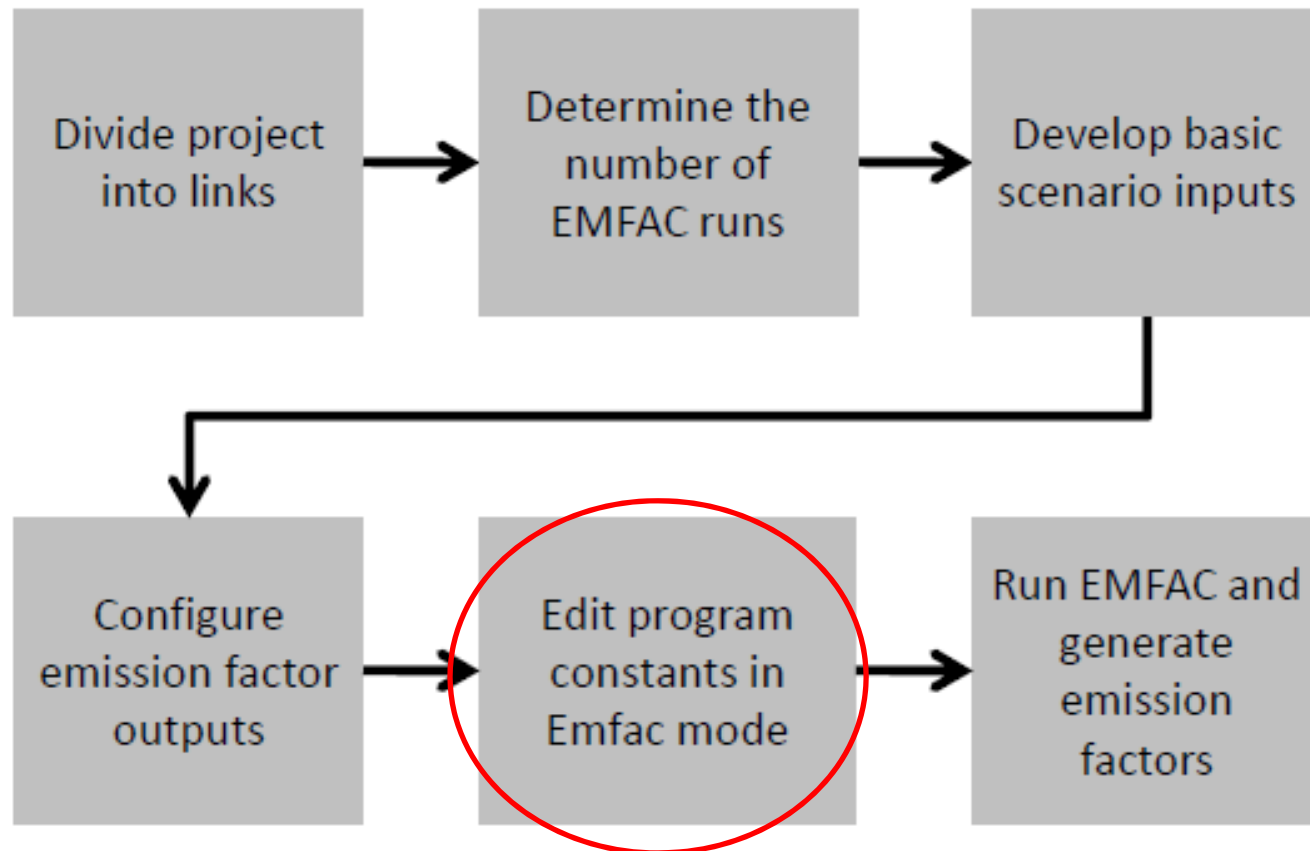
Program Constants

- Exhaust Control Tech Fractions
- Evaporative Control Tech Fractions
- *Vehicle Population*
- Accrual Rates
- *Trips /Starts*
- *VKT*
- Speed Fractions (VKT)

Running EMFAC-HK at the Project Scale

Determining Road Link Emission Rates using EMFAC-HK

- Determine road type / vehicle fleet mix
- Develop/obtain traffic flow and average speed for link (ie., AADT from ATC by TD).
- If daily, use a diurnal profile to convert daily to peak hourly flow (example provided in Exercise).
- Convert ATC vehicle classes to EMFAC-HK vehicle classes (example provided for ATC classes in Exercise)
- Determine VKT by vehicle class for link (traffic flow * link-length)

Emission Factor Output

- EMFAC mode approach
  - Set up EMFAC-HK runs using Emfac mode
  - Configure outputs for
    - ambient temperature;
    - relative humidity; and,
    - Speed
  - Look up emission factors by vehicle class for average speed in RTL file
  - May use "All" if project-specific fleet-mix and average speed accurately entered in to EMFAC-HK run; otherwise,
  - Compute "composite" (i.e., fleet-average) emission factor for link by weighting the emission factors for each vehicle class and speed by vehicle-specific VKT.

Emission Factor Output

- Burden approach
  - Obtain/apply temperature, relative humidity and speed fractions by vehicle type directly into EMFAC-HK
  - Obtain emission factors by dividing total tonnes by VKT.

Emission Factor Output

- Select the appropriate emission factor and combine with the corresponding link length and link volume
  - Convert to grams/vehicle-mile for input to CALINE4