People's Republic of China
Poverty Reduction and
Regional Cooperation Fund

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12–13 декабря 2019 г. | Бангкок, Таиланд

RAILWAY SECTOR DEVELOPMENT IN CENTRAL ASIA REGIONAL ECONOMIC COOPERATION COUNTRIES

THE TRANSPORT MODEL

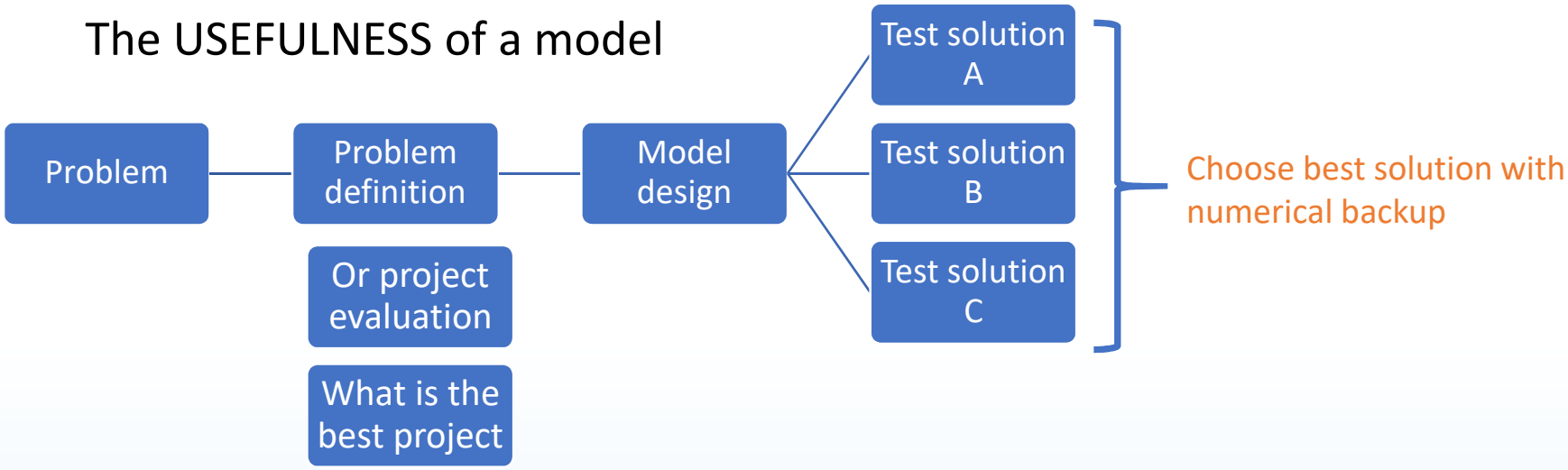
- Len Johnstone
- Transport Modelling Resource Person

This Presentation

I. An Overview – General Approach
II. Socio-economic Data
III. The Network Extent
IV. The Model – Analytical Approach
V. Model Verification
VI. The Manual
VII. Next Steps
VIII. ReCap

I. An Overview – General Approach

Why a model?


The USEFULNESS of a model
Problem
Problem definition
Or project evaluation
What is the best project
Model design
Test solution A
Test solution B
Test solution C
Choose best solution with numerical backup

Modal choice ??

Transportation decision?

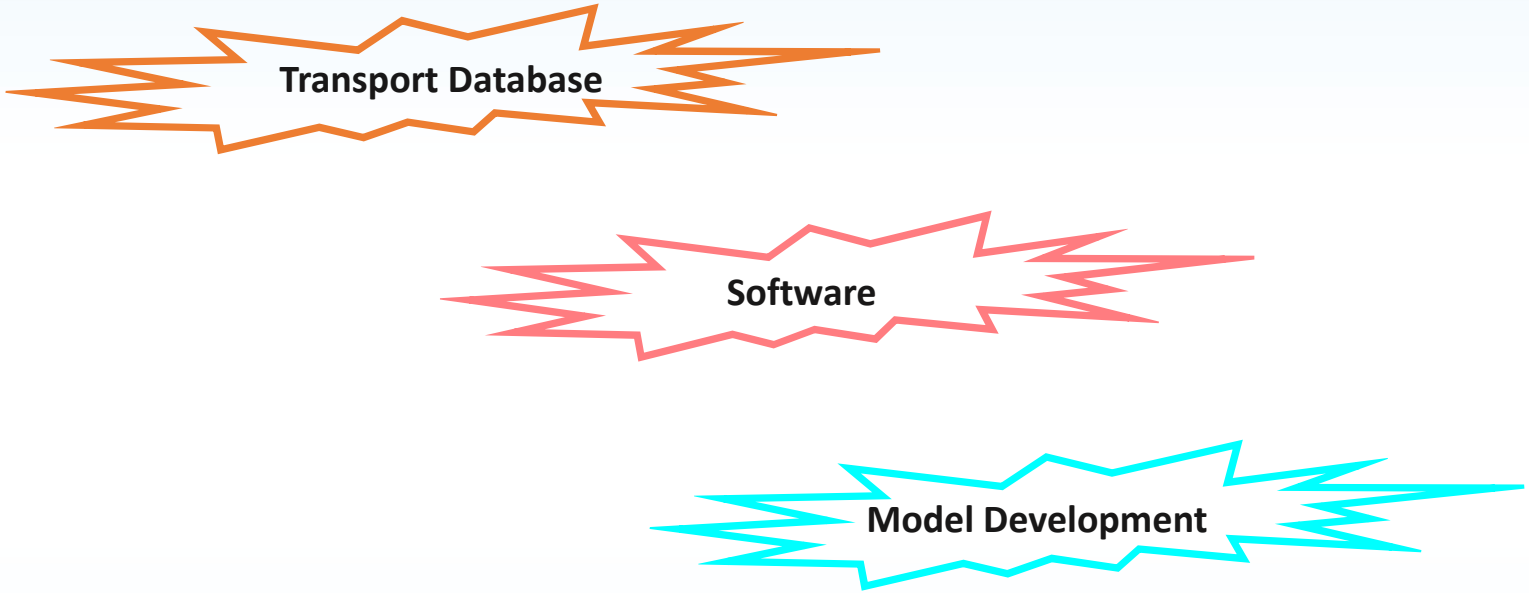
Road Transport



Rail, Maritime Transport


- Proposed Alternative Transport Solutions
- Limited Resources
- Evaluate Best Use of Resources use numerical analysis
- Rank Projects

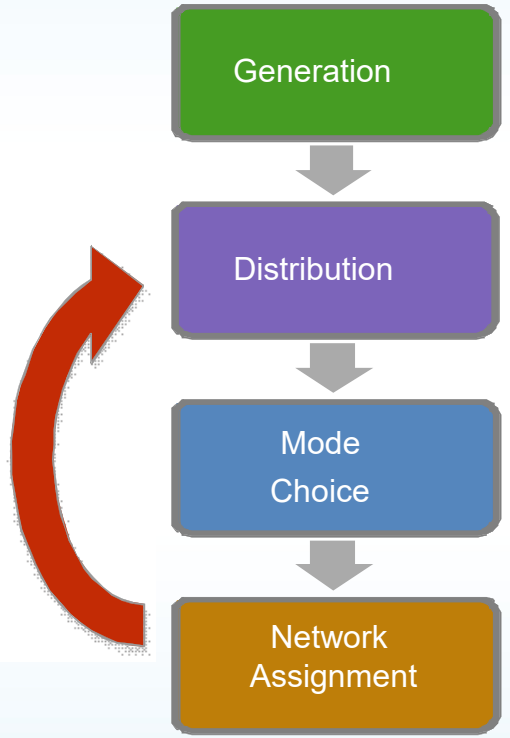
Structural definition



A Model is a beautiful but some times complex set of mathematical equations that attempts to propose the hypothesis of all transport movement.

The Four-Step Modelling Process

- One (extremely common) method of forecasting travel demand.
- Trip ends (productions and attractions) are generated based upon socio-economic and demographic factors.
- These are distributed between zones based upon aggregate travel costs.
- Logit models are used to split person trips between different travel modes.
- Trips by mode are factored by time of day and assigned to specific network paths.
- Modern versions of this process feedback costs from assignment to earlier steps.

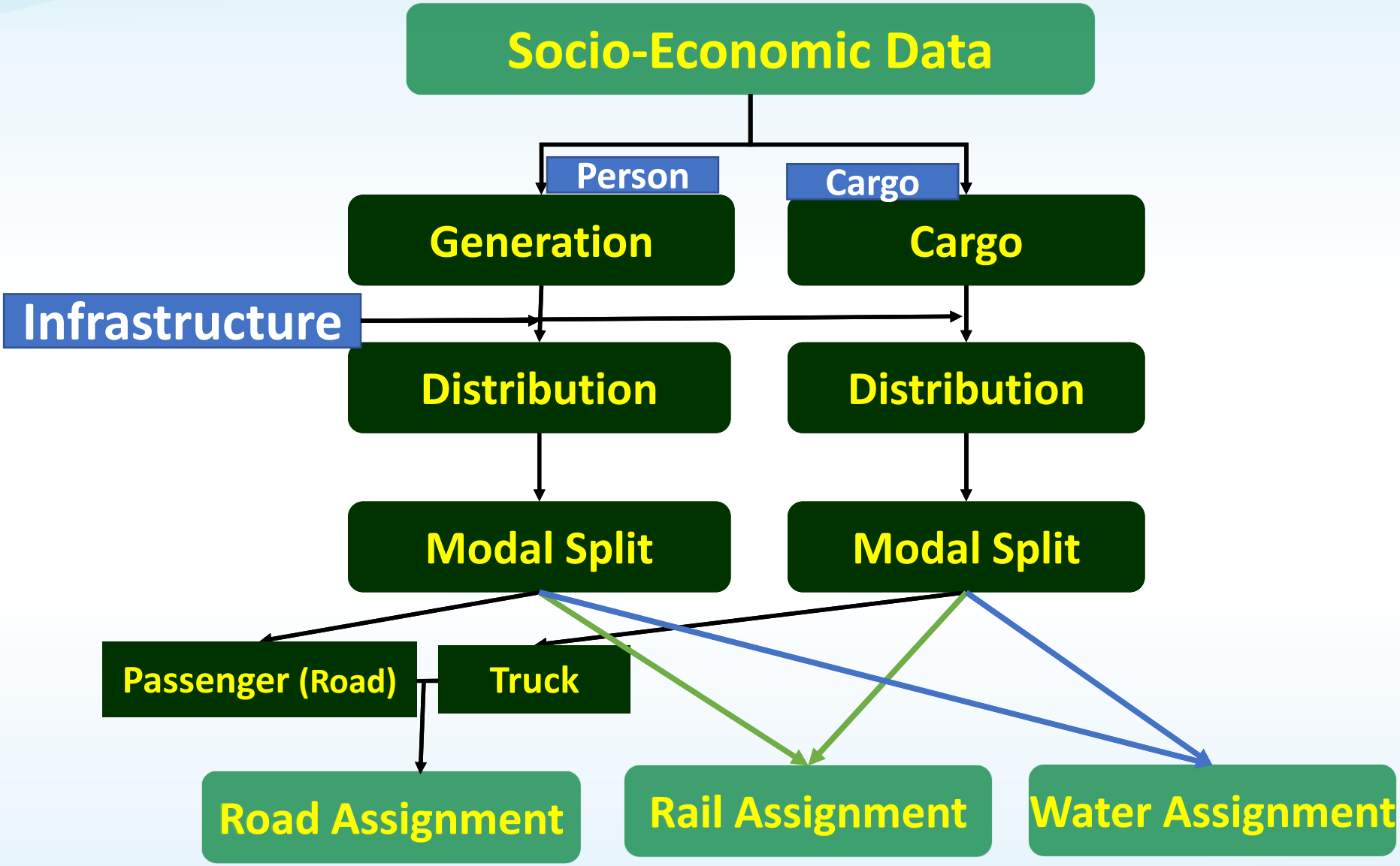


CAREC Region Transport Model- CRTM

Features.

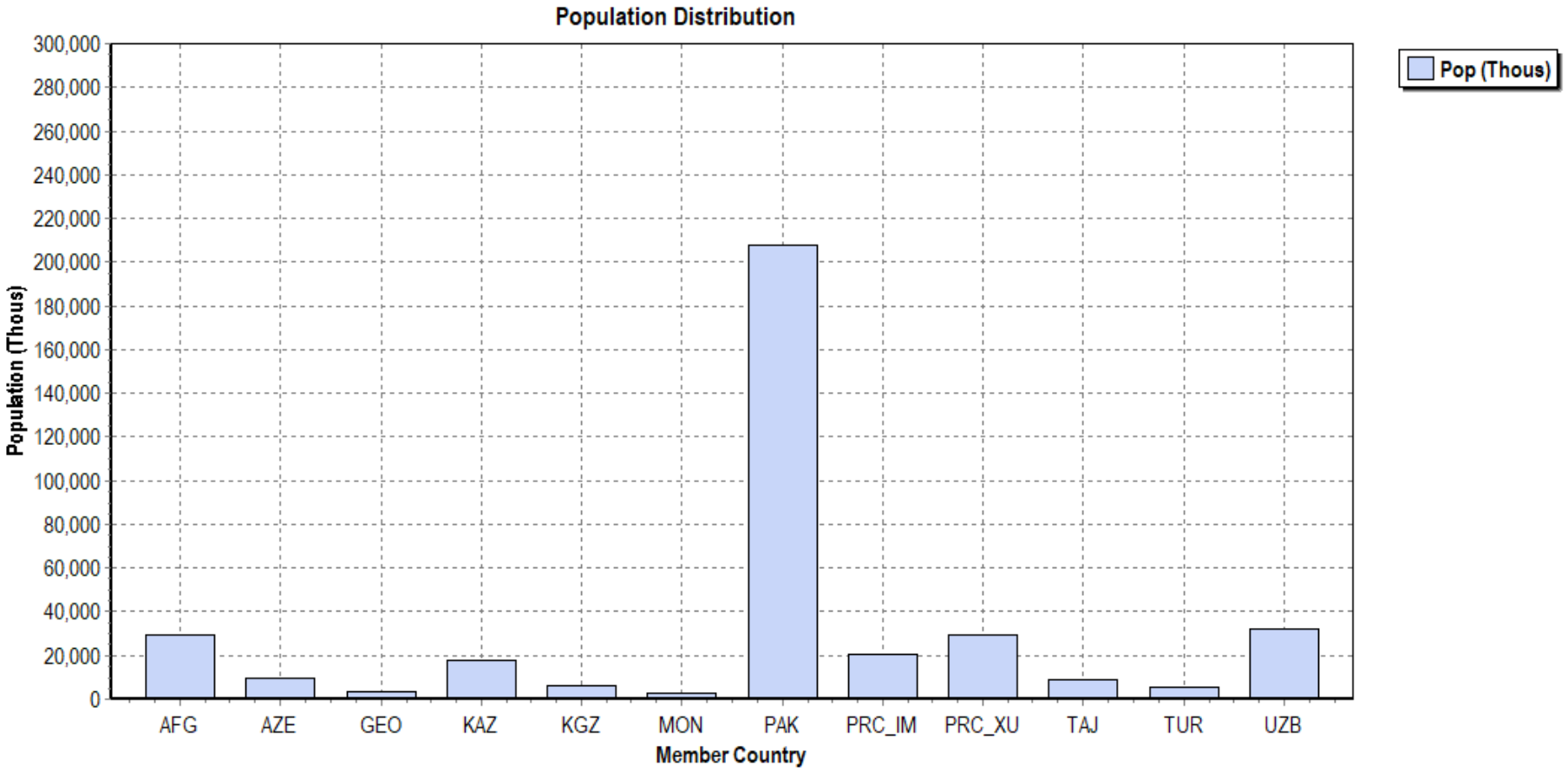
1. **Our Model is developed from existing available data sources – NO NEWDATA COLLECTION.**
2. **A key initial starting point was the ADB GIS database for CAREC.**
3. **The model is developed as a Living Framework for all future transport related data collected within the CAREC.**
4. **The model database in future is maintained within CAREC and now incorporates key features of the earlier CAREC GIS database.**
5. **The model is developed within the framework of the CUBE transport modeling software platform.**
6. **The mode base year is 2017. (Network links developed after 2017 are not includes in the base.)**
7. **All monetary input is in constant USD base 2015, unless otherwise stated.**
8. **Forecasts and planning data prepared for three-time horizons namely short medium and long term, years 2025, 2030 and 2050.**

General modeling approach--CRTM

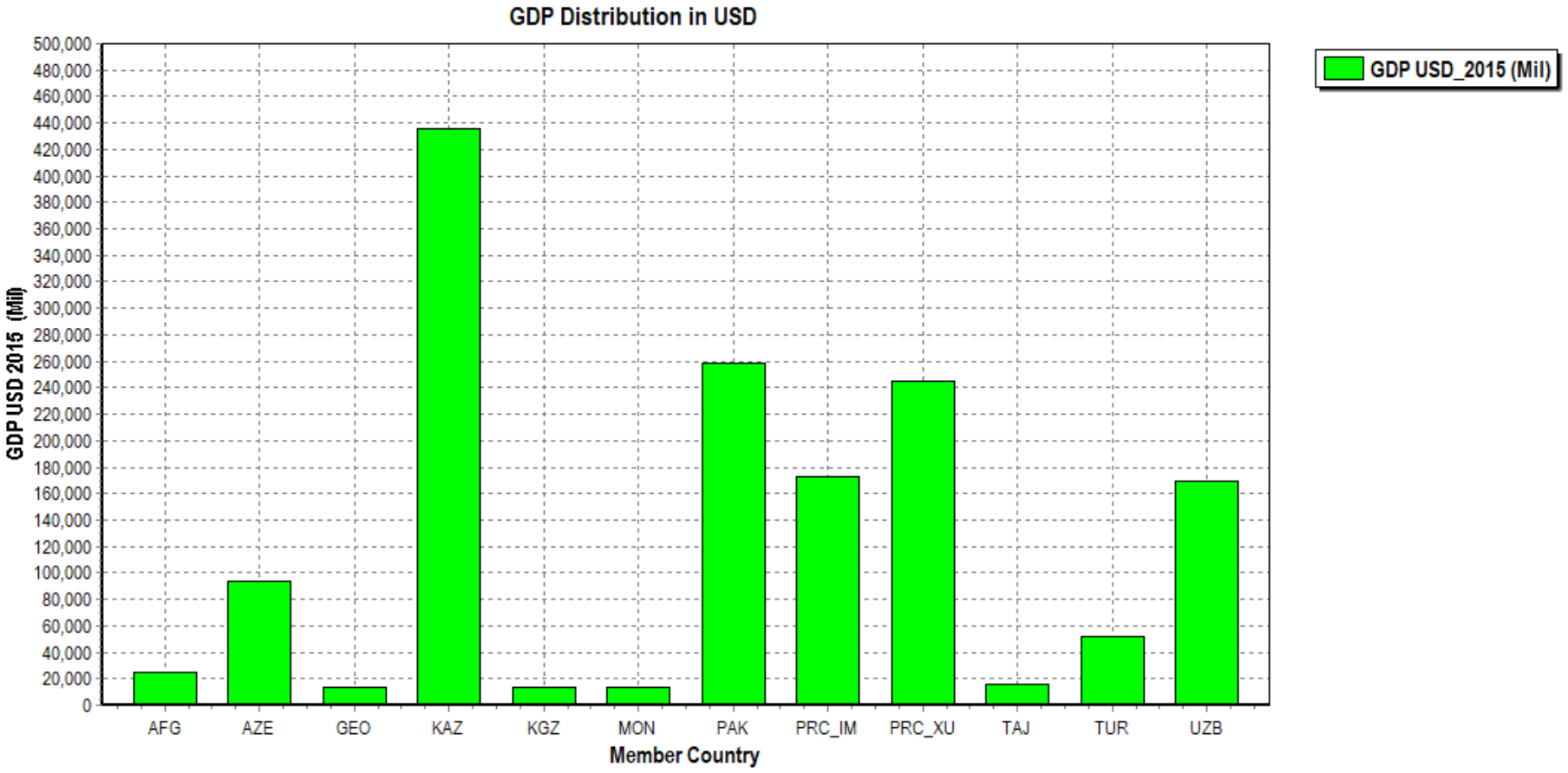


II. SOCIO-ECONOMIC DATA

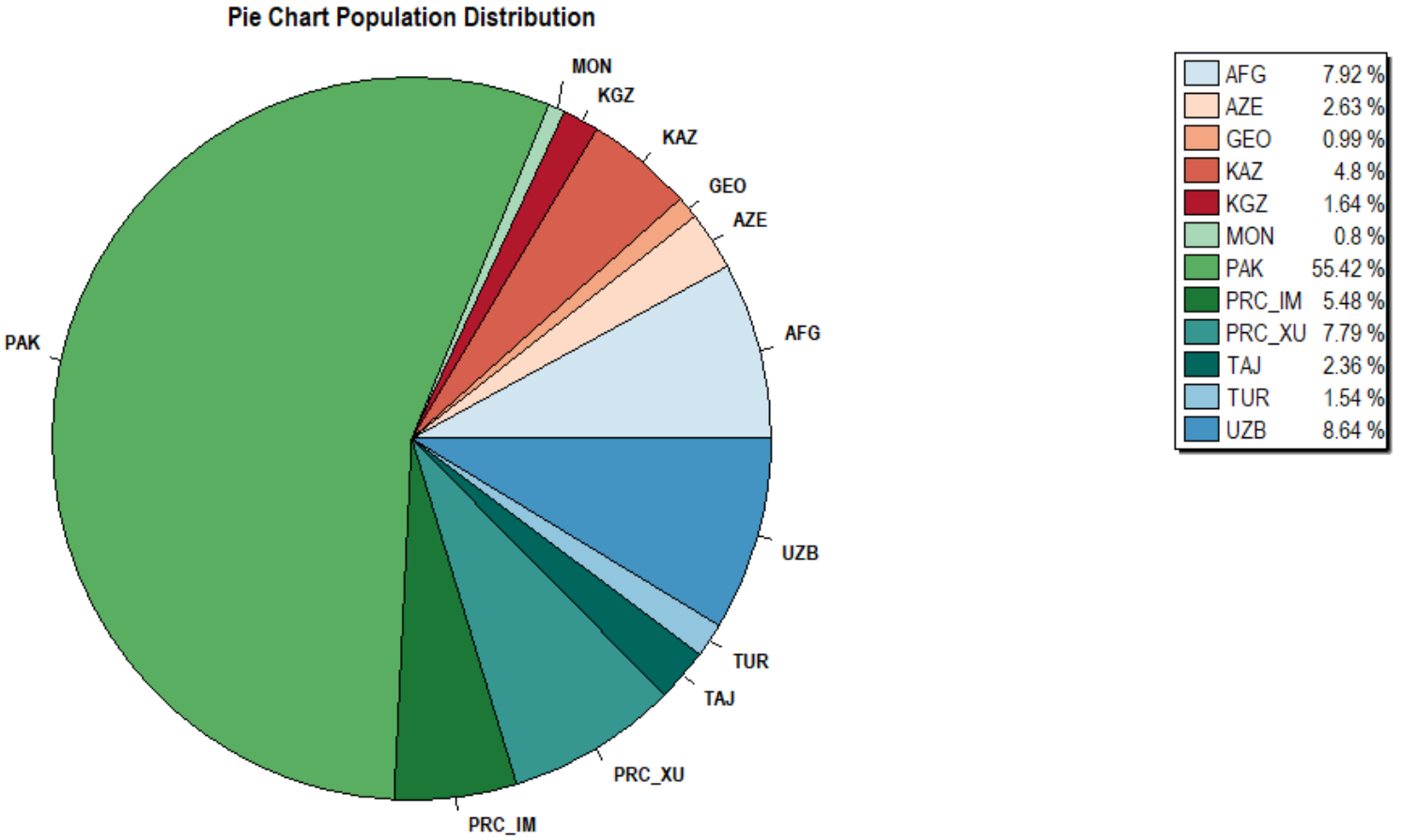
Base population distribution



Base GDP distribution

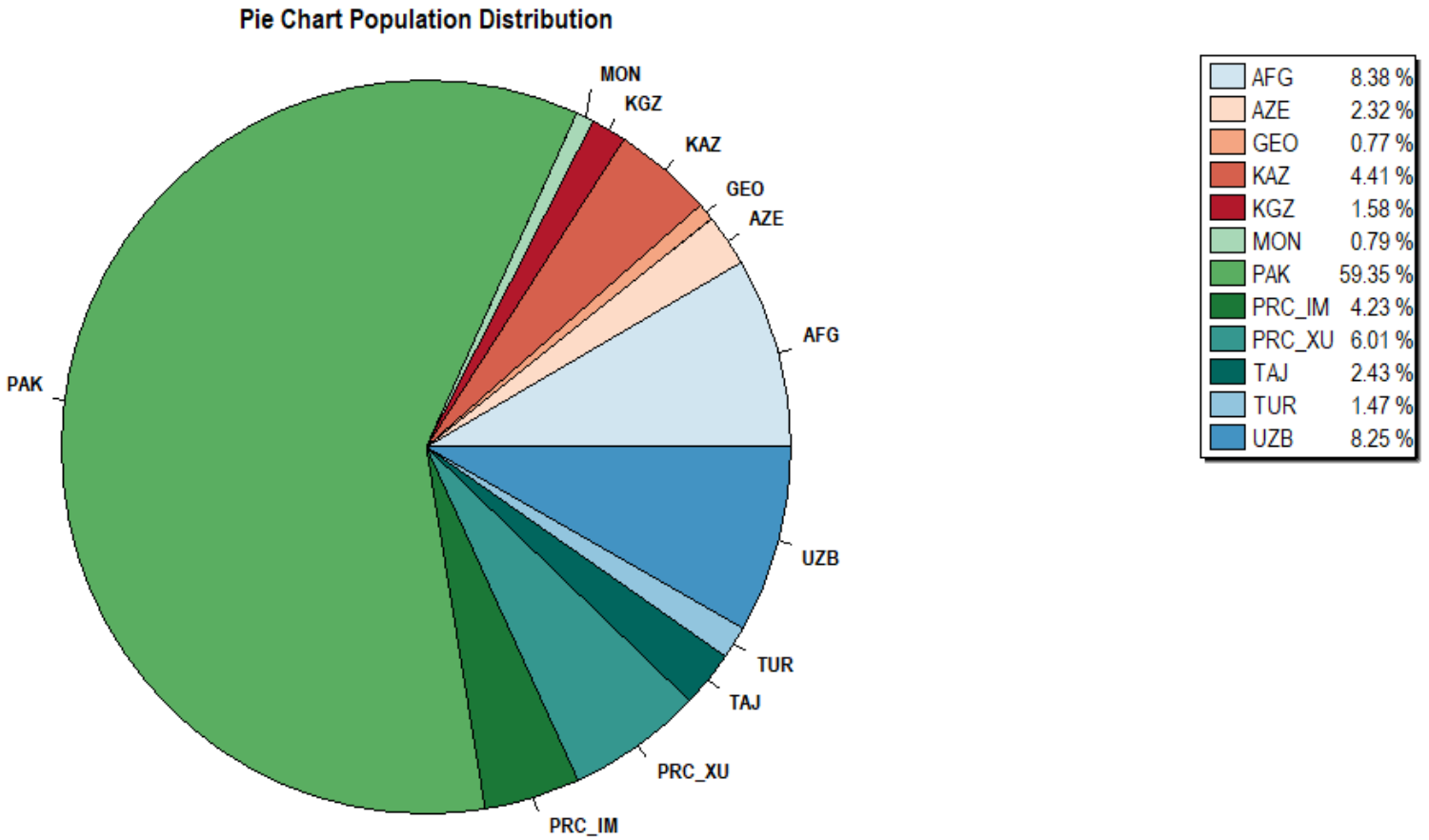


Base year population distribution by MC



Source: CRTM

Year 2050 population distribution by MC



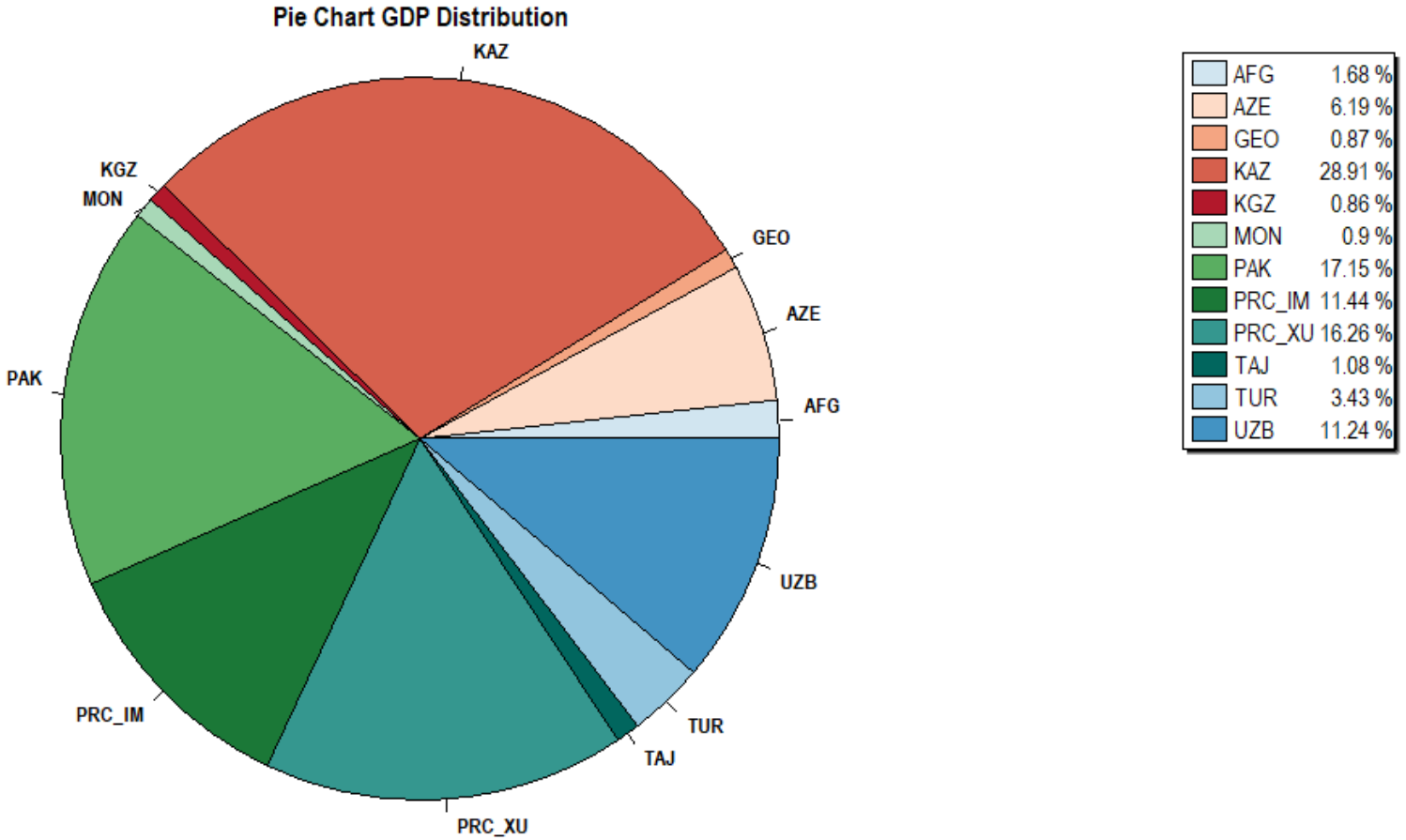
Source: CRTM

Regional socio-economic growth

Region	Annual Average Percentage Growth Rate per annum *(2017 to 2050 ---preliminary results)*
Population	1.1 %
GDP	6.8 %
Person movement	5.7 %
Cargo movement (tonnes)	4.0 %

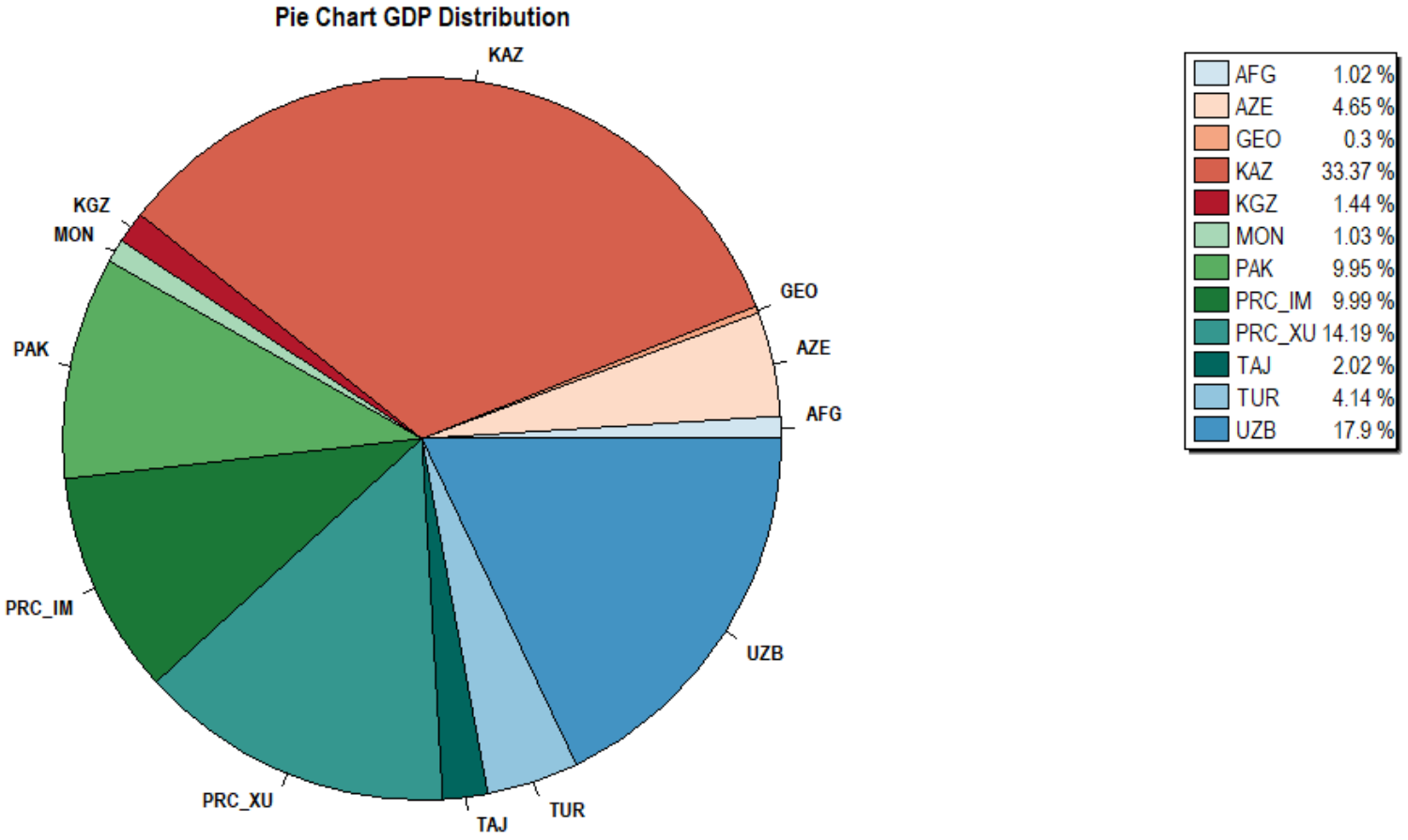
Source: CRTM

Base year GDP distribution by MC



Source: CRTM

Year 2050 GDP distribution by MC



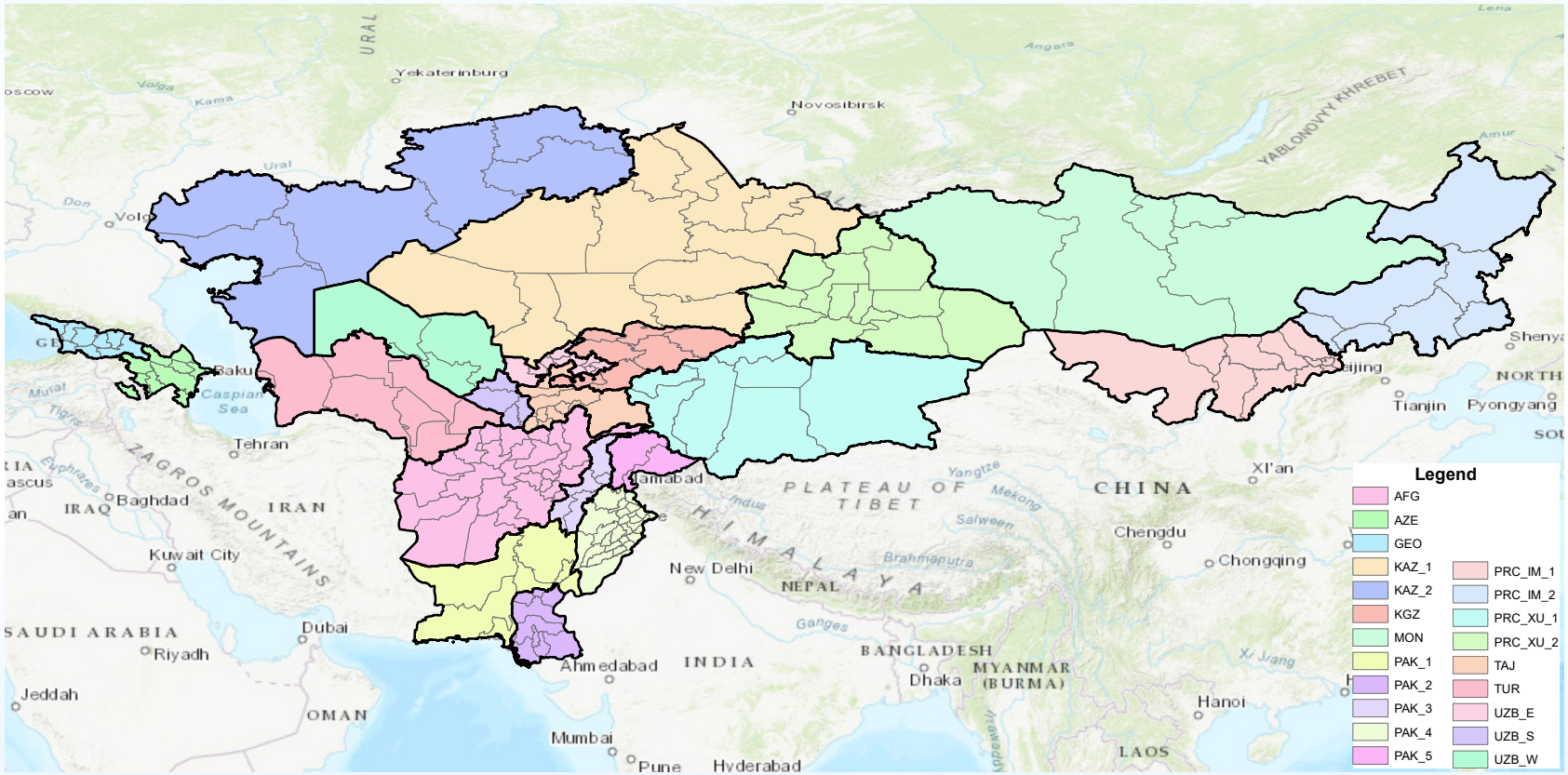
Source: CRTM

III. THE NETWORK EXTENT

CRTM zone system (a)

MC	Name	Number of zones		
		Fine or Small	Large or Big	Model abbreviation
1	Afghanistan	25	1	*AFG*
2	Azerbaijan	10	1	*AZE*
3	Georgia	9	1	*GEO*
4	Kazakhstan	20	2	*KAZ*
5	Kyrgyz Republic	8	1	*KGZ*
6	Mongolia	5	1	*MON*
7	Pakistan	50	5	*PAK*
8	People's Republic of China (Xinjiang Uygur and Inner Mongolia Autonomous Regions)	40	4	*PRC* (PRC-XU and PRC-IM)
9	Tajikistan	10	1	*TAJ*
10	Turkmenistan	9	1	*TUR*
11	Uzbekistan	20	3	*UZB*
Internal total		206	21	
External		20	20	
TOTAL		226	41	

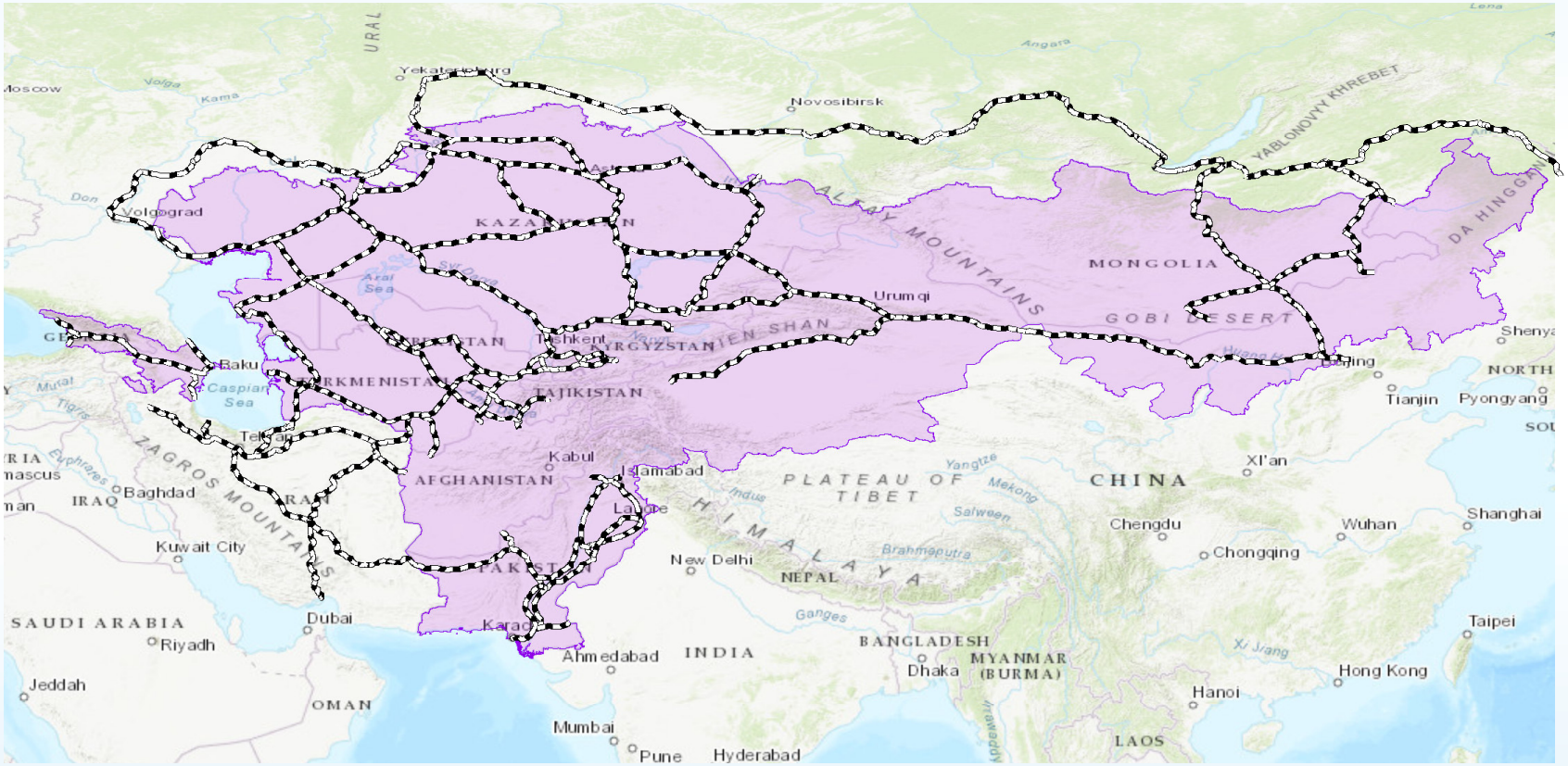
CRTM zone system (b)



Socio-economic data estimated by traffic analysis zone

- Population
  - Three economic activity levels
- Employment
  - Three employment classes
- GDP
- Vehicles

Major rail network - Base

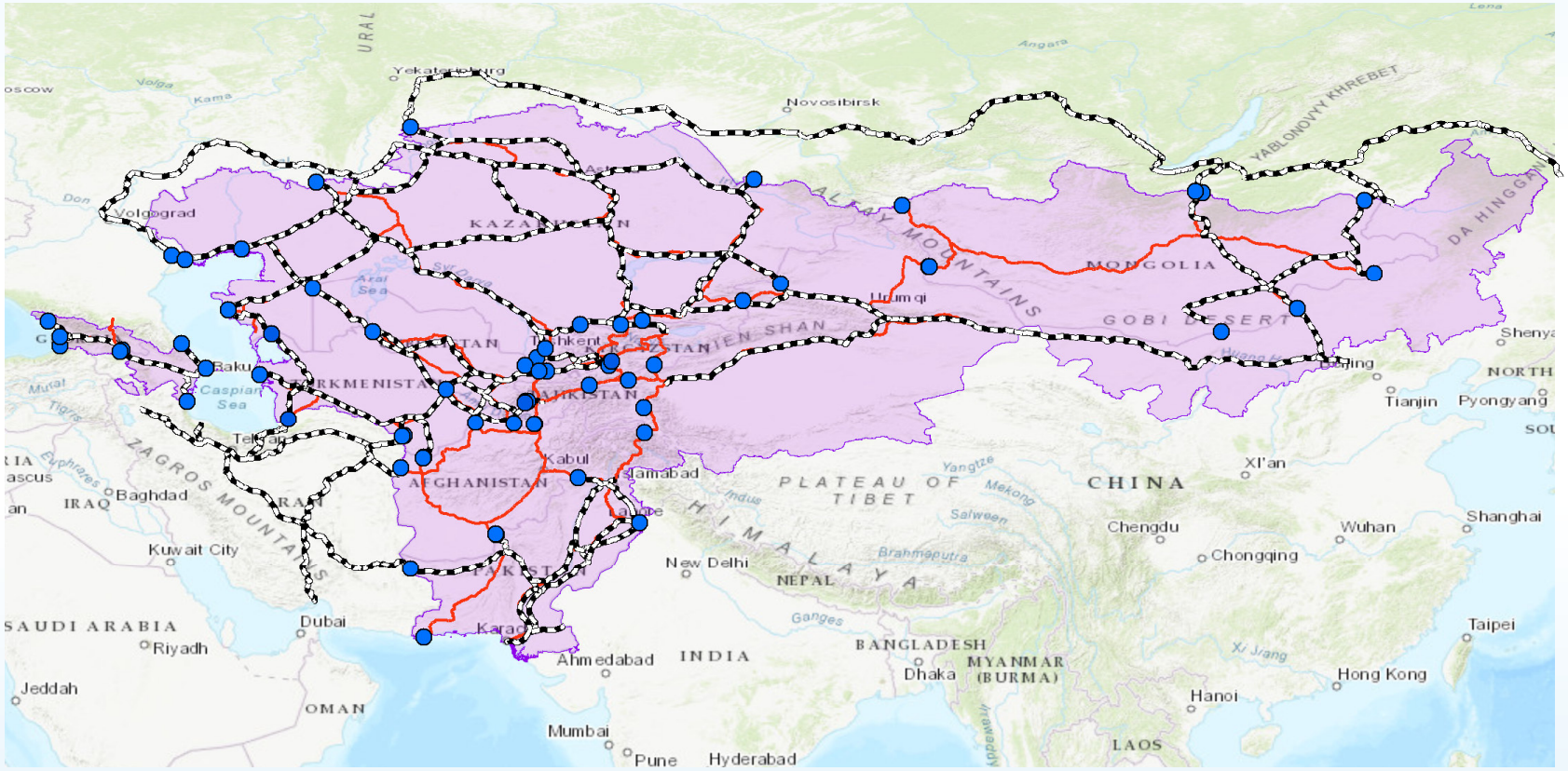


Road Rail

Major road network - Base

Road Rail

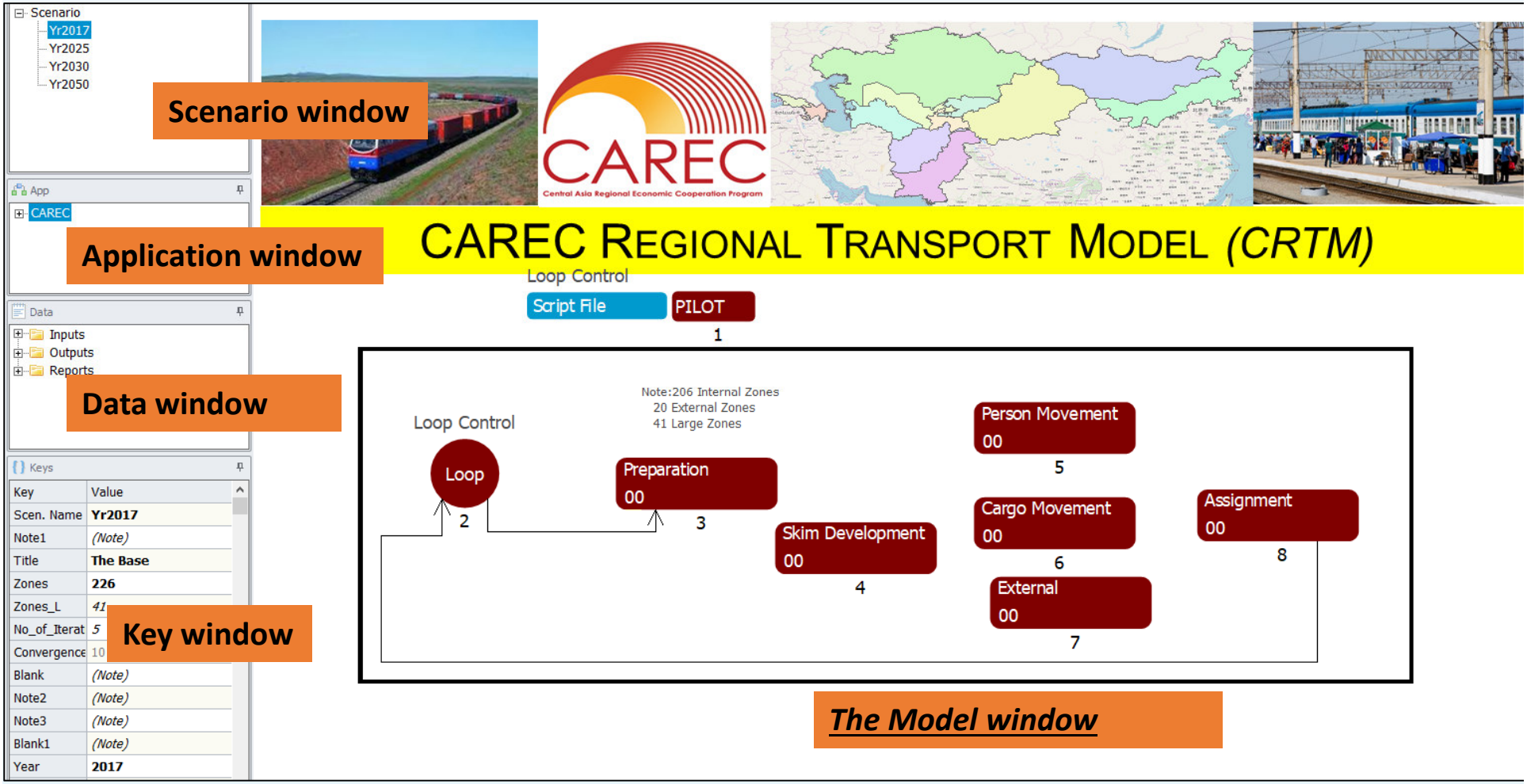
Major combined network - Base



Road Rail BCP

IV. The Model – Analytical Approach

Model framework



Model input window (current status)

CAREC
Central Asia Regional Economic Cooperation Program

CAREC REGIONAL TRANSPORT MODEL *(CRTM)*

General Inputs

Scenario Title: The Base
Number of Zones: 226
Number of Large Zones for Cargo model and Summary: 41
Maximum Number of Iterations: 5
Percentage Convergence Criteria based on change in VKT: 10

Basic Detail

Socio-economic data Input

IF MC Planning Data specified for one year must be specified for all years to ensure consistency

Choose the analysis year for estimation of socio economic parameters: 2017

Model year

Is AFG data available? (Data available for specified scenario) [0 - Implies new data not specified - Tick box not marked

AFG socio-economic data (CRTM format as specified in manual): C:\ADB_CAREC\Model\0.Preparation\0.3.Economics\

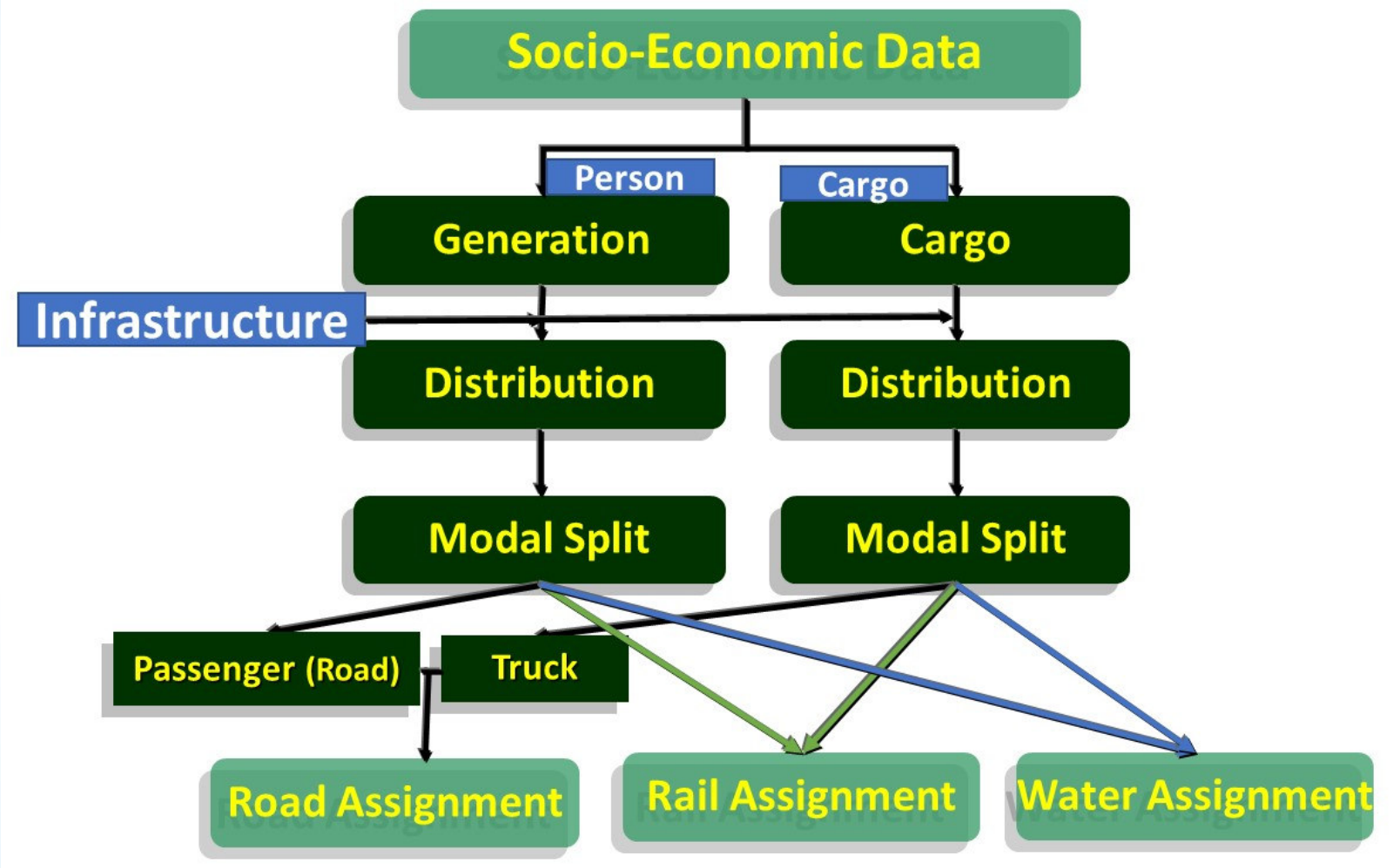
Availability of detailed socio-economic data by MC

Annual Percentage Rate of Decline in Carbon after 2030: 1

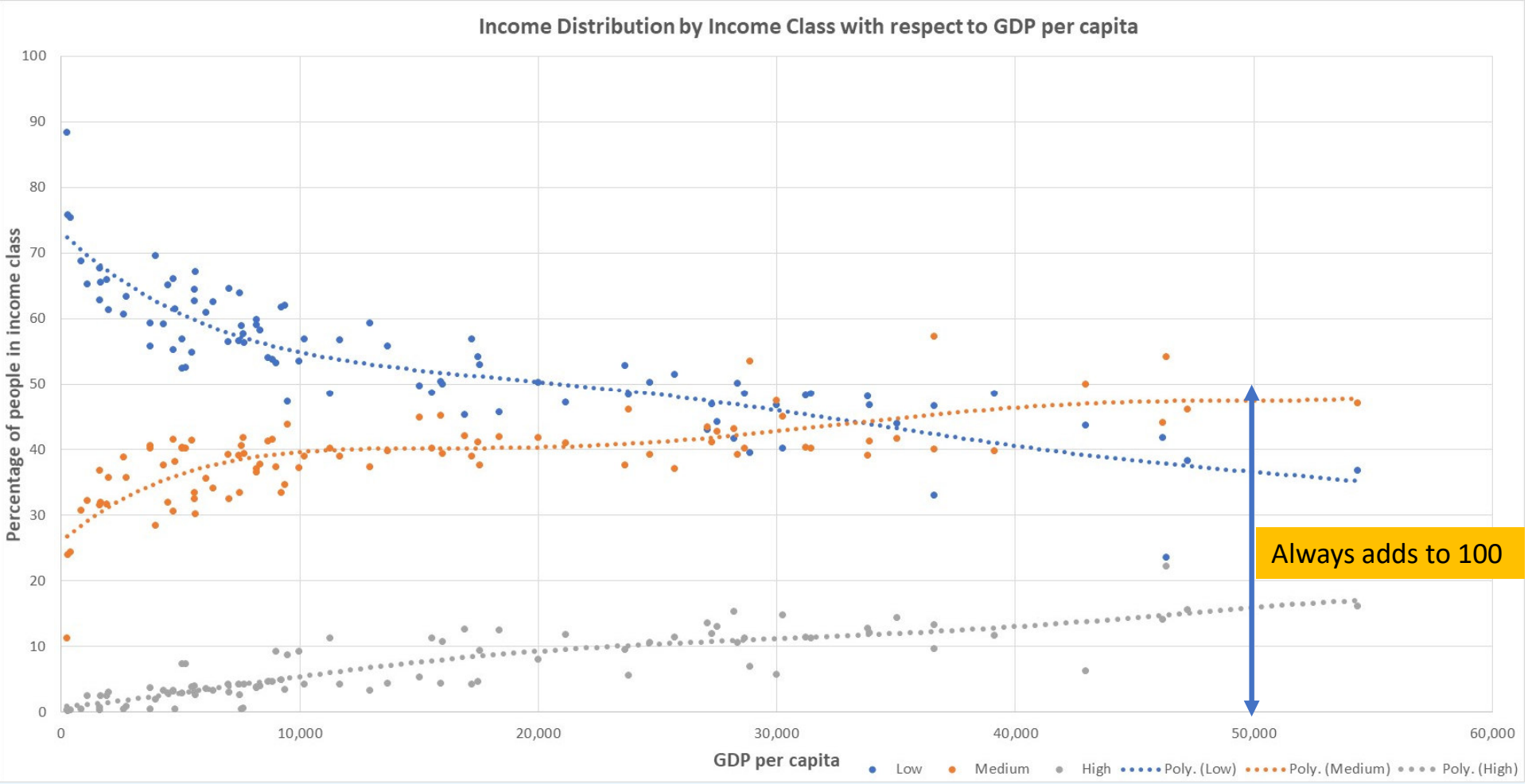
Negative carbon growth rate

Save | Close | Next... | Back... | Run

Reflection

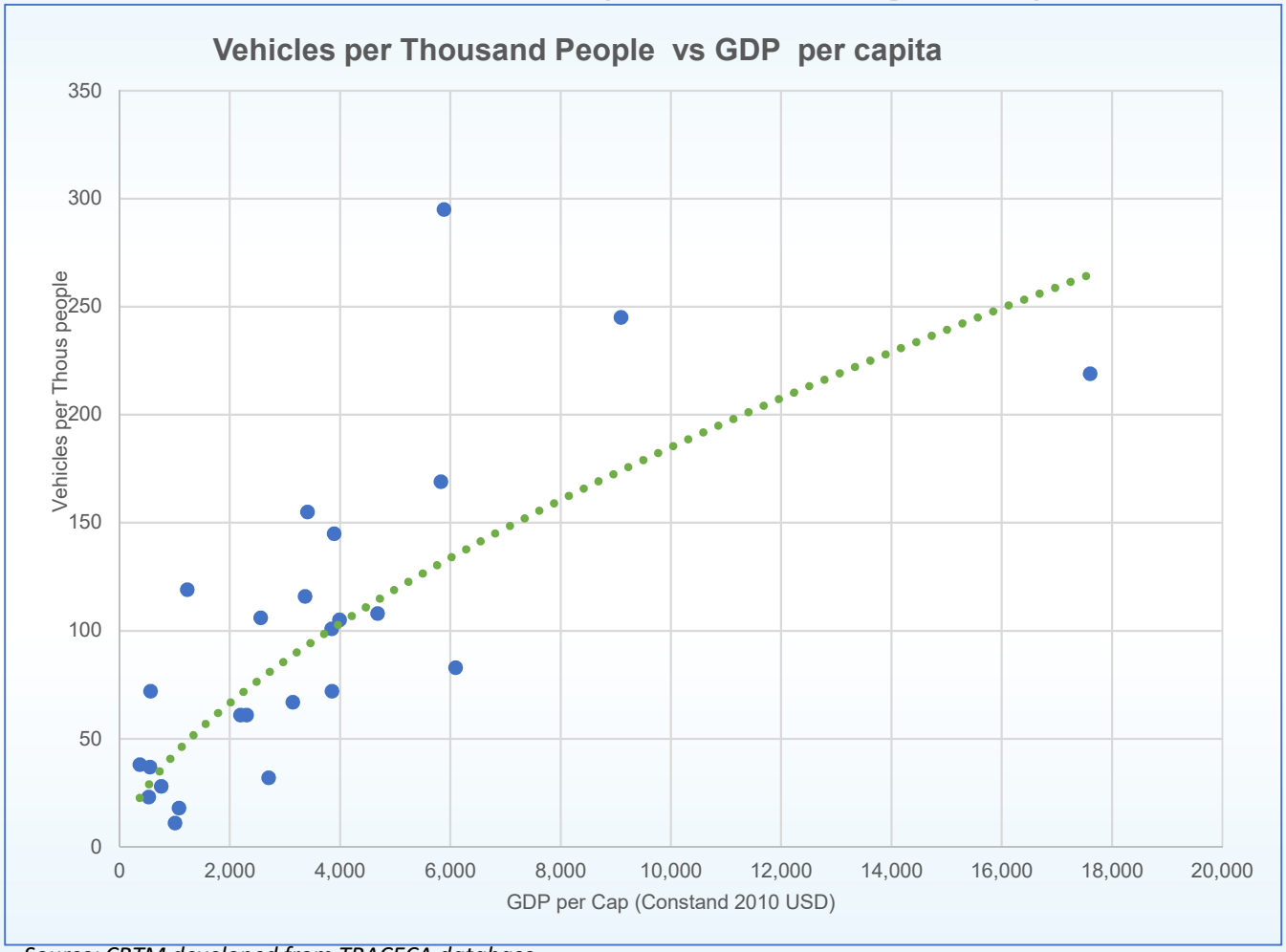

Socio-Economic Data
Person
Cargo
Generation
Cargo
Infrastructure
Distribution
Distribution
Modal Split
Modal Split
Passenger (Road)
Truck
Road Assignment
Rail Assignment
Water Assignment

Person income distribution



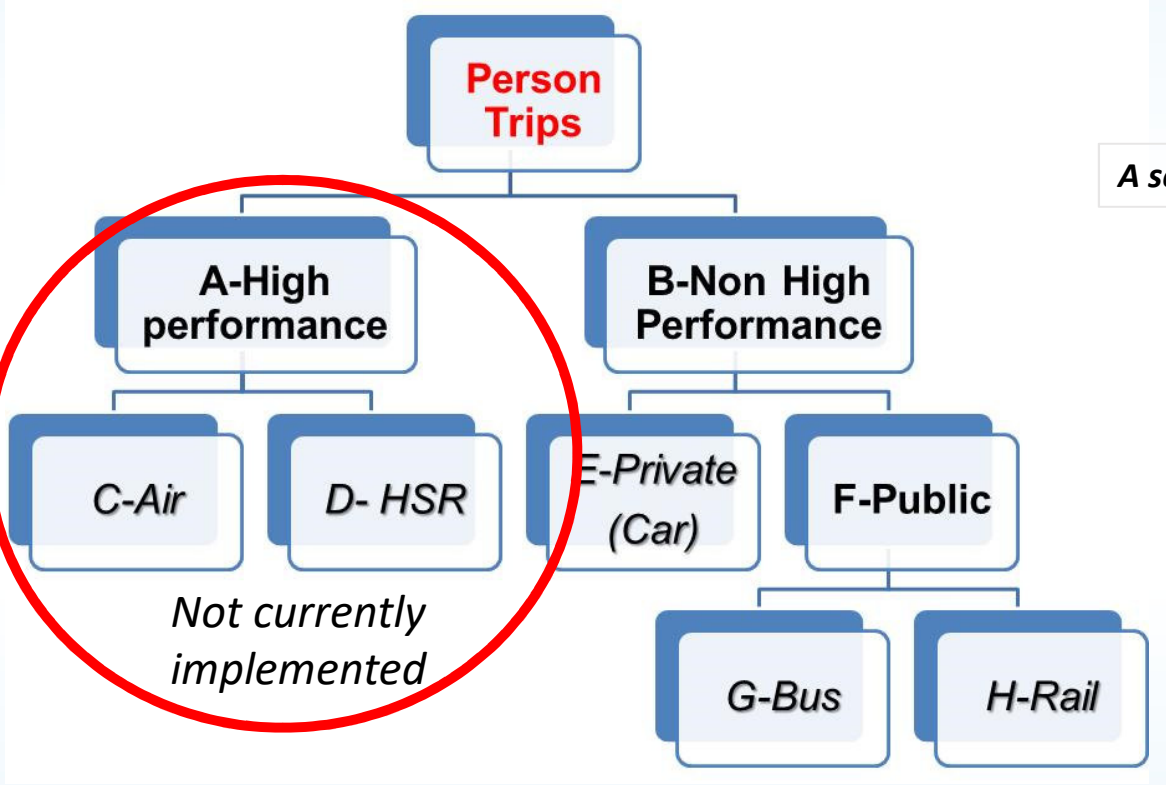
Source: CRTM developed from TRACECA database.

Car ownership category



Source: CRTM developed from TRACECA database.

Mode split person



A series of binary logit models:

$$P_i = \frac{e^{V_1}}{e^{V_1} + e^{V_2}} = \frac{1}{1 + e^{V_2 - V_1}}$$

where:

Pi: Modal share of mode i

V: systematic term of Utility or Cost

J: # of transit. Modes

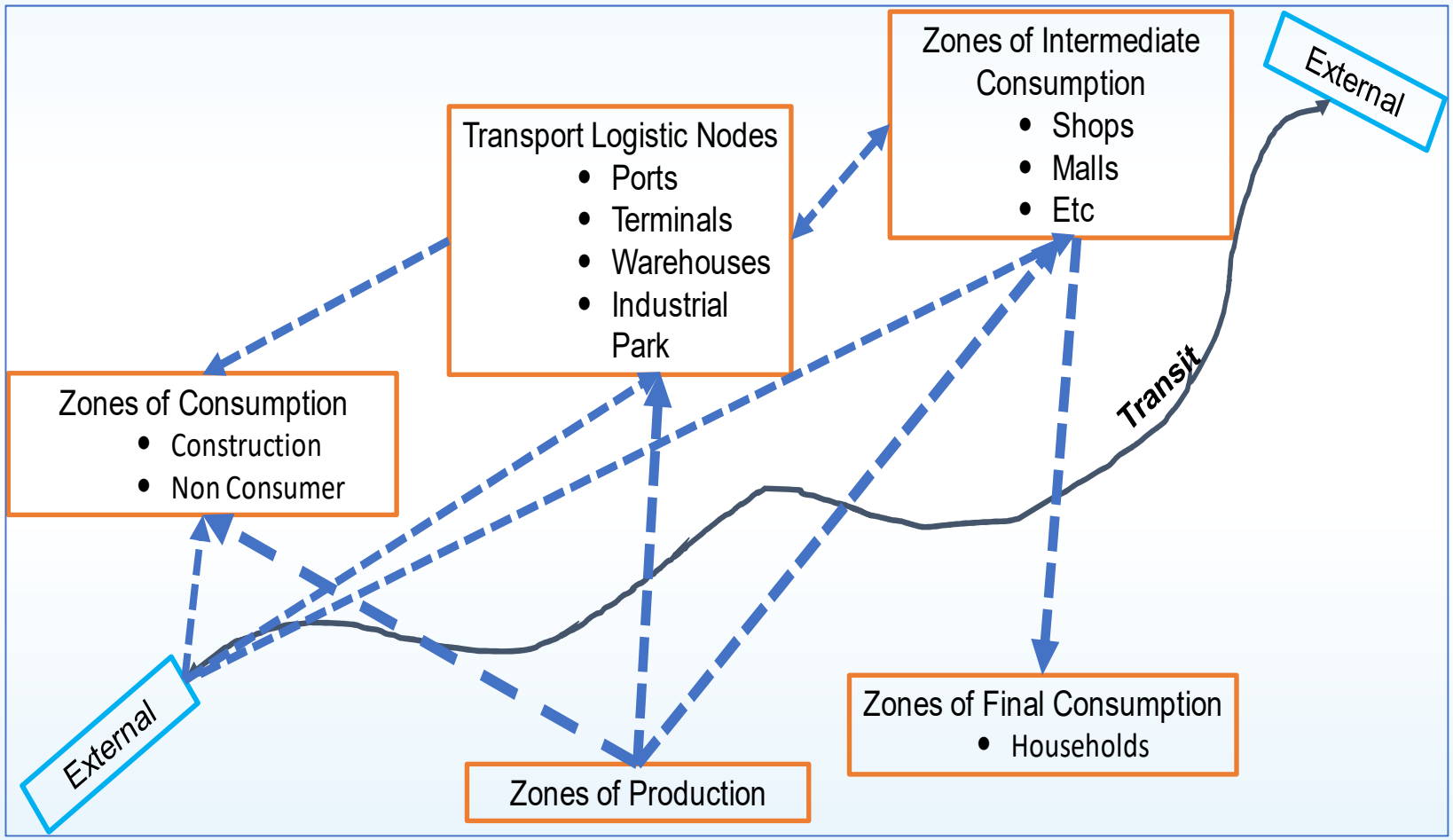
Equations prepared for each economic income class

Cargo model – Trip Generation

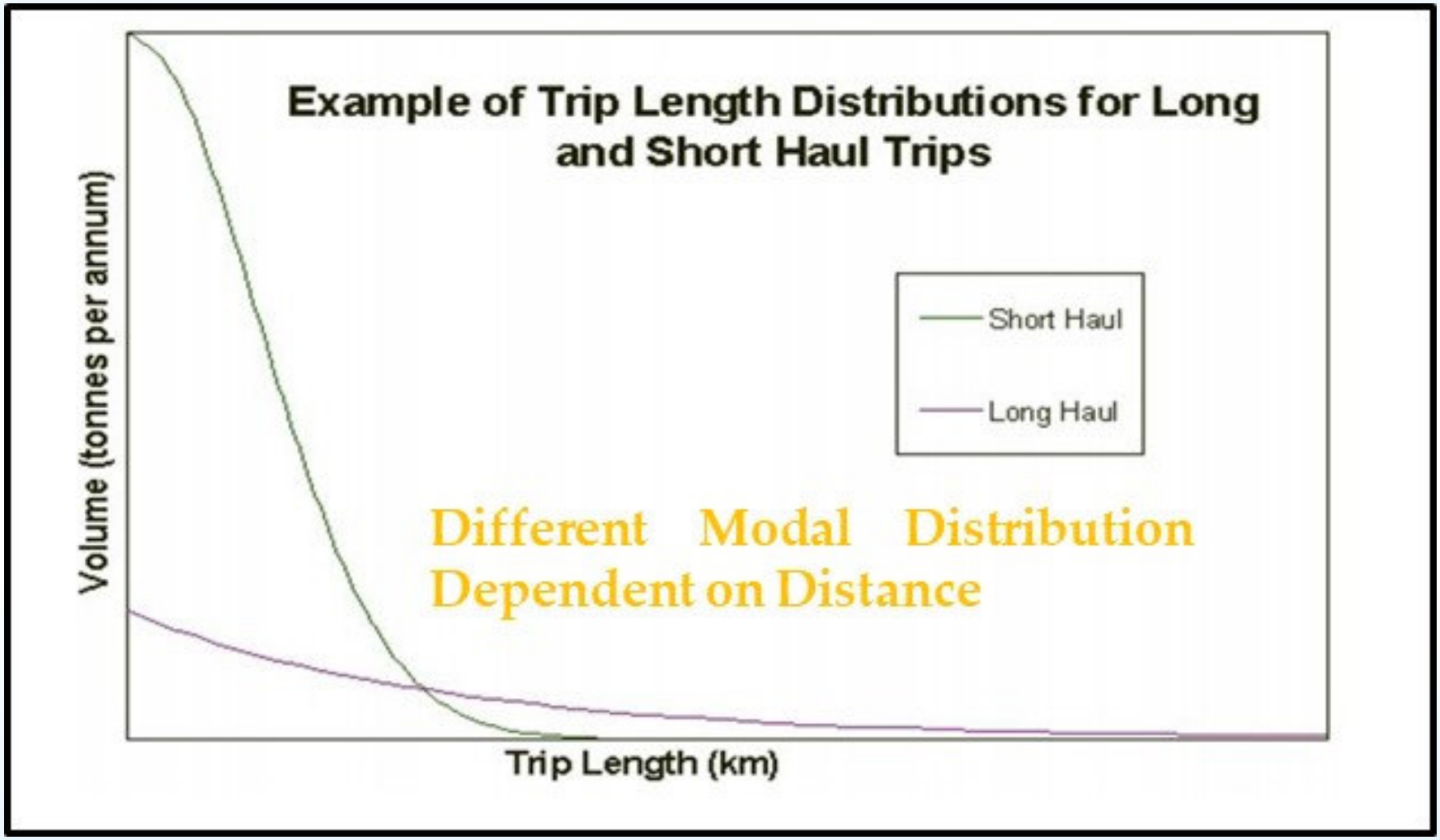
Cargo is described using the Harmonized System (HS) of commodity grouping

Group	Description	HS-Start	HS-End	Detail Description
1	Agricultural	1	5	*Animal & Animal Products*
1	Agricultural	6	15	*Vegetable Products*
2	Processed Food	16	24	*Foodstuffs*
3	Chemical/Mineral	25	27	*Mineral Products*
6	Coal Products	2701	2708	*Coal Products*
7	Oil products	2709	2715	*Petroleum Products*
3	Chemical/Mineral	28	38	*Chemicals & Allied Industries*
3	Chemical/Mineral	39	40	*Plastics / Rubbers*
4	Wood and Skins	41	43	*Raw Hides, Skins, Leather, & Furs*
4	Wood and Skins	44	49	*Wood & Wood Products*
3	Chemical/Mineral	50	63	*Textiles*
4	Wood and Skins	64	67	*Footwear / Headgear*
5	Miscellaneous	68	71	*Stone / Glass*
5	Miscellaneous	72	83	*Metals*
5	Miscellaneous	84	85	*Machinery / Electrical*
5	Miscellaneous	86	89	*Transportation*
5	Miscellaneous	90	97	*Miscellaneous*

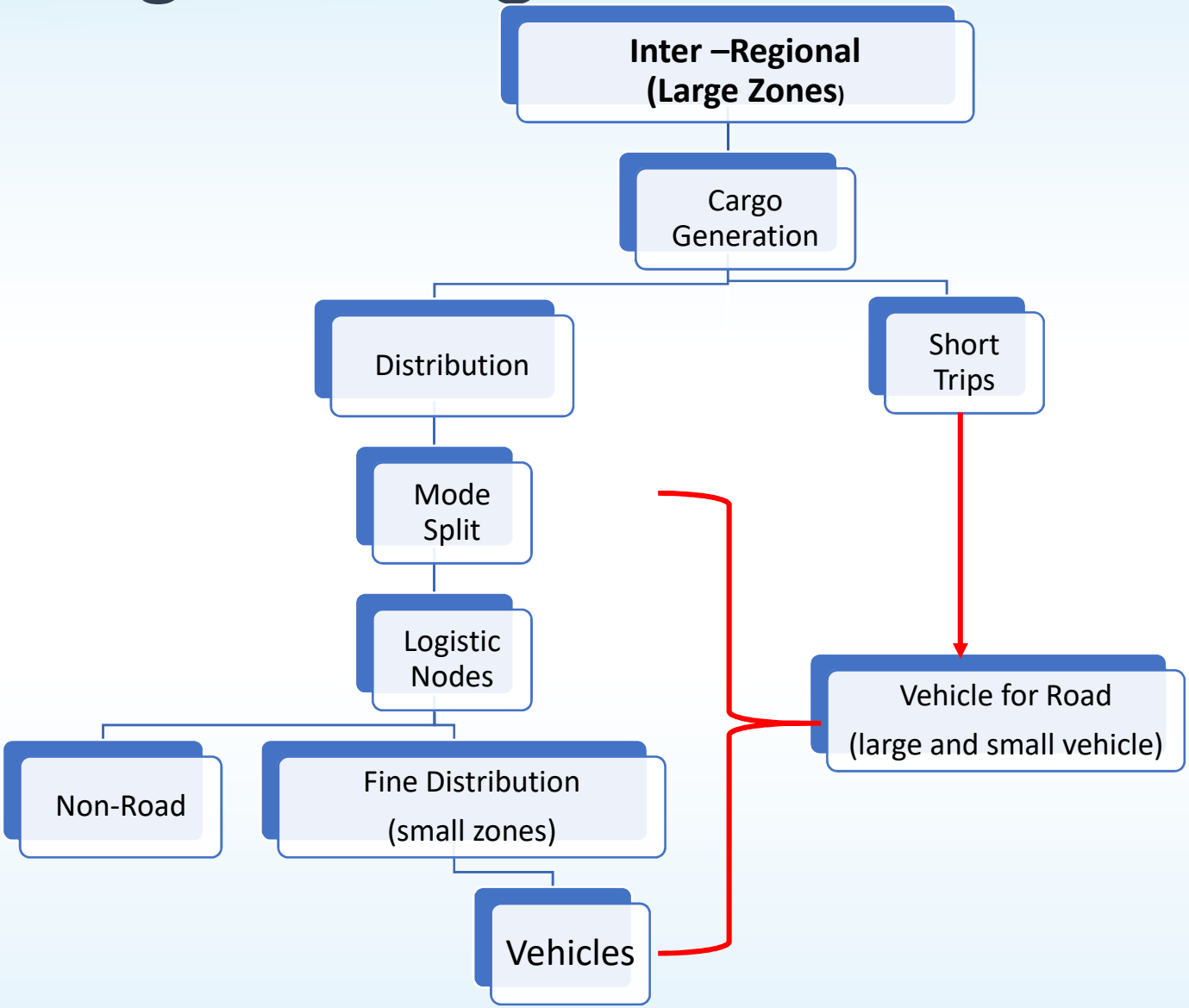
Cargo model – Structure



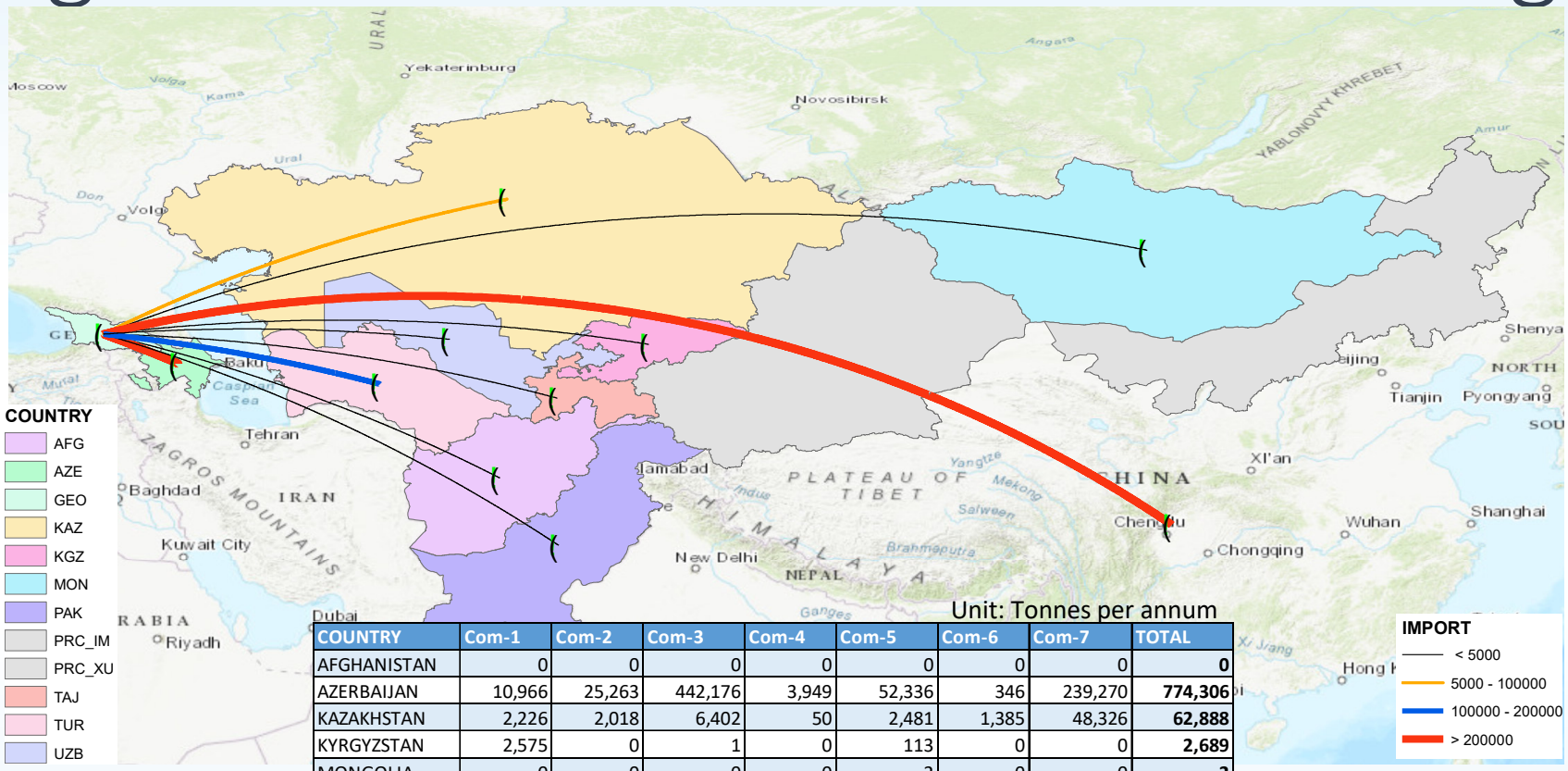
Different trip classes
in association with trip length



Cargo strategic structure



Cargo movement from the east-Georgia

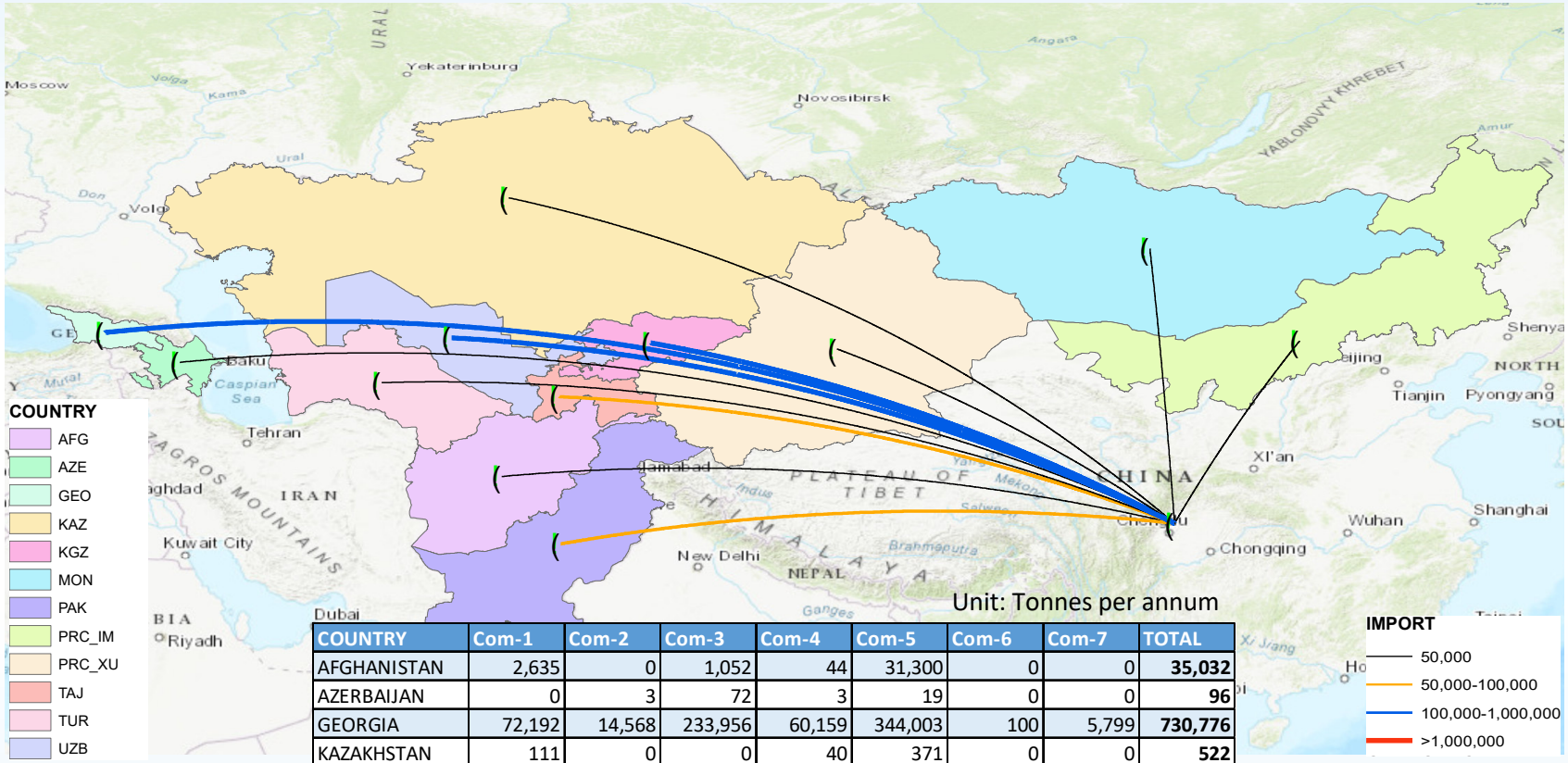


Unit: Tonnes per annum

COUNTRY	Com-1	Com-2	Com-3	Com-4	Com-5	Com-6	Com-7	TOTAL
AFGHANISTAN	0	0	0	0	0	0	0	**0**
AZERBAIJAN	10,966	25,263	442,176	3,949	52,336	346	239,270	**774,306**
KAZAKHSTAN	2,226	2,018	6,402	50	2,481	1,385	48,326	**62,888**
KYRGYZSTAN	2,575	0	1	0	113	0	0	**2,689**
MONGOLIA	0	0	0	0	2	0	0	**2**
PAKISTAN	4,706	10	125	8	19	0	0	**4,870**
PRC	10,273	3,212	48,000	46,397	171,860	5	95	**279,842**
TAJIKISTAN	0	0	0	0	0	0	0	**0**
TURKMENISTAN	0	36	1,141	0	993	0	189,331	**191,501**
UZBEKISTAN	2,118	48	2,101	0	302	0	59	**4,628**

Reconciliation of cargo movements from supplied customs data.(On-going)

Cargo movement from the west-PRC



Unit: Tonnes per annum

COUNTRY	Com-1	Com-2	Com-3	Com-4	Com-5	Com-6	Com-7	TOTAL
AFGHANISTAN	2,635	0	1,052	44	31,300	0	0	**35,032**
AZERBAIJAN	0	3	72	3	19	0	0	**96**
GEORGIA	72,192	14,568	233,956	60,159	344,003	100	5,799	**730,776**
KAZAKHSTAN	111	0	0	40	371	0	0	**522**
KYRGYZSTAN	38,862	5,707	60,565	389,853	966	163,957	0	**659,911**
MONGOLIA	9	20	1	1	4	0	0	**35**
PAKISTAN	11,726	622	32,169	3,515	8,430	10	15	**56,487**
TAJIKISTAN	3,886	571	6,057	38,985	4,285	16,396	0	**70,180**
TURKMENISTAN	496	0	34,470	4,066	368	25	0	**39,426**
UZBEKISTAN	44,325	105	592,493	1,323	6	0	697	**638,948**

Note: Excludes sea transport

Model outputs

- Cargo and Person Trips estimated By Mode
  - The specific routes or links used by trips, and at what level of intensity;
  - For the road network- Combine Cargo and Person; and
    - Both Person and cargo are converted into vehicles and hence passenger car unit (pcu); and
    - Equilibrium: all used paths have equal and minimum travel cost;
  - Non-Road network, trip are assigned onto exclusive right of ways using all or nothing assignment.

- Network Links
  - Person Travel by Mode; and
    - Travel on road link to access say air mode is also included.
  - Cargo Travel by Mode.
    - Travel on road link to access say rail mode is also included.

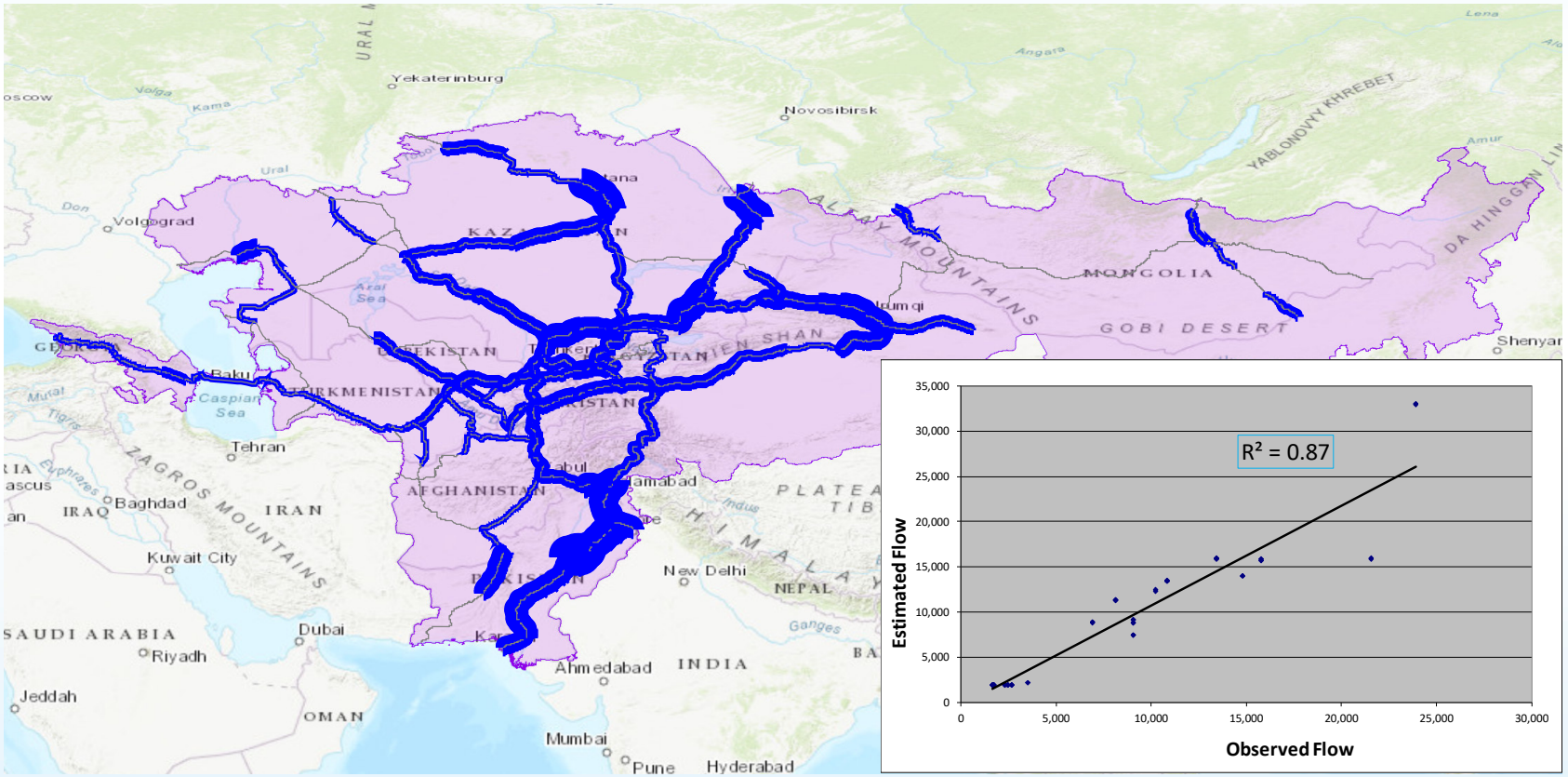
V. Model Verification

Comparisons between observed and model estimation

- Some typical statistics for comparison
  - Individual Link flows where appropriate
  - Vehicle registration data
  - Person-km of travel by mode by mode by MC
  - Tonne-km of cargo movement by mode by MC

Overall vehicle link flow comparisons across CAREC—preliminary results

across selected links



VI. The Manual

The detail

Model Manual

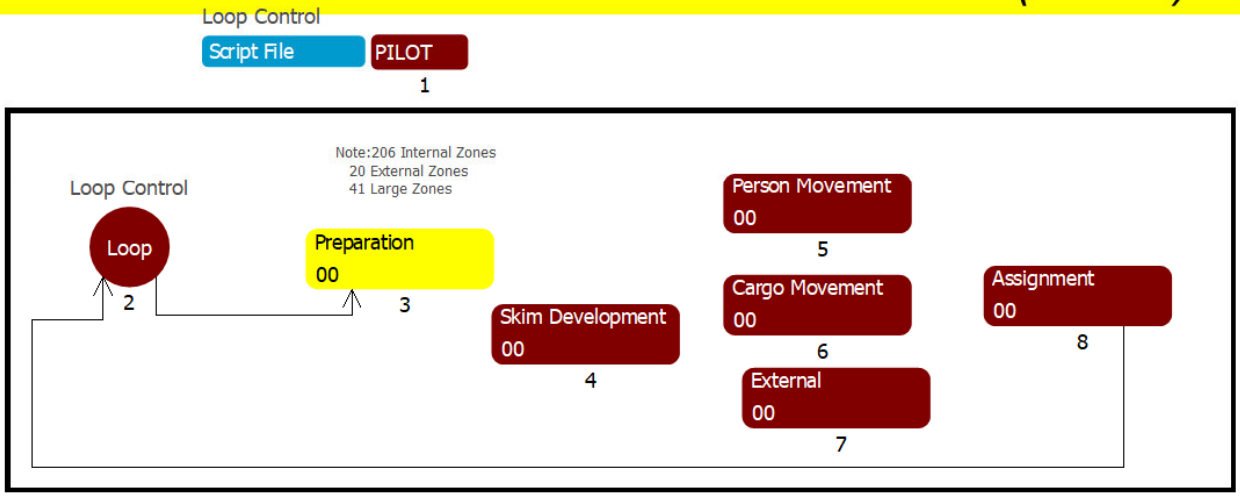
- 0.Preparation
  - 0.1Inputs -- Prepare background information
  - 0.2Networks -- Prepare master network for specific scenario
  - 0.3Economics -- prepare socio-economic data for specific scenario for each locality
- 1.Skim_Developmen
  - 1.1Person Highway --- Develop highway skims
  - 1.2Person Transit --- Develop transit skims
  - 1.3Person Cargo --- Develop cargo skims
- 2.Person_Movement
  - 2.1Generation -- Develop person trip generation for specified scenario
  - 2.2Distribution -- Develop person trip distribution for specified scenario
  - 2.3Mode Split -- Develop person mode split for specified scenario
- 3.Cargo_Movement
  - 3.1Generation -- Develop cargo trip generation for specified scenario
  - 3.2Distribution and Mode split -- Develop cargo trip distribution and mode split for specified scenario
- 4.Assignment
  - 4.1 Convergence --Convergence for feedback loop
- Scenario -----Scenario specific inputs
  - 2017
  - 2025
  - 2030
  - 2050

The manual will describe in detail every link CRTM including the numerical background of the relevant equations.

Sample detailed flowchart (Level 1)

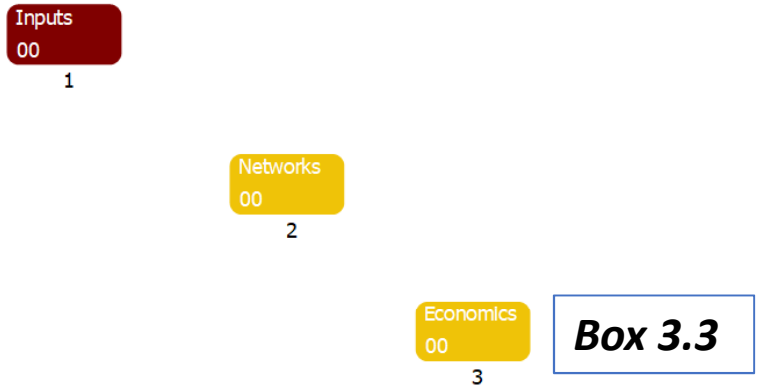
CAREC
Central Asia Regional Economic Cooperation Program

CAREC REGIONAL TRANSPORT MODEL *(CRTM)*



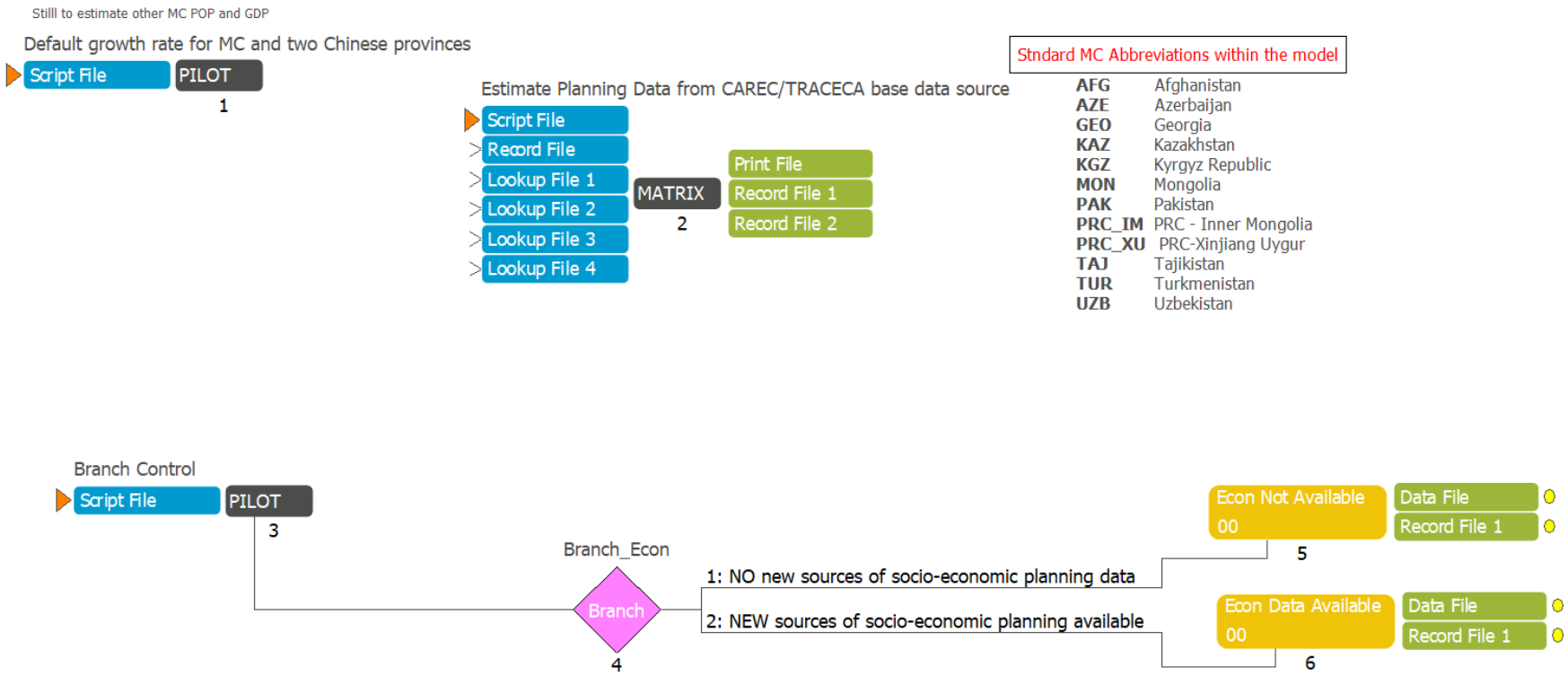
The Model is a series of interlinking flowcharts or modules eg the economic module

Sample detailed flowchart (Level 2)



The Model is a series of interlinking flowcharts or modules eg the economic module

Sample detailed flowchart (Level 3)



The Model is a series of interlinking flowcharts or modules eg the economic module
(illustrates also box numbering convention)

VII. Next Steps

Immediate next steps

SCHEDULE

Task	2019								2020			
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1. Pre-Model Development												
> *Review of TRACECA*												
> *Manilla Workshop*												
> *Workshop with national consultants*												
> *Issue appreciation via country visits*												
>*Approach paper preparation*												
2. Model Preparation												
> *Network preparation*												
> Rail												
> Road												
> Water												
> *Zoning System*												
> Small zones												
> Large zones												
> *Travel Skim Estimation*												
> *Socio-economic data for MC's*												
3. Person module												
> *Generation*												
> *Distribution*												
> *Mode split*												
4. Cargo module												
> *Generation*												
> *Distribution*												
> *Mode split*												
5. External module												
6. Assignment and Feedback Loop												
7. Calibration												
8.Documentation												
> *Initial Documentation preparation*												
>*ESCAP Meeting*												
>*Finalization of model documentation*												
9.Project Testing												
> *Network Preparation*												
> *Network testing*												
>*Finalization of all documentation*												

The key next steps

- Finalization of cargo module development
- Finalization of Calibration
- Finalization of documentation
- Preparation for testing of CAREC RWG proposals
- Testing of CAREC RWG proposals

VIII. RECAP

I. THE GENERAL APPROACH AND THE NEED FOR A TRANSPORT MODEL.
II. THE BASE YEAR PLANNING DATA AND THE FUTURE PLANNING DATA – A KEY INPUT INTO THE TRANSPORT MODEL
III. THE BASE NETWORK DEVELOPED FROM THE CAREC GIS BASE.
IV. DETAILED ASPECTS OF THE CRTM MODEL STRUCTURE
V. THE MODEL VARICATION PROCESS THAT IS ONGOING
VI. THE OVERALL STRUCTURE OF THE MODEL MANUAL
VII. THE NEXT STEPS THAT INCLUDE THE COMPLETION OF THE MODEL BASE YEAR VALIDATION AND THENCE THE TESTING OF FUTURE PROJECT PROPOSALS TO PROVIDE INPUT INTO ECONOMIC ANALYSIS. *IN THE FUTURE THE MODEL IS THUS AN ESSENTIAL TOOL FOR EVALUATION OF ANY CAREC TRANSPORT INFRASTRUCTURE PROJECT.*