Introduction to Cube: Cube Base, Scenario Analysis, Editing, Mapping, and Scripting
Objectives for Participants

- **General**
  - Overview of Citilabs and Cube
  - Typical four step modeling process
  - Understand how best to use Cube for your planning projects
  - Use and application of statewide models

- **Technical**
  - Review of the training model
  - Working with the GIS Window
  - Applying the Cube forecasting system
  - Case studies with Cube
  - Model scripting with Cube
Agenda/Training Contents

- **Lesson 1:** Introductions, overview, and context of training
- **Lesson 2:** The 4-step modeling process
- **Lesson 3:** Overview of Citilabs and Cube (*including new features*)
- **Lesson 4:** Review of training model (*Cubetown, aka Fargo, ND*)
- **Lesson 5:** Working with Cube Base + GIS Window + data prep
- **Lesson 6:** Applying Cube forecasting system
- **Lesson 7:** Case studies with Cube
- **Lesson 8:** Cube Reports
- **Lesson 9:** Scripting environment in Cube6
- **Lesson 10:** Special topics: statewide models, transferability, validation
Typical Uses of Transportation Planning Models

- **Systems planning**
  - Highways and intersections
  - Buses and rapid transit
  - Scheme evaluation and appraisal

- **Corridor and sub-area studies**
  - Traffic impact studies
  - Alternatives analysis
  - Environmental impact
  - Utilization and revenue
  - Project design

- **Strategic planning**
  - Project programming
  - Pricing and demand elasticity
  - Statistical facts and queries
Typical Transportation Planning Model Elements

**Inputs:**
- Zonal Data – Internal, External
- Highway Networks – Study area definition
- Intersection Data
- Public Transport Data

**Processes:**
- Trip Generation
- Trip Distribution
- Mode Split
- Network Assignment

**Outputs:**
- Trip ends by zone
- Zone-to-zone trip tables
- Loaded networks
Lesson 2: Four-Step Modeling Process
The Four-Step Modeling 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
Typical Four-Step Travel Demand Model

1 - Trip Generation
2 - Trip Distribution
3 - Mode Split
4 - Highway Assignment

Potential Feedback to Convergence
Zonal Data

- **Data structure:**
  Flat table, sometimes the attribute table of a polygon boundary layer (e.g. shapefile)

- **Boundaries:**
  Defined by transportation planning staff, taking into account various factors
  - Transportation geography (e.g. road features)
  - Census area (tract and block) boundaries
  - Socio-economic characteristics

- **Attributes:**
  - Sequentially numbered from 1-# of zones
  - Households by type (e.g. size and income)
  - Employees by type (e.g. industry code)
  - Trips by purpose (productions and attractions)
Network data

- A network is one of the basic data structures of a travel demand model
- Represents the transport infrastructure
- Includes a table of nodes (points) and links (lines between nodes)
- Required node attributes: N, X, Y
- Required link attributes: A, B
- The A and B numbers correspond to the N numbers of the start and end nodes
- Other variables store optional attributes of the links and nodes, e.g. distance, time, polar coordinates, etc…
Highway Networks

- **Data structure:**
  directed graph (nodes and links)

- **Centroids:**
  - Represent zones in the network
  - Include external stations at study area boundary
  - Connected to network via "centroid connectors"

- **Functional classification or facility types:**
  freeways, arterials, collectors, local roads

- **Other attributes:**
  number of lanes, posted speeds, area types

- **Distances:**
  maintained using geographic information systems (GIS) or hand-coded directly
Intersection Data

- Only required if performing intersection-constrained highway traffic assignment

- Calculate capacity for each turn at nodes
  - Highway Capacity Manual 2000 (USA)
  - Supplied saturation flows

- Intersection types and models:
  - Roundabout – gap-acceptance / empirical
  - Priority (yield) – geometric / saturation
  - Fixed-time signal – geometric / saturation
  - Adaptive signal – geometric / saturation
  - Two-way stop
  - All-way stop

- Turning movements (flows and delays)
Public Transport (PT) Data

- Defined in relation to underlying transportation infrastructure network (highway network + transit-only links)

- Public Transport lines:
  - Sequence of nodes traversed by transit service
  - Stop nodes distinguished from non-stop nodes
  - Running time taken from underlying network links, with additional dwell, delay adjustments
  - Line-level attributes (e.g., headways and modes)

- Non-transit legs:
  - Provide zone-to-zone network connectivity
  - Access, transfer, and egress connections

- System: modes, operators, fares, users
Visualization Environments

- **Network Window**
  - Uses native Citilabs Cube Graphics functions
  - Permits display of one binary (NET) format highway network with overlaid layers
  - Transit layer – lines and non-transit legs
  - Drawing layer – map annotation and symbols
  - Shapefile layers – boundary, polyline and point
  - Image layer – background image files

- **GIS Window**
  - Uses embedded ESRI ArcGIS functions
  - Displays model data stored in geodatabases
  - View and edit any ESRI-compatible data
  - Open/save ArcGIS map document (MXD) files
Step 1: Trip Generation

- **Answers the question:** “how many trips are produced by and attracted to each zone”

- **Productions and attractions are a function of socio-economic attributes of zone,** such as households and employers

- **Categories of trips:**
  - Home-based-work (commute)
  - Home-based-non-work (e.g., social/recreational, school)
  - Non-home-based (e.g., mid-day errands)

- **Typical model forms:**
  - Cross-classification (average trip rates by household size, auto availability, DU type, presence of workers or children)
  - Simplified trip rate (often used for trip attractions)
  - Linear regression (least-squares estimation)
Cross-Classification

Trip Chaining

<table>
<thead>
<tr>
<th>TRIP PURPOSE</th>
<th>PRODUCTION</th>
<th>ATTRACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HB WORK</td>
<td>ZONE A</td>
<td>ZONE B</td>
</tr>
<tr>
<td>2. NHB</td>
<td>ZONE B</td>
<td>ZONE C</td>
</tr>
<tr>
<td>3. HB SHOP</td>
<td>ZONE A</td>
<td>ZONE C</td>
</tr>
</tbody>
</table>
Concepts underlying trip “purpose”

• Throughout a demand model, principles of market segmentation are used to analyze categories of travel separately
Typical Trip Purposes

• **Home-Based Work:**
  - Home-Based *Work Direct* (from home to work)
  - Home-Based *Work Strategic* (e.g., drop off kids, pick up coffee on the way)

• **Home-Based Non-Work:**
  - Home-Based *School*
  - Home-Based *Shopping*
  - Home-Based *Social/Recreation*
  - Home-Based *Other* (e.g., leisure, visit family)
  - Home-Based *University*
  - Home-Based *Airport*

• **Non-Home Based:**
  - *Work-Based Other aka NHB Work* (e.g., to lunch, shopping)
  - *Non-Home Non-Work aka NHB Other* (all the rest - e.g., from a store to school)
  - *Commercial vehicles*
    - Trucks (often split into heavy duty, medium, light duty or by vehicle class, etc.)
    - Taxis

• **External Trips:**
  - *External-External* (through trips)
  - *Internal-External/External-Internal* (one trip end inside and one outside study area)
Trip Generation - Scripts

- **FILEI ZDATI[x]**
  - Zonal variables are referenced in script as Zi.x.variable

- **FILEI LOOKUPI[x]**
  - Lookup tables contain production and attraction rates

- **FILEO PAO[x]**
  - Output file contains productions and attractions to be used in the distribution phase

- **PARAMETERS**
  - zones=num ; defines the number of zones

- **ILOOP Phase**
  - COMP P[num]=… ; num refers to a particular user class
  - COMP A[num]=…

- **ADJUST Phase**
  - COMP P[num][zone]= ; zone=0 produces the total of the array
  - BALANCE ..
Example: 4-purpose Trip Generation

; ----- E-I trip data file
FILEI ZDATI[2] = "C:\TrainingModel\Model\EITRIPS.DBF"
; ----- land use data file
FILEI ZDATI[1] = "{Zones}"

; DBF: Z=zone field name
; TXT: Z=zone field location, var=field location, var=field location ....
ZONES = 25

IF (I<=16)
;
; ----- calculate productions by purpose
P[1] = 0.74*zi.1.hh1+1.67*zi.1.hh2+2.01*zi.1.hh3+2.58*zi.1.hh4
P[2] = 2.00*zi.1.hh1+4.10*zi.1.hh2+5.94*zi.1.hh3+7.89*zi.1.hh4
P[3] = 0.96*zi.1.hh1+1.82*zi.1.hh2+2.65*zi.1.hh3+3.13*zi.1.hh4
;
; ----- calculate attractions by purpose
A[1] = 1.45*zi.1.total_emp
A[2] = CmpNumRetNum(zi.1.areatype,’=’,1,2,0,9.0)*zi.1.retail+1.7*zi.1.service+0.5*zi.1.other+0.9*zi.1.households
A[3] = CmpNumRetNum(zi.1.areatype,’=’,1,1.4,4.1)*zi.1.retail+1.2*zi.1.service+0.5*zi.1.other+0.5*zi.1.households
ELSE
P[4] = zi.2.eitrips
ENDIF
;
; ----- adjust zonal attractions so total attractions match total productions
PHASE=ADJUST
BALANCE, A2P=1,2, NHB=3
;
; ----- output zonal productions and attractions
FILEO PAO[1] = "{SCENARIO_DIR}\TRIPENDS.DBF",
Step 2: Trip Distribution

- **Answers the question** “where do trips produced by zones go, and where do trips attracted to zones come from?”

- **Function of activity concentrations and zone-to-zone travel costs**

- **Process calibrated to match observed trip length distribution** (e.g. from surveys)

- **Typical forms:**
  - FRATAR – growth factor based (usually external trips)
  - Gravity model – relative attractiveness with friction factors and possibly k-factors for adjustment
  - Destination choice – random utility model (logit)
I. Trip Generation Estimates

<table>
<thead>
<tr>
<th>Zone</th>
<th>Production</th>
<th>Attraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>250</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>600</td>
<td>600</td>
</tr>
</tbody>
</table>

II. Trip Distribution (Zones)

- **Zone 1**: 100 Production, 250 Attraction
  - 20 Trips, 5 Minutes
  - 30 Trips, 15 Minutes
  - 50 Trips remain as Intrazonal Trips

- **Zone 2**: 300 Attraction
  - 30 Trips, 15 Minutes

- **Zone 3**: 50 Attraction
  - 20 Trips, 5 Minutes
Gravity Model

\[
\text{Trip}_{i \rightarrow j} = \frac{P_i \times A_j \times f(\text{Im } p_{i \rightarrow j}) \times k_{i \rightarrow j}}{\sum_{r=1}^{\text{zones}} A_r \times f(\text{Im } p_{i \rightarrow r}) \times k_{i \rightarrow r}}
\]

Where

- \(P_i\): The number of trips produced from zone \(j\)
- \(A_j\): The number of trips attracted to zone \(j\)
- \(\text{Im } p_{i \rightarrow j}\): The travel impedance from zone \(j\) to zone \(j\)
- \(f(\text{Im } p_{i \rightarrow j})\): The friction factor, which is a function of travel impedance
- \(k_{i \rightarrow j}\): The specific zone-to-zone adjustment factor
Final model should replicate trips by time interval. This proves the model allocates trips properly.
Desire Lines: Direction and Magnitude of Travel
Trip Distribution - Scripts

- **GRAVITY Command**: Performs traditional gravity model distribution
  - PURPOSE=num; number of trip purposes
  - LOS=matrix; defines the cost matrices (e.g., travel time, cost, distance)
  - FFACTORS=lookup#; defines the impedance curve in minutes by purpose
  - KFACTORS=matrix; identifies zones and values for k-factor adjustment

- **SETPA**: defines balancing of productions and attractions by trip purpose
  - P[num]=.....
  - A[num]=.....

Where num corresponds to the trip purpose number
Example: 4-purpose Gravity Model

LOOKUP, FILE = "C:\TrainingModel\MODEL\FFACTORS.DBF",
INTERPOLATE=Y, NAME=FF,
    LOOKUP[1]=1, RESULT=2,
    LOOKUP[2]=1, RESULT=3,
    LOOKUP[3]=1, RESULT=4,
    LOOKUP[4]=1, RESULT=5
;

----- setup the working p's and a's
;

----- get the los matrix into work mat
MW[10] = MI.1.1
;

----- do 3 gravity models
GRAVITY PURPOSE=1, LOS=MW[10], FFACTORS=FF
GRAVITY PURPOSE=2, LOS=MW[10], FFACTORS=FF
GRAVITY PURPOSE=3, LOS=MW[10], FFACTORS=FF
GRAVITY PURPOSE=4, LOS=MW[10], FFACTORS=FF

Source: NCHRP 365
Step 3: Mode Split (aka Mode Choice)

- **Answers the question**, “how do trips get from productions to attractions, given the available set of network options?”

- **Possible modes**: public transit, personal vehicle, non-motorized transport, as well as detailed path/vehicle type options

- **The probability of selecting a given mode is a function of the relationship between the “cost” of competing modes**
  - Travel Time, Cost, Transfers
  - Walk Time, Wait Time
  - User Characteristics and Biases

- **Typical forms**:
  - Multinomial logit (random utility model)
  - Nested or hierarchical logit (most common… see chart)
  - Incremental logit (based on changes in cost)
Nested Logit Model

\[ P_a = \frac{e^{U_a}}{\sum_{i=1}^{m} e^{U_i}} \]

where,

- \( P_a \) is the probability of a traveler choosing mode \( a \);
- \( U_a \) is the utility (or attractiveness) of mode \( a \); and
- \( \sum U_i \) is the sum of the utilities for all \( m \) modes.

The utility equation, \( U_a \), is mode-specific and can be represented in the following general form:

\[ U_a = c_1 \times Distance_a + c_2 \times Fare_a + c_3 \times InVehicleTime_a + \ldots + C_a \]

where,

- \( U_a \) is the utility (or attractiveness) of mode \( a \);
- \( Distance_a \), \( Fare_a \), \( InVehicle Time_a \), \( \ldots_a \) are level of service variables of mode \( a \) for this trip;
- \( c_1, c_2, \ldots \) are coefficients estimated for each of the terms based on survey results;
- \( c_a \) is the constant for mode \( a \) – obtained through calibration.
Nested Logit Model – Logsum Function

\[ U_b = c_{nest} \times \ln \left( \sum_{i=1}^{n} e^{U_i} \right) + C_b \]

where:

- \( U_b \) is the utility for nest b
- \( C_{nest} \) is a coefficient called the nesting coefficient, or theta; and
- \( C_b \) is a nest level constant for nest b—obtained through calibration.
Typical Nested Logit Structure

- **Total Person Trips**
  - **Auto Mode Share**
    - Drive-Alone Mode
      - HOV-2 Mode
    - Shared-Alone Mode
      - HOV-3 Mode
  - **Transit Mode Share**
    - Walk Access
    - Auto Access
      - HOV-4+ Mode
Mode Split – Choice Modeling in Cube

**XCHOICE Command**

- **ALTERNATIVES=...** ; Define each alternative choice (e.g. Car, PT)
- **DEMANDMW=...** ; Define input trip matrix to be split
- **COSTSMW=...** ; Define cost matrices for each alternative
- **ODEMANDMW=...** ; Define working matrices to store output trip matrices for each alternative
- **STARTMW=...** ; Define a working matrix for internal calculation
- **SPLIT=...** ; Define the choice model (i.e. structure and scale)

**Choice Models that can be developed in Cube include:**

Simple binary or multinomial; hierarchic; destination choice

Absolute or incremental

Cost or utility based
Example: Absolute logit model for 3 modes

; Do not change filenames or add or remove FILEI/FILEO statements using an editor. Use Cube/Appl.
RUN PGM=MATRIX PRINTFILE="C:\Abishek\Projects\Scripting_Training\Training\UF_Training\CubeVoyager\"
FILEI MATI[1] = "\{SCENARIO_DIR\}\PERSONTRIPS.MAT"
FILEI MATI[2] = "C:\CubeTrainingModel\MODEL\TML0000A.MAT"
FILEI MATI[3] = "C:\CubeTrainingModel\MODEL\TML0000B.MAT"
FILEI MATI[4] = "C:\CubeTrainingModel\MODEL\DEFRA00A.MAT"
FILEO MATO[1] = "\{SCENARIO_DIR\}\MOETRIPS.MAT",
   MO = 4-8, 14, 24, 34,
   NAME = CAR, PT, WALK, TOTAL, EXT_CAR, HBW_CAR, HBO_CAR, NHB_CAR
; Car matrices are output by purpose for time-of-day factoring

MW[1] = mi.1.HBW
MW[2] = mi.1.HBO
MW[3] = mi.1.NHB

; Auto generalized costs in equivalent time units
MW[11] = mi.2.3

; Transit generalized costs in equivalent time units
MW[12] = mi.3.1 + \{ASC_PT\}

; Walk access assuming speed of 2.5 miles per hour
MW[13] = 60*mi.2.DISTANCE/2.5 + \{ASC_WK\}

;HBW mode choice model
XCHOICE,
   ALTERNATIVES = car pt walk,
   DEMANDMW = 1,
   COSTSMW = 11, 12, 13,
   ODEMANDMW = 14, 15, 16,
   SPLIT = total \{HBW_Scale\} car pt walk,
   STARTMW = 100
Time-of-Day Factoring *(Intermediate Step)*

- **Answers the question,** “when do trips between origins and destinations occur?”

- **Trip Generation, Distribution, and Mode Split** create *trip tables in production-attraction format*, where each cell represents both outbound and return.

- **To translate from P/A into origin-destination format,** trip tables must be transposed, added together, and divided by two.

- **Time-of-day factors are simultaneously applied,** representing probability that the outbound or return portion of a trip occurs during the time period to be analyzed.
Time of Day Trip Allocation

Figure -- Time-of-Day of Travel

Percent of Total Trips

Starting Time of Trips

HBW  HBNW  NHB  TOTAL
# Time of Day Trip Distribution - Example

**P->A (From Home to Other)**

<table>
<thead>
<tr>
<th>Period</th>
<th>HBWD</th>
<th>HBWS</th>
<th>HBW</th>
<th>HBSH</th>
<th>HBO</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>0.353</td>
<td>0.496</td>
<td>0.389</td>
<td>0.067</td>
<td>0.210</td>
</tr>
<tr>
<td>MD</td>
<td>0.066</td>
<td>0.096</td>
<td>0.074</td>
<td>0.202</td>
<td>0.113</td>
</tr>
<tr>
<td>PM</td>
<td>0.020</td>
<td>0.030</td>
<td>0.022</td>
<td>0.073</td>
<td>0.099</td>
</tr>
<tr>
<td>NT</td>
<td>0.062</td>
<td>0.074</td>
<td>0.065</td>
<td>0.094</td>
<td>0.086</td>
</tr>
<tr>
<td>TOTAL</td>
<td>0.501</td>
<td>0.696</td>
<td>0.550</td>
<td>0.436</td>
<td>0.508</td>
</tr>
</tbody>
</table>

**A->P (From Other to Home)**

<table>
<thead>
<tr>
<th>Period</th>
<th>HBWD</th>
<th>HBWS</th>
<th>HBW</th>
<th>HBSH</th>
<th>HBO</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>0.004</td>
<td>0.016</td>
<td>0.007</td>
<td>0.011</td>
<td>0.030</td>
</tr>
<tr>
<td>MD</td>
<td>0.079</td>
<td>0.064</td>
<td>0.075</td>
<td>0.222</td>
<td>0.141</td>
</tr>
<tr>
<td>PM</td>
<td>0.296</td>
<td>0.153</td>
<td>0.259</td>
<td>0.165</td>
<td>0.155</td>
</tr>
<tr>
<td>NT</td>
<td>0.120</td>
<td>0.071</td>
<td>0.109</td>
<td>0.166</td>
<td>0.166</td>
</tr>
<tr>
<td>TOTAL</td>
<td>0.499</td>
<td>0.304</td>
<td>0.450</td>
<td>0.564</td>
<td>0.492</td>
</tr>
</tbody>
</table>

**Non-Home-Based**

<table>
<thead>
<tr>
<th>Period</th>
<th>HBWD</th>
<th>HBWS</th>
<th>HBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>0.062</td>
<td>0.121</td>
<td>0.097</td>
</tr>
<tr>
<td>MD</td>
<td>0.562</td>
<td>0.463</td>
<td>0.504</td>
</tr>
<tr>
<td>PM</td>
<td>0.282</td>
<td>0.223</td>
<td>0.247</td>
</tr>
<tr>
<td>NT</td>
<td>0.094</td>
<td>0.193</td>
<td>0.152</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Example: Time of Day and Vehicle Trip Factoring

; Do not change filenames or add or remove FILEI/FILEO statements using an editor. Use Cube/Application Manager.
RUN PSW=MATRIX MSG='Auto time of day and occupancy factoring'
FILEI LOOKUP[2] = "C:\CubeTrainingModel\MODEL\DIURNAL_FACTOR.DBF"
FILEI LOOKUP[1] = "C:\CubeTrainingModel\MODEL\OCCUPANCY_ADJ.DBF"
FILEI MATI[1] = "\{SCENARIO_DIR\}"MODETRIPS.MAT"
FILEI MATO[1] = "\{SCENARIO_DIR\}"HOURLY.MAT",
MO=1-24

LOOKUP NAME=occ_adj,
LOOKUP[1] = hr, RESULT = HSW_adj,
LOOKUP[2] = hr, RESULT = HBO_adj,
LOOKUP[3] = hr, RESULT = HHB_adj,
LOOKUP1 = 1

LOOKUP NAME=diurnal_factor,
LOOKUP[1] = hr, RESULT = HSW_P2A, ;from home
LOOKUP[2] = hr, RESULT = HSW_A2P, ;to home
LOOKUP[3] = hr, RESULT = HBO_P2A, ;from home
LOOKUP[4] = hr, RESULT = HBO_A2P, ;to home
LOOKUP[5] = hr, RESULT = HHB, ;bi-directional
LOOKUP[6] = hr, RESULT = Total, ;for external etc.
LOOKUP1 = 2

LOOP HR=1,24

MSW[HR] = diurnal_factor(1, HR) * 0.5 * mi.1.HBW_CAR / MIN(1.11 + occ_adj(1, HR), 1) +
diurnal_factor(2, HR) * 0.5 * mi.1.HBW_CAR.t / MIN(1.11 + occ_adj(1, HR), 1) +
diurnal_factor(3, HR) * 0.5 * mi.1.HBO_CAR / MIN(1.67 + occ_adj(2, HR), 1) +
diurnal_factor(4, HR) * 0.5 * mi.1.HBO_CAR.t / MIN(1.67 + occ_adj(2, HR), 1) +
diurnal_factor(5, HR) * 0.5 * mi.1.NHB_CAR / MIN(1.11 + occ_adj(2, HR), 1) +
diurnal_factor(5, HR) * 0.5 * mi.1.NHB_CAR.t / MIN(1.11 + occ_adj(3, HR), 1) +
diurnal_factor(6, HR) * 0.5 * mi.1.EXT_CAR +
diurnal_factor(6, HR) * 0.5 * mi.1.EXT_CAR.t

ENDLOOP
ENDRUN
Step 4: Highway and Transit Assignment

- **Answers the question** “what specific routes or links are used by trips, and at what level of intensity?”

- **Function of interaction between travel demand and transportation supply including congestion (and potentially transit crowding effects)**

- **Equilibrium:** all used paths have equal and minimum travel cost; no trip can unilaterally divert without increasing cost

- **Typical forms:**
  - All-or-nothing (shortest paths only)
  - User equilibrium (convex combinations)
  - Route choice (transit multi-path analysis)
Highway Module Structure

• **Phases – multiple iterative loops**
  - SETUP: initialize certain variables and/or arrays
  - LINKREAD: obtain required initial values that and compute link values referenced elsewhere.
  - ILOOP: loop across all zones, building and loading minimum paths as requested
  - ADJUST: revise the link variable values for output or use in the next iteration
  - CONVERGE: check to determine whether additional iterations are necessary

• **Methods – convex combinations**
  - Multi-user class equilibrium, average or weighted assignment,
  - incremental assignment, all-or-nothing,
  - multi-user class link and intersection constrained equilibrium assignment,
  - user defined…
Highway Module Commands and Keywords

• **PARAMETERS:**
  - COMBINE – specify convergence method
  - MAXITERS – limit total number of iterations

• **LINKREAD functions:**
  - Reference input link variables as LI.name
  - Working link variables: LW.name
  - ADDTOGROUP: define exclusion sets

• **ILOOP functions:**
  - PATHLOAD – build paths from I to all J
    - PATH = …
    - EXCLUDEGROUP = …
    - VOL[#] = …
    - MW[#] = PATHTRACE(linkVar)
  - ROWSUM, ROWMIN, ROWMAX, etc…
Example: Single Matrix Equilibrium

Do not change filenames or add or remove FILEI/FILEO statements using an editor. Use Cube/Application Manager.

RUN FILE=HIGHWAY PROFILE="C:\CubeTrainingModel\MODEL\ASHW00A.PRN" MSG='Peak hour congested equilibrium assignment'
FILEO JUNCTIONS = "{SCENARIO_DIR}\INTERSECTIONS.INT" FILEI JUNCTIONS = "{Junctions}"
SET(1, PERIOD)=60
FILEO PATH[1] = "{SCENARIO_DIR}\HIGHWAY.276"
FILEI NETI = "C:\CubeTrainingModel\MODEL\SHNET00A.NET"
FILEI MAI[1] = "{SCENARIO_DIR}\HOURLY.MAI"
FILEO MAIO[1] = "C:\CubeTrainingModel\MODEL\CONGESTED.MAI", MO=1-5, NAME=LINE, DISTANCE, COST COMBINE=I
FILEO NETO = "{SCENARIO_DIR}\HW_LOADS.NET"

PARAMETERS MAXITERS=10, COMBINE=AVE

PARAMETERS TCCEFF[1] = 0.18, TCEXP[1] = 8.5
PARAMETERS TCCEFF[3] = 0.70, TCEXP[3] = 5.0

TURNS N=26-99999

; default TC = TO *(1 + TCCEFF * (V/C) ^ TCEXP)

PROCESS PHASE=LINKREAD
   IF (li.LINKCLASS = 1.5) ADDGROUP = 1
   IF (li.LINKCLASS = 2-3) LINKCLASS = 2
   IF (li.LINKCLASS = 4-5) LINKCLASS = 3
ENDPROCESS

PROCESS PHASE=ILOCOP
   PATHLOAD PATH=COST, PENI=1, CONSOLIDATE=I, EXCLUDEGROUP=1, VOL[1]=MI.1.16, ; load trips
   PATHO=1, NAME="AllPaths"
ENDPROCESS

PROCESS PHASE=ADJUST
   FUNCTION IC[10] = 10
   FUNCTION COST = TIME+60*(li.toll+(VOC)*li.distance)/{VOC}
; Code custom LinkWork update computations here as needed
ENDPROCESS

ENDRUN
Highway Select Link Analysis

Where’s traffic coming from or going to?

- **Select Link Map**
  - Show where volumes are coming from and going to
  - Build select link trip table for district-to-district type summaries
Highway Turning Movement Estimation

Highway Select Link Analysis
Lesson 3: Overview of Citilabs & Cube
CITILABS – THE COMPANY

- Develops software for the modeling of transportation systems

- Offices
  - USA: Tallahassee, San Francisco, Hartford
  - Europe: London, Milan, Munich
  - Asia: Beijing, Mumbai, Bangkok

- Used in 2,500 cities on 6 continents in more than 80 countries
CITILABS – THE COMPANY (cont’d)

- Longstanding ESRI business partner

- Owners:
  - Management and staff – 60%

- Professional services/consulting
CUBE: PROFESSIONAL TRANSPORTATION MODELING SUITE

System Interface
- **Cube Base**: comprehensive interface for data editing, mapping, reporting, model development and scenario creation and management

Demand Modeling
- **Cube Voyager**: urban, regional and long distance demand forecasting and assignment
- **Cube Land**: land use model for combined transport-land use modeling
- **Cube Cargo**: commodity-based freight forecasting

Simulation
- **Cube Avenue**: meso-scopic traffic simulation (DTA)
- **Cube Dynasim**: multimodal micro-simulation

Specialized
- **Cube Cluster**: reduces run-times by allocating calculations over multiple processors and machines
- **Cube Analyst & Analyst Drive**: advanced matrix estimation

Cube Cloud
- Application and sharing framework for transportation planning
Other Citilabs Products

- **Sugar Network Editor** — *ArcGIS extension for editing networks*
- **Accession** — *GIS-based accessibility calculation and mapping*
- **Beta versions** — *sign up online to participate*
- **Turnkey Models and Tools** — *e.g., GFTS conversion tool*
- **GIS Web Apps** — *under development*
The Flow-Chart: Easy Model Development

- Famous for its flow-charting environment for designing and building transportation models.

- Modules are accessed through pull-down menus

- Dropped into a flow chart

- Data inputs and outputs linked by drag-and-drop.
Built for Scenario Testing

- Easy to use environment:
  - Create
  - Test
  - Manage
  - Analyze scenarios

- Menus prompt user for inputs and parameters to test

- Integrated report and charting generators to assist in analysis
Flexibility

The only system equipped with its own comprehensive scripting language for transportation modeling

- Create customized models without difficult programming languages
- Access many scripts through simple menu clicks
- Move custom scripts and add as point and click functions within Cube
Transportation GIS Built on ESRI

• Only modeling system that comes with a complete transportation GIS built on ESRI’s market leading GIS technology.

• Store all data directly in ESRI’s geodatabase format.

• No need to convert data back and forth between the GIS Department and the modeling team.

• ArcGIS Extension for network editing (Sugar)
Data Manager

- **Toolbar buttons** – provide access to commonly performed functions:
  - Add Data – to add a geodatabase or file folder to the workspace.
  - Create Geodatabase – to create a new file or personal geodatabase
  - Build Network From Shape – to build a Cube network from a feature class
  - Import/Export Data – to import or export data to or from a geodatabase

- **Workspace** – lists established connections to personal, file, and SDE geodatabases & their contents
New Features in Cube 6

- Cube User Interface Components
- Cube – GIS
- New Text Editor
- Cube PT – New Features
- *New Functions and Commands as well*

Welcome Screen

Displayed by default after launch
Cube File Options

Tools available to use now include:

• Merge Transit DBF
• Process Templates
• Cluster Node Management
• GIS Geoprocessing
Cube File Options (Cont’d)

- **New Import options** (from other software formats)

- **New Export options**
New Ribbon Interface

- Ribbon is designed to help quickly find commands that users need
- Commands organized in logical groups, collected together under tabs. Each tab is related to a type of activity such as:
  - Scenario
  - Intersections
  - Analysis
- Some tabs are shown only when needed
Ribbon Customization

- **Right-click** the Ribbon and choose *More Commands*

- You may drag commands onto and off ribbon, the Quick Access toolbar, etc …
Docking Windows

- The ‘side’ windows from Scenario Manager (scenario, data, application, keys..) are now fully:
  - Dockable
  - Collapsible
  - Have auto-hide functionality
Tabbed Window Interface

- Easy to select a needed window
- Tabs may also be dragged left and right to reorder
- Tabbed interface can be enabled in Options
- Can add special commands to Quick Access Toolbar
Application Manager

- New graphics with rounded corners, and color schemes.
- Application stays organized when changing resolution.

Click for process templates.
Quick Access Bar Customization

- Click dropdown arrow to right of toolbar. Select *More Commands* to launch same customization interface used with Ribbon
- Alternately, right-click the Quick Access Toolbar
Tab Mode Toggle

1. Click ‘More Buttons’
2. Choose ‘Tab Mode Toggle’
3. Click ‘Tab Mode Toggle’
4. Choose a tab option
Network Window Toolbar

• Toolbar can float over interface
• Easy to customize
Cube - Bookmark this view

- Allows user to save network views
- And restore saved views...
Cube – Build Shortest Path

• User can specify additional criteria to find shortest path...

  and

• Either display or save the paths to a text or database file...
Cube Data Manager

- Data Manager allows copy/paste/renaming between and within geo-databases
Cube – GIS

- GIS Editor now allows post links and post nodes options
Cube – GIS (cont’d)

- GIS Windows are now fully dockable, collapsible with auto-hide functionality
Cube – GIS (cont’d)

- Multi-bandwidth now available
New Text Editor

- Smart ‘autocomplete’ for commands and keys with new ‘code assistant’
- Column mode editing
- Search and replace with bookmark support
- Line numbers
- Use of markers by clicking to the right of line number
- Collapsible comment ‘groups’
- Zooming functionality
- Incorporation of ‘tab’
- Color themes
Updates to Public Transport (PT) Module

• **PT Matrix Estimation** is now supported with full features.
  - Previously, this wasn’t possible if you implemented crowding or other advanced PT options.

• **PT Period-Based Keywords.** Headway[p] used to be the only variable indexed by the HDWAYPERIOD parameter...now you can also index:
  - Node specific keywords:
    - DWELL[p]
    - DELAY[p]
  - Line specific keywords
    - DWELL_DEFAULT[p]
    - DELAY_DEFAULT[p]
    - TIMEFAC[p]
Updates to PT Module (Cont’d)

• **PT Fares during path-building (in Enumeration phase)**
  - Now allows simplified fare evaluations (Flat, Distance based…) during enumeration as well.
  - This gives user another method of controlling enumeration when filtering realistic alternatives.

• **PT Drive Access generation enhancements…tons of new options…**

• **Some highlights:**
  - Weighting drive access time versus in-vehicle and wait times associated with the PT trip.
  - Specific options for Park-n-Ride versus Kiss-n-Ride.
  - Considers weighting and allows specific limits on directionality of a trip…
  - Controls ‘backtracking’…i.e., driving ‘away’ from destination to access public transport even if better option.
  - More options on weighting of service types…premium service considerations.
New PT Keywords

- Enhanced Transit Route Enumeration
  - QUICKESTPATH
  - QUICKESTMULTI

| QUICKESTPATH | [K?] | When true, enumerates a single path. Default is false. |
| QUICKESTMULTI | [K?] | When true, enumerates a single fastest path for each “departure time.” Default is false. |

- Enhanced Drive-Access Generation
- Enhanced Fares along with BestPathOnly
- Enhanced Transit Line Keywords
Enhanced PT Drive-Access Generation

- Enhanced Drive-Access Generation
- Drive-Access Generation in 5.x
- Drive-Access Generation Examples in 5.x
- Drive-Access Generation in 6.x
- Enhanced Drive-Access Generation Example
Examples of PT Drive-Access Coding

- Aerial photograph for parking lot & transit stops
Examples of PT Drive-Access Coding

- Schematic diagram
## PT Drive-Access Generation in 6.x

- Cube Voyager 6.0 has built upon features of existing Generate command to now consider:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AATRATIO</td>
<td>to specify the ratio of drive-access time to IVT mode choice coefficients</td>
</tr>
<tr>
<td>AOC</td>
<td>to specify the auto operating cost</td>
</tr>
<tr>
<td>AUTOCCPNR</td>
<td>to specify the auto occupancy for PNR</td>
</tr>
<tr>
<td>AUTOCKNR</td>
<td>to specify the auto occupancy for KNR</td>
</tr>
<tr>
<td>AUTOMATCH</td>
<td>to indicate if using original AUTOCON logic or enhanced AUTOCON logic</td>
</tr>
<tr>
<td>AUTOMODE</td>
<td>to allow user specify the mode for auto access connectors (for AUTODAT file)</td>
</tr>
<tr>
<td>CBDZONE</td>
<td>to Specify the CBD area</td>
</tr>
<tr>
<td>CHECKRELEVANCE</td>
<td>flag to indicate whether to check relevance of the connectors</td>
</tr>
<tr>
<td>CHECKBACKTRACT</td>
<td>flag to indicate whether to check backtracking of the connectors</td>
</tr>
<tr>
<td>CONNREPORT</td>
<td>to specify the PRINTO number for connector list</td>
</tr>
<tr>
<td>DEFDRIVETIME</td>
<td>to specify default drive-access time used if time from matrix is zero</td>
</tr>
<tr>
<td>DISTANCEFACTOR</td>
<td>to specify the factor to convert distance to coordinate</td>
</tr>
<tr>
<td>DISTMAT</td>
<td>numerical expression used to get the distance skim matrix</td>
</tr>
<tr>
<td>GENREPORT</td>
<td>to specify the PRINTO number for AUTOCON report</td>
</tr>
<tr>
<td>INFLTRANSITFARE</td>
<td>to specify inflation factor for transit fare</td>
</tr>
<tr>
<td>INFLAOOC</td>
<td>to specify inflation factor for auto operating cost</td>
</tr>
</tbody>
</table>

*Default*: True (=original)
## PT Drive-Access Generation in 6.x (cont’d)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT</td>
<td>AUTOCON</td>
<td></td>
</tr>
<tr>
<td>INFLPARKINGCOST</td>
<td>to specify inflation factor for parking cost</td>
<td></td>
</tr>
<tr>
<td>INTERNALZONES</td>
<td>to specify the internal zones to process</td>
<td></td>
</tr>
<tr>
<td>KNR</td>
<td>flag indicating whether to turn on the additional Kiss and Ride generation</td>
<td>False</td>
</tr>
<tr>
<td>KNRMODE</td>
<td>to allow user specify the mode for KNR connectors</td>
<td></td>
</tr>
<tr>
<td>MAXBACKDIST</td>
<td>to specify the maximum backtracking distance allowed</td>
<td></td>
</tr>
<tr>
<td>MAXBACKFACTOR</td>
<td>to specify the maximum backtracking factor allowed</td>
<td></td>
</tr>
<tr>
<td>MAXCHECK</td>
<td>to specify the maximum connectors to consider</td>
<td></td>
</tr>
<tr>
<td>MAXCONN</td>
<td>to specify the maximum connectors to use</td>
<td></td>
</tr>
<tr>
<td>MODEPRIORITY</td>
<td>to indicate priority by mode</td>
<td>999</td>
</tr>
<tr>
<td>ORIGINTERMTIME</td>
<td>to specify the terminal time for origin</td>
<td></td>
</tr>
<tr>
<td>OVRT RATIO</td>
<td>to specify the ratio of OVT/IVT mode choice coefficients</td>
<td></td>
</tr>
<tr>
<td>PERIOD</td>
<td>to indicate the AUTOCON process period (0 - Off-peak, 1 - peak)</td>
<td></td>
</tr>
<tr>
<td>PNR</td>
<td>flag indicating whether to turn on the enhanced AUTOCON process</td>
<td>False</td>
</tr>
<tr>
<td>PNRMODE</td>
<td>to allow user specify the mode for PNR connectors</td>
<td></td>
</tr>
<tr>
<td>PREMIUMMODE</td>
<td>to indicate premium service by mode (0 - not premium, 1 - premium)</td>
<td></td>
</tr>
<tr>
<td>SKIPZONES</td>
<td>to specify the zones should not be considered in the AUTOCON process</td>
<td>no skip zones</td>
</tr>
<tr>
<td>TIMEMAT</td>
<td>numerical expression used to get the time skim matrix</td>
<td></td>
</tr>
<tr>
<td>VOT</td>
<td>to specify the value of time in $/hour</td>
<td></td>
</tr>
<tr>
<td>XTRAAUTONTLEGI</td>
<td>to specify the NTLEGI file number to use</td>
<td>no override</td>
</tr>
</tbody>
</table>
Enhanced PT Fare Process in 6.x

- User may specify a simple fare structure while enumerating routes to enhance path building process.

- Cube Voyager 6.0 includes additional fare keywords along with BestPathOnly:
  
  - **ENUMFARE**: if set to True, will allow *subset of fare systems* to be considered in best path enumeration process.
  - **EVALFARE**: if set to True, will allow *fare to be calculated* in best path evaluation and skimming process.
  - **EFARE**: flag indicating whether to input descriptions of fare systems. If ENUMFARE=T and no fare skimming and route evaluation required, EFARE must be set to True to *allow fares to be considered* during the BESTPATHONLY route enumeration process.
Enhanced PT Transit Line Keywords in 6.x

1. Cube Voyager’s PT program uses a series of keywords embedded in description of public transport line data to save information.

2. To provide better ways to calibrate and adjust transit travel times, some node specific keywords (specifically DWELL and DELAY) have also been made available as line level keywords:

- **DWell_DEFAULT**: dwell time, in minutes, the line spends at all stop nodes for the line until one specifies a DWell_C or DWell sub-keyword.
- **Delay_DEFAULT**: additional time delay added to all link times for the line until one specifies a Delay_C or Delay sub-keyword.
- **TimeFAC**: time factor applied to the travel time of all links the line traverses.
CUBE 6.1

- Released: April 10, 2013
- Service Pack 1 released shortly thereafter with some additional updates (May 2, 2013)
- An update to Cube 6 keeping the same overall look and feel
- Addition of many commonly requested features and tools
- Major overhaul of an entire library
COMPATIBILITY UPDATES

- Cube is now compatible with ESRI ArcGIS 10.1/SP 1 and uses this as the default ArcGIS Engine
- Cube is also now compatible with Windows 8 & Server 2012
- 64-bit version of Cube is in Beta testing

ArcGIS 10.1  

Windows 8  

Windows Server 2012
USABILITY UPDATES

- Snap-to-grid in application manager
- Improved editing of file geodatabases
- View larger matrices in Cube Base
- Bigger road networks *(up to 10 million nodes and links)*
- Multi-language capabilities in Cube script editor
- And numerous others..
IMPROVEMENTS TO HIGHWAY MODELING

- Cube Base, Cube Voyager and Cube Avenue now support 1,000 volume sets! Allows simultaneous assignment and storage of up to 1,000 trip matrices and/or select link results.
- Bi-Conjugate Frank-Wolfe Assignment has a new SMOOTH parameter to reduce oscillation patterns at the tail of the curve.
- Update: currently in internal beta: new traffic assignment algorithm – bush-based assignment for tight closure at high speed.
Cube 6 - The only system offering Cloud Computing

- Computer servers not located in your office or home—but in another location
- You access these computers and storage through the internet
- Computation, software, data and storage services do not require knowledge of the physical location and configuration of the system that delivers the services.
- Parallels to this concept can be drawn with the electricity grid
At Cube Cloud store: nationwide block-level socio-economic data for the USA (free!)

Now available: here (NAVTEQ™) nationwide roadway network and traffic database
Free apps provide access to commonly used analytic tools. Comes standard with Cube Cloud!

Paid apps allow users to “sell” their models on the Cloud…
## CUBE CLOUD STORE: RESOURCES

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Category</th>
<th>Type</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Household Travel Survey (NHTS)</td>
<td>Comprehensive data on travel and transportation patterns in the USA</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Public Use Microdata Sample (PUMS)</td>
<td>Public Use Microdata Sample files from the American Community Survey - US Census</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>American Community Survey (ACS)</td>
<td>Ongoing survey that provides data every year from the US Census</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Census Transportation Planning Package (CTPP)</td>
<td>Census data specific to transportation analysis</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>CTPP Data on the web</td>
<td>CTPP Data available on the web</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Longitudinal Employer-Household Dynamics (LEHD)</td>
<td>Census employment data</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Quarterly Census of Employment and Wages</td>
<td>Bureau of Labor Statistics - Quarterly Census of Employment and Wages</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Census Population forecast estimates</td>
<td>Census Population forecast estimates</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Travel Estimation Techniques for Urban Planning - NCHRP 365</td>
<td>Travel estimation techniques and parameters from TRB</td>
<td>Report</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Online Travel Survey Manual</td>
<td>Guide to travel survey design</td>
<td>Report</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Characteristics of Urban Transportation Demand (TCRP Report 73)</td>
<td>Guide to urban travel demand characteristics</td>
<td>Report</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Batch geo-coding API (Choose Yahoo or Google)</td>
<td>Useful tool to geocode multiple addresses</td>
<td>Tool</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>ArcGIS Base Maps for download</td>
<td>Base maps for ArcGIS</td>
<td>Tool</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>2011 TIGER/Line Shape files</td>
<td>Place to download TIGER files</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Florida Geographic Data Library (FGDL)</td>
<td>Downloadable geographic data for Florida</td>
<td>Data</td>
<td>Web Link</td>
<td>United States</td>
</tr>
<tr>
<td>Library of German Transport data</td>
<td>Downloadable geographic data for Germany</td>
<td>Data</td>
<td>Web Link</td>
<td>Germany</td>
</tr>
<tr>
<td>German Road Statistics</td>
<td>Downloadable statistics for German roadways</td>
<td>Data</td>
<td>Web Link</td>
<td>Germany</td>
</tr>
<tr>
<td>Bavarian Road Statistics</td>
<td>Downloadable statistics for Bavaria</td>
<td>Data</td>
<td>Web Link</td>
<td>Germany</td>
</tr>
<tr>
<td>Austrian Road Statistics</td>
<td>Downloadable statistics for Austria</td>
<td>Data</td>
<td>Web Link</td>
<td>Austria</td>
</tr>
<tr>
<td>Swiss Road Statistics</td>
<td>Downloadable statistics for Switzerland</td>
<td>Data</td>
<td>Web Link</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Census data for England</td>
<td>Downloadable census data for England</td>
<td>Data</td>
<td>Web Link</td>
<td>UK</td>
</tr>
</tbody>
</table>
Cube 6: Moving Your Model to Cube Cloud

TRAVEL MODEL
Amazon’s EC2 Cloud Computing Environment

- Model Developed with **Cube**
- Model Run with **Cube Cloud**

- Develop the Model with **Cube** in the Desktop Environment
- Publish the Model from **Cube** to the Cube Cloud
- Create, run and analyze scenarios from anywhere
Run Scenarios with a Simple Web-Interface
Make it Easy to Map Results

Santa Clara Valley Transportation Authority

AM Peak Volumes
Model: VTA
Scenario: Base

Select Basemap
VTA
- Base
- Year 2005

Copyright © 2012 Citilabs
Make it Easy to Get Charts and Tables
Cube Cluster

• Distributed processing to increase operational speed

• Cube Cluster for your model can be managed in two ways:
  - Using the interactive cluster node management tool available in Cube Base
  - As a command line in a Voyager PILOT script
Nashville (Minimum # of Cores = 8)

Cube Cluster
Provides the ability to spread calculations across not only multiple processors but multiple computers as well.

99% reduction vs. single core
MiniQuiz 1

- The following programs are used to build a passenger travel demand model in Cube
  
  A. Cube Cargo  
  B. Cube Base  
  C. Cube Land  
  D. Cube Voyager  

- The following programs are used to built a meso-scoptic simulation in Cube
  
  A. Cube Cargo  
  B. Cube Base  
  C. Cube Avenue  
  D. Cube Voyager