THE CANADIAN FORCES RECRUITMENT/ATTRITION MODEL[1]

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Introduction

The Directorate of Strategic Human Resource Analysis (DSHRA), of the Department of National Defence (DND), as part of its mandate to provide analysis of potential impacts of trends and change on defence and defence related issues, has designed a prototype model of recruitment and attrition of the Canadian Forces (CF). This model is designed to look at both demand, that is what recruitment is required to meet a Canadian Forces human resource scenario, and supply, that is what is the potential recruitable population for the Canadian Forces. Unlike other models with this aim, the CF recruitment model incorporates both internal and external influences. Specifically, the general Canadian population and much of its socio-economic profile is the feeder into this model of recruitment and attrition, and as a result, it requires extensive amounts of data. This model is a state space model (number of people stratified by various dimensions) and is in the class of models referred to as "Design Approach" models by Gault et. al.[2]

The motivation to develop this prototype is the dramatic change in the demographic landscape across Canada: the traditional recruitable population, which is white male, high school educated (with no future educational aspiration), healthy, fit and rural is shrinking as a proportion of the 18 through 24 year age cohort. What are the implications for recruiting over the next 20 years if the traditional recruitable population remains the primary recruitable population for the Canadian Forces? Given the rapid technological changes and the concurrent military developments as a consequence of RMA, who is it that we will need in the future and will we need to be looking at a different segment of the population with different skills, education and background? In essence, we are developing a comprehensive model to assist in assessing the wide range of recruiting implications and the need to tap into new segments of the Canadian population. It is our hope that this prototype will be expanded in the future to incorporate sociographic variables such as value tribe affiliation, and that this model will be applicable not only to DND but to the public service as a whole.

In considering the design of this model, we felt it essential to incorporate an understanding of the major forces driving societal change and of the inter-relationships among them. In other words, forecasts of the future can not necessarily be extrapolated from past behaviour, one

1.The contents of this paper are the responsibility of the authors and do not necessarily reflect the official position of the Department of National Defence.

2. "The Design Approach to Socio-Economic Modelling" F.D.Gault, K.E.Hamilton, R.B.Hoffman and B.C.McInnis, Futures Feb. 1987

must have a stronger understanding of present day complexities. Therefore, important population drivers such as economic indicators (Gross Domestic Product, unemployment rates, wage differentials, etc.), population components (founding people, official language, net immigration, mortality, fertility, birth share, urban/rural split, sex, age, etc.), and education variables (enrollment, graduation rate (all levels) etc) are all included in the derivation of the feeder population from which CF recruitment takes place. Again, the same environment is considered when estimating attrition.

Although the entire model has been conceptualized diagrammatically, the "inertial trend" portion that incorporates economic factors (such as advertising efforts, ratio of military to civilian wage rates, unemployment rate, GDP per capita etc.) into the derivation of recruitment and attrition of CF members has yet to be coded and calibrated with data. We anticipate enhancing the model with these economic components sometime during the early part of 1999.

The model is in no way trying to benchmark separations, but rather is trying to create a dynamic population flow into and out of the Canadian Forces based on a number of dimensions including those economic variables indicated above. The purpose of the model is to look out into the future (over the horizon) in order to better anticipate the availability and interest of Canadians in joining and remaining in the CF. This purpose is realized in the current model by independently simulating a demographic constrained source population stratified by the above mentioned dimensions and a Canadian Forces demographic constrained recruitment, attrition, promotion flow structure that is commensurate with a given planned strength pattern. The ratio of required recruitment to recruitable population can then be explored via scenario analysis.

Model Requirements:

Since the aim is to create a dynamic population flow model that was able to project out in time, the model requirements were quite specific. These include:

-specialized applications/tools developed must be infinitely extendable and can be applied to any already developed model;

-models must be developed through diagram process;

-the diagram modelling process must be introduced into the software language/one language throughout;

-the software must not be dedicated to any one particular mathematical idiom;

-the modelling software must deal with the data variables as truly multi-dimensional objects/continuous scaling;

-the software must be capable of generating multi-dimensional scenarios such that the data files can communicate with each other automatically;

-the software must support On Line Analysis and processing (OLAP);

-the software must be capable of coding model design, implementation, analysis and professional reports, all in one language; and,

-the software must be time/dynamic oriented Geographical Information Systems (GIS).

A modelling tool called "whatIf" was used to design, program and implement this ambitious

model. The tool is a complete environment for designing, implementing and calibrating large scale simulation models and for using them for scenario analysis and exploring complex systems. Among other reasons, the “whatIf” modelling software was selected for its mathematical flexibility and its use as a communication tool for management presentations. Through scenario analysis, the full implications of policies or actions can be simulated before decisions are made. In addition, decisions can be made with more information on the potential socio-economic/demographic landscape of the future.

The CF Recruitment/Attrition model is served from a Unix (Solaris for PC) server to clients on windows or MAC environment. The model is intra/internet accessible.

Data Requirements

The quantity of data required for the model is significant. Both military community and general population data were collected for the time period 1982-1997. In some cases, the general population data went back as far as 1861, as was done with annual immigration in order to develop a flow rate. Most of the Canadian demographic data were provided by Statistics Canada, a federal government statistical institution. Aboriginal demographic data were provided by Indian and Northern Affairs, a federal government department dedicated to the study of Canadian Native, Aboriginal and Inuit communities. Military demographic data were all collected from within the Department of National Defence.

All Canadian population demographic data for the general population as well as the native communities were collected by age, sex and year. All Canadian Forces military data for both officers and non-commissioned members were collected by age, sex, rank, military occupational classification and year. Data collected include those in table 1 below:

Table 1:

CANADIAN POPULATION 1980-1997	CANADIAN FORCES 1982-1997
General population	Officer strength population
Immigration	Non-Commissioned Member strength population
Emigration	Recruitment
School enrolment – elementary, high school, post secondary & university	Promotions
School graduation – elementary, high school, post secondary & university	Occupational Classification Transfers
Fertility rates and total births	Mortality rates and observed deaths
Mortality rates and observed deaths	Attrition

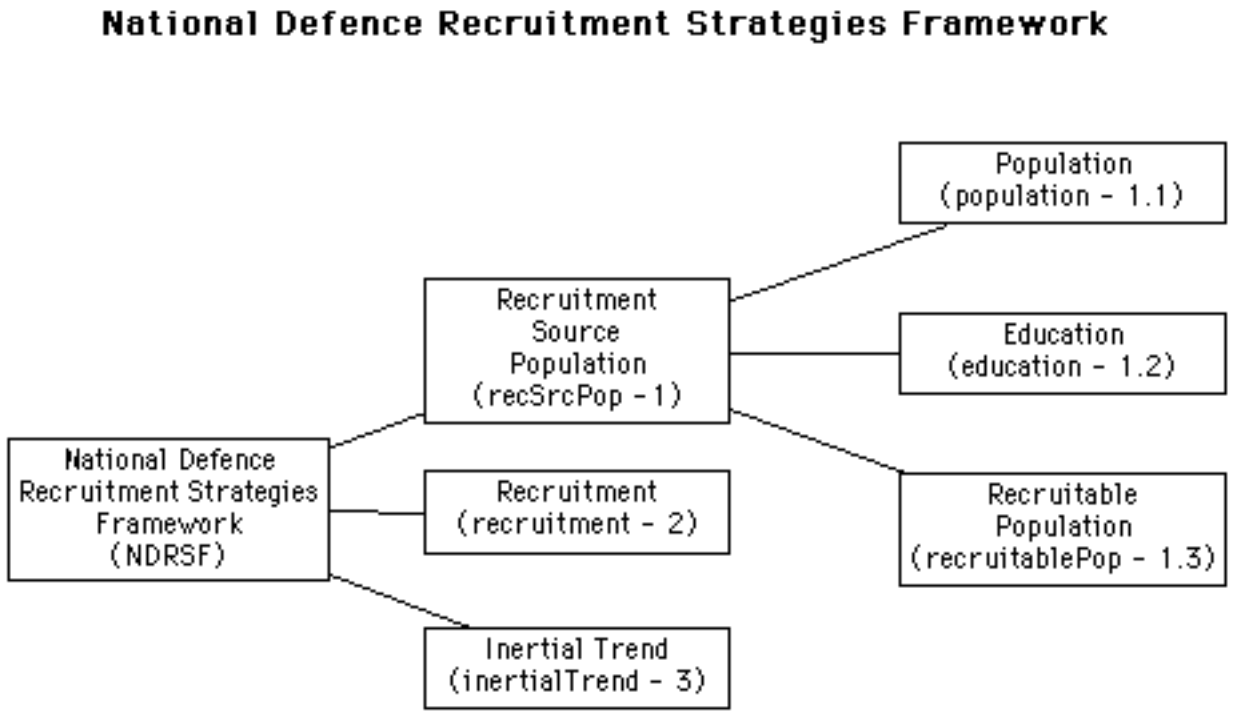
Table 1:

CANADIAN POPULATION 1980-1997	CANADIAN FORCES 1982-1997
Birth by mom's age	NCM to Officer commissions
Male birth share	Strength on Training
Urban/rural split	Strength on Leave
Official language – english, french or native	

Model Development, Simulation and Calibration

Simulation Model Structure

The initial stage of the modelling process is the conceptual design of the model (see Appendix A). It should be noted that the model developed is a prototype and there is much room for improvement, additions and change. The model is able to accommodate expansion at any point if CF programs should change over time. At this point, not all data have been collected or incorporated into the iterative process. Some historical data have been estimated based on model structure and accounting constraints. The model hiearchy is shown below.



Source Recruitable Population

STEP 1 : Population

The first step of the model process is to generate a detailed general population from which the Canadian Forces can draw its recruits. Through data manipulation we derived a detailed population which can be viewed through dimensions such as founding people (French, English aboriginal), urban/rural split, immigration status (i.e. first generation immigrants versus those born in Canada), sex, time and age.

STEP 2 : Education

The detailed population is further evolved to incorporate the highest education level achieved. In order to create pools of possible recruits based on formal education completed, the data are differentiated such that we generate two populations: the first consists of those without a degree and not in school between the ages of 16 and 24 [3]; the second population is as all graduates between the ages of 16 and 35 of high school, university and other post secondary institutions. These populations can be viewed through the dimensions indicated above as well as highest education level achieved.

STEP 3 : Recruitable Population

The recruitable populations, one for officers and one for non-commissioned members (NCM), are evolved from the detailed population. Both the population not in school and the population of graduates feed the NCM recruitable population. A proportion of both those populations is likely to enroll as an NCM in the Canadian Forces conditional on a number of factors including economic indicators (the inertial trend).

The recruitable officer population is derived by the population of graduates likely to enroll into the officer program and is a condition of, among other things, the economic indicators.

Both officer and NCM recruitable populations are a function of founding people, education, urban/rural split, immigration status, sex, time and age.

It should be noted that the Canadian Forces do have a commissioning program whereby non-commissioned members are offered the opportunity to obtain the required education and then be commissioned to the officer ranks. This component of the recruitable officer population has not yet been incorporated into our model.

Required Recruitment

In this component of the simulation model, the human resource flow structure of the Canadian Forces is simulated to determine required recruitment to meet any specified strength pattern over time. The simulation starts with the current Canadian Forces human resource stock. It sim-

3. Those without formal education are more likely to enroll in the CF at an earlier age than those with formal training, thus the age differentiation between the two populations.

ulates the Canadian Forces human resource by rank, occupational classification, sex and age. The simulation includes promotion, attrition, deaths and occupational transfers.

Simulation Model Use

The current model structure can be used to explore the way in which the ratio of required recruitment to recruitable population depends on assumptions (scenarios) concerning the way any of the simulation variables change over time. This also includes the fixed scenario in which all variables are held constant at their levels in the last year of history. It is important to note that, even in this fixed scenario, the ratio of required recruitment to recruitable population will vary over time because of the demographic aging of both the population at large and the Canadian Forces human resource pool. The calibration model provides the historical binding implicit in the stocks of people in the population at large and the Canadian Forces human resources. This calibration model also provides estimates of the simulation parameters over time so that a model user can see the level they are currently at as well at their time trends. This calibration of simulation parameters facilitates the exploration of the simulation model via scenario construction.

Calibration Model

The diagrammatic structure of the calibration model is shown in Appendix B.

In Design Approach[4] models there are two aspects to validity. The first, correspondence, is heuristic and speaks to human sensory understanding. There must be an understandable mapping between concepts in the model and aspects of reality. The second, calibration, is numerical. For a Design Approach model to be valid there must be a correspondence to reality and one must be able to find at least one calibration.

Model calibration consists of finding a set of input variable instances such that the set of inputs and outputs of the simulation model, when run over history, tracks over the observed set of data. The calibration model is a model that ensures, to the degree required, that a calibration is found. Depending on the relationship between the variety implicit in the input variables and that in the set of observed data three cases may be distinguished. If the input variable variety is less than the observed data set variety an exact track cannot, in general, be found and one must introduce some measure theory to select a calibration. If these varieties are equal, a unique calibration might be found. If the input variable variety is greater than the observed data set variety, many possible calibrations may be found and some form of heuristic guidance may be required to select one. Design approach models are usually examples of this latter case, as is this model. In other words, with input variables exceeding the observed variables in the model, there will be more than one possible solution. A visual graphical inspection of the input and observed variables provides a simple method of verification.

The value of a calibration is that it determines the historical binding implicit in the stocks represented in the simulation model as well as values of the control variables over history. This historical binding gives the simulation model a place in state space from which to start. The values of

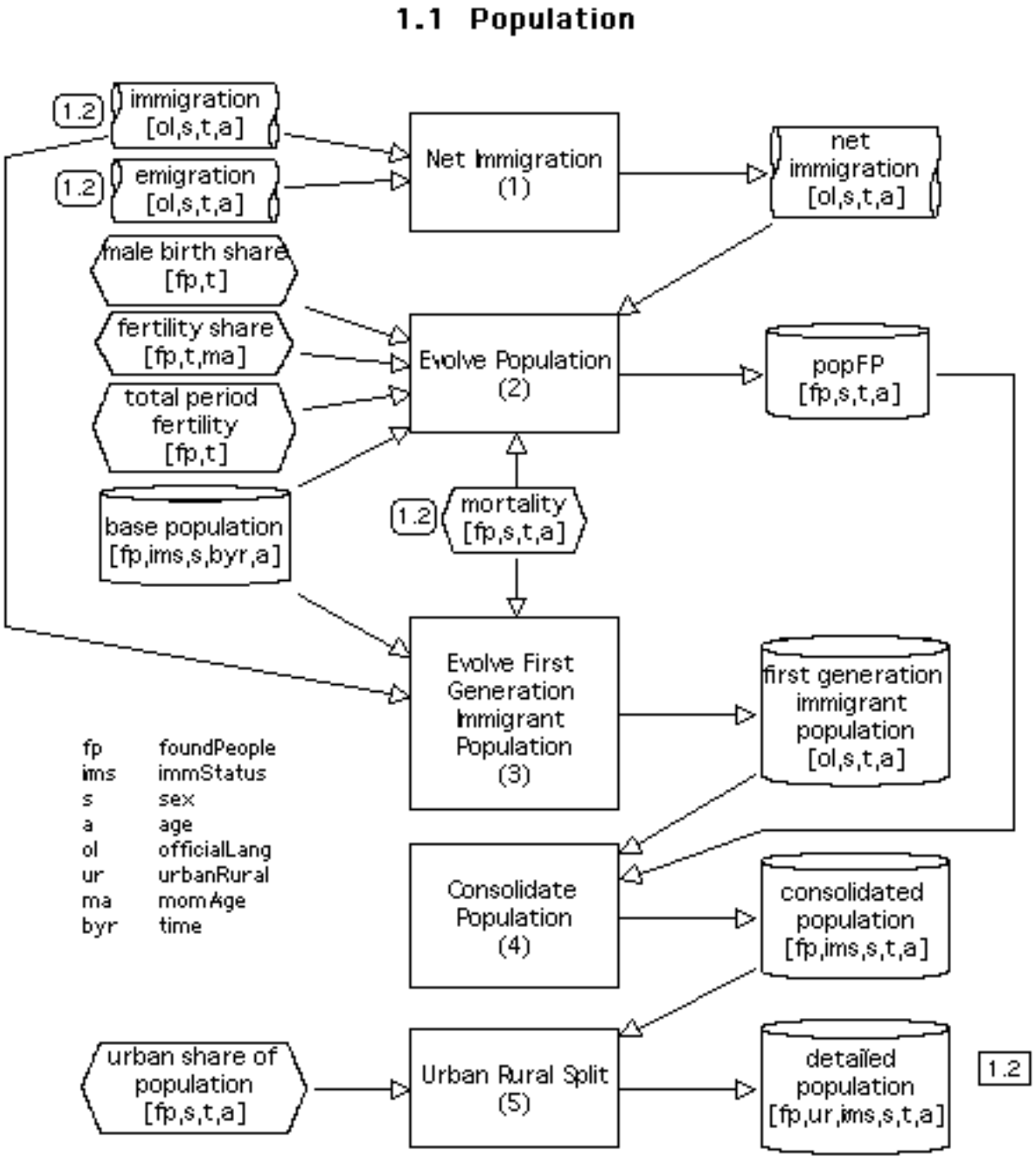
4. ibid. 1.

the control variables give a good indication of their current value and the time trends.

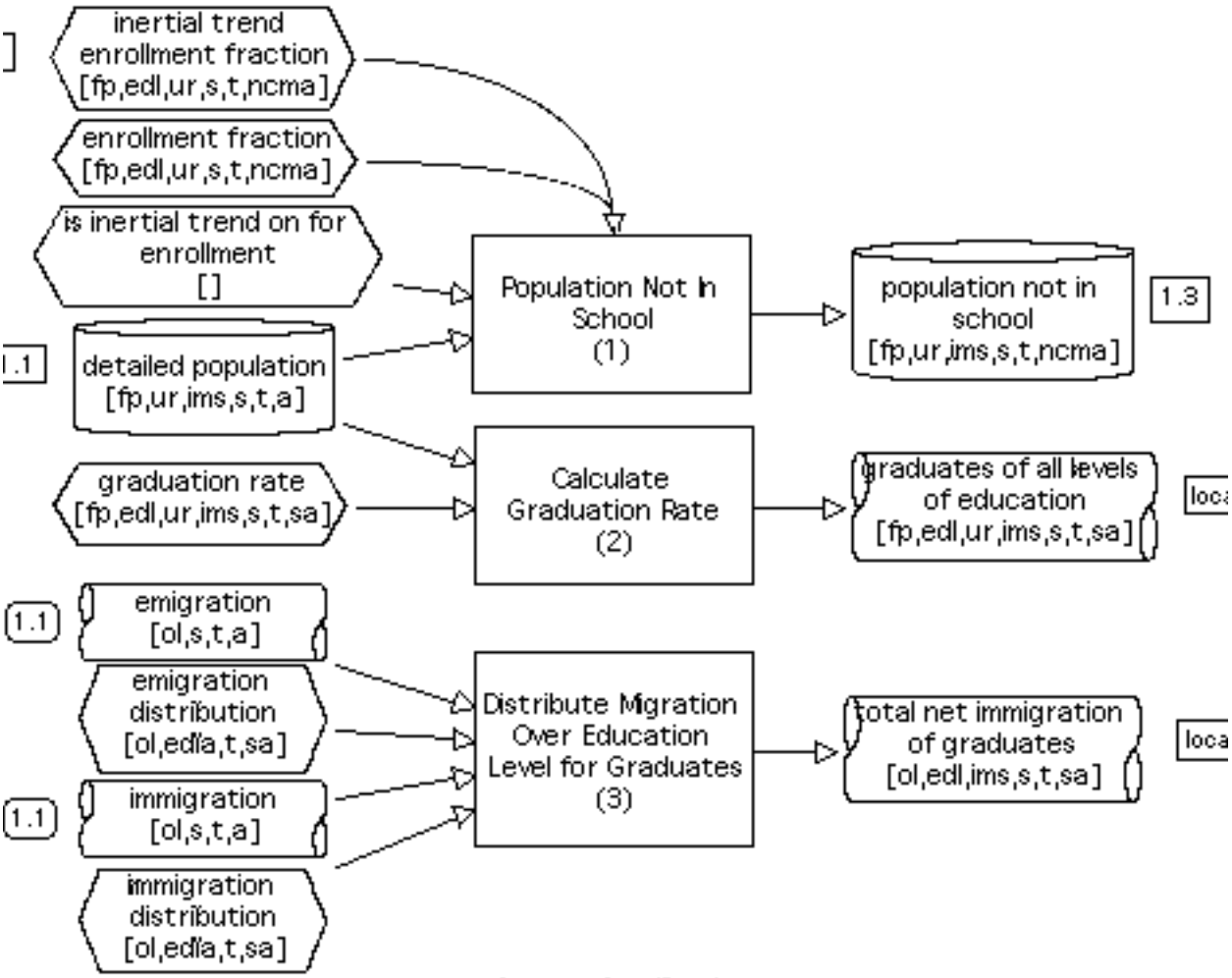
Conclusions

More and more organizations are shifting to a strategic focus in their short and longer term planning. Certainly for the longer term planning this requires powerful modelling tools and realistic scenario development, amongst other things such as knowledge and skills. Recent developments in software applications and tools have made this form of modelling possible. This paper has provided an overview of the work required to create such a model

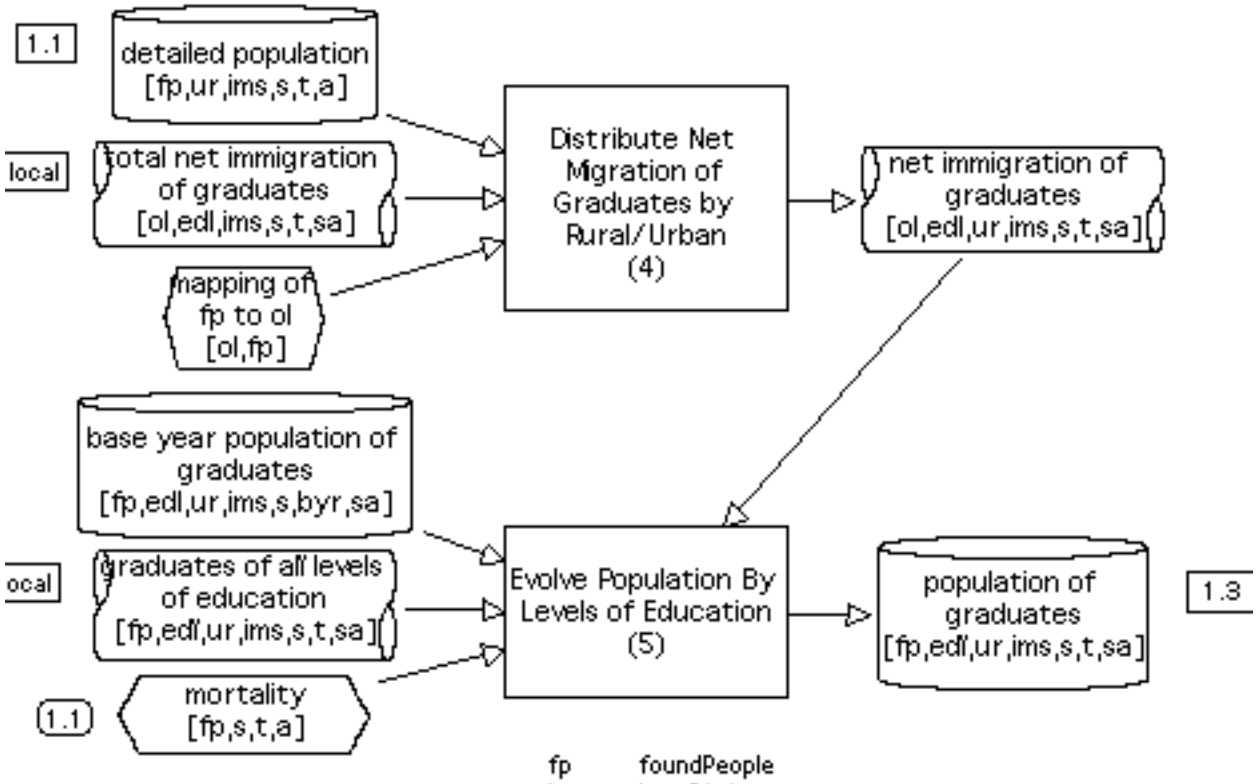
Appendix A: Simulation Model



1.2 Education

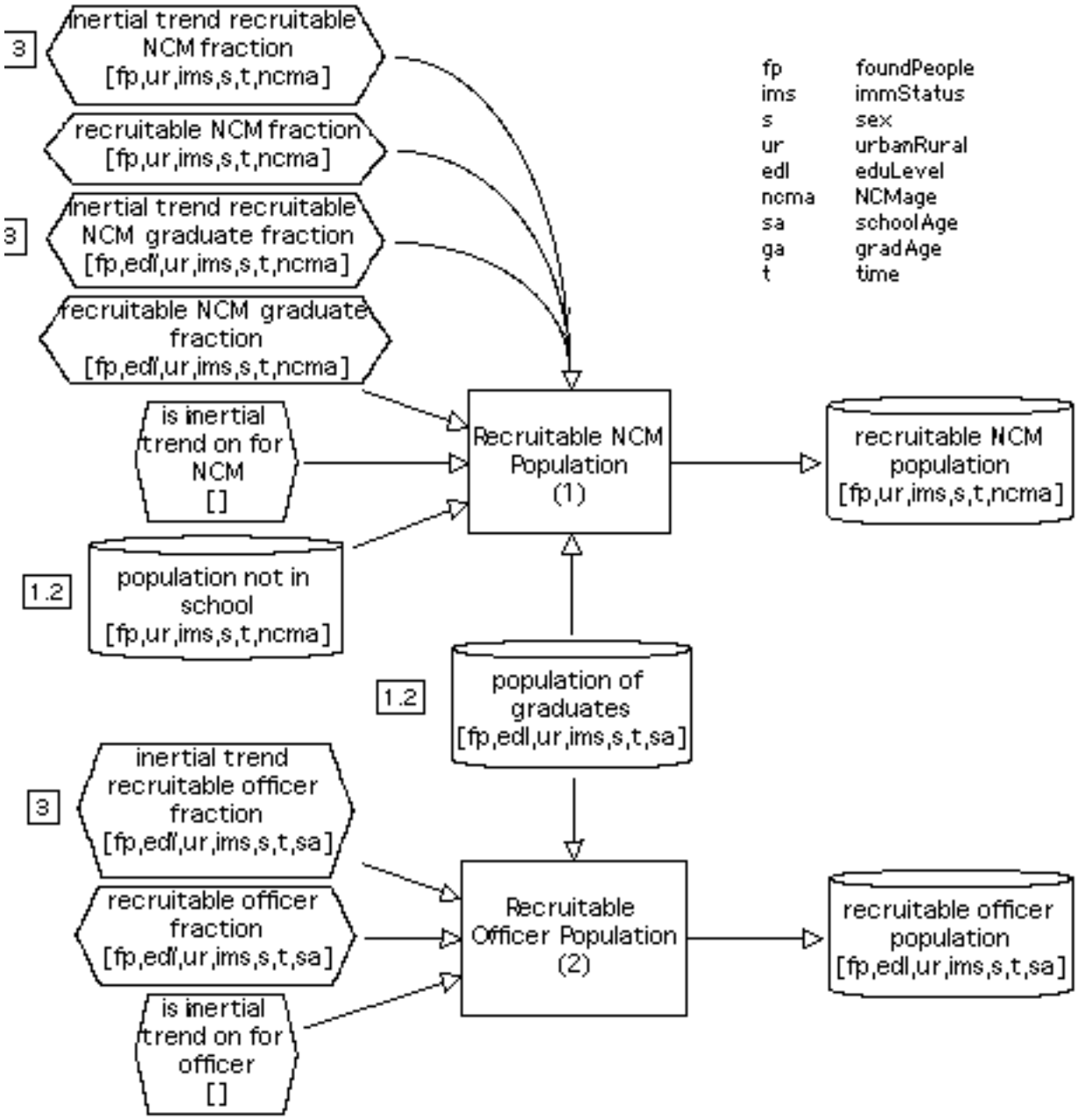


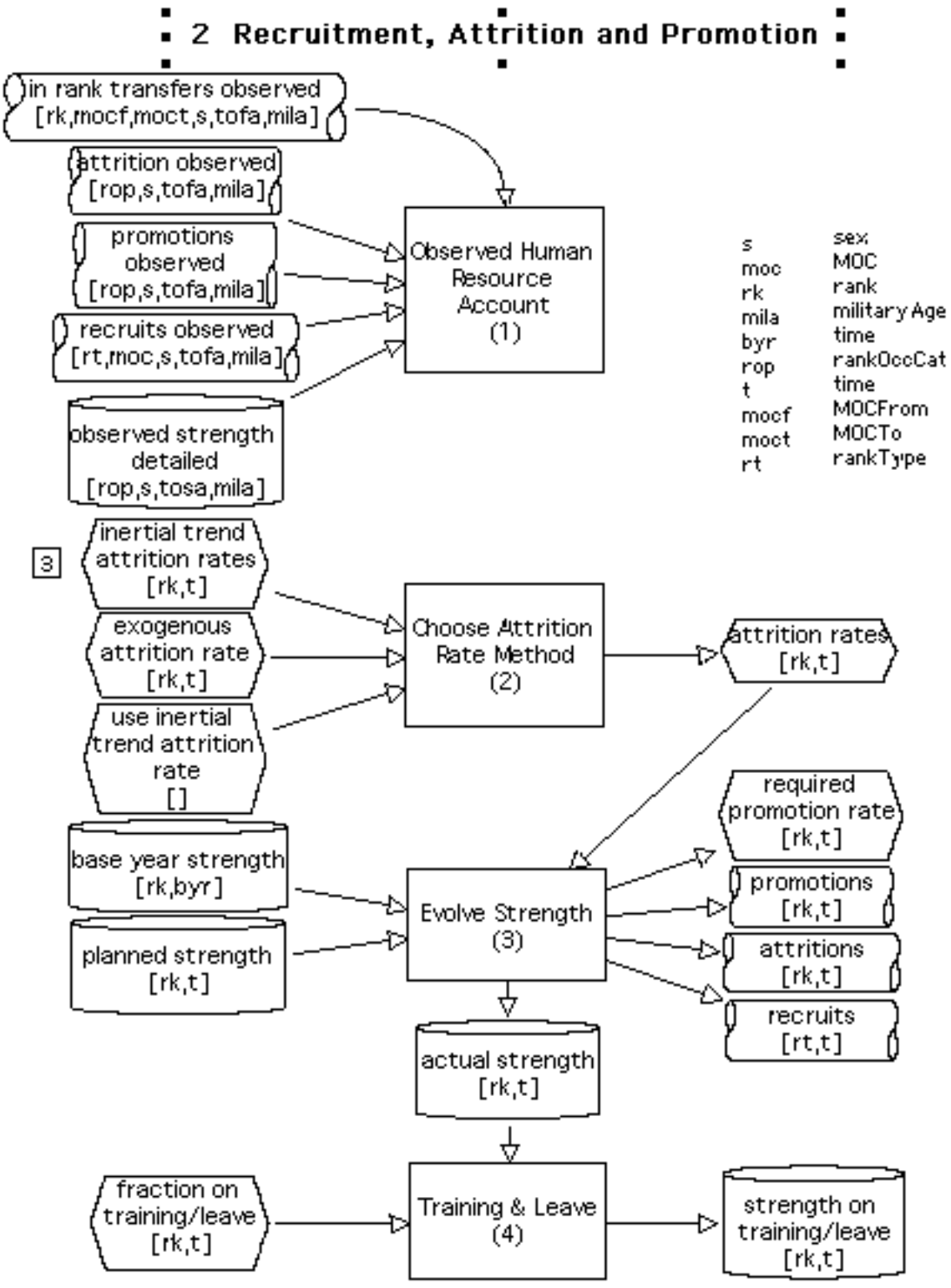
fp	foundPeople
ims	immStatus
s	sex
a	age
ol	officialLang
ur	urbanRural
edl	eduLevel
ncma	NCMage
sa	schoolAge
t	time
edla	eduLevelAll



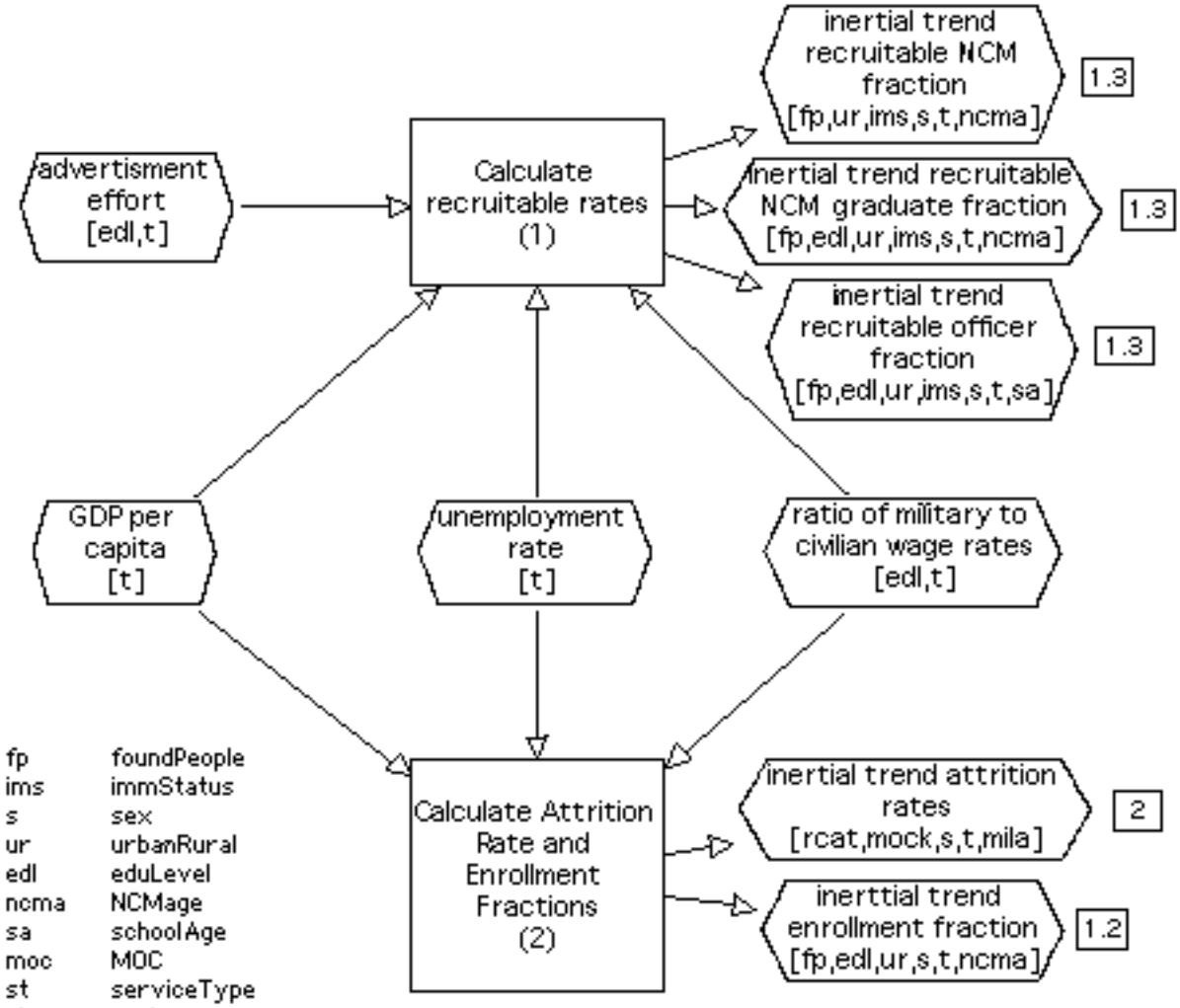
fp	foundPeople
ims	immStatus
s	sex
a	age
ol	officialLang
ur	urbanRural
edl	eduLevel
sa	schoolAge
byr	time
t	time

1.3 Recruitable Population




2 Recruitment, Attrition and Promotion
in rank transfers observed [rk,mocf,moct,s,tofa,mila]
attrition observed [rop,s,tofa,mila]
promotions observed [rop,s,tofa,mila]
recruits observed [rt,moc,s,tofa,mila]
observed strength detailed [rop,s,tosa,mila]
Observed Human Resource Account (1)
s sex
moc MOC
rk rank
mila militaryAge
byr time
rop rankOccCat
t time
mocf MOCFrom
moct MOCTo
rt rankType
3
inertial trend attrition rates [rk,t]
exogenous attrition rate [rk,t]
use inertial trend attrition rate []
Choose Attrition Rate Method (2)
attrition rates [rk,t]
base year strength [rk,byr]
planned strength [rk,t]
Evolve Strength (3)
required promotion rate [rk,t]
promotions [rk,t]
attritions [rk,t]
recruits [rt,t]
actual strength [rk,t]
fraction on training/leave [rk,t]
Training & Leave (4)
strength on training/leave [rk,t]

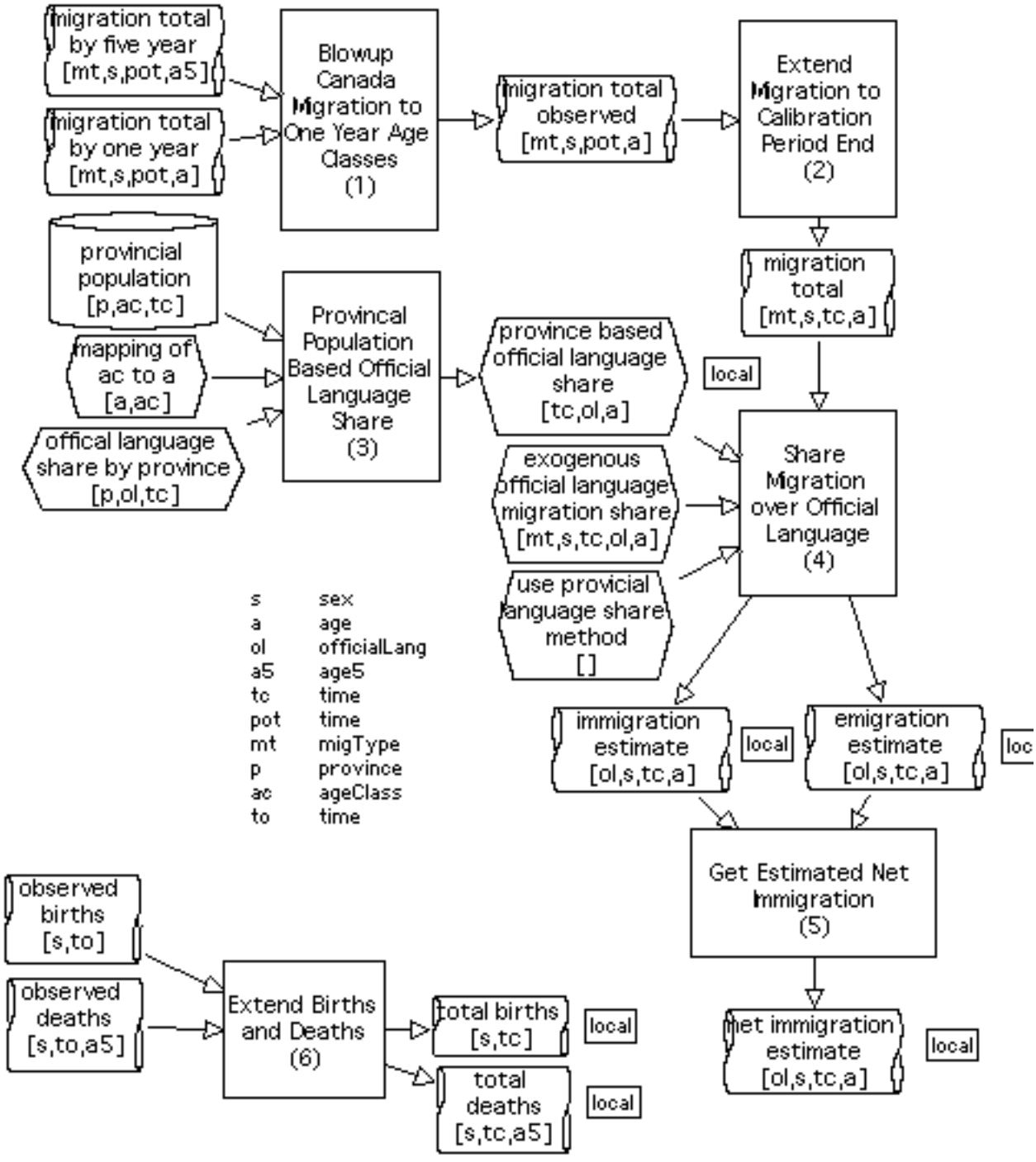
3 Inertial Trend

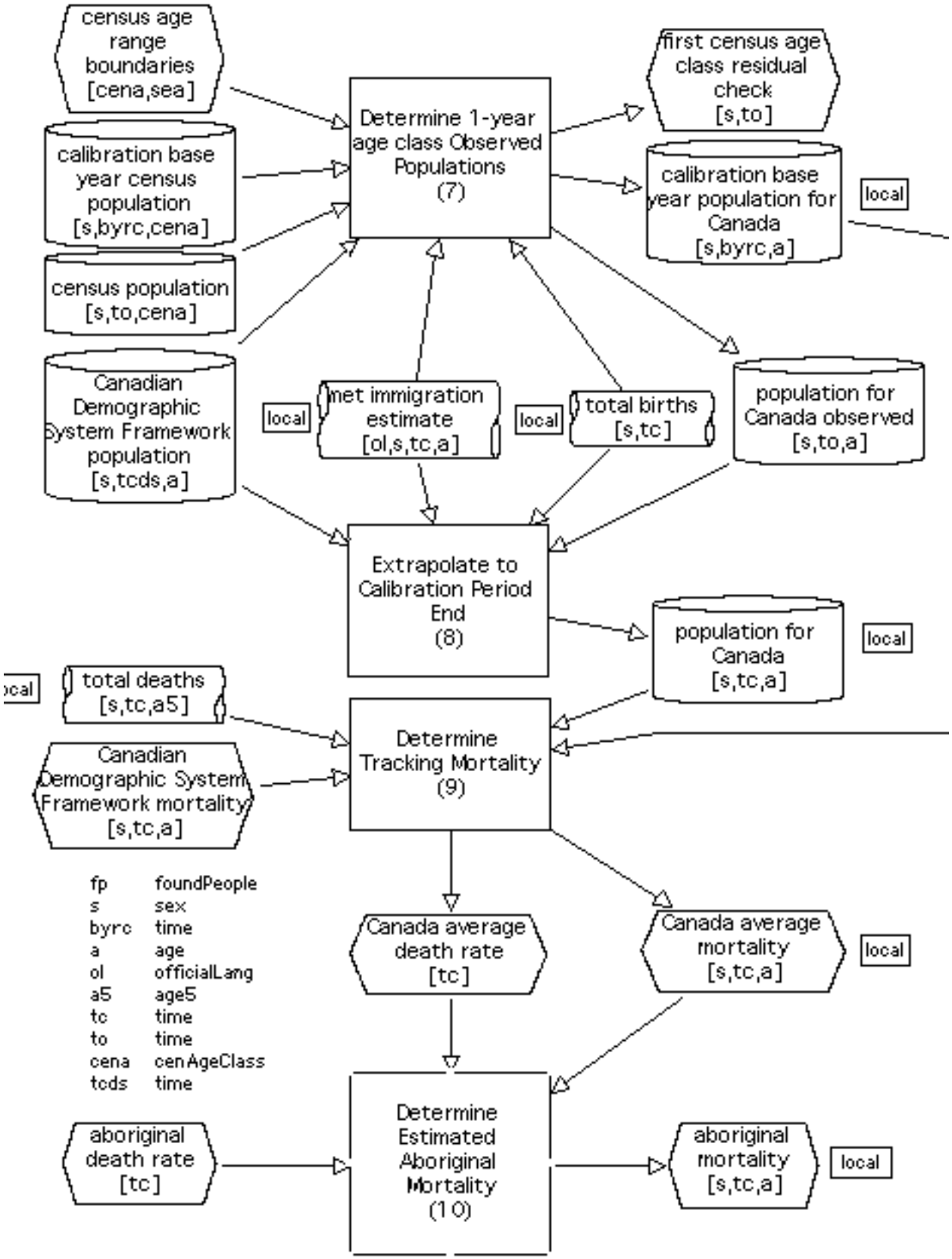


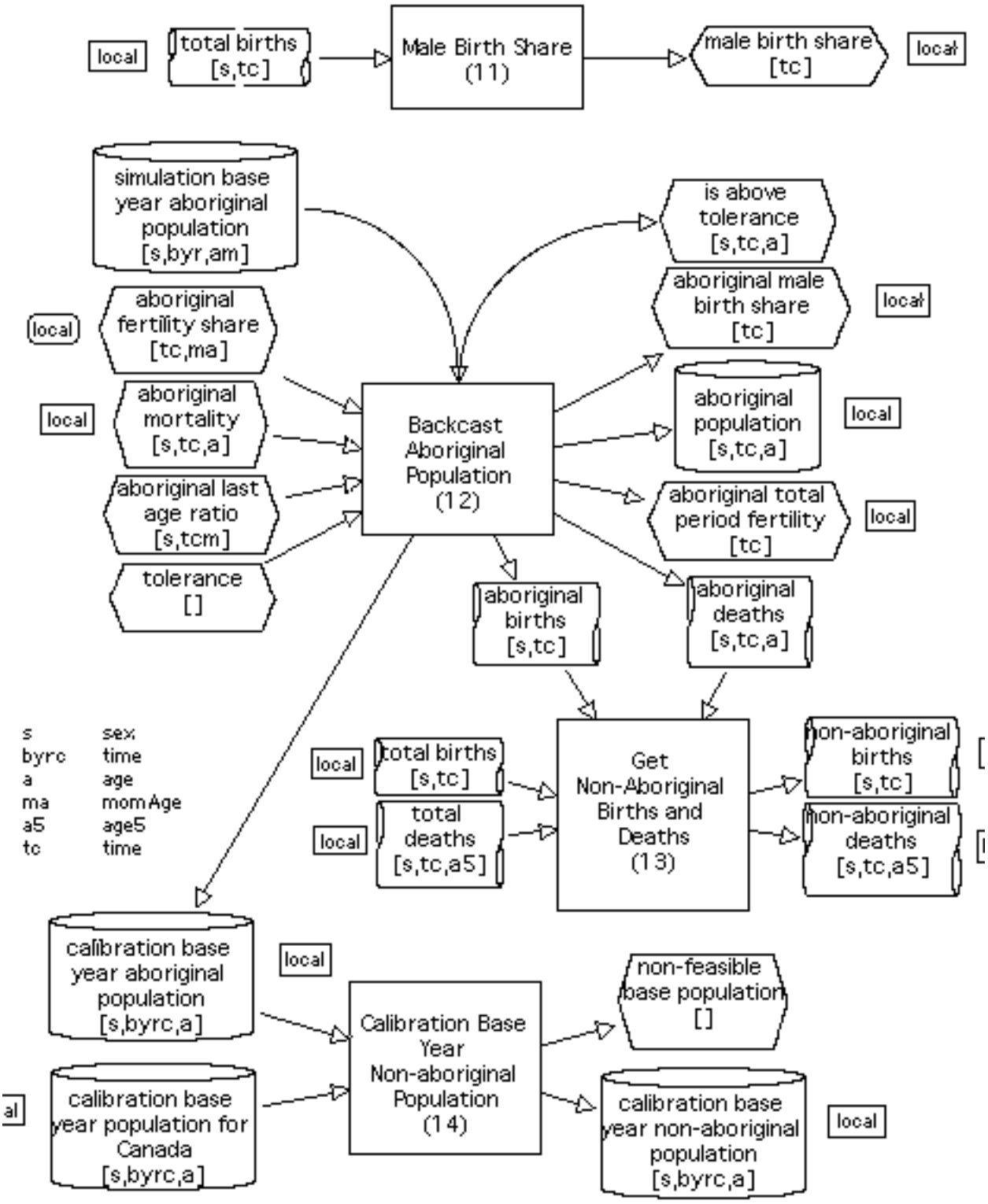
fp	foundPeople
ims	immStatus
s	sex
ur	urbanRural
edl	eduLevel
ncma	NCMage
sa	schoolAge
moc	MOC
st	serviceType
rk	rank
mila	militaryAge
t	time

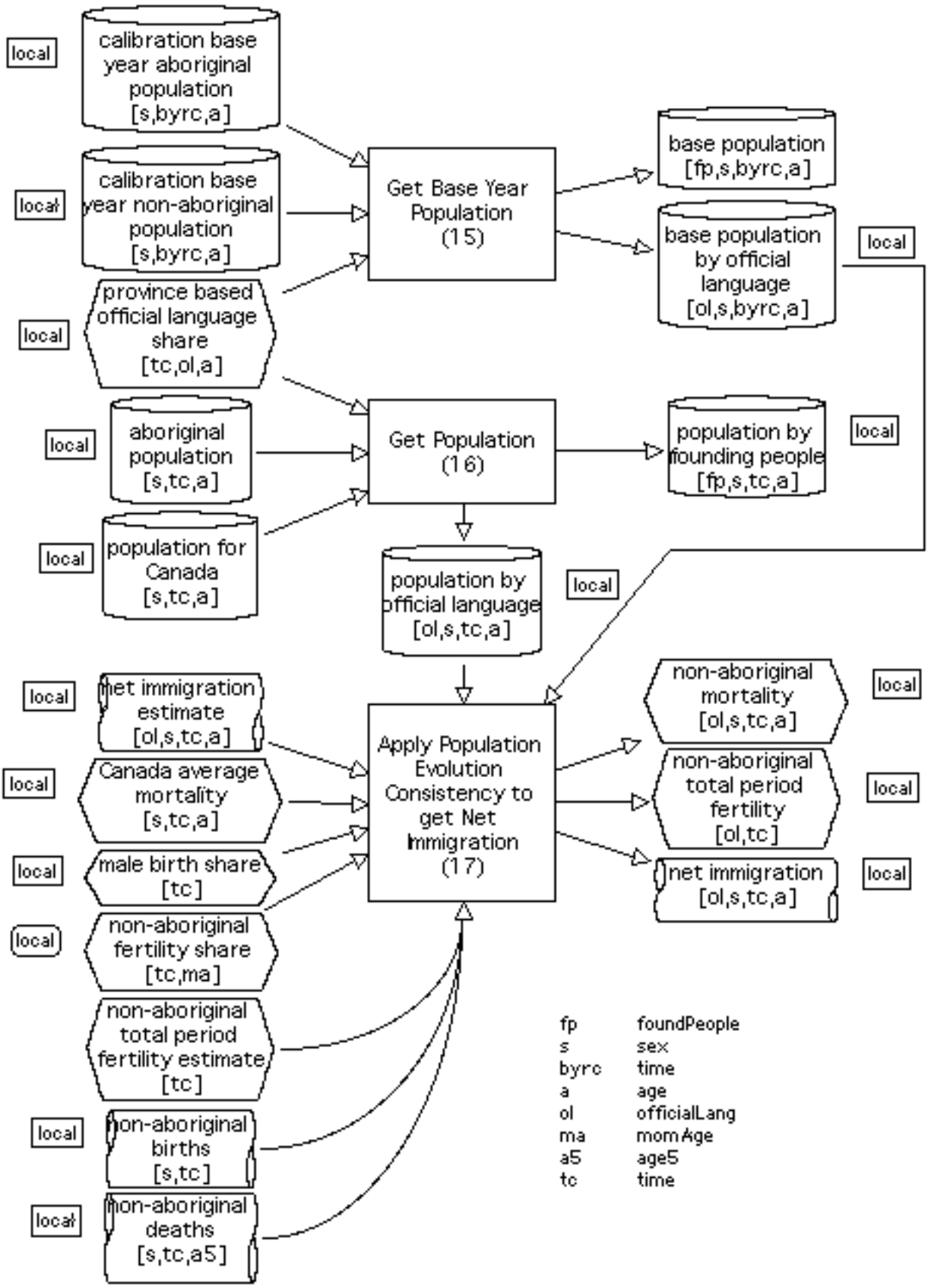
Appendix B: Calibration Model

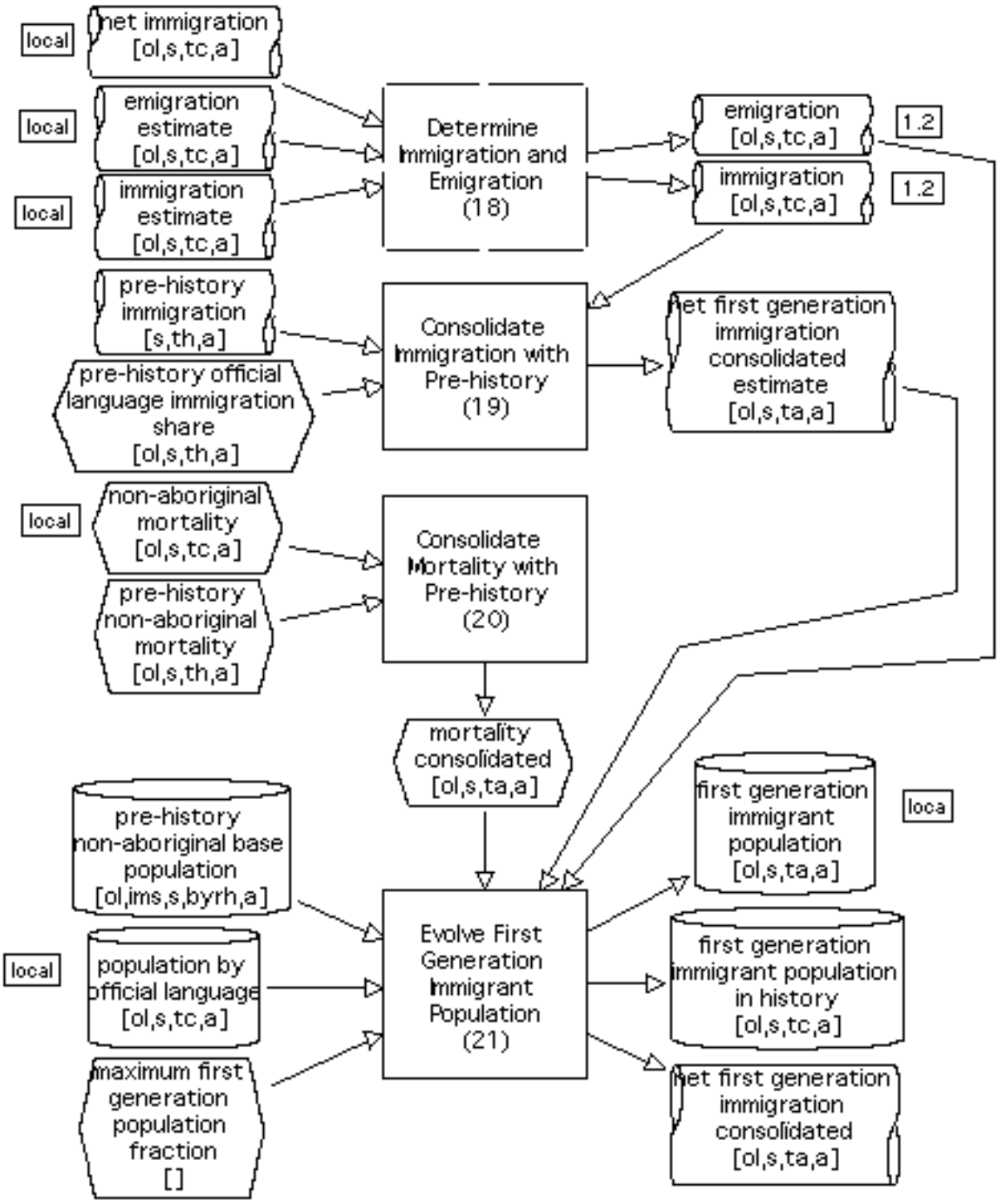
1.1 Population



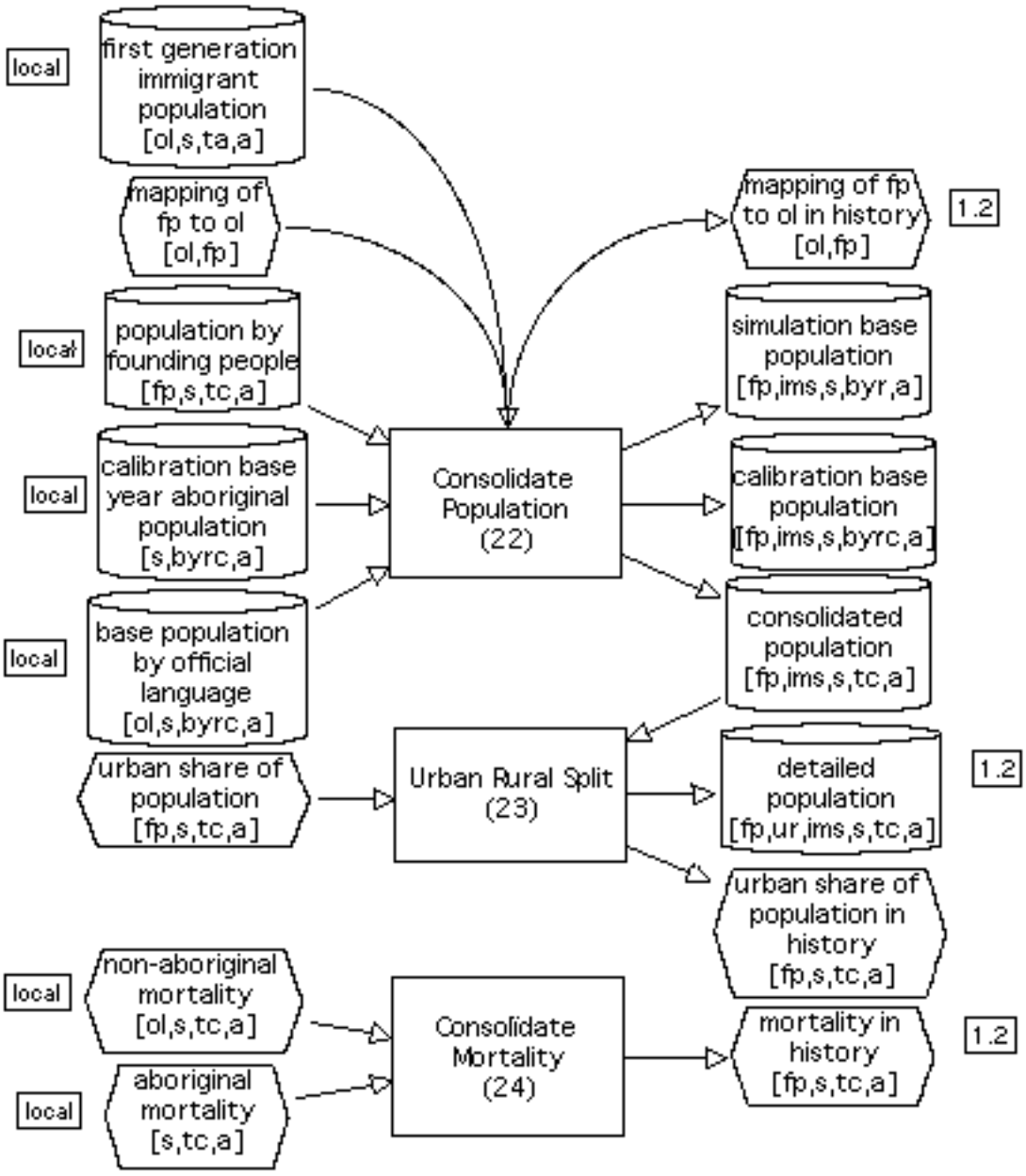

census age range boundaries [cena,sea]
calibration base year census population [s,byrc,cena]
census population [s,to,cena]
Canadian Demographic System Framework population [s,tcds,a]
Determine 1-year age class Observed Populations (7)
first census age class residual check [s,to]
calibration base year population for Canada [s,byrc,a]
local
net immigration estimate [ol,s,tc,a]
total births [s,tc]
population for Canada observed [s,to,a]
Extrapolate to Calibration Period End (8)
population for Canada [s,tc,a]
total deaths [s,tc,a5]
Canadian Demographic System Framework mortality [s,tc,a]
Determine Tracking Mortality (9)
fp foundPeople
s sex
byrc time
a age
ol officialLang
a5 age5
tc time
to time
cena cenAgeClass
tcds time
Canada average death rate [tc]
Canada average mortality [s,tc,a]
aboriginal death rate [tc]
Determine Estimated Aboriginal Mortality (10)
aboriginal mortality [s,tc,a]


local
total births [s,tc]
Male Birth Share (11)
male birth share [tc]
local
simulation base year aboriginal population [s,byr,am]
is above tolerance [s,tc,a]
aboriginal male birth share [tc]
local
local
aboriginal fertility share [tc,ma]
local
aboriginal mortality [s,tc,a]
aboriginal last age ratio [s,tcm]
tolerance []
Backcast Aboriginal Population (12)
aboriginal population [s,tc,a]
local
aboriginal total period fertility [tc]
local
aboriginal births [s,tc]
aboriginal deaths [s,tc,a]
s sex
byrc time
a age
ma momAge
a5 age5
tc time
local
total births [s,tc]
local
total deaths [s,tc,a5]
Get Non-Aboriginal Births and Deaths (13)
non-aboriginal births [s,tc]
non-aboriginal deaths [s,tc,a5]
calibration base year aboriginal population [s,byrc,a]
local
calibration base year population for Canada [s,byrc,a]
Calibration Base Year Non-aboriginal Population (14)
non-feasible base population []
calibration base year non-aboriginal population [s,byrc,a]
local


local
calibration base year aboriginal population [s,byrc,a]
local
calibration base year non-aboriginal population [s,byrc,a]
local
province based official language share [tc,ol,a]
Get Base Year Population (15)
base population [fp,s,byrc,a]
base population by official language [ol,s,byrc,a]
local
local
aboriginal population [s,tc,a]
local
population for Canada [s,tc,a]
Get Population (16)
population by founding people [fp,s,tc,a]
local
population by official language [ol,s,tc,a]
local
local
net immigration estimate [ol,s,tc,a]
local
Canada average mortality [s,tc,a]
local
male birth share [tc]
local
non-aboriginal fertility share [tc,ma]
local
non-aboriginal total period fertility estimate [tc]
local
non-aboriginal births [s,tc]
local
non-aboriginal deaths [s,tc,a5]
Apply Population Evolution Consistency to get Net Immigration (17)
non-aboriginal mortality [ol,s,tc,a]
local
non-aboriginal total period fertility [ol,tc]
local
net immigration [ol,s,tc,a]
local
fp foundPeople
s sex
byrc time
a age
ol officialLang
ma momAge
a5 age5
tc time

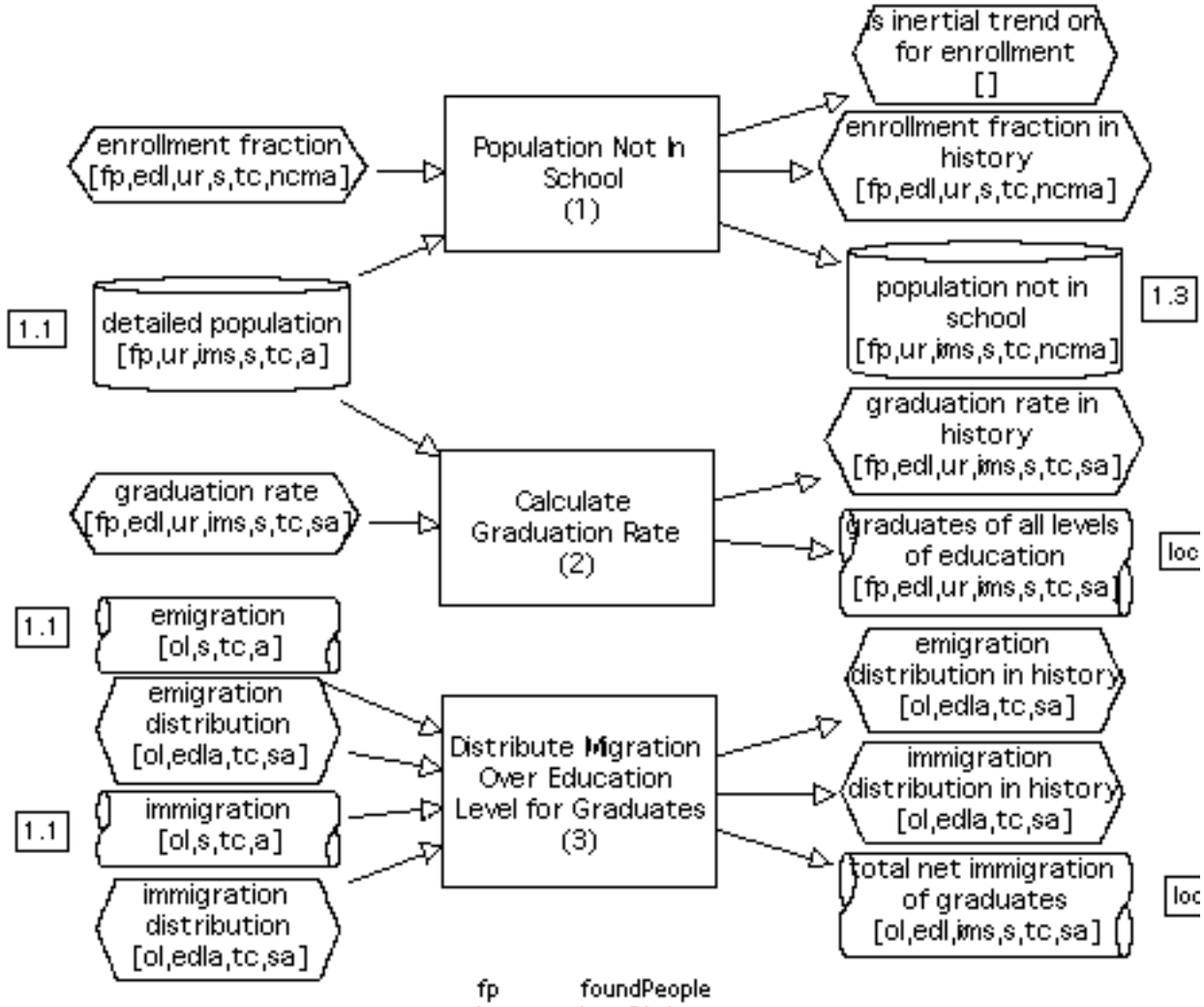


ims	immStatus
s	sex
a	age
ol	officialLang
tc	time
byrh	time
th	time
ta	time

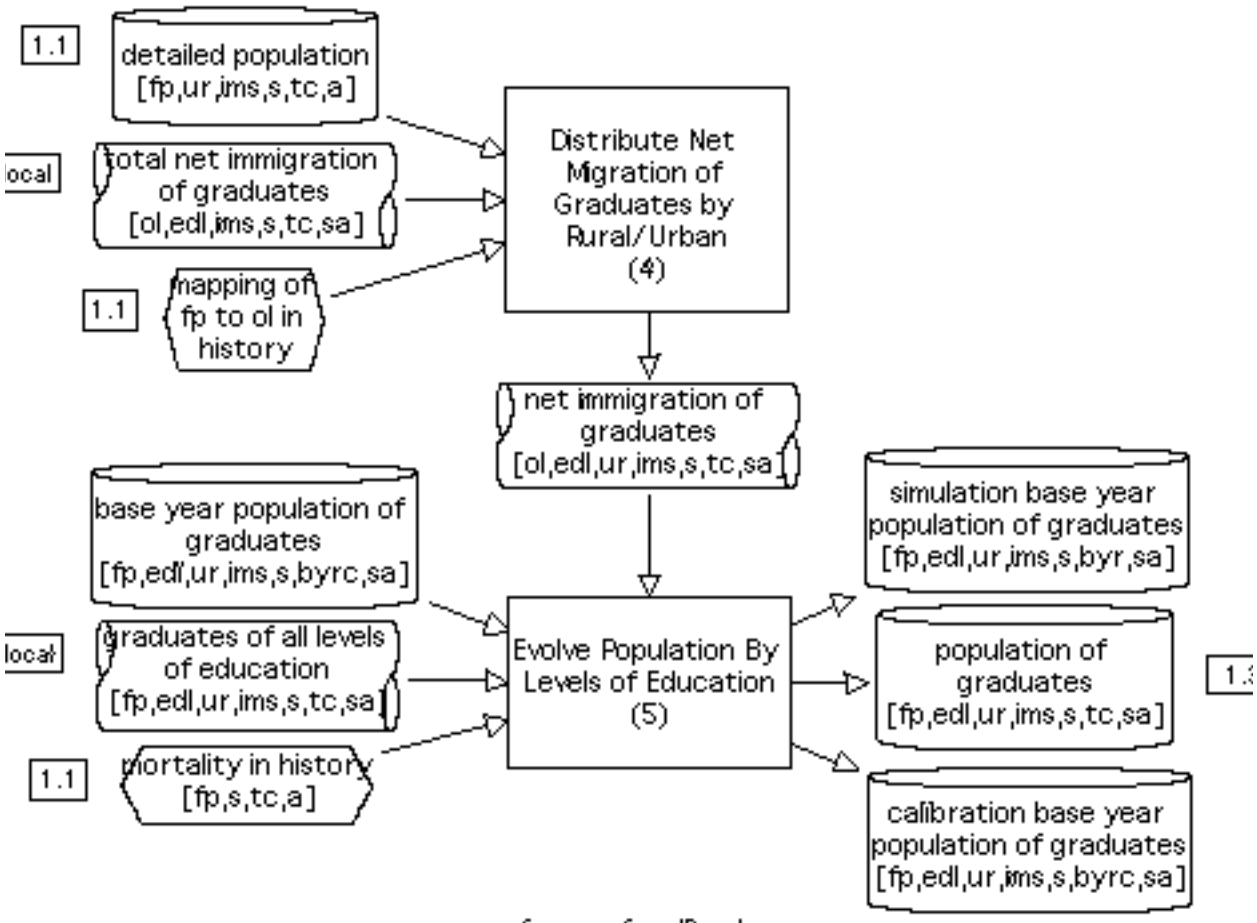


fp	foundPeople
ims	immStatus
s	sex
a	age
ol	officialLang
ur	urbanRural
ma	momAge
tc	time
byr	time
ta	time

1.2 Education

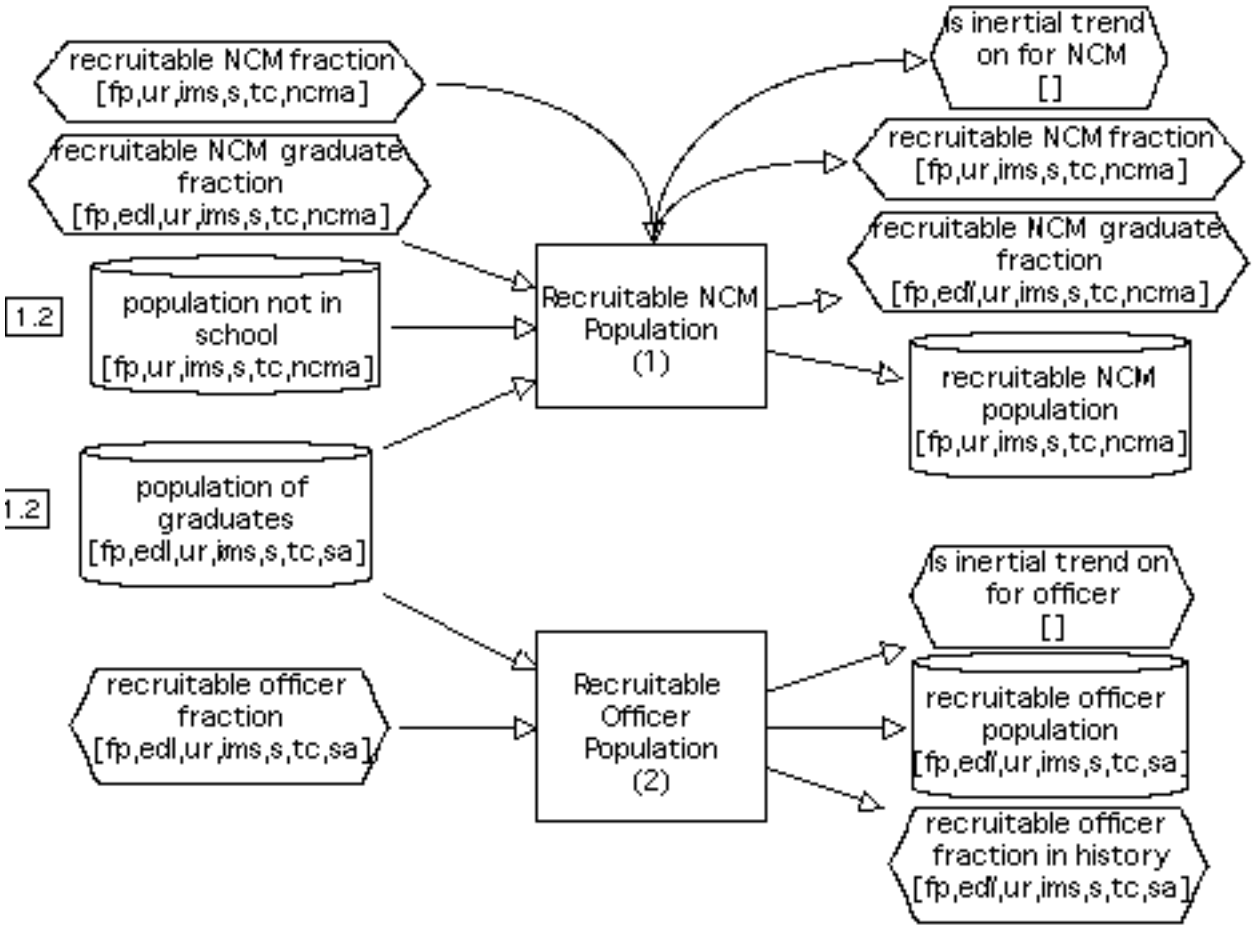


fp	foundPeople
ims	immStatus
s	sex
a	age
ol	officialLang
ur	urbanRural
edl	eduLevel
ncma	NCMage
sa	schoolAge
tc	time
edla	eduLevelAll



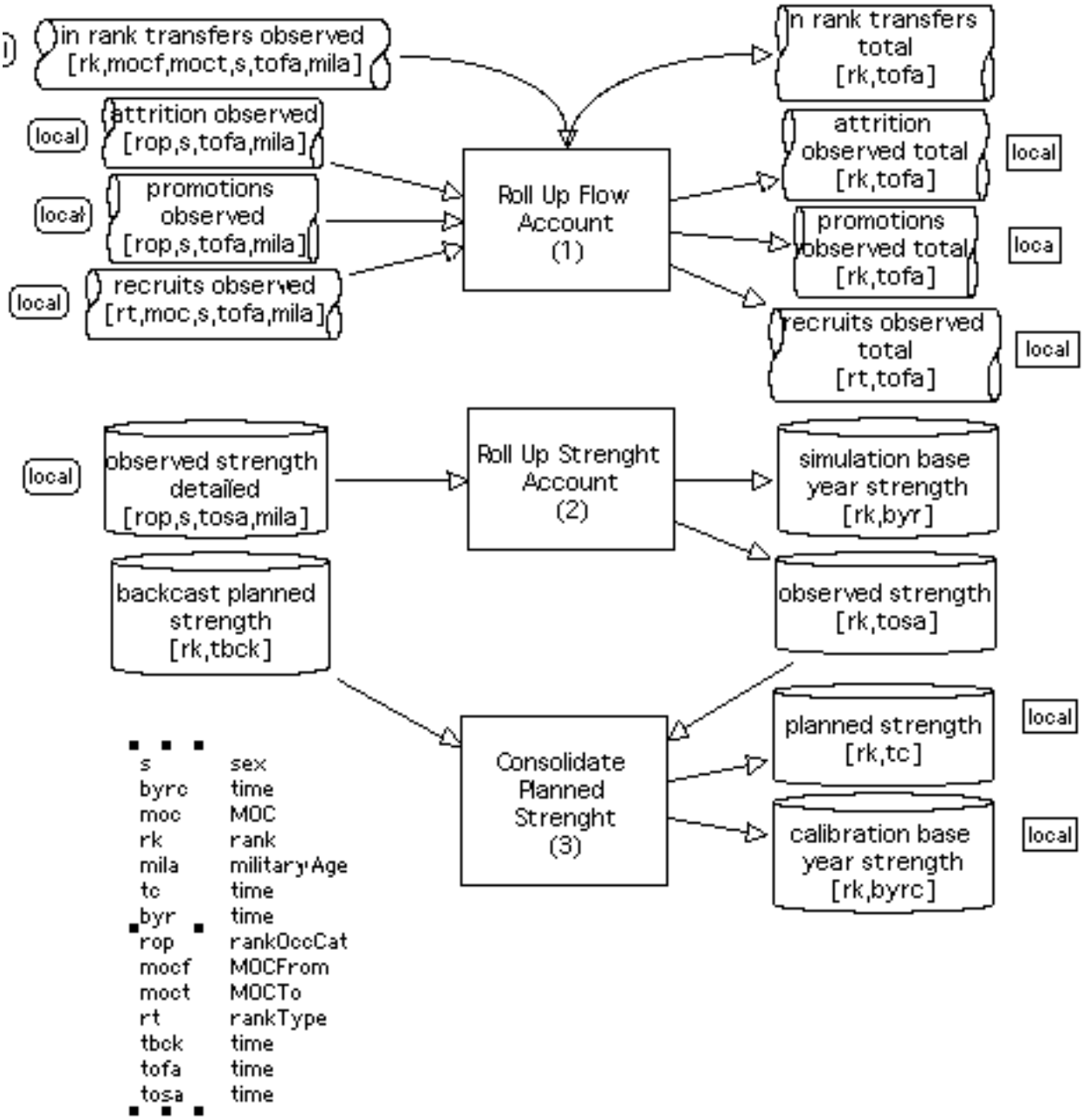
fp	foundPeople
ims	immStatus
s	sex
byrc	time
a	age
ol	officialLang
ur	urbanRural
edl	eduLevel
sa	schoolAge
tc	time
byr	time

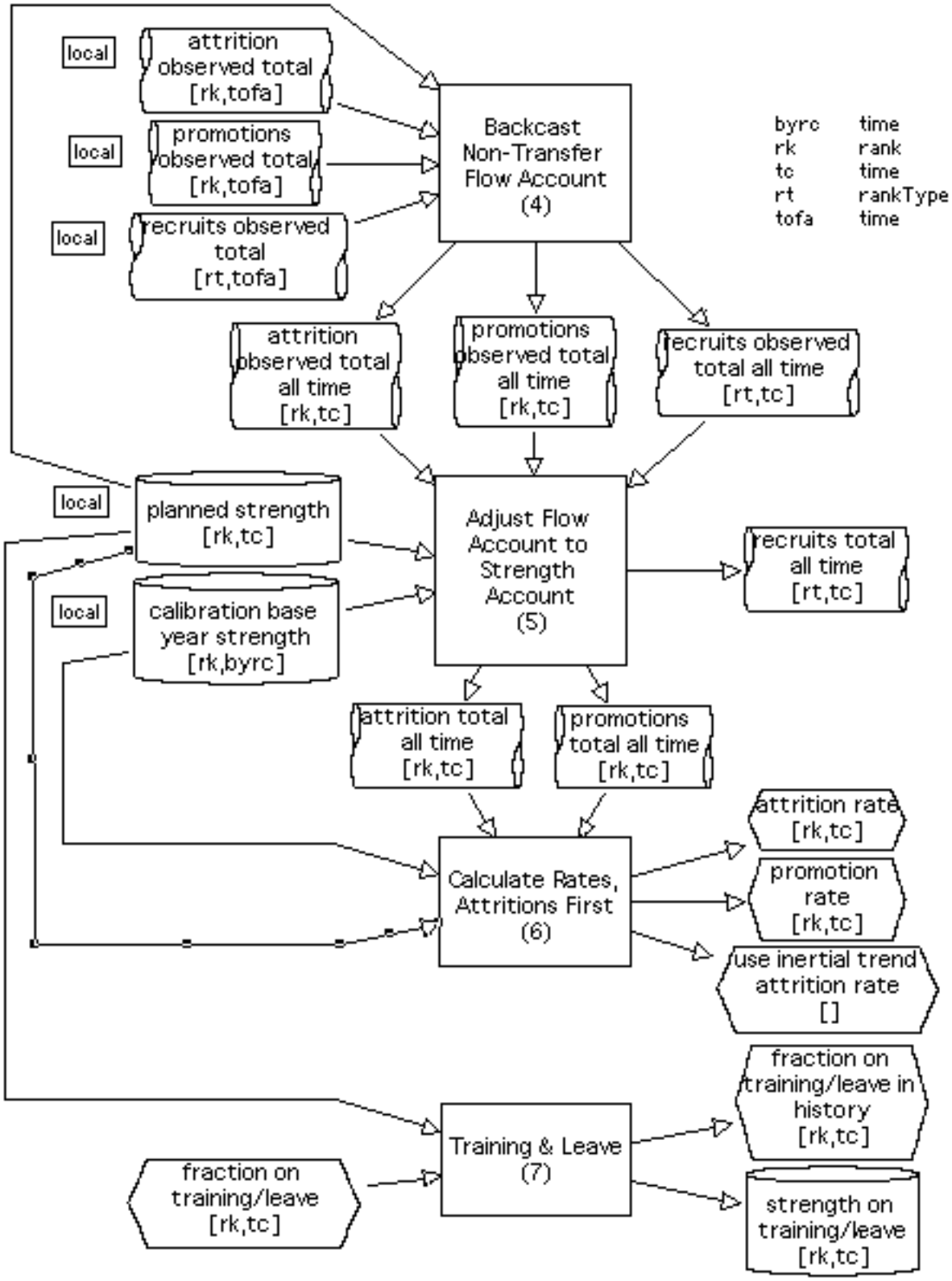
1.3 Recruitable Population

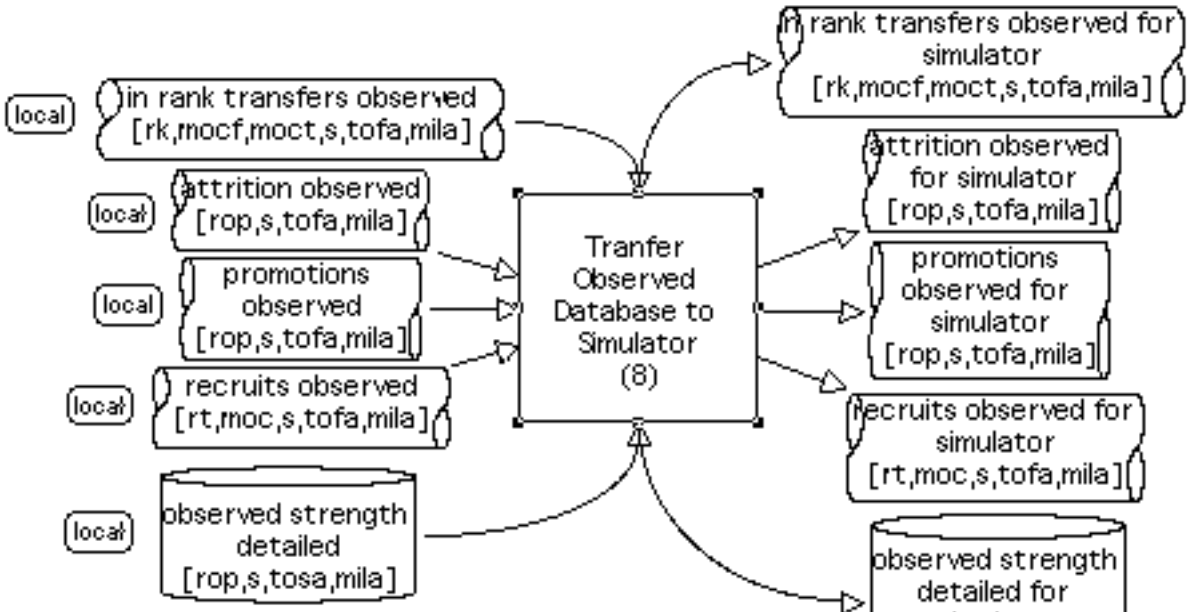


fp	foundPeople
ims	immStatus
s	sex
ur	urbanRural
edl	eduLevel
ncma	NCMage
sa	schoolAge
tc	time

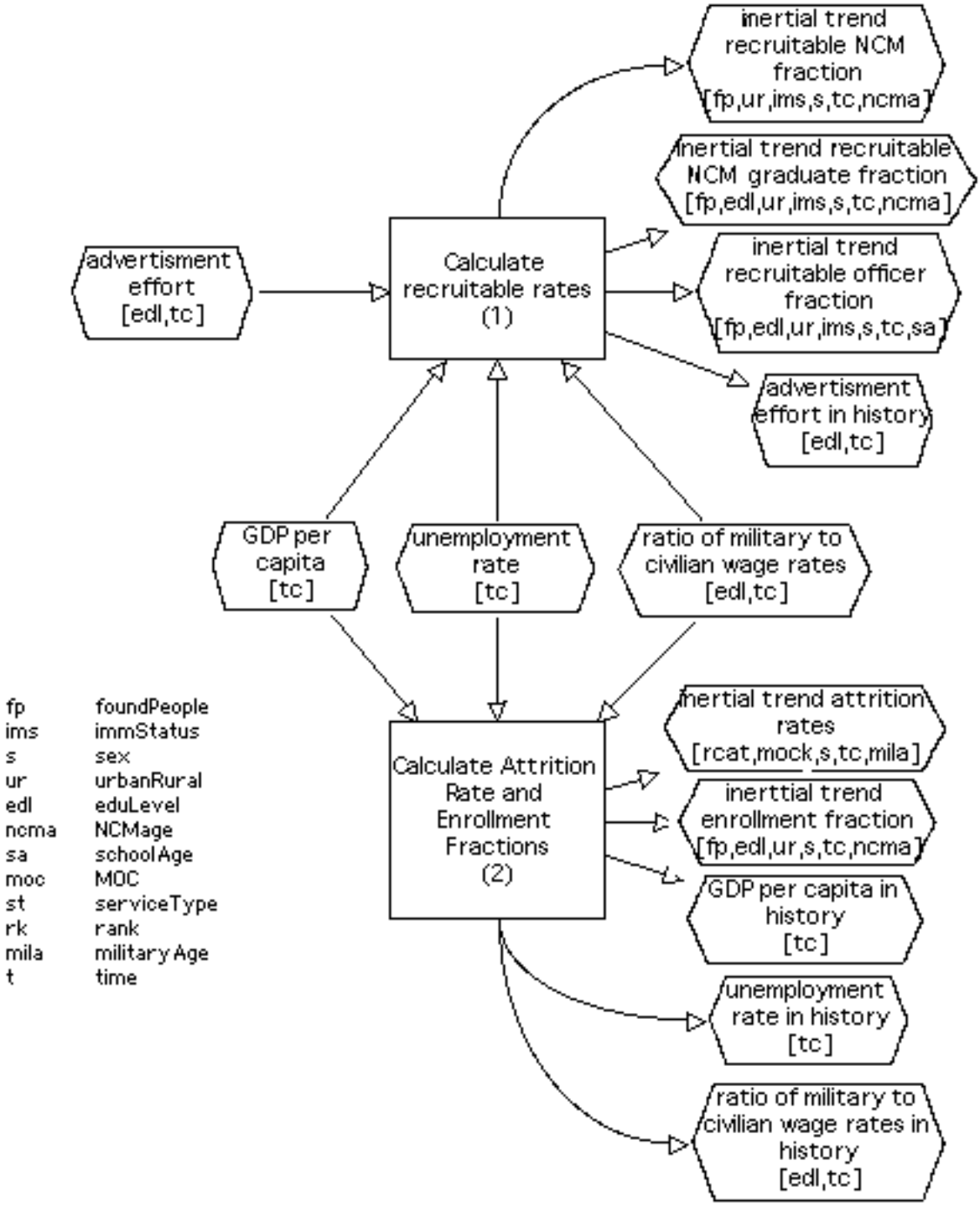
2 Recruitment, Attrition and Promotion




local
attrition observed total [rk,tofa]
local
promotions observed total [rk,tofa]
local
recruits observed total [rt,tofa]
Backcast Non-Transfer Flow Account (4)
byrc time
rk rank
tc time
rt rankType
tofa time
attrition observed total all time [rk,tc]
promotions observed total all time [rk,tc]
recruits observed total all time [rt,tc]
local
planned strength [rk,tc]
local
calibration base year strength [rk,byrc]
Adjust Flow Account to Strength Account (5)
recruits total all time [rt,tc]
attrition total all time [rk,tc]
promotions total all time [rk,tc]
attrition rate [rk,tc]
promotion rate [rk,tc]
use inertial trend attrition rate []
Calculate Rates, Attritions First (6)
fraction on training/leave in history [rk,tc]
Training & Leave (7)
fraction on training/leave [rk,tc]
strength on training/leave [rk,tc]


local
in rank transfers observed
[rk,mocf,moct,s,tofa,mila]
local
attrition observed
[rop,s,tofa,mila]
local
promotions
observed
[rop,s,tofa,mila]
local
recruits observed
[rt,moc,s,tofa,mila]
local
observed strength
detailed
[rop,s,tosa,mila]
Tranfer
Observed
Database to
Simulator
(8)
rank transfers observed for
simulator
[rk,mocf,moct,s,tofa,mila]
attrition observed
for simulator
[rop,s,tofa,mila]
promotions
observed for
simulator
[rop,s,tofa,mila]
recruits observed for
simulator
[rt,moc,s,tofa,mila]
observed strength
detailed for
simulator
[rop,s,tosa,mila]
s sex
moc MOC
rk rank
mila militaryAge
rop rankOccCat
mocf MOCFrom
moct MOCTo
rt rankType
tofa time
tosa time

3 Inertial Trend



fp	foundPeople
ims	immStatus
s	sex
ur	urbanRural
edl	eduLevel
ncma	NCMage
sa	schoolAge
moc	MOC
st	serviceType
rk	rank
mila	militaryAge
t	time