Population and Housing Demand Projections for Metro Boston

Regional Projections and Provisional Municipal Forecasts

January, 2014
Metropolitan Area Planning Council

Appendix F:
Formulas for calculation

MAPC 50 YEARS
METROPOLITAN AREA PLANNING COUNCIL
SMART GROWTH AND REGIONAL COLLABORATION

Base Population

$Pt_{A,R,G}^{P,Y}$	**Total population,** in place P, at time Y, by Age (5 year Age Cohorts), Race/Ethnicity (NH_White, NH_Black, NH_API, NH_Other, Hispanic) and Gender (M/F). Launch year value derived from SF2 Table PCT 3
$Ph_{A,R,G}^{P,Y}$	**Population in households,** in place P, at time Y, by Age (5 year Age Cohorts), Race/Ethnicity (NH_White, NH_Black, NH_API, NH_Other, Hispanic) and Gender (M/F): Launch year value derived from SF2 Table PCT 5
$Pg_{A,R,G}^{P,Y}$	**Population in group quarters,** in place P, at time Y, by Age (5 year Age Cohorts), Race/Ethnicity (NH_White, NH_Black, NH_API, NH_Other, Hispanic) and Gender (M/F). Launch year value derived from SF2.
$Pe^{P,Y}$	**Census Population Estimate,** in place P, at time Y (total population only); Source: US Census estimates program; available for 2000 – 2009. $Pe^{P,2010}$ not estimated by census and assumed to be equal to: $(Pe^{P,2009} - Pe^{P,2008}) + Pe^{P,2009}$
$Po^{P,2010}$	**Census Over/Underestimate ratio**: The ratio of the Census-estimated population change from 2000 – 2010 to the actual population change from decennial census. >1.0 means an overestimate; <1.0 means underestimate Equal to: $(\frac{(Pe^{P,2010} - Pe^{P,2000})}{(Pt^{P,2010} - Pt^{P,2000})})$
$Pa^{P,Y}$	**Adjusted population Estimate,** in place P at time Y, to account for Census over/under estimates. Equal to: $\frac{(Pe^{P,Y} - Pt^{P,2000})}{Po^{P,2010}} + Pt^{P,2000}$
$Ps_{A,R,G}^{P,Y}$	**Cohort Share of Total Population,** in place P, at time Y. For 2000 and 2010, derived from Census SF2. For intervening years, interpolated as follows: $((Ps_{A,R,G}^{P,2010} - Ps_{A,R,G}^{P,2000}) * \frac{(Y-2000)}{10}) + Ps_{A,R,G}^{P,2000}$
$Pt_{A,R,G}^{P,2007-09}$	**Estimated Cohort Population, 2007 – 2009** (average), in place P, by Age, Race, and Gender; repeat for 2006 – 2008 $\frac{\sum^{2007-2009} Ps_{A,R,G}^{P,Y} * Pa^{P,Y}}{3}$
$Pc_{A,R,G}^{P,2010}$	**Estimated Cohort HH Share, 2007 - 2009;** cohort population in households as compared to the total cohort population; derived from SF1 or SF2 for 2010. Not interpolated. Repeat for 2006 – 2008 $\frac{Ph_{A,R,G}^{P,2010}}{Pt_{A,R,G}^{P,2010}}$
$Ph_{A,R,G}^{P,2007-2009}$	**Estimated Cohort Population in Households, 2007 – 2009,** based on adjusted population estimate, cohort share, and cohort HH share. Repeat for 2006 – 2008. $Pt_{A,R,G}^{P,2007-09} * Pc_{A,R,G}^{P,2010}$

Natural Change

$B_{A,R}^{P,Y}$	**Births**, in place P, at time Y, by Age and Race of mother; from MassCHIP
$F_{A,R}^{P,Y}$	**Fertility** (births per decade), in place P, at time Y, by Age and Race of mother. For launch year, equal to: $\frac{B_{A,R}^{P,2007-09}}{Ph_{A,R,G}^{P,2007-09}} * 10$ *Note*: this assumes that all births are to women in households; excludes mothers in Group Quarters (college, institutions, group homes, prison) from the denominator so may slightly overstate true birth rate for females in HH.
$D_{A,R,G}^{P,Y}$	**Deaths**, in place P, at time Y, by Age and Race, and Gender; from MassCHIP
$Dm_{A,R,G}^{P,Y}$	**Mortality** (deaths per decade), in place P, at time Y, by Age, Race, and Gender. For launch year, equal to: $\frac{D_{A,R}^{P,2006-08}}{Pt_{A,R,G}^{P,2006-08}} * 10$ *Note*: this is a mortality rate for the entire population, based on the assumption that residents in HH and in GQ will have similar mortality rates; 65+ GQ population may include more frail and very elderly residents with higher likelihood of mortality, so this equation may overestimate the mortality for seniors in HH.

Regional Migration

$Pe^{US-MA,Y}$	**Population Estimate** for future years (2015, 2020, 2025, 2030) for the rest of country (US minus MA). Available from Census.
$Pe^{MA-5C,Y}$	**Population Estimate** for future years (2015, 2020, 2025, 2030) for the rest of State (MA minus 5 County region). Available from Census.
$MIdfst^{5C,2006-2010}$	**Interstate In migration rate**: For the 5 County region, annual rate of in-migrants from a different state. Derived from total in-migrants from different state divided by population estimate for 2006-10 for the US-MA region. ACS 2006-10
$MIsmst^{5C,2006-2010}$	**Intrastate In migration rate:** For the 5 County region, annual rate of in-migrants from within MA. Derived from total in-migrants from within MA divided by population estimate for 2006-10 for the MA-5C region. ACS 2006-10
$MIabr^{5C,2006-2010}$	**International net migration:** Net migration number of total migrants from different country to 5 County region.
$MOdfst^{5C,2006-2010}$	**Interstate Out migration rate**: For the 5 County region, annual rate of out-migrants to a different state. Derived from total out-migrants to different state divided by population estimate for 2006-10 for the 5C region. ACS 2006-10
$MOsmst^{5C,2006-2010}$	**Intrastate Out migration rate:** For the 5 County region, annual rate of out-migrants moving within MA (outside the 5C region). Derived from total out-migrants to MA divided by population estimate for 2006-10 for the 5C region. ACS 2006-10

$MI\Delta dfst^{5C}$	**Interstate In migration rate change:** Assumption of annual change in in-migration from different state for future years.
$MI\Delta smst^{5C}$	**Intrastate In migration rate change:** Assumption of annual change in in-migration from within MA for future years.
$MO\Delta dfst^{5C}$	**Interstate Out migration rate change:** Assumption of annual change in out-migration to different state for future years.
$MO\Delta smst^{5C}$	**Intrastate Out migration rate change:** Assumption of annual change in in-migration from within MA for future years.
$MI\Delta abr^{5C}$	**International migration change:** Assumption of percent change in number of international net migrants to the 5 County region. (note that the % change assumptions for domestic in and out migration are applied to the rates while international rate change is applied to the absolute number of net migrants from abroad)
$MIdfst\%_A^{5C,2006-2010}$	**Interstate In-Migrant share:** Percent of total in-migrants from US- MA that are in age cohort A. ACS 2006-10
$MIsmst\%_A^{5C,2006-2010}$	**Intrastate In-Migrant share:** Percent of total in-migrants from within MA that are in age cohort A. ACS 2006-10
$MIabr\%_A^{5C,2006-2010}$	**International Migrant share:** Percent of total net-migrants from abroad that are in age cohort A. ACS 2006-10
$MOdfst\%_A^{5C,2006-2010}$	**Interstate Out-Migrant share:** Percent of total out-migrants to US- MA that are in age cohort A. ACS 2006-10
$MOsmst\%_A^{5C,2006-2010}$	**Intrastate Out-Migrant share:** Percent of total out-migrants to MA that are in age cohort A. ACS 2006-10
$MIdfst_A^{5C,Yi}$	**Interstate In-Migrants- Initial:** For future year Y, annual in-migrants from outside MA in cohort A in the beginning of 10-year period. $(Pe^{US-MA,Y-10} * MIdfst^{5C,2006-2010}) * MIdfst\%_A^{5C,2006-2010}$
$MIdfst_A^{5C,Yf}$	**Interstate In-Migrants- Final:** For future year Y, annual in-migrants from outside MA in cohort A in the ending of 10-year period. $((Pe^{US-MA,Y-10} * (MIdfst^{5C,2006-2010})) * MIdfst\%_A^{5C,2006-2010}) * (1 + (10 * +MI\Delta dfst^{5C}))$
$MIdfst_A^{5C,Y}$	**Interstate In-Migrants:** Total in-migrants from outside MA that are added to the region in the 10-year period. $10 * ((MIdfst_A^{5C,Yi} + MIdfst_A^{5C,Yf})/2)$
$MIsmst_A^{5C,Y}$	**Intrastate In-Migrants:** Similar calculations to $MIdfst_A^{5C,Y}$ using corresponding numbers for intra-state in-migration.
$MOdfst_A^{5C,Yi}$	**Interstate Out-Migrants-Initial:** For future year Y, annual out-migrants to different state in cohort A in the beginning of 10-year period. $(Pe^{5C,Y-10} * MOdfst^{5C,2006-2010}) * MOdfst\%_A^{5C,2006-2010}$

$MOdfst_A^{5C,Yf}$	**Interstate Out-Migrants-Final:** For future year Y, annual out-migrants to different state in cohort A in the ending of 10-year period. $((Pe^{5C,Y-10} * (MOdfst^{5C,2006-2010})) * MOdfst\%_A^{5C,2006-2010}) * (1 + (10 * + MO\Delta dfst^{5C}))$
$MOdfst_A^{5C,Y}$	**Interstate Out-Migrants:** Total in-migrants from outside MA that are added to the region in the 10-year period. $10 * ((MOdfst_A^{5C,Yi} + MOdfst_A^{5C,Yf})/2)$
$MOsmst_A^{5C,Y}$	**Intrastate Out-Migrants:** Similar calculations to $MOdfst_A^{5C,Y}$ using corresponding numbers for intra-state out-migration.
$MIabr_A^{5C,Yi}$	**International Net Migration-Initial:** For cohort A, total international net migrants in the beginning of the 10-year period. $(MIabr^{5C,2006-2010}) * MIabr\%_A^{5C,2006-2010}$
$MIabr_A^{5C,Yf}$	**International Net Migration-Final:** For cohort A, total international net migrants in the ending of the 10-year period $(MIabr^{5C,2006-2010} * MIabr\%_A^{5C,2006-2010}) * (1 + 10 * MI\Delta abr^{5C})$
$MIabr_A^{5C,Y}$	**International Net Migrants:** Total international net migration for the 10 year period. $10 * ((MIabr_A^{5C,Yi} + MIabr_A^{5C,Yf})/2)$
$MIdfst_{A,R}^{PUMA,2006-2010}$	**Race share of Interstate In-Migrants:** Race share (5 Race categories) by age of In migrants from outside MA. PUMS 2006-10.
$MIsmst_{A,R}^{PUMA,2006-2010}$	**Race share of Intrastate In-Migrants:** Race share (5 Race categories) by age of In migrants from within MA. PUMS 2006-10.
$MIabr_{A,R}^{PUMA,2006-2010}$	**Race share of International Net-Migrants:** Race share (5 Race categories) by age of In migrants from abroad. PUMS 2006-10.
$MOdfst_{A,R}^{PUMA,2006-2010}$	**Race share of Interstate Out-Migrants:** Race share by age of Out migrants to other states. PUMS 2006-10
$MOsmst_{A,R}^{PUMA,2006-2010}$	**Race share of Intrastate Out-Migrants:** Race share by age of Out migrants to other MA PUMAs. PUMS 2006-10
$MIdfst_{A,R,G}^{5C,Y}$	**Interstate in-migrants:** Total in-migrants from other states by age, race and sex. $(MIdfst_A^{5C,Y} * MIdfst_{A,R}^{PUMA,2006-2010})/2$
$MIsmst_{A,R,G}^{5C,Y}$	**Intrastate in-migrants:** Total in-migrants from within MA by age, race and sex. $(MIsmst_A^{5C,Y} * MIsmst_{A,R}^{PUMA,2006-2010})/2$
$MIabr_{A,R,G}^{5C,Y}$	**International migrants:** Total in-migrants from abroad by age, race and sex. $(MIabr_A^{5C,Y} * MIabr_{A,R}^{PUMA,2006-2010})/2$
$MI_{A,R,G}^{5C,Y}$	**Total In-Migrants:** to the region in future year Y by age race and sex. $MIdfst_{A,R,G}^{5C,Y} + MIsmst_{A,R,G}^{5C,Y} + MIabr_{A,R,G}^{5C,Y}$

$MOdfst_{A,R,G}^{5C,Y}$	**Interstate out-migrants:** Total out-migrants to other states by age, race and sex. $(MOdfst_{A}^{5C,Y} * MOdfst_{A,R}^{PUMA,2006-2010})/2$
$MOsmst_{A,R,G}^{5C,Y}$	**Intrastate out-migrants:** Total out-migrants to other MA areas by age, race and sex. $(MOsmst_{A}^{5C,Y} * MOsmst_{A,R}^{PUMA,2006-2010})/2$
$MO_{A,R,G}^{5C,Y}$	**Total Out-Migrants:** from the region in future year Y by age race and sex. $MOdfst_{A,R,G}^{5C,Y} + MOsmst_{A,R,G}^{5C,Y}$
$Mn_{A,R,G}^{5C,Y}$	**Total Net Migration:** Net migration in the region by age, race and sex. $MI_{A,R,G}^{5C,Y} - MO_{A,R,G}^{5C,Y}$

Regional Population Projections

$Ph_{A,R,G}^{P,Y}$	**Projected Population in Households,** for future year Y $Ph_{A-10,R,G}^{P,Y-10}$ - ($Ph_{A-10,R,G}^{P,Y-10}$ * (0.25* $Dm_{A-10,R,G}^{P,Y-10}$ + 0.50* $Dm_{A-5,R,G}^{P,Y-10}$ + 0.25* $Dm_{A,R,G}^{P,Y-10}$)) + ($MNr_{A,R}^{P,Y-10}$* $Ph_{A-10,R,G}^{P,Y-10}$)
$Ph_{0-4,R}^{P,Y}$	**Projected newborn population,** for future year Y ($\sum_{A-Z}(Ph_{A,R,G}^{P,Y-10} * (0.25 * F_{A+5,R,G}^{P,Y-10} + 0.25 * F_{A+10,R,G}^{P,Y-10}))$) * Bg_{G}^{Y} * (0.5 * $Dm_{0-4,R,G}^{P,Y}$) + ($MNr_{A,R}^{P,Y-10}$* $Ph_{A-10,R,G}^{P,Y-10}$)
$Ph_{5-9,R}^{P,Y}$	**Projected 5 – 9 year old population,** for future year Y ($\sum_{A-Z}(Ph_{A,R,G}^{P,Y-10} * (0.25 * F_{A+5,R,G}^{P,Y-10} + 0.25 * F_{A+10,R,G}^{P,Y-10}))$) * Bg_{G}^{Y} * (0.5 * $Mo_{0-4,R,G}^{P,Y}$ + 0.25 * $Mo_{5-9R,G}^{P,Y}$)

Regional Household Projections

$H_{A,Ty}^{P,Y}$	**Headship Rate by household type:** Percent of population by age likely to form household; by household type (family and non-family household). From Census 2010 SF1 Table P22 $\frac{Hh_{A,Ty}^{P,2010}}{Ph_{A}^{P,2010}}$
$H_{A,Ty,Tn}^{P,Y}$	**Headship Rate by HH type and Tenure**: Percent of population by age likely to form household; by household type (family and non-family household); and tenure (rent or own). From Census 2010 SF2 Table HCT9 $\frac{Hh_{A,Ty,Tn}^{P,2010}}{Ph_{A}^{P,2010}}$
$Hh_{A,Ty,Tn}^{P,Y}$	**Households by type and tenure by age of householder**: for future year Y $Ph_{A}^{P,Y} * H_{A,Ty,Tn}^{P,Y}$

Regional Housing Unit Projections

<table>
<tr><td>$Hs_{A,Ty,Tn}^{PUMA,Y}$</td><td>Household size ratio: 3 household size categories (Living Alone, 2-3, 4+) ratios from PUMS ACS data ratios applied to householder characteristics. Data available for overlapping PUMA geography.
$\frac{Hh_{A,Ty,Tn,S}^{PUMA,2010}}{\sum_{S=1}^{4+} Hh_{A,Ty,Tn,S}^{PUMA,2010}}$</td></tr>
<tr><td>$Hi_{A,Ty,Tn,S}^{PUMA,Y}$</td><td>Household Income ratio: Percent households by 4 Area Median Income (AMI) categories (30%, 50%, 80%, and 100%) by household size and householder characteristics. PUMS 2006-10 ACS data.
$\frac{Hh_{A,Ty,Tn,S,\$}^{PUMA,2010}}{\sum_{\$=0.3}^{1} Hh_{A,Ty,Tn,S,\$}^{PUMA,2010}}$

<table>
<tr><th colspan="9">FY 2010 Income Limit Category :Boston-Cambridge-Quincy, MA-NH HUD Metro FMR Area (Source)</th></tr>
<tr><th>Income Limit</th><th colspan="8">Household Size</th></tr>
<tr><th>AMI: $91,800</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th></tr>
<tr><td>Very Low (50%)</td><td>$32,150</td><td>$36,750</td><td>$41,350</td><td>$45,900</td><td>$49,600</td><td>$53,250</td><td>$56,950</td><td>$60,600</td></tr>
<tr><td>Extremely Low (30%)</td><td>$19,300</td><td>$22,050</td><td>$24,800</td><td>$27,550</td><td>$29,800</td><td>$32,000</td><td>$34,200</td><td>$36,400</td></tr>
<tr><td>Low (80%)</td><td>$45,100</td><td>$51,550</td><td>$58,000</td><td>$64,400</td><td>$69,600</td><td>$74,750</td><td>$79,900</td><td>$85,050</td></tr>
</table></td></tr>
<tr><td>$Hh_{A,Ty,Tn,S,\$}^{P,Y}$</td><td>Households by HH size and income (by type and tenure by age of householder): for future year Y. Household Income breaks applied for FY2010 Income categories as per HUD
$Hh_{A,Ty,Tn}^{P,Y} * Hs_{A,Ty,Tn}^{PUMA,Y} * Hi_{A,Ty,Tn,S}^{PUMA,Y}$</td></tr>
</table>

<table>
<tr>
<td>$Hu^{P,Y}_{A,Ty,Tn,S,\$,Un}$</td>
<td>Housing Unit Type ratio: Percent of housing units type (SF, Small MF, Medium MF, Large MF, Boat/RV, N/A), by income, HH size, and householder characteristics. PUMS 2006-10 ACS data.
$\frac{Hu^{PUMA,2010}_{A,Ty,Tn,S,\$,Un}}{\sum_{Un=1}^{n} Hu^{PUMA,2010}_{A,Ty,Tn,S,\$,Un}}$

<table>
<tr><th>PUMS Housing Unit Classification</th><th>MAPC Classification</th></tr>
<tr><td>bb .N/A (GQ)</td><td>NA</td></tr>
<tr><td>01 .Mobile home or trailer</td><td>Mobile Home</td></tr>
<tr><td>02 .One-family house detached</td><td>Single Family</td></tr>
<tr><td>03 .One-family house attached</td><td rowspan="3">Small Multifamily</td></tr>
<tr><td>04 .2 Apartments</td></tr>
<tr><td>05 .3-4 Apartments</td></tr>
<tr><td>06 .5-9 Apartments</td><td rowspan="2">Medium Multifamily</td></tr>
<tr><td>07 .10-19 Apartments</td></tr>
<tr><td>08 .20-49 Apartments</td><td rowspan="2">Large Multifamily</td></tr>
<tr><td>09 .50 or more apartments</td></tr>
<tr><td>10 .Boat, RV, van, etc.</td><td>Boat/RV/Van</td></tr>
</table>
</td>
</tr>
<tr>
<td>$Ht^{P,Y}_{A,Ty,Tn,S,\$,Un}$</td>
<td>Total Occupied Housing Units: for future year Y
$\sum \quad Hu^{P,Y}_{A,Ty,Tn,S,\$,Un} * Hh^{P,Y}_{A,Ty,Tn,S,\$}$</td>
</tr>
<tr>
<td>$Hd^{P,Y}$</td>
<td>Total Housing Unit Demand: Vacancy Rate assumption for total housing units applied to get housing unit demand for future year Y.
$(1 + Vac\%) * Ht^{P,Y}_{A,Ty,Tn,S,\$,Un}$</td>
</tr>
</table>

Municipal Base Year Population

$Pt_{A,G}^{P,Y}$	**Total Population** by age (5 year cohorts) and sex in each municipality in the modeling region (164). Launch year population from SF2 PCT3
$Ph_{A,G}^{P,Y}$	**Population in households** by age and sex in each municipality in the modeling region (164). Launch year population from SF2 PCT5
$Pg_{A,G}^{P,Y}$	**Population in group quarters** by age and sex in each municipality in the modeling region (164).
$Pt_{A,G}^{P,N}$	**Inter-Census year total population estimate** by age and sex for mortality rate calculation ('06 to '08 death data available). Assumes annual change for each cohort (age and sex) by change between 2000 and 2010 population. $\frac{Pt_{A,G}^{P,2010} - Pt_{A,G}^{P,2000}}{10} * N$
$Ph_{A,G}^{P,N}$	**Inter-Census year household population estimate** by age and sex for fertility rate calculation ('07 to '09 birth data available). Assumes annual change for each cohort (age and sex) by change between 2000 and 2010 population. $\frac{Ph_{A,G}^{P,2010} - Ph_{A,G}^{P,2000}}{10} * N$
$D_A^{P,Y}$	**Death Count by age for each municipality.** Annual counts from Masschip for each year 2000-2009.
$B_A^{P,Y}$	**Birth count total for each municipality.** Annual counts from Masschip for each year 2000-2009, by age of mother.

Municipal Natural Change

F_A^P	**Fertility** by age of mother by each municipality. Base year data obtained from average birth records for years 2007 to '09 and MAPC household population estimates $Ph_{A,G}^{P,N}$ for those years. Masschip fertility rates also used for comparison. $\frac{B_A^{P,2007-09}}{Ph_{A,female}^{P,2007-09}}$
$D_{A,G}^P$	**Mortality** by age and sex by each municipality. Base year data obtained from average death records for years 2006 to '08 from Masschip and MAPC total population estimates $Pt_{A,G}^{P,N}$ for '06 to 08. Masschip mortality rates also used for comparison. $\frac{D_{A,G}^{P,2006-08}}{Pt_{A,G}^{P,2006-08}}$
$Ps_{A,G}^{P,Y}$	**Surviving Population** at time Y by age and sex $Pt_{A,G}^{P,Y-10} * (1 - D_{A,G}^P)^{10}$ Surviving population under 10 calculated as: $(Ph_{A,female}^{P,Y} * (F_A^P)^{10}) * (1 - D_A^P)^{10}$ Births assumed to be evenly distributed across the decade with equal numbers in cohorts 1 & 2.

Migration – Modified Vital Statistics Method

$Ps_A^{P,2010}$

Surviving Population in 2010 by age.

$$Pt_{A-10}^{P,2000} - \left(\left(0.25 * D_{A-10}^{P,2000-09}\right) + \left(0.5 * D_{A-5}^{P,2000-09}\right) + \left(0.25 * D_A^{P,2000-09}\right)\right)$$

For cohorts under 10 years age, and 85 years and over in 2010- corresponding cohorts in 2000 do not exist (for those under 10 years), and 85 years groups from 75-79, 80-84 and 85P in 2000. For these cohorts, alternate ratios to the standard 0.25, 0.5, and 0.25 are used as shown in the table below.

Cohort 2000	Alt- 0.25	Alt-0.5	Alt-0.25	Cohort 2010
-	-	-	$(NB^{P,2000-09}/2)$*$(0.25*D_{0-4}^{P,2000-09})$	00-04
-	-	$(NB^{P,2000-09}/2)$*$(0.5*D_{0-4}^{P,2000-09})$	$0.25*D_{5-9}^{P,2000-09}$	05-09
75-79	$0.25*D_{75-79}^{P,2000-09}$	$0.5*D_{80-84}^{P,2000-09}$	$0.125*D_{85P}^{P,2000-09}$	85P
80-84	$0.25*D_{80-84}^{P,2000-09}$	$0.375*D_{85P}^{P,2000-09}$	-	85P
85P	$0.5*D_{85P}^{P,2000-09}$	-	-	85P

$MNpp_A^{P,Y}$

Migration, Net: estimate for prior period:

$Pt_A^{P,2010}$ - $Ps_A^{P,2010}$

$MNrpp_A^{P,Y}$

Migration, Net: rate for prior period:

$$\frac{MNpp_A^{P,Y}}{Pt_A^{P,Y-10}}$$

Cohorts 1 & 2 in year Y have a population at Y-10 of zero, so the rate is calculated as:

$$\frac{MNpp_A^{P,Y}}{Ps_A^{P,Y}}$$

$MNhyb_A^{P,Y}$

Migration, Net: hybrid estimate for future period:

If $MNpp_A^{P,Y} < 0$,
then $MNrpp_A^{P,Y} * Pt_{A,G}^{P,Y-10}$,
else, $MNpp_A^{P,Y}$

Negative rates for Cohorts 1&2 are applied to $Ps_A^{P,Y}$

$MAsct_A^{P,Y}$

Migration Adjustment, Sub Community Type:

Manually specified age-specific adjustments for Migration Rates, by Community Type

$MAmuni^{P,Y}$	**Migration Adjustment, Municipality:** Manually specified adjustments for Migration Rates, by municipality

Municipal Population Projection

$Pi_A^{P,Y}$	**Initial Total Population estimate** $Ps_{A,}^{P,Y} + MNhyb_A^{P,Y} + MAsct_A^{P,Y} + MAmuni^{P,Y}$
$Pa_A^{P,Y}$	**Adjusted Total Population** $(Pt_A^{Region,Y} / \sum_{\mathbf{164}} Pi_A^{P,Y})$ * $Pi_A^{P,Y}$
$Pgq_A^{P,Y}$	**Group Quarter Population** For population in cohorts 15-19 and 20-24, the group quarter population is held at a constant number same as 2010 GQ pop for place P, while for all other cohorts GQ pop is assumed as a share of total population. Assumptions about change in GQ pop share (PctChg or NumChg) or total number are accounted for in future year calculations. $Pa_A^{P,Y} * ((1 + Pct\Delta^{2010-Y}) * \frac{Pgq_A^{Y,2010}}{Pt_A^{Y,2010}})$ For cohorts 15-19 and 20-24 y.o, $(Pgq_A^{Y,2010} + Num\Delta^{2010-Y})$

Household and Housing Unit Projection

$Ph_A^{P,Y}$	**Household Population** $Pa_A^{P,Y}$-$Pgq_A^{P,Y}$
$Hh_{A,Ty}^{P,Y}$	**Households** Using regional headship rates by household type, households in each municipality by household type (family/ non-family) are estimated. $Ph_A^{P,Y} * H_{A,Ty}^{164,Y}$ Base year (Y-10) numbers are also calculated using the same method to estimate change in households. $Hh_{A,Ty}^{P,Y-10} = Ph_A^{P,2010} * H_{A,Ty}^{164,2010}$

$Hu^{P,Y}_{A,Ty,Tn,Un}$	**Municipal Housing Unit Preference**. By adjusting the PUMS housing unit preference to reflect the existing housing stock in each municipality (ACS data), a municipal specific housing unit preference is estimated for each cohort and household type.
$Hu\%\Delta^{Y}_{A,Un}$	**Housing Unit Preference change.** Assumption for percent shift in housing unit preference by age of head of household.
$Hu\Delta^{P,Y-(Y-10)}_{A,Ty,Tn,Un}$	**Housing Unit Change** by Age, Household Type, Tenure and Housing Unit Type. Using regional housing unit and tenure data (PUMS), one scenario for each municipality estimates the net demand in housing with regional preference. $(Hh^{P,Y}_{A,Ty}$*$(Hu^{164,Y}_{A,Ty,Tn,Un}$+$Hu\%\Delta^{Y}_{A,Un}))$- $(Hh^{P,Y-10}_{A,Ty}$* $Hu^{164,Y-10}_{A,Ty,Tn,Un})$ Municipal preference housing unit demand. $(Hh^{P,Y-10}_{A,Ty}$*$(Hu^{P,Y}_{A,Ty,Tn,Un}$+$Hu\%\Delta^{Y}_{A,Un}))$- $(Hh^{P,Y-10}_{A,Ty}$* $Hu^{P,Y-10}_{A,Ty,Tn,Un})$
$Vac\%^{P,2010}_{Tn}$	**Existing Vacancy** rate by tenure at each municipality.
$Hu\Delta^{P,Y-(Y-10)}_{Tn,Un}$	**Housing Unit Demand** Assuming regional vacancy rates by tenure for 2020 (7% for rental and 1.5% for owned units), total housing unit demand for each municipality is calculated. $((\sum_{A,Ty} Hu^{P,Y}_{Tn,Un})/(1-Vac\%^{P,Y}_{Tn}))$--$((\sum_{A,Ty} Hu^{P,2010}_{Tn,Un})/(1-Vac\%^{P,2010}_{Tn}))$ For subsequent decades (beyond 2020), the vacancy rate by tenure was applied to the net housing unit demand. $\sum_{A,Ty} Hu\Delta^{P,Y-(Y-10)}_{Tn,Un} \quad * \; Vac\%_{Tn}$