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Projecting Prison Populations with SAS® Simulation Studio

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ABSTRACT

The majority of the states in the USA have a process to project prison populations for the purpose of planning adequate capacity. Typical time series methods are ineffective because they do not take into account factors like sentence length, prior criminal history, revocations of community supervision, and legislative changes. Discrete event simulation has proven to be a viable alternative. The North Carolina Sentencing and Policy Advisory Commission collaborated with SAS to build a model in SAS Simulation Studio that projects the number of prison beds needed for the next ten years. The model uses current prison population data, recent court convictions, revocations of community supervision, and estimates of growth to play out the admissions and releases of inmates over the time horizon of the model. The prison projections are updated by the Sentencing Commission on an annual basis.

INTRODUCTION

The North Carolina Sentencing and Policy Advisory Commission has a legislative mandate to prepare prison population (bed) projections on an annual basis. The projections are prepared in conjunction with the Department of Public Safety and are used by the Department and the General Assembly to help determine correctional resource needs for adult offenders. The ten-year prison population projections are an important tool for balancing sentencing and correctional policies with available resources, such as prison capacity and correctional supervision in the community.

For more than twenty years, the NC Sentencing Commission has been using a C-based simulation model to project North Carolina's prison population. The availability of criminal justice system data in combination with this simulation model has resulted in highly accurate projections over the years. However, with the NC General Assembly's passage of the Justice Reinvestment Act of 2011, the most significant changes in over twenty years were made to the state's sentencing and correctional practices.

In order to incorporate the significant changes to North Carolina's criminal justice system into the prison projection process, the Administrative Office of the Courts contracted SAS Institute to develop a new prison population projection model for the Sentencing Commission. This collaboration focused on the development of a simulation model to project the adult felon prison population using SAS Simulation Studio. There are several advantages to using Simulation Studio to develop the new model. First, the user-interface available with Simulation Studio gives transparency to the process flow of the model, all the way down to the level of specific computational formulas. The user can adjust the model by making changes to the logic, data formats, and formulas, as well as to the output data that is collected and post-processed. With the old model, the user is only able to adjust values for certain pre-defined parameters, not the actual logic or formulas used to drive the simulation. Furthermore, the user is unable to adjust the pre-defined model outputs. Finally, the Simulation Studio model is designed to use existing SAS data sets that contain probabilistic information needed to drive the simulation model, whereas in the old model these values have to be manually entered. Since Simulation Studio is under active development, future support for the model is available.

The following sections provide an overview of the model built in Simulation Studio of the prison projection process, beginning with a description of the inputs required to drive the simulation and the output data collected. A description is then given of the general process flow of an offender through the NC correctional system and how this process is translated into a Simulation Studio model. Finally, the steps required to run the model and generate the projections are provided.

MODEL INPUTS AND OUTPUTS

The primary purpose of the Simulation Studio model is to project the adult felon prison population in North Carolina. Misdemeanors are not considered in the model because, under current law, most misdemeanants serve their active

sentences in local jail facilities (that is, not prison). It is also not necessary to consider juveniles in the model because resource projections for juveniles are prepared separately.

The projections are developed using the following inputs: court data, stock data, parameter data, and growth estimates. The two primary sources of data used to produce the projections are the Administrative Office of the Courts (AOC) and the Department of Public Safety's Division of Adult Correction (DAC). The court data from the AOC contain information on convictions and sentences imposed during the most recent fiscal year, while the stock data from the DAC provide a snapshot of the resident inmate population (the inmates who are currently in prison) at the beginning of the projection period. The court and stock data files contain individual-level information including demographics, offense information, and sentence information. The model uses the court data on convictions to project new prison admissions over the ten-year projection period. The sentence length information for new convictions and the expected release dates for the DAC's resident prison population are used to determine the timing of releases from prison over the ten-year projection period. The model simultaneously processes prison releases and prison admissions to determine the projected prison population at any given time over the projection period.

While the model primarily uses data on individuals for its projections, aggregate-level data from the AOC and the DAC are also used to determine various parameters for the simulation model. For example, the AOC data on convictions are used to determine the probability of receiving an active sentence (prison sentence) by offense class and prior record level. Data from the DAC are used to determine confinement rates for violations of probation and post-release supervision by offense class, as well as the lag-time between placement on probation or post-release supervision and return to prison for violations of the conditions of supervision.

In addition, the projections take into account external factors such as North Carolina's population growth or crime trends through the development of growth rates for each year of the projection. The growth rates are determined by the Sentencing Commission's Forecasting Advisory Group after examining demographic trends, crime trends, arrest trends, court filing and disposition trends, and prison entry and exit trends. The growth rates help account for anticipated changes in the growth of convictions over the projection period.

The outputs for the simulation model include annual prison population projections with breakdowns by various attributes that are important for prison facility planning (such as sex and age). Information is also captured on total admissions and releases, as well as on specific categories of admissions and releases.

In addition to producing the overall prison population projections, Sentencing Commission staff use the simulation model to produce impact projections during the legislative session for bills that affect criminal penalties. The overall prison projections are also the foundation of prison custody projections prepared by the Department of Public Safety.

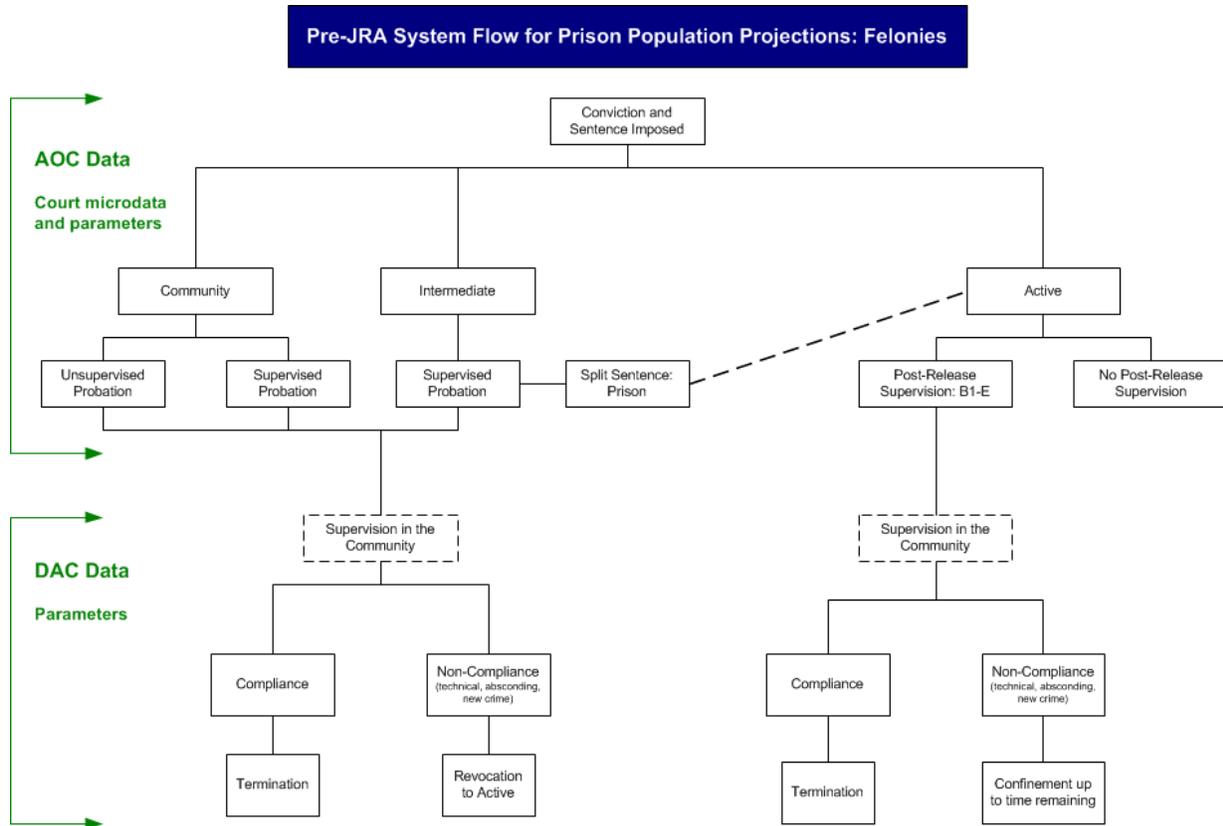
PRISON PROCESS FLOW

The prison population is primarily determined by the empirical distribution of offenders convicted and sentenced under the Structured Sentencing Act. Offenders convicted of felony offenses are sentenced using the felony punishment chart. The punishment imposed (active, intermediate, or community sentence) and sentence length are determined by the seriousness of the offense (offense class) and the offender's prior criminal history (prior record level). Under current law, offenders with an active sentence serve their sentence in prison and are placed on post-release supervision (PRS) for a period of 12 months (Class B1-E felons), 9 months (Class F-I felons), or 60 months (sex offenders) upon their release. Offenders with a non-active sentence (an intermediate or community sentence) are placed on probation and supervised in the community. Violation of the conditions of probation or post-release supervision may result in prison confinement.

North Carolina's Justice Reinvestment Act (JRA) of 2011 made substantial changes to the state's sentencing practices and correctional policies. Some of the most substantial changes are in relation to the supervision of offenders in the community on probation or PRS. For probation and PRS, limits are now placed on confinement for technical (non-new crime) violations of the conditions of supervision, with revocation and activation of the full suspended sentence available only for those who abscond supervision or commit a new crime. PRS, which was previously available only for offenders convicted of Class B1-E felony offenses (violent felonies), has been expanded to offenders convicted of Class F-I felony offenses (non-violent felonies). The changes to the criminal justice system under the JRA will impact prison admissions, prison releases, and time to be served – all critical factors in determining and projecting the prison population.

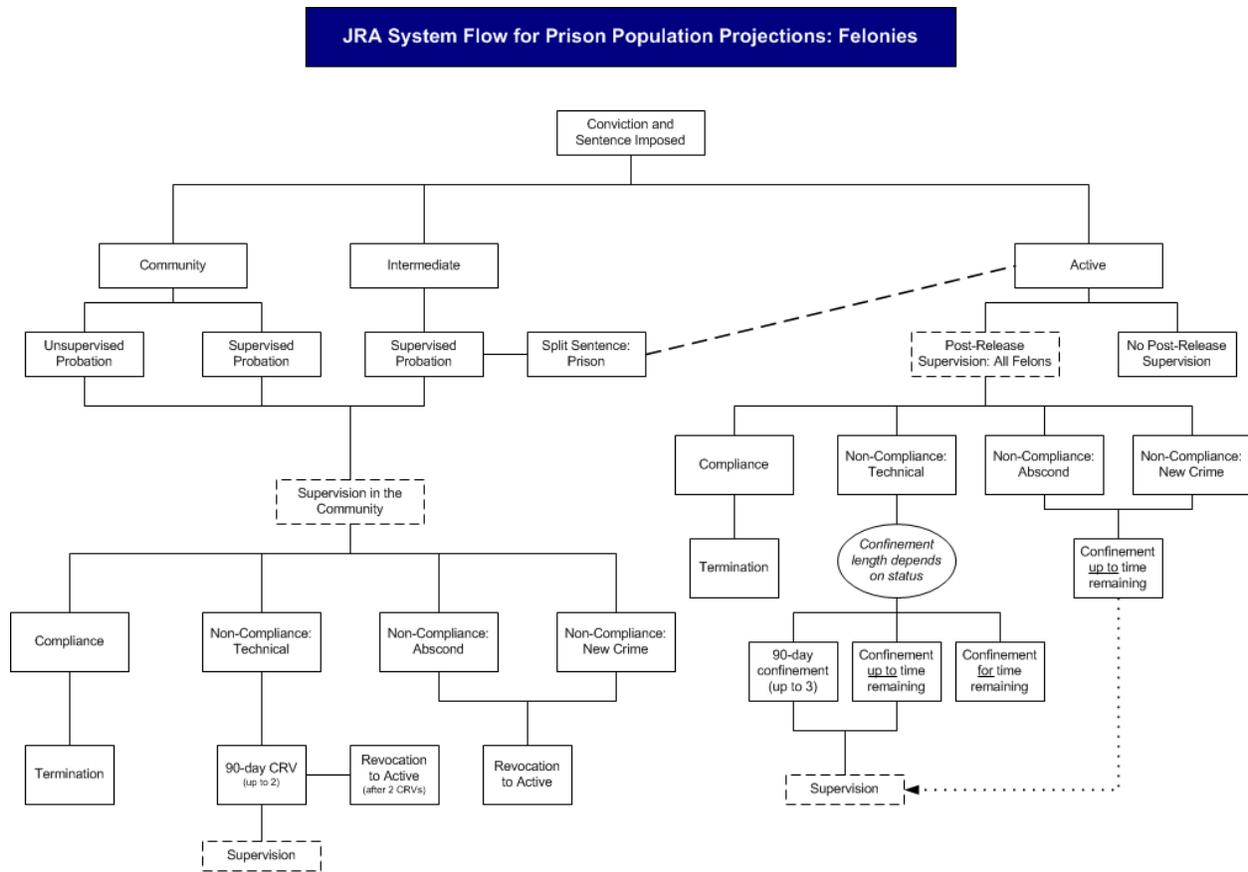
Flowcharts of the criminal justice system were developed to provide the framework for the Simulation Studio prison projections model (see Figure 1 for the Pre-JRA system flow and Figure 2 for the JRA system flow). The system flow does not differ at the initial point in the process – convictions and sentences imposed are the starting points for projecting new admissions. An offender's path through the system depends on the type of punishment imposed: active punishment or supervision in the community with a community or intermediate punishment. The primary differences in system flow between the two processes in Figures 1 and 2 center around which offenders receive post-release supervision and what happens when offenders on probation or PRS are non-compliant. Prior to the JRA (as

shown in Figure 1), PRS was limited to Class B1-E felons and there were no distinctions in terms of the length of confinement for probation or PRS non-compliance based on the type of violation (technical, new crime, or absconding). With the JRA, PRS has been expanded to all felons and the length of confinement varies based on the type of violation.



NC Sentencing and Policy Advisory Commission
5/2/2012

Figure 1. System Flow Before the Justice Reinvestment Act



NOTE: This diagram provides a summary system flow. See also detailed system flow diagrams for Probation, Post-Release Supervision, and Post-Release Supervision for Sex Offenders.

NC Sentencing and Policy Advisory Commission
5/24/2012

Figure 2. System Flow After the Justice Reinvestment Act

SIMULATION MODEL OVERVIEW

Even though most of the JRA provisions went into effect December 1, 2011, there will be a period of time for which portions of the JRA do not apply to certain offenders. As a result, the new simulation model must incorporate both the pre-JRA and JRA process flows shown in Figures 1 and 2 in a single combined model. This section describes the various components of the model and how the JRA and pre-JRA process flows were translated into a Simulation Studio model. Figure 3 shows the combined model as built in Simulation Studio. Each square in Figure 3 is a Simulation Studio Compound block that can be opened to display the logic collapsed within. For additional detail on the Simulation Studio blocks mentioned in this section and on Simulation Studio in general, please see the Simulation Studio documentation (SAS Institute Inc. 2012).

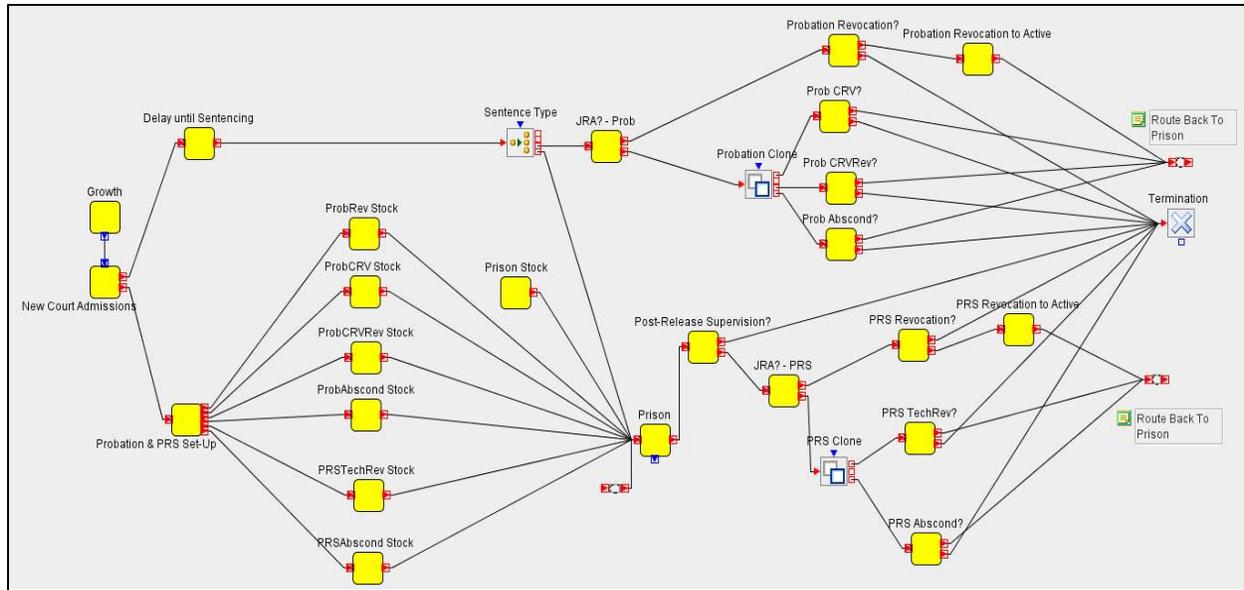


Figure 3. Combined Model in Simulation Studio

ENTITY GENERATION

The entities in the model represent cases and have attributes (or properties) such as case number, gender, race, age, and prison term. At the start of the simulation (time 0), three different groups of case entities are generated. First, a case entity is generated for each row in the prison stock data set and the demographic, offense, and sentence information for each case is stored as attributes on the entity. After creation, the prison stock case entities are routed to the prison block where they are held until the release time is reached.

Second, case entities are generated at time 0 to represent those currently on PRS and probation for each type of non-compliance at the start of the projection period. Because these case entities represent the individuals not currently in prison and because the data for cases subject to non-compliance are not readily available, it is necessary to estimate the number of prison entries each month due to non-compliance resulting from a case that is not in prison at time 0 of the simulation. This is achieved by sampling future releases from the prison stock data and backdating the release time so that it occurs before time zero. The result is a population of case entities at time 0 that are out in society but still under some form of supervision with a possibility of revocation for non-compliance.

Third, case entities are generated at time 0 for each row in the court data set. After creation, these case entities (representing new court admissions) are routed to a Delay block where they wait until their sentencing time so that convictions are properly distributed across each fiscal year during the simulation. Every twelve months, case entities are generated again for each row in the court data set and the weight for each case entity is increased by the growth rate for the current year. The weight attribute assigned to each case entity represents the number of actual people that the case entity represents. A single person can have multiple cases, and there are no identifiable data available to indicate when two different cases pertain to the same person. Therefore, the initial weight of a case is determined by computing the ratio of the number of people in prison to the number of cases with active sentences. The weight is increased each year by the percentage of growth expected in that year.

PROBATION PROCESSING

When the sentencing time for a new court admission case entity is reached, a Switch block is used to route the entity to either the prison block or the probation processing part of the model, depending on the sentence type. In the probation processing part of the model, entities are randomly selected for revocation as a result of probation violations, with revocation rates applied by offense class.¹ Prior to the JRA, there were no distinctions made between those revoked for technical violations of supervision, for absconding supervision, or for committing a new crime. Under the JRA, there is a different response and different sentence length depending on the different types of violations – revocation may only occur for those who abscond supervision or commit a new crime. For technical

¹ The term “revocation” is used as an overall term to describe the different confinement responses available for violations of probation or post-release supervision.

violations, 90-day periods of confinement (known as CRVs) may be imposed, with revocation available only after imposition of two prior CRVs. Those case entities that are randomly selected for one of these revocation events will be routed back to the prison block after a delay representing the length of time until the event occurs. Those case entities that do not have a revocation event exit the model. Figure 4 shows an expanded Compound block as an example of the detailed Simulation Studio logic used to model revocation, including blocks for sampling random numbers and routing the case entities.

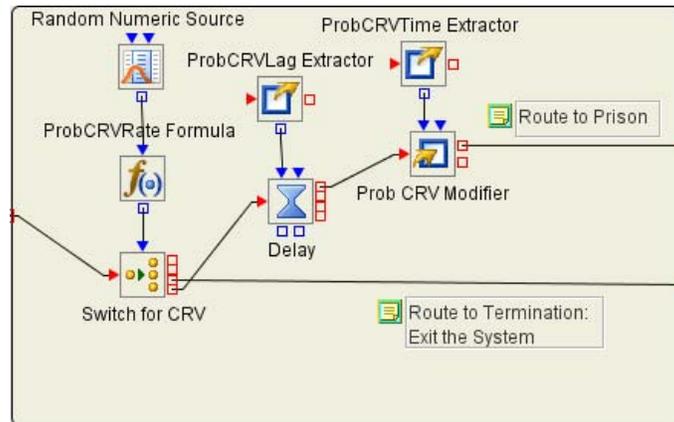


Figure 4. Expanded Compound Block for Revocation Logic

POST-RELEASE SUPERVISION PROCESSING

When the prison sentence duration for a particular case entity is complete, the entity is routed to the post-release supervision part of the model. Prior to the JRA, post-release supervision was limited to Class B1 through Class E felons. With the JRA, post-release supervision has been expanded to Class F through I felons. Much like the probation processing, entities are randomly selected for revocation as a result of violations of post-release supervision, differentiating between types of violations for the JRA process. Those case entities that are selected for revocation will be routed back to the prison block after a delay representing the length of time until the event occurs. Those case entities that do not have a revocation event exit the model.

RUNNING THE MODEL

One particularly useful feature of Simulation Studio that makes running the model easier is the ability to define specific model parameters as factors and include them in the Simulation Studio Experiment window. The file paths for the court, stock, and growth data are set as factors so that they can easily be changed when necessary. The numbers of observations in the court and stock data sets are also defined as factors. With this approach, the user only has to make edits to the Experiment window, rather than trying to find the specific block in the model where the parameter is located.

During a simulation run, the Bucket block is used to collect the data. As each case entity enters prison, it first passes through a Bucket block where its attributes are recorded as a row in a SAS data set. Similarly as each entity leaves the Delay block representing prison, it passes through another Bucket block where its attributes are again recorded as a row in a SAS data set. At the end of the simulation, the two SAS data sets generated by the Bucket blocks provide a complete history of prison admissions and releases over the ten-year projection period. Figure 5 shows the expanded Compound block for prison including the Delay block and the two Bucket blocks used to capture data for admissions and releases.

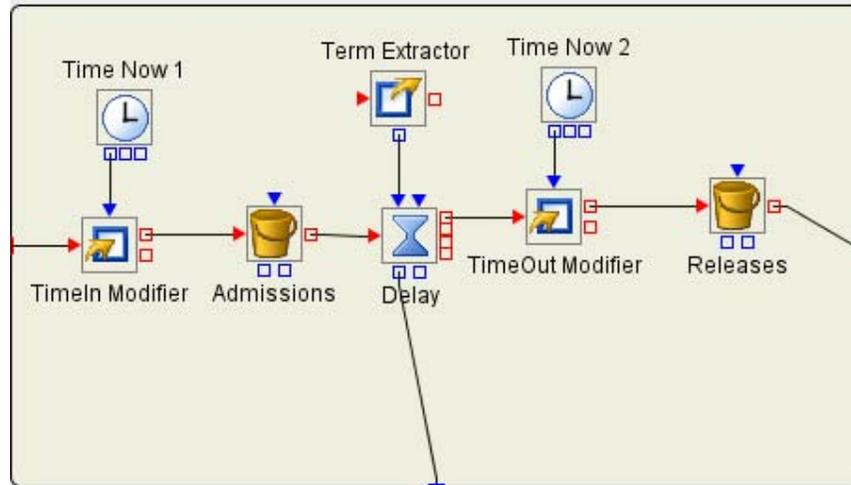


Figure 5. Expanded Compound Block for Prison Logic

The raw admission and release data (in the format of SAS data sets) provide the basis for computing the total weight of cases, which corresponds to the total number of estimated people in prison during each month. Having access to all of the case entity attributes in the data sets allows a SAS coder to use Base SAS data steps and procedures such as SQL to track population numbers according to any combination of attributes. The most common attributes are age, gender, and type of offense. The current post-processing code produces SAS data sets containing monthly populations for each of these attributes as well as the total population.

Common practice in simulation is to run more than one replication to get results with greater statistical robustness. Simulation Studio allows the user to control the number of replications run for the prison projection model. Results from multiple replications are averaged in the post-processing code.

VALIDATION

The accuracy of the Simulation Studio model was tested using the pre-JRA portion of the new simulation model. Multiple years of historical data were utilized for the testing, with the accuracy of the new model compared to the actual prison population and to previous projections. Once the accuracy of the Simulation Studio model was affirmed for the pre-JRA process, the model was modified to incorporate the new criminal justice processes under the JRA and was tested against the projections published in February of 2012 (NC Sentencing and Policy Advisory Commission 2012).

RESULTS

The first official results obtained from the new Simulation Studio model were published in February of 2013 (NC Sentencing and Policy Advisory Commission 2013). Figure 6 presents the projected prison population and capacity for FY 2013 through FY 2022. The prison population is projected to increase from 36,838 to 37,680 across the ten-year projection period – an increase of 842 or just over 2%. Figure 7 contains a graph of the past prison population and future projections in relationship to standard and expanded operating prison capacity. The current projections, as well as projections from previous years, are located on the Sentencing Commission's [website](#).

PRISON POPULATION PROJECTIONS AND CAPACITY

Fiscal Year End	Prison Population as of June 30 ¹		Prison Capacity ^{2,3}	
	Previous Projection	Current Projection	Expanded Operating Capacity	Standard Operating Capacity
2013	38,999	36,838	40,718	34,779
2014	39,062	36,967	40,970	34,973
2015	39,091	37,107	40,970	34,973
2016	39,047	36,861	40,970	34,973
2017	39,135	36,748	40,970	34,973
2018	39,291	36,722	40,970	34,973
2019	39,490	36,894	40,970	34,973
2020	39,699	37,179	40,970	34,973
2021	39,976	37,468	40,970	34,973
2022	N/A	37,680	40,970	34,973

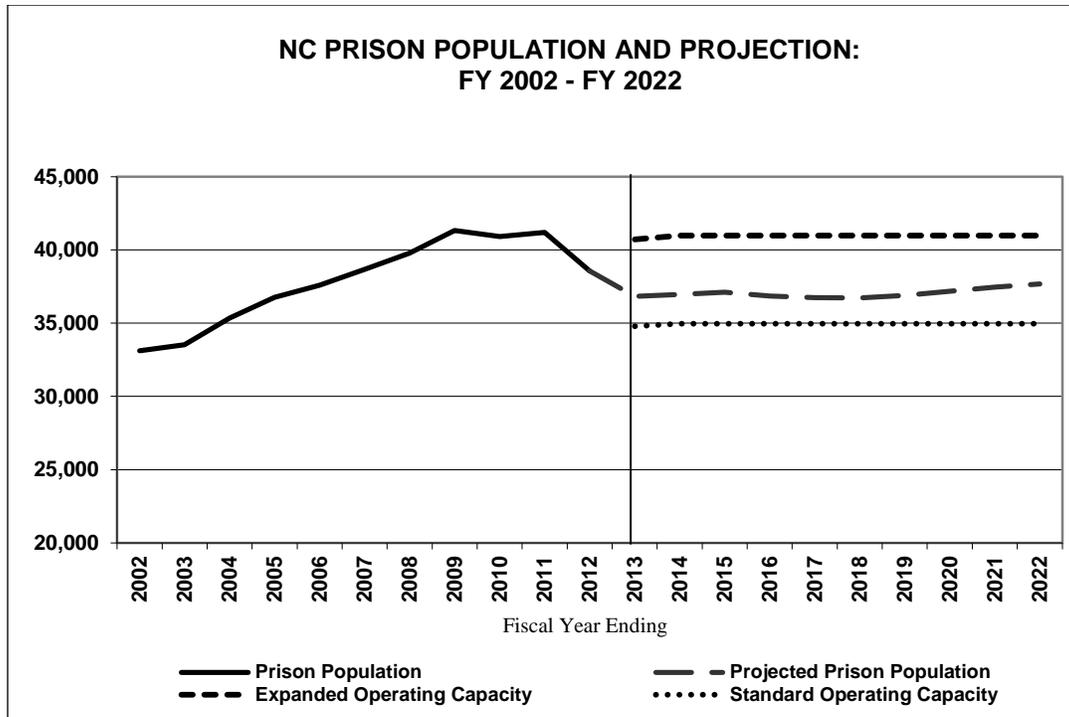
SOURCE: NC Sentencing and Policy Advisory Commission and NC Department of Public Safety

¹The previous projection, which was released in February 2012, was based on assumptions about how the criminal justice system will operate under the JRA and was developed using the old projection model. Because the old projection model was designed to simulate the processes of the criminal justice system as it existed prior to the JRA, there were limitations in incorporating changes under the JRA into the projection.

²Standard Operating Capacity (SOC) is the number of single cells with one inmate per cell plus the number of inmates who can be housed in dormitories by dividing the gross square feet of each dormitory by 50 square feet and rounding to the closest double bunk configuration. Expanded Operating Capacity (EOC) is the number of inmates housed in dormitories that operate at varying percentages (not to exceed 130%) beyond their SOC, plus the number of single cells with one inmate per cell, plus the number of single cells that house two inmates per cell.

³The EOC and SOC capacity estimates for 2013 include minor changes due to conversion in bed types, as well as expansions at Lanesboro CI (504 medium custody), Bertie CI (504 medium custody), and Maury CI (504 medium custody). The increases in funded capacity for 2014 include expansion at Tabor CI (252 minimum custody).

Figure 6. Projections for Year 2013



SOURCE: NC Sentencing and Policy Advisory Commission and NC Department of Public Safety

Figure 7. Projections Compared to Operating Capacity

CONCLUSION

This project exemplifies a successful effort in applying Simulation Studio to model a complex real-life system and to produce long-term projections of the associated high-stakes resource needs of that system. The requisite elements of the effort included a sophisticated computer model and a fully articulated and analyzed real life system. The ultimate test of the model, of course, will be the accuracy of the projections over time, and its elasticity to be revised as needed to reflect empirical changes in the system and the wider sociopolitical environment within which it functions. The infrastructure and basic logic of the model can also be extended to project other criminal justice populations both in North Carolina and other states.

REFERENCES

NC Sentencing and Policy Advisory Commission. 2013. *Current Population Projections: Fiscal Year 2013 to Fiscal Year 2022*. Raleigh, NC: NC Sentencing and Policy Advisory Commission

NC Sentencing and Policy Advisory Commission. 2012. *Current Population Projections: Fiscal Year 2012 to Fiscal Year 2021*. Raleigh, NC: NC Sentencing and Policy Advisory Commission

SAS Institute Inc. 2012. *SAS Simulation Studio 12.1: User's Guide*. Cary, NC: SAS Institute Inc.

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