



Ministry
of Justice



Prison Population Projections 2016 – 2021 England and Wales

Ministry of Justice
Statistics Bulletin

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Introduction

This bulletin presents prison population projections for England and Wales from August 2016 to March 2021. It is produced to aid policy development, capacity planning and resource allocation within the criminal justice system (CJS) and the National Offender Management Service (NOMS). The latest published useable operational capacity (19 August 2016) is 87,001¹.

The projection is produced using a model of flows of offenders into and out of prison which counts the resulting prison population each month. It is based on assumptions about future custodial convictions and incorporates the anticipated impacts of agreed policy and procedural initiatives. It does not, however, attempt to estimate the impact of any future Government policy that is yet to achieve Royal Assent, and therefore becomes less certain over time.

The latest statistics and commentary on the current and historic prison population are published in the Offender Management Statistics Quarterly publication. This is available online on GOV.UK at: www.gov.uk/government/collections/offender-management-statistics-quarterly

The Story of the Prison Population provides a summary of what happened to the prison population between 1993 and 2016 and the major factors contributing to these changes:

<https://www.gov.uk/government/statistics/story-of-the-prison-population-1993-to-2016>

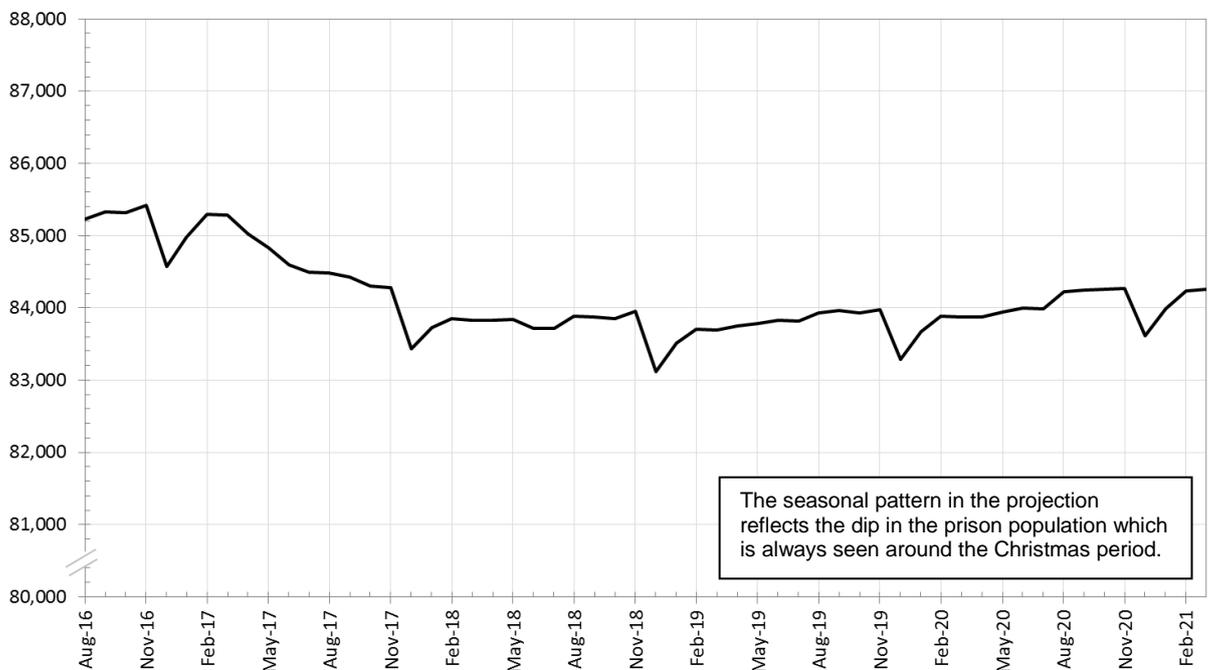
The next edition of the Annual Prison Population Projections will be published on **Thursday 24th August 2017 9:30am**.

¹ <https://www.gov.uk/government/statistics/prison-population-figures-2016>

Key findings

- The prison population is projected to remain largely stable over the projection horizon to March 2021.
- The projection of a small decline in the prison population reflects a lower level of demand on the criminal justice system that has been observed in upstream crime levels and court receipts. Falls in court receipts have already been reflected in a lower remand population, with the determinate sentenced population taking longer to adjust to the lower level of demand.
- In the longer term underlying growth in the determinate sentenced population is expected due to recent trends in offender case mix, where we have seen more serious cases (e.g. sexual offences) come before the courts. This results in offenders receiving longer custodial sentence lengths, which in turn places an upward pressure on the prison population.
- The over 50, over 60 and over 70 year old populations are projected to rise both in absolute terms and as increasing proportions of the total population. This is driven by projected shifts in the offence mix of prisoners towards offences which have a disproportionate impact on these age-groups relative to the rest of the prison population (e.g. increases in the number of sexual offenders).

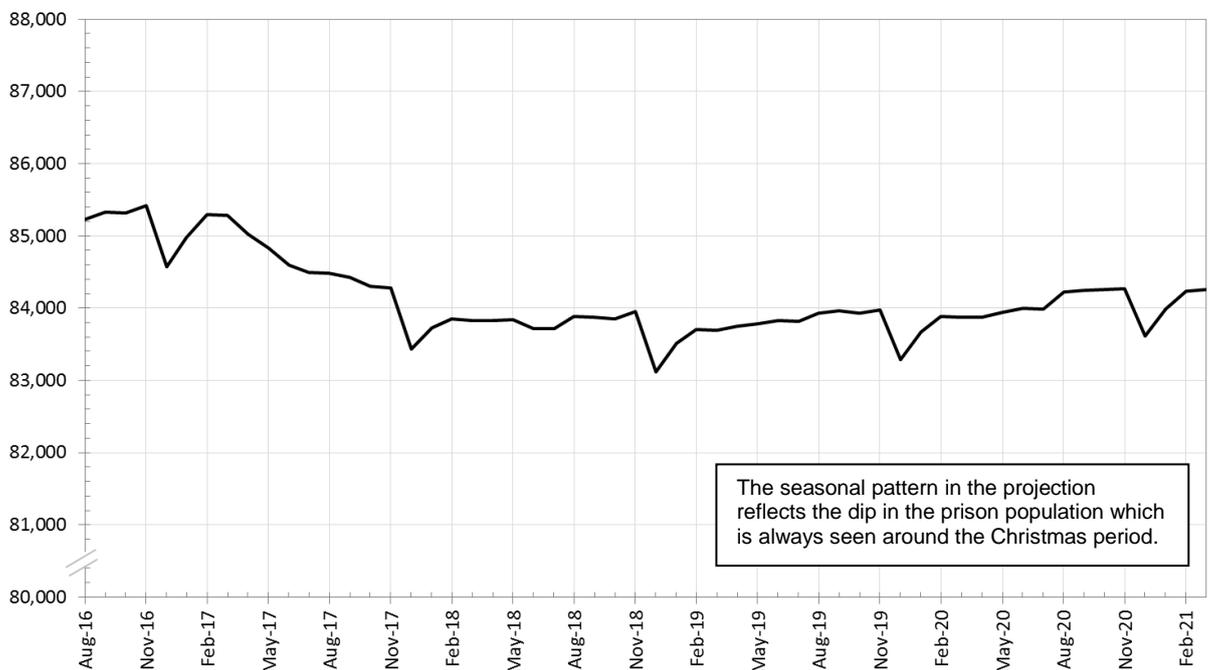
Chart 1: Total population projections for August 2016



1. The 2016 projection

The prison population is projected to remain largely stable over the projection horizon to March 2021. In the short run the population is projected to increase to a peak of 85,400 in November 2016. It is then projected to decline in the medium term to a lower position of 83,700 in March 2019 (ignoring the seasonal low in December 2018), as the population responds fully to lower projected levels of court receipts. The population is then projected to rebound to 84,300 at the end of the projection in March 2021. Chart 1 presents the prison population projection from August 2016 to March 2021.

Chart 1: Total population projection for August 2016



The small projected decline in the medium-term population, relative to current levels, reflects lower levels of demand on the criminal justice system observed in upstream crime levels and court receipts. Receipts into both the magistrate’s court and the Crown Court have declined since 2014, most noticeably in Triable-either-way cases which account for the majority of custodial sentences issued. Falls in court receipts are already reflected in a lower remand population, while the determinate sentenced population² is expected to take some time to adjust to the lower level of demand.

In the longer term, underlying growth in the determinate sentenced population is expected due to recent trends in offender case mix, where we have seen more serious cases (e.g. sexual offences) come before the courts. This results in offenders receiving longer custodial sentence lengths, which in turn places an upward pressure on the prison population. Growth in the sentenced determinate

² The remand population is made up of defendants who spend time in custody before their trial and sentence. A determinate sentence is one where the court has set the length of the sentence imposed, for example 12 months’ imprisonment.

population serving custodial sentences of 4 or more years further reflects the abolition of Sentences of Imprisonment for Public Protection³ (IPPs) and the resulting increase in offenders receiving longer determinate tariffs, including those sentenced to Extended Determinate Sentences⁴ (EDS).

The indeterminate population is projected to continue declining over time. The indeterminate population consists of those offenders who continue to serve Sentences of Imprisonment for Public Protection (IPPs) and life sentences. As a result of the abolition of the IPP sentence in 2012, offenders are no longer receiving these sentences. IPP prisoners are only therefore being released or recalled. All indeterminate recalls are counted in the recall projection.

The Recall population⁵ is projected to increase slightly above current levels. This reflects growth in the population of offenders recalled under the Offender Rehabilitation Act (ORA) 2014, which is explained in more detail below. Further growth is driven by the increases in the indeterminate recall population. Prisoners released from indeterminate sentences remain on licence for long periods following their release from prison. As the number of indeterminate sentenced offenders released from prison increases, driven by the declining IPP population, the number of indeterminate recalls is projected to increase.

Further changes in the prison population are expected as the result of a range of policies, including those already in effect but not yet fully represented in the population and those expected to take effect over the projection horizon. The projections only take into account the impact of government policies which have achieved Royal Assent⁶. These include:

- The impacts of the Offender Rehabilitation Act 2014, whereby offenders sentenced to custodial sentences of less than 12 months are now released subject to licence with a resulting possibility of being recalled to custody. This also incorporates a new post-sentence supervision period following licence for offenders released from custodial sentences of less than 2 years, again with potential for breach and return to custody for that breach offence⁷;

³ Sentences of Imprisonment for Public Protection (IPPs) were created by the Criminal Justice Act 2003 and started to be used in April 2005. Offenders sentenced to an IPP are set a minimum term (tariff) which they must spend in prison. After they have completed their tariff they can apply to the Parole Board for release. The Parole Board will release an offender only if it is satisfied that it is no longer necessary for the protection of the public for the offender to be confined.

⁴ Extended Determinate Sentences are sentences for dangerous criminals convicted of serious sexual and violent crimes with no automatic release from prison halfway through their sentence. Offenders are only released when they have served at least two-thirds of their prison sentence and may be kept inside prison until the end of their term.

⁵ When an offender is released from custody they may be released under licenced supervision to the Probation Service, They will be subject to a set of licence conditions such as living at an address approved by the Probation Service. If the offender breaches the conditions of their licence they may be recalled into prison.

⁶ Once a bill has completed all parliamentary stages, it is ready to receive Royal Assent. This is when the Queen formally agrees to make the bill into an Act of Parliament (source: <http://www.parliament.uk/about/how/laws/passage-bill/lords/lrds-royal-assent/>)

⁷https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/199804/offender-rehabilitation-bill-impact-assessment.pdf

- Following the Release on Temporary Licence (ROTL) review in January 2014, all offenders who have previously absconded are no longer returned to the open estate or released on temporary licence except in exceptional circumstances;
- The impacts of the Criminal Justice and Courts Act 2015 which includes provisions for restricting the use of cautions; changes to the framework for the sentencing and release of serious and dangerous sexual and violent offenders; and the introduction of a new test for the release of recalled determinate sentence prisoners⁸;
- The impacts of the Serious Crime Act 2015 which includes provisions for additional caseload and associated custodial sentences relating to new offences for controlling or coercive behaviour in an intimate or family relationship⁹;
- The impacts of the Prisoner Transfer Framework Decision allowing the UK to deport and receive prisoners to and from other EU member states¹⁰;
- The impacts of the Modern Slavery Bill, which introduces Slavery and Trafficking Prevention Orders (STPOs) and Slavery and Trafficking Risk Orders (STROs). Breach of these orders may result in a prison sentence¹¹.

Appendix A contains tables for projected end of June populations¹², average financial year populations and total monthly populations. More detailed breakdowns of the projections are provided for specific sub-populations.

⁸ <https://www.gov.uk/government/publications/criminal-justice-and-courts-bill-impact-assessments>

⁹https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/370943/Serious_Crime_Bill_-_Overarching_Impact_Assessment_-_Commons_Intro.pdf

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/393814/Impact_Assessment_-_Strengthening_the_Law_on_Domestic_Abuse.pdf

¹⁰www.gov.uk/government/uploads/system/uploads/attachment_data/file/326699/41670_Cm_8897_Print_Ready.pdf

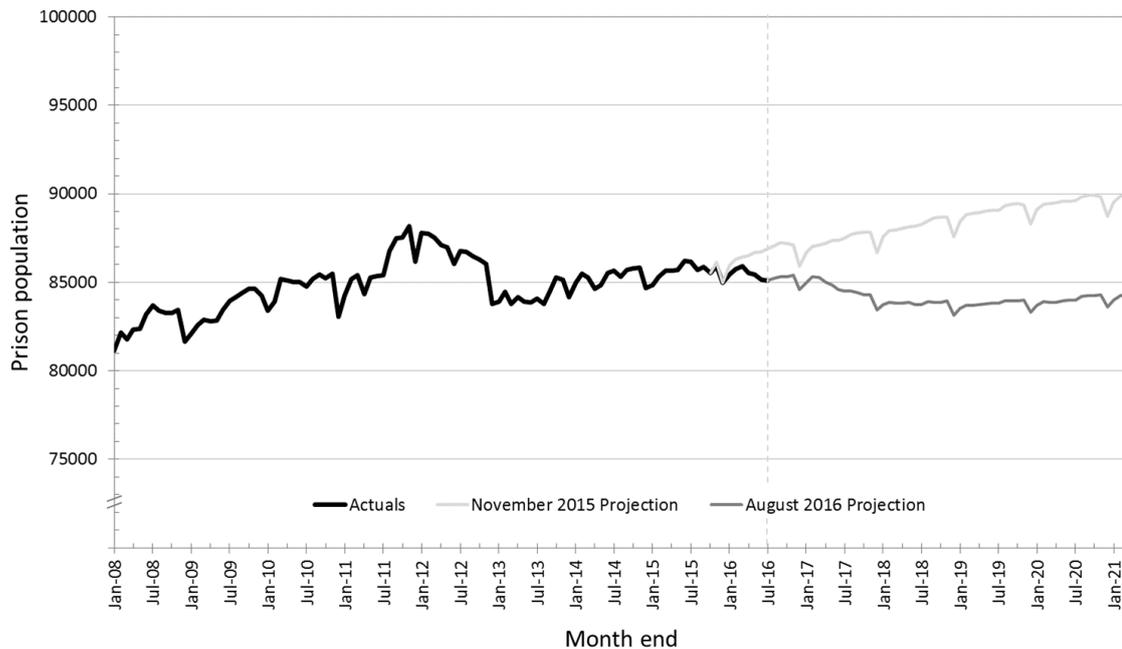
¹¹https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/371057/MSB_IA.pdf

¹² June is chosen as it is a month relatively free from seasonal effects and therefore provides a robust measure of the prison population for comparison

2. Comparison to previous projection

A comparison of the November 2015 total population projection against actuals to date and the latest August 2016 projection is presented in Chart 2. At the end of July 2016 the total prison population was tracking 1,800 places below the November 2015 projection (-2%).

Chart 2: Comparison of November 2015 total population projection against actuals and latest August 2016 projection



The 2016 projection reflects the reduction in criminal justice system demand observed since the previous projection. Falls in remand relative to levels projected previously account for the majority of this decline to date. The delayed impact of continuing lower demand on the sentenced determinate population drives further divergence from the previous projection in the longer term.

3. Uncertainty in the projection

Chart 3 shows the 2016 projection as a solid line. This can be interpreted as the single most likely population projection, given the agreed set of assumptions. Around the projection are three bands, indicating the range of expected populations with estimated 30%, 60% and 90% likelihoods. For all bands the width increases over time, as the level of uncertainty increases with time after the date of projection.

Chart 3: Uncertainty in 2016 total population projection

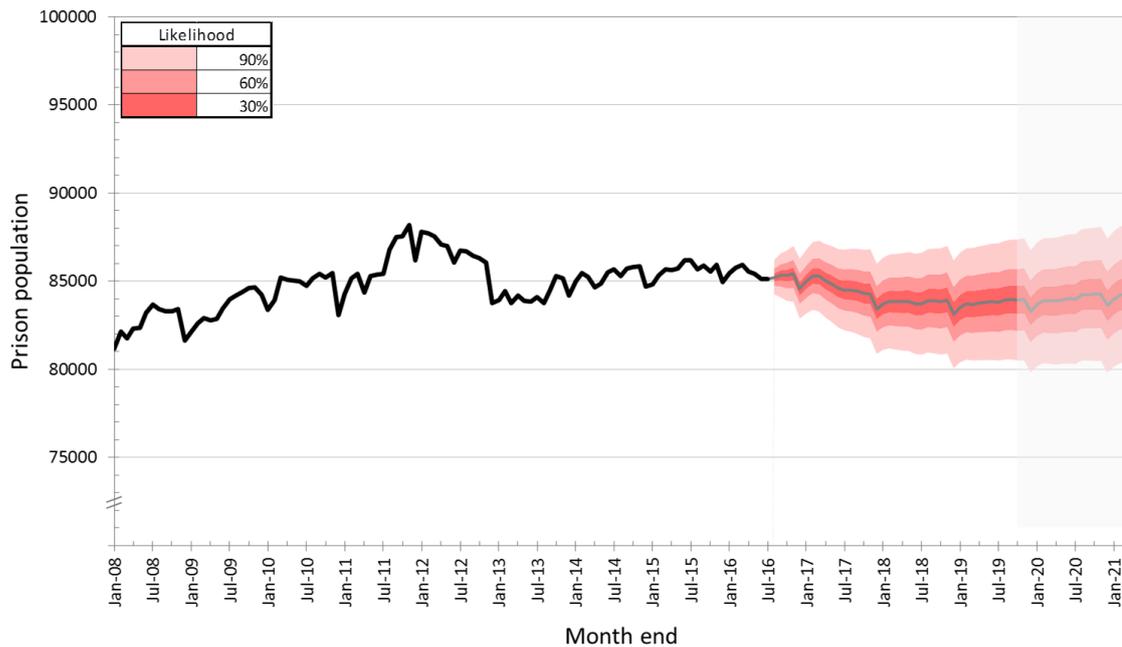


Table A.8 in appendix A provides measures of each likelihood bound relative to the population projection.

The methodology for calculating the fan chart is described in appendix C of this publication. The methodology has been refined since the previous publication, where this fan chart was included as an experimental statistic. An additional 9 months of observed data has been included for comparison against previous projections.

As there are only a limited number of previous published projections, sufficient data on past performance of published projections beyond a three year horizon is not yet available. The shaded portion of the chart is therefore estimated based on extrapolation rather than past measurement of performance

4. Projection of over 50, 60 and over 70 year old populations

The over 50, over 60 and over 70 year old populations are projected to rise both in absolute terms and as increasing proportions of the total population. This is driven by projected shifts in the offence mix of prisoners (e.g. increase in the number of sexual offenders) which has a disproportionate impact on these age-groups relative to the general prison population.

The over 50 year old population is projected to grow from 12,700 as at 30 June 2016¹³, to 13,900 by the end of June 2020. The over 60 year old population is projected to grow from 4,500 to 5,400 over the same period.

We have extended the age projection methodology this year to include projections of the over 70 year old prison population. This group is projected to grow from 1,400 at June 2016 to 1,900 in June 2020.

¹³ Table 1.3 Offender Management Statistics Quarterly :
<https://www.gov.uk/government/statistics/offender-management-statistics-quarterly-january-to-march-2016>

5. Modelling methodology

The prison projections model is part of wider work within the Ministry of Justice to develop a consistent and coherent suite of models of the criminal courts and offender management, driven by common projections of demand for the Ministry of Justice's services. Two key components of this suite are used to develop these projections, a custodial convictions model and a prison population projection model.

The custodial convictions model is driven by projections of numbers of defendants entering the criminal courts. In order to project volumes of defendants being given a custodial sentence, it also takes into account:

- the age, gender and offence of defendants entering the system;
- resources required to process cases through the courts; and
- the sentences which concluded cases attract.

The prison population projections model takes projections of custodial convictions, converts them to projections of prison receptions and then models the amount of time that offenders spend in prison to calculate the resulting prison population. The model also simulates the ageing of the prison population over time. The benefits of this method are that it allows us to:

- explicitly project custodial convictions (rather than just convictions);
- understand the criminal justice system factors which contribute to change in the prison population, such as time served, sentences given, changes to court processes or shifts in defendant demographics; and
- more easily model the impact on the prison population of specific Ministry of Justice and other criminal justice agency policy changes relating to specific offences or specific sentences.

The assumptions informing these projections, and therefore the projections themselves, are subject to uncertainty. The level of uncertainty of the projections is estimated and presented in Chart 3 above and Table A.8 in appendix A. The methodology applied to estimate the uncertainty in the projection is outlined in appendix C.

The projection model is based on latest available data from various sources including court proceedings and performance data, sentencing data and prison receptions and population data.

The method used for generating projections of the prison population in England and Wales for the 2016-2021 projections is consistent with the approach used to generate the 2015-2021 projections published on 26 November 2015.

Appendix B provides further details of the methods used to produce the prison population projections and the assumptions behind them.

6. Caveats on prison population projections

The projections presented reflect the impact of trends in sentencing, in the age, gender and offence of defendants entering the system and in the flow of defendants through the courts. The impacts of publically announced changes to legislation and guidance which took place before August 2016 and views of future parole hearing frequency and outcomes for indeterminate sentence prisoners have also been taken into account.

The projections do not reflect the impact of legislative, policy, operational or procedural change or guidance for which there is no definite timetable for implementation. The projections therefore provide a “baseline” against which the impacts of future changes can be assessed.

Even without these possible changes, the actual future prison population may not match the projection. Changes to criminal justice processes could influence the numbers of offenders being brought to the point of sentence or the way that offenders are managed. Changes to sentencing behaviour may also be different from those modelled. Finally, both sentencing behaviour and criminal justice processes, as well as policy decisions, can respond to a multitude of environmental factors which cannot be anticipated, such as high profile criminal cases, events like the August 2011 public disorder events, and public debate.

Assumptions for modelling were agreed through consultation with policy and operational experts at the Ministry of Justice, National Offender Management Service, Home Office and Crown Prosecution Service. The assumptions are based on analysis (where reliable data are available) and on expert judgement from policy makers, key deliverers and system influencers. The assumptions are therefore likely to be more robust for those measures and processes that have a well-defined boundary than for those that do not.

7. Links to related Ministry of Justice statistics

For further information on:

- The latest statistics on court receipts visit:
<https://www.gov.uk/government/collections/criminal-court-statistics>
- The latest statistics on the criminal justice system, including information on sentencing, visit:
<https://www.gov.uk/government/collections/criminal-justice-statistics-quarterly>
- The latest statistics and commentary on the prison population visit:
<https://www.gov.uk/government/collections/offender-management-statistics-quarterly>
- The Story of the Prison Population 1993-2016 visit:
<https://www.gov.uk/government/statistics/story-of-the-prison-population-1993-to-2016>
- Weekly prison population and capacity figures visit:
<https://www.gov.uk/government/collections/prison-population-statistics>

Appendix A: Additional tables¹⁴

Table A1: Projected prison population (end of June figures¹⁵)

	Total	Determinate	Indeterminate	Remand	Recall	Non-Criminal	Fine
Jun-17	84,600	56,400	10,800	9,000	6,700	1,500	100
Jun-18	83,700	56,100	10,300	8,900	6,800	1,500	100
Jun-19	83,800	56,500	9,900	8,900	7,000	1,500	100
Jun-20	84,000	56,900	9,500	8,900	7,100	1,500	100

Table A2: Average projected prison population (financial year figures)

	Total
2017/18	84,300
2018/19	83,700
2019/20	83,800
2020/21	84,100

Table A3: Comparison of 2015 projection and 2016 projection (end of June figures)

	2015	2016	Difference
Jun-16	89,100	--	--
Jun-17	87,400	84,600	-3.2%
Jun-18	88,200	83,700	-5.1%
Jun-19	89,000	83,800	-5.8%
Jun-20	89,600	84,000	-6.3%

Table A4: Juvenile, young adult and adult populations by gender (end of June figures)

	Male			Female		
	15-17	18-20	21+	15-17 ⁽¹⁾	18-20	21+
Jun-17	600	4,000	76,100	0	100	3,800
Jun-18	600	3,900	75,300	0	100	3,700
Jun-19	600	3,900	75,500	0	100	3,700
Jun-20	600	3,900	75,600	0	100	3,700

Table A5: Projected male 21 years and over prison population (end of June figures)

	Males 21 years and over						
	Total	Determinates	Indeterminate	Remand	Recall	Non-Criminal	Fine
Jun-17	76,100	50,100	10,400	8,000	6,200	1,400	100
Jun-18	75,300	49,800	9,900	7,900	6,300	1,400	100
Jun-19	75,500	50,300	9,500	7,900	6,400	1,400	100
Jun-20	75,600	50,600	9,100	7,900	6,500	1,400	100

¹⁴ All figures are rounded to the nearest hundred. Sub-populations may not sum to total populations due to rounding and due to overlaps in some sub-population categories.

¹⁵ June is chosen as it is a month relatively free from seasonal effects and therefore provides a robust measure of the prison population for comparison

Table A6: Projected over 50, over 60 and over 70 year old prison population (end of June figures)

	Over 50 year old	Over 60 year old	Over 70 year old
Jun-17	13,200	4,800	1,600
Jun-18	13,300	4,900	1,600
Jun-19	13,600	5,200	1,800
Jun-20	13,900	5,400	1,900

Table A7: Monthly values of the overall projected prison population (end of month figures)

	2016/17	2017/18	2018/19	2019/20	2020/21
April	-	85,000	83,800	83,800	83,900
May	-	84,800	83,800	83,800	83,900
June	-	84,600	83,700	83,800	84,000
July	-	84,500	83,700	83,800	84,000
August	85,200	84,500	83,900	83,900	84,200
September	85,300	84,400	83,900	84,000	84,200
October	85,300	84,300	83,900	83,900	84,300
November	85,400	84,300	83,900	84,000	84,300
December	84,600	83,400	83,100	83,300	83,600
January	85,000	83,700	83,500	83,700	84,000
February	85,300	83,900	83,700	83,900	84,200
March	85,300	83,800	83,700	83,900	84,300

Table A8: Uncertainty bands on projected total prison population (end of June figures)

	<i>Likelihood total population will be lower than level at each date</i>						
	5%	20%	35%	50% ¹⁶	65%	80%	95%
Jun-17	82,400	83,500	84,100	84,600	85,100	85,700	86,800
Jun-18	80,900	82,300	83,100	83,700	84,400	85,200	86,600
Jun-19	80,500	82,100	83,100	83,800	84,600	85,500	87,100
Jun-20	80,300	82,100	83,100	84,000	84,900	85,900	87,700

¹⁶ 50% position reflects our prison population projection, the single most likely population given the agreed set of assumptions.

Appendix B: Detail of models and assumptions

The modelling approach

The prison projections form part of the Ministry of Justice's wider work to develop a consistent and coherent suite of models of the criminal courts and offender management, driven by common projections of demand for the Ministry of Justice's services.

The prisons model used to generate this projection has not changed substantially from that used in the last projections. As in the 2015 projections, custodial sentence lengths used in the model are disaggregated by gender, age of the offender and offence type. The total time to be served in prison by projected future prisoners is assigned by matching their gender and age characteristics to relevant distributions of (i) custodial sentence lengths and (ii) the percentage of custodial sentence served. These distributions are derived from latest available data. This allows us to:

- understand the criminal justice system factors which contribute to change in the prison population, including sentence lengths issued, the percentage of sentence served in custody, trial court and sentencing court changes, or shifts in the demographic characteristics of defendants;
- model the impact on the prison population of specific Ministry of Justice and other criminal justice agency policy changes; and
- quantify the impact of uncertainty around the time a defendant serves in prison on the prison population.

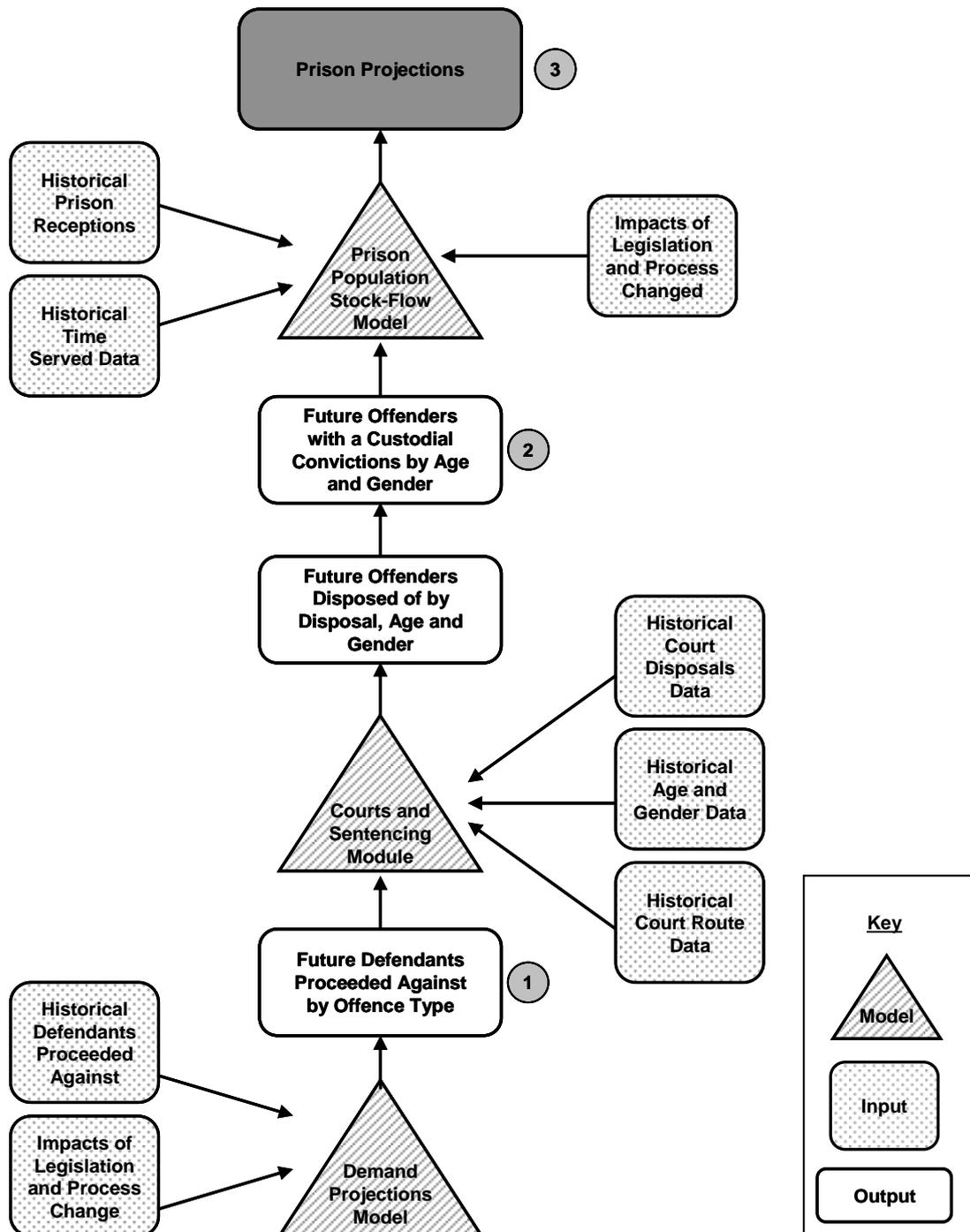
Overview of the modelling approach

Central to the modelling approach is the Prison Population Stock-Flow model. Projections of future custodial convictions are fed into this model and outputs are adjusted to account for the impact of changes in legislation and process on the prison population, as shown in Figure B1, and described below.

1) Producing projections of defendants proceeded against

Projections of defendants proceeded against at court are chosen as the entry point to the modelling system because this is the entry point of defendants into the Ministry of Justice's area of responsibility. Underlying crime levels and the activities of the police and CPS will have an impact on the volume of defendants proceeded against.

Figure B1: Key Components of the prisons projections modelling system



The Demand Projections Model produces baseline projections of all defendants proceeded against at court for high-level offence categories. This is based on historical time series data at a monthly resolution sub-divided by region and age for the Magistrates' court and region for the Crown Court.

The demand projections are based on time series forecasting methods such as Seasonal Exponential Smoothing (SES).

It should be noted that these projections cannot be expected to track actual volumes of defendants proceeded against if there is any sudden or cumulative change which takes demand volumes or offence mix well outside the trends seen historically.

2) Converting the demand projections into custodial convictions

A Courts and Sentencing Module converts the demand projections into a set of projections of disposals by disposal type (including custodial convictions), offence, sex and age band at a monthly resolution. These projections of custodial convictions by sex, age and offence type are used as a key input for the Prison Population Stock-Flow model.

The Courts and Sentencing Module is a combination of the Magistrates' and Crown Court Workload Models and the Sentencing Module. The demand projections are used as an input into a Magistrates' Workload Model, which uses historical data to split defendants into court routes (Table B1) and tracks their flow through the system.

The Crown Court workload model takes forecasts of caseload and assigns various attributes (e.g. early guilty plea, effective trial mix) to estimate likely hearing times and the resulting flow of cases through the system. The cases disposed of are then converted to the number of defendants disposed of using recent data for the observed ratio between cases and defendants.

The key assumptions that are used in the Courts and Sentencing Module are:

- that there is no prioritisation of any age or sex group within the Magistrates' and Crown Court;
- the number of working days in each month is the primary driver of seasonality within the Magistrates' and Crown Court;
- no change in offence type occurs as cases move through the system;
- defendants that are tried at the Magistrates' Court proceed to sentencing without delay;
- delays within the Magistrates' Court are not significant for the monthly timescales used in the modelling; and
- a Magistrates' Court backlog will not develop during the forecast period.

The Sentencing Module takes the number of defendants disposed of in the Magistrates' Workload Model and the Crown Court Workload Model and applies sentencing splits based on analysis of court proceedings data. This results in a set of projections as broken down in Table C1. These are aggregated providing forecasts for each offence, gender, age and disposal category, which are used as the custodial conviction projections.

Table B1: Courts and Sentencing Module Splits Dimensions

Offence Type	Gender	Age Band	Court Route	Disposal
Burglary	Male	Age 10-17	MC	Discharge
Criminal Damage	Female	Age 18-20	MCCC	Fine
Fraud and Forgery		Age 21+	CC	Community Sentence
Indictable Motoring				Suspended Sentence
Other				Custodial <6 months
Robbery				Custodial 6 months - <1year
Sexual Offences				Custodial 1year - 4 year
Summary Motoring				Custodial 4 year+
Summary Non-Motoring				Indeterminate
Theft and handling				Otherwise Dealt With
Violence Against the Person				

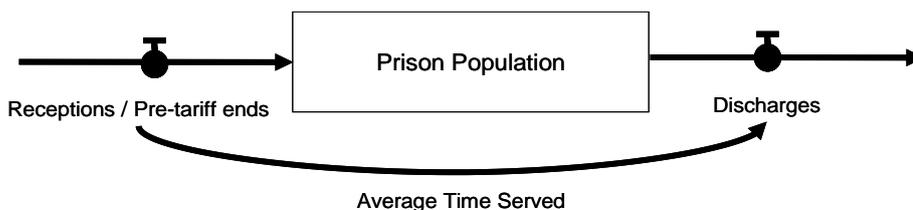
Key to the court route splits: MC: those tried and sentenced in the Magistrates Court; MCCC: those who are tried in the Magistrates Court and Sentenced in the Crown Court; CC: combines those defendants who are committed for trial in the Crown Court and sent for trial in the Crown Court into a single category.

If required, the Courts and Sentencing Module allows trends in offender demographics and courts and sentencing processes to be incorporated into custodial convictions projections. This procedure was implemented to create the custodial convictions projections used in this projection.

3a) Producing prison population projections

Prison population projections are produced using the Prison Population Stock-Flow Model. The principal sub-populations in prison – determinate sentence, life sentence, imprisonment for public protection (IPP) and remand – are modelled using stock-flow structures based on the generic structure shown in Figure C2. The stock-flow structures model the flow of offenders into and out of prison and count the resulting prison population at the end of each month.

Figure C2: Generic stock-flow structure in the Prison Population Stock-Flow Model



For the determinate population, the monthly inflows to prison are based on the custodial convictions projections described above. These custodial convictions include offenders that may already be serving a sentence for a previous crime or those who would serve their whole custodial sentence on remand, meaning that they would not be a new reception to prison. To convert from custodial convictions to prison receptions we apply a conversion ratio derived from the historical proportions of custodial convictions to prison receptions for each sub-population averaged over the last twelve months of historical data.

Monthly outflows for the determinate population are based on observed custodial sentence lengths and the observed percentage of sentence length served. Each projected offender that enters the model is given a custodial sentence length that is randomly selected from the relevant distribution. These distributions are populated with custodial sentence lengths from actual offender receptions who

share the same characteristics of offence, gender and age group in the observed time period. The percent of custodial sentence length served is derived in the same manner, except that the observed distribution is made up of discharged offenders further disaggregated by custodial sentence length band.

For offenders who receive the new EDS sentence an adjustment is made to the percent of custodial length served to reflect that these offenders will spend a greater proportion of their sentence in custody than standard determinate sentenced offenders discharged to date.

Projected prison receptions are sub-divided by age category (Juvenile, Young Adult, Adult) with the exact age of the offender attributed in the same manner as the custodial sentence lengths. This allows the model to explicitly age the offenders whilst in prison (e.g. move from Juvenile to Young Adult categories).

The approach for the other sub-populations is similar and has not been substantially revised since the 2015 publication. The methodology applied to each is briefly outlined below.

The remand population is projected based on latest available time-series data around remand stocks and flows of offenders into and out of remand. The projection takes account of changes in operational performance and policies that are expected to have impacts on time served on remand via the Courts and Sentencing Module.

IPP and life sentence prisoners have an extra section in the stock-flow structure which models the indeterminate nature of their sentence lengths. Outflows for IPP and life sentence prisoners depend on the tariff lengths they receive and on the frequency and outcome of Parole Board hearings. The values of these parameters are set and calibrated to reflect the most recent data on Parole Board outcomes.

The recall population is projected based on latest available time-series data on the stock of offenders on recall. Indeterminate recalls are treated explicitly based on data and assumptions around future release and recall rates, and conditional on Parole Board capacity as per the indeterminate population.

The population in prison at the end of each modelled month is aggregated into the categories defined by gender, current age group and, for determinate sentence prisoners, sentence length band, to produce raw, unadjusted prison population projections.

3b) Accounting for the impacts of circumstance, legislation, and for seasonal effects

The raw, unadjusted prison population projections are subject to model adjustments to show the impact of certain provisions in the Offender Rehabilitation Act 2014, the ROTL review, the Criminal Justice and Courts Act 2015, the Serious Crime Act 2015 and the EU Prisoner Transfer Framework Decision. Model adjustments are also used to account for seasonal variation in the population.

Custodial conviction projections for each sub-population were smoothed using a centred 12 month average. No seasonality in prison receptions and discharges was modelled explicitly. Seasonality was measured in the historical prison population and applied as a series of percentage adjustments to the final population projections. Seasonal factors for the determinate population were identified for each month by measuring statistically significant deviations from a centred 12 month average.

Appendix C: Method for calculating projection uncertainty

As with any projection, there is uncertainty in the projection of the prison population, arising from several sources. This includes uncertainty in model parameters as well as future changes in behaviour or policy that are uncertain or unexpected at the time of projection.

This publication includes a fan chart, a commonly-used method of communicating uncertainty in a time series projection. The performance of previous published projections against the actual population has been analysed and used to estimate the uncertainty in the prison population.

Projections of the total prison population have been published annually since 2008. We therefore have several years' worth of projections to compare estimates against actuals. The fan chart should be considered an estimate of the expected levels of uncertainty, informed by past performance, rather than a precise set of limits on the population.

Fan chart and interpretation

Chart 3 shows the prison population projection as a solid line. This can be interpreted as the single most likely population, given the agreed set of assumptions. Around the projection are three bands, indicating the range of populations with estimated 30%, 60% and 90% likelihoods. The interpretation is that, assuming no significant differences between the conditions under which the previous projections were made and the conditions under which the current projection has been made, there is a 30% likelihood that the population will stay within the inner band, a 60% likelihood that the population will stay within the second band and a 90% likelihood that the population will stay within the outer band.

The shaded portion of the chart indicates the period beyond which estimates of uncertainty are based on extrapolation, not explicit measurement of performance, as explained below.

Technical details

The fan chart is calculated by fitting a distribution to the percentage errors between prior projections and observed actual population figures. Distributions of errors are calculated at each time interval from date of start of projection. We fit a normal distribution at each interval, characterised by a mean and a standard deviation. For this fan chart, the mean is assumed to be the prison population projection. As more published projections become available in future, it may be possible to further refine the characterisation of uncertainty (for example assessing whether a skewed two-piece normal distribution is more appropriate).

The standard deviation at each time point is calculated in the following way:

1. Calculate the percentage difference between the projected and actual populations for each time interval (i.e. difference one month after forecast, two months after forecast etc.) after the forecast date;

2. Calculate the standard deviation of the percentage differences for each time interval from date of projection;
3. Fit a power law to this series of standard deviations as a function of time interval (i.e. a function of the form $y = ax^b$, where y is the standard deviation and x is the time after projection);
4. Use this function to infer estimates of the standard deviation of errors at each time interval up to the end of the projection period.

This method is in line with the method used in the previous 2015 publication. We now have additional data on past projection performance that has allowed us to extend the horizon used to fit trends in standard deviations in step (3) up to an interval of 3 years following projection. We have also reviewed the methodologies used for previous projections and adjusted these for data improvements observed since the projections were published. This has allowed us to more accurately estimate the expected uncertainty given the latest data and methodological improvements applied in the projection method.

Contact points for further information

Current and previous editions of this publication are available for download from www.justice.gov.uk/publications/statistics-and-data/index.htm

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