The X-13A-S Seasonal Adjustment Program

Brian C. Monsell

U. S. Census Bureau

Statistical Research Division, Washington DC 20233-9100 email: brian.c.monsell@census.gov

Abstract

In collaboration with the current developers of the SEATS seasonal adjustment program, an experimental version of X-12-ARIMA that produces model–based seasonal adjustments from SEATS has recently been made available to a few users. This program allows producers of seasonally adjusted series to generate X-11 and SEATS seasonal adjustments using the same interface, and compare these seasonal adjustments using a common set of diagnostics. This paper will demonstrate how SEATS adjustments are integrated into the X-12-ARIMA procedure and give examples of new modeling options such as seasonal outliers and pulse regressors.

Key Words: Model-based signal extraction, seasonal adjustment diagnostics, intervention effects, outliers.

Disclaimer

This report is released to inform interested parties of ongoing research and to encourage discussion of work in progress. Any views expressed on statistical, methodological, technical, or operational issues are those of the author and not necessarily those of the U.S. Census Bureau.

1 Introduction

Monsell, Aston, and Koopman (2003) detailed two alternatives for dealing with model-based approaches to seasonal adjustment. One was an experimental version of X-12-ARIMA that produces model-based seasonal adjustments from the SEATS seasonal adjustment procedure (Gómez and Maravall, 1997) and is a collaboration between the Census Bureau and the current developers of SEATS, Agustín Maravall and Gianluca Caporello. This program allows users to generate X-11 and SEATS seasonal adjustments using the same interface and to compare these seasonal adjustments using a common set of diagnostics.

This paper gives a description of the program, which will soon be released by the Census Bureau. I will discuss how this software is different than previous versions of X-12-ARIMA by noting new modeling options which simulate classical intervention effects and improvements in seasonal adjustment diagnostics and seasonal adjustment.

2 Overview of X-13A-S

X-13A-S is the current name for the product of a collaboration between the developers of X-12-ARIMA and SEATS. It is a merged version of the two programs. This program was developed to assist in evaluating the effectiveness of model-based seasonal adjustment and to allow for the seamless integration of these adjustments into production processes that currently are designed to use only X-12-ARIMA.

The version of X-12-ARIMA used in X-13A-S is Version 0.3 of X-12-ARIMA, released in May 2007. The most important new features of Version 0.3 are listed below:

- an updated automatic ARIMA model identification procedure;
- a new `force` spec which incorporates new options for forcing the yearly totals of the seasonally adjusted series to match those of the original series;
- revised procedures for composite seasonal adjustment;
- a unified diagnostics file;
- a new `metadata` spec which allows users to incorporate their own metadata into the unified diagnostics file;
- new options to render X-12-ARIMA's output accessible for people with limiting conditions;

- a technique for running X-12-ARIMA with files that have spaces in their names.

For more information on these and other new features of the software, see Monsell (2007). Overviews of the updated automatic model identification procedure is given in Monsell (2002) and Census (2007). Special care has been taken to integrate the results from SEATS seasonal adjustments into such features as composite seasonal adjustment and forcing seasonally adjusted series.

The version of SEATS incorporated into the most recent build of X-13A-S was generated by the Bank of Spain in June of 2005. This version is enhanced with new model-based seasonal adjustment diagnostics developed at the Census Bureau. The next build of X-13A-S will have updated source from the developers of SEATS with several important revisions.

With this program, analysts have access to SEATS seasonal adjustments using the familiar X-12-ARIMA input syntax, and can compare SEATS and X-12-ARIMA seasonal adjustments using the seasonal adjustment diagnostics produced by the X-12-ARIMA seasonal adjustment program, most notably the spectrum, sliding spans and history diagnostics (Findley, Monsell, Bell, Otto, and Chen, 1998), as well as the diagnostic graphs of X-12-Graph (Hood, 2002; Lytras, 2006).

This program includes all the signal extraction routines from the SEATS seasonal adjustment program. To minimize revisions to the base SEATS code, an interface routine available within the standard SEATS source code is used as an interface between the signal extraction code and source code used to generate seasonal adjustment diagnostics and other special output. Additional routines allow for the transfer of regARIMA model information from the data structures used in X-12-ARIMA's model estimation procedures to the format required for use with SEATS.

As mentioned previously, the program uses the same user interface conventions as previous versions of X-12-ARIMA. To specify a SEATS seasonal adjustment, the user specifies options within a separate `seats` spec. All options deemed useful by the developers of SEATS from the stand-alone SEATS program are available to users of X-13A-S; these can be set by specifying arguments within the `seats` spec. Users can save the components of SEATS seasonal adjustments in external files using the `save` argument in the same format used to save other tables in X-12-ARIMA.

Table 1 shows a sample X-13A-S spec file, which generates a default SEATS seasonal adjustment and saves the seasonal component of the SEATS adjustment to a separate file.

```
series{title= "US Imports"
  format="datevalue"
  file="m0.dat"
  name="m0"  }
transform { function=log }
arima{ model=(0 1 1)(0 1 1) }
forecast{ maxlead = 24 }
seats { save = s10 }
slidingspans { savelog = pct }
```

Table 1: X-13A-S input file for initial run of U. S. Imports

Note that currently the program can only perform either a SEATS or an X-11 seasonal adjustment from a given spec file. SEATS adjustments generated by X-13A-S can be slightly different from results derived from the stand-alone version of the SEATS program, even if the same model is specified, due to differences in the regARIMA model estimation procedures of TRAMO and X-12-ARIMA .

The program can also be used with the recently released Windows Interface to the X-12-ARIMA program. This program provides a point and click interface for running X-12-ARIMA and X-13A-S for PCs running Windows 2000 (or higher), and also creates basic input specification files (spec files) and metafiles for the user. For more details, consult Feldpausch (2006).

3 New Modeling Options in X-13A-S

This section will give details of new regressors either planned or already implemented into X-13A-S. Some are included to duplicate existing features in the TRAMO modeling program; others result from requests of X-12-ARIMA users.

3.1 Seasonal Outliers

One of the effects included in the most recent version of X-13A-S is a seasonal outlier effect identical to the Seasonal Level Shift outlier discussed in Kaiser and Maravall (2002). The new seasonal outlier effect can be used with other predefined regression variables specified in regARIMA models. The automatic outlier identification procedure has also been modified to include identification of these seasonal outliers effects (although not by default).

A seasonal outlier effect beginning at time t_0 is defined as

$$SO_t^{(t_0)} = \begin{cases} 0 & \text{for } t \geq t_0 \\ 1 & \text{for } t < t_0, t \text{ same month as } t_0 \\ -1/(s-1) & \text{otherwise} \end{cases}, \tag{1}$$

where s is the period of the time series being modelled (12 for monthly series, 4 for quarterly series).

This regressor captures an abrupt change in the seasonal pattern, and maintains the level of the series with a contrasting change spread over the remaining months or quarters.

It is equivalent the seasonal level shift found in Kaiser and Maravall (2002), given below:

$$SLS_t^{(t_0)} = \begin{cases} 0 & \text{for } t < t_0 \\ 1 & \text{for } t \geq t_0, t \text{ same month as } t_0 \\ -1/(s-1) & \text{otherwise} \end{cases}, \tag{2}$$

The seasonal level shift outlier implemented in X-13A-S is defined differently than the one found in Kaiser and Maravall (2002). In X-13A-S the regressor is constructed so that the seasonal pattern of the data before the date of the seasonal outlier is changed to conform with the seasonal pattern of the present, rather than altering the seasonal pattern of the present to conform with that of the past. Also, there can be a slight change in the level of the adjusted series when this outlier is used; it would be better to avoid changes in level to the most recent data.

An example of a seasonal outlier factor series is given in Figure 1.

Sometimes, having two of these outliers in tandem can create a seasonal outlier effect similar to one proposed in Burman (1980) and used in Buszuwski and Scott (1993). This type of outlier effect captures an abrupt change in the seasonal pattern which is then compensated by an equal change in the opposite direction in the next month or quarter. An example of this type of seasonal outlier is given in Figure 2.

Users should be careful when specifying this effect with other preexisting outliers, as seasonal differencing can cause a seasonal outlier regressor to be very similar to level change outlier regressors for the same date and cause difficulties with model estimation due to the singularity or near singularity of the regression matrix. Currently, the program will not attempt to identify seasonal change outliers along with level change outliers for the final year of data when the model contains a regular and seasonal difference, as in this case the differenced seasonal and level change outliers are practically identical.

Empirical analysis will be done to examine how best to identify seasonal outliers in practice, and whether other types of outliers, like the seasonal outlier effect in Buszuwski and Scott (1993), should be considered.

3.2 Pulse and Intervention Regressors

An additional type of regressor that is being incorporated from `TRAMO` software is pulse regressors. A new **`pulse`** spec will be used to generate a linear regressor of zeroes and ones by specifying starting dates for a series of pulses and the duration of the effect starting at the pulse.

For example, specifying a `pulse` spec with

```
pulse {   begin = 1990.jan    duration = 5   }
```

will generate a regressor with a series of ones starting in January of 1990 that lasts for five observations. The regressor will be zero otherwise.

Seasonal (δ_s) and nonseasonal (δ) parameters can be specified within the `pulse` spec that allow for filtering of these pulse regressors.

$$X_t' = \frac{1}{(1-\delta B)} X_t$$

$$X_t' = \frac{1}{(1-\delta_s B^s)} X_t$$

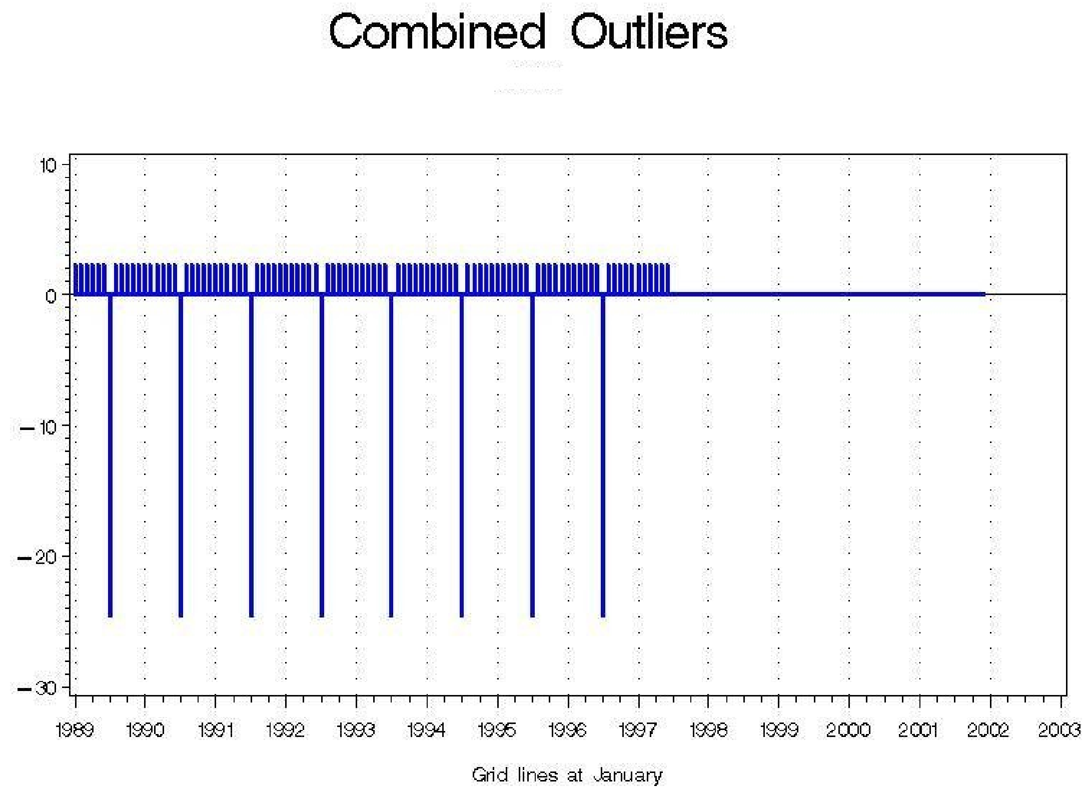

Figure 1: Seasonal Outlier Factor for an Import Series (source: U. S. Census Bureau).

Using the `pulse` spec arguments `deltas` and `delta` to set δ and δ_s allow for the estimation of very flexible intervention effects of the type outlined in Box and Tiao (1975).

A spec file that reproduces the model from one of the examples from this paper is given in Table 2, which also appears as an example in Gómez and Maravall (1997). The model fit for this example is

$$\begin{aligned}(1-B^{12})(1-\phi B)y_t = \\ \frac{\omega_1}{1-B}\xi_{1,t} + \frac{\omega_2}{1-B^{12}}\xi_{2,t} + \frac{\omega_3}{1-B^{12}}\xi_{3,t} + \\ (1-\Theta_{12}B^{12})a_t\end{aligned}$$

where

$$\xi_{1,t} = \begin{cases} 1 & \text{for } t = \text{January 1960} \\ 0 & \text{otherwise} \end{cases},$$

$$\xi_{2,t} = \begin{cases} 1 & \text{for June through October, starting in 1966} \\ 0 & \text{otherwise} \end{cases},$$

$$\xi_{3,t} = \begin{cases} 1 & \text{for November through May, starting in 1966} \\ 0 & \text{otherwise} \end{cases}.$$

Note that each pulse regressor is specified within its own `pulse` spec. If only one value is specified for the duration of the pulse effect, then this is assumed to be the duration for all the starting dates specified in the `begin` argument.

These intervention effects were incorporated into the model to examine the impact of air pollution control laws; for more information on the analysis, see Box and Tiao (1975).

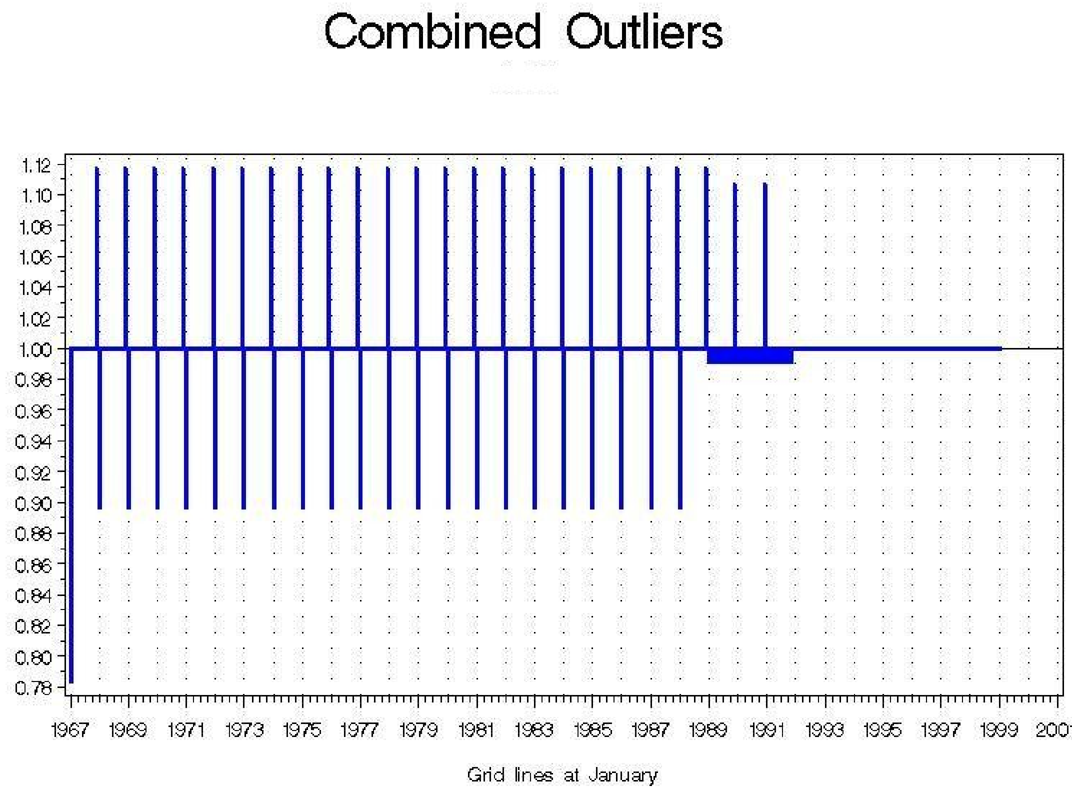

Figure 2: Seasonal Outlier Factor for a Retail Sales Series (source: U. S. Census Bureau).

Note from the example in Table 2 that the pulse spec can be called more than once, a departure from previous versions of X-12-ARIMA. Each instance of the pulse spec inserts a new pulse regressor into the regARIMA model. Users can also define pulse ”events” for anticipated effects - this allows the program to incorporate expected pulses into forecasts generated by X-13A-S.

3.3 Constrained Stock Trading Day Regressors

Currently, X-13A-S provides a simplified model for trading day variation of monthly or quarterly flow series that uses only one regressor, a weekday-weekend contrast variable:

$$TD(t) = N_t^{WD} - \frac{5}{2}(N_t^{SS}) \tag{3}$$

where N_t^{WD} is the number of weekdays in month/quarter t and N_t^{SS} is the number of Saturdays and Sundays in month/quarter t. The underlying assumption for this constraint is that all weekdays (Monday through Friday) have identical effects, and Saturday and Sunday have identical effects. This regressor originally appeared in the TRAMO modeling software.

For inventory series, Bell (1984) and Bell (1995) developed regressors that could be used for to estimate trading day effects. For a given integer value w assumed to be the day of the month where inventory is taken, these regressors are defined as

$$\begin{aligned} I_{1,t} &= \begin{cases} 1 & \tilde{w}^{\text{th}} \text{ day of month } t \text{ is a Monday} \\ -1 & \tilde{w}^{\text{th}} \text{ day of month } t \text{ is a Sunday} \\ 0 & \text{otherwise} \end{cases}, \\ \cdots, \quad I_{6,t} &= \begin{cases} 1 & \tilde{w}^{\text{th}} \text{ day of month } t \text{ is a Saturday} \\ -1 & \tilde{w}^{\text{th}} \text{ day of month } t \text{ is a Sunday} \\ 0 & \text{otherwise} \end{cases}, \end{aligned} \tag{4}$$

```
series{
  title= "Oxident recordings, LA"
# show how to specify pulse spec
  format="datevalue"
  span=(1955.1,1972.12)
  file="boxtiao.dat"
  name="O3LA" }
arima { model = (1 0 0)(0 1 1) }
pulse {
  begin = 1960.jan
  duration = 1
  delta = 1 }
pulse {
  begin = ( 1966.jun 1967.jun
  1968.jun 1969.jun 1970.jun
  1971.jun 1972.jun 1973.jun
  1974.jun )
  duration = 5
  deltas = 1.0 }
pulse {
  begin = ( 1966.nov 1967.nov
  1968.nov 1969.nov 1970.nov
  1971.nov 1972.nov 1973.nov
  1974.nov )
  duration = (7 7 7 7 7 7 7 7 2)
  deltas = 1.0 }
check { }
forecast { maxlead = 24 }
```

Table 2: X-13A-S input file for Oxident O_3 level recordings in downtown Los Angeles (Jan 1955-Feb 1972, source: JASA)

where $\tilde{w}$ is the smaller of w and the length of month t; $w = 31$ assumes that inventory is taken at the end of the month.

Findley and Monsell (2007) shows how flow day-of-week constraints like the one used to generate the regressors in equation (3) can be imposed upon the stock trading day model, and shows that a constrained stock trading day regressor based on the constraints in equation (3) can be generated from the regressors in equation (4):

$$D_t = -\frac{3}{5}I_{1,t} - \frac{1}{5}I_{2,t} + \frac{1}{5}I_{3,t} + \frac{3}{5}I_{4,t} + I_{5,t} \tag{5}$$

Findley and Monsell (2007) also gives the results of applying these regressors to a set of end-of-month inventory series, showing the constrained stock trading day regressors of (5) are preferred more often than the conventional stock trading day shown in (4).

As a result, the one-parameter stock trading day regressor has been incorporated into X-13A-S; there are plans to incorporate this feature into TRAMO as well. Users can access it from the `variable` argument of the `regression` spec. A spec file specifying such a regressor is given in Table 3; note that the stock day w must be specified as with the current stock trading day regressor.

4 Diagnostics

A recent change in the X-13A-S diagnostics is the inclusion of finite filter versions of seasonal adjustment and trend diagnostics that were originally computed using the infinite length Wiener-Kolmogorov filter statistics, which assumed an infinite span of data. The new diagnostics are computed using matrix formulas first shown in Bell and Hillmer (1988) and developed more fully

```
series{
  title= "Shoe store inventories"
# show how to specify 1 coef.  stock TD
  format="datevalue"
  file="invshoe.dat"
  name="invshoe" }
arima { model = (0 1 1)(0 1 1) }
regression {
  variables = tdstock1coef[31]
  save = td }
check { }
outlier { }
forecast { maxlead = 24 }
```

Table 3: Sample X-13A-S input file for constrained stock trading day

in McElroy (2005) which produce finite-sample ARIMA model-based signal extraction filters along with the error covariances of their estimates.

Early versions of these finite-sample diagnostics have been examined previously in Findley, McElroy, and Wills (2005). A large scale study using U. S. Census Bureau series to determine the effectiveness of these diagnostics has begun (Findley, Gagnon, and McElroy, 2006).

For users interested in the properties of the SEATS signal extraction filters, X-13A-S produces spectral diagnostics for the finite concurrent signal extraction filter, as well as the filter weights for the finite concurrent adjustment filter. These are the filters that are used to adjust the most recent observations, and can be compared to concurrent filters from X-11 based adjustments (Bell and Monsell, 1992)) rather than the infinite central filters.

Comparison of SEATS and X-11-ARIMA adjustment filters can be found in Findley and Martin (2006). Squared gain and time-shift diagnostics are also implemented in X-13A-S. These are discussed extensively with applications in Findley and Martin (2006).

4.1 Seasonal Adjustment Diagnostics

The most recent addition to the set of diagnostics included in the X-13A-S software is a model-based F-statistic for determining if there is stable seasonality in the original series.

This F-test is generated from the chi-square test of groups of regressors generated by earlier version of the X-12-ARIMA and X-13A-S software, which used to determine if a particular group of regression parameters in the regARIMA model are collectively zero. The chi-square test statistic is given below:

$$\hat{\chi}^2 = \hat{\beta}' \left[Var(\hat{\beta})^{-1} \right] \hat{\beta}. \tag{6}$$

One such group of predefined regressors is the fixed seasonal regressors. This type of regressor can be expressed in two ways - monthly (or quarterly) indicator variables or a trigonometric representation of a fixed monthly pattern. More details on these regressors can be found in Census (2007).

When these regression terms are included in the regARIMA model, the chi-square test of the seasonal regressors is produced, and serves as an indication of the stable seasonality in the series.

The chi square test of the seasonal regressors can be corrected to account for the error in the estimation of the innovation variance by using the test statistic $\tilde{\chi}^2/k$, generated as follows:

$$\frac{\tilde{\chi}^2}{k} = \frac{\hat{\chi}^2}{k} \times \frac{n-d-k}{n-d} \tag{7}$$

where $\hat{\chi}^2$ is the chi-squared statistic from (6), n is the number of observations in the series, d is the degree of differencing, and k is the number of regressors for the group being tested in (6). The test statistic in (7) follows an $F_{k,n-d-k}$ distribution.

Lytras, Feldpausch, and Bell (2007) compared the performance of the $\tilde{\chi}^2/k$ statistic to several tests for stable seasonality that are commonly used by seasonal adjustors but whose statistical properties are unknown. The simulation studies examined led the authors to recommend the use of the $\tilde{\chi}^2/k$ statistic over more traditional diagnostics found in X-12-ARIMA.

Another seasonal adjustment diagnostic is the *sliding spans diagnostics*; these compare seasonal adjustments from overlapping spans of a given time series. Up to four spans of data are chosen, with the final span ending in the last year of the series, and the preceding spans formed by dropping a year of data from the end of the span and adding a year of data to the beginning of the span. Data points common to more than one span are examined to see if their adjustments are stable – observations whose adjustments are too variable from span to span cannot be considered reliable. For more details on sliding spans analysis, see Findley, Monsell, Shulman, and Pugh (1990) and Findley, Monsell, Bell, Otto, and Chen (1998).

One important choice that needs to be made in a sliding spans analysis is the length of the overlapping spans. When used with the `x11` spec of X-12-ARIMA, where seasonal adjustment is performed with fixed length seasonal filters, the length of the span is based on the length of the seasonal filter. The ARIMA model-based seasonal adjustment filters of SEATS are always as long as the data span being adjusted (when the ARIMA model specified has a moving average component), so a different approach is needed.

Findley, Wills, Aston, Feldpausch, and Hood (2003) develops an approach for determining span lengths that is based on an analysis of SEATS model-based adjustment filters associated with the airline model, the model chosen for about half the series adjusted by SEATS, see Gómez and Maravall (1997). Since values of θ and Θ are known for which the SEATS seasonal adjustment filters have gain and phase-shift properties very close to those of the X-11 filters (see Planas and Depoutot (2002) and Findley and Martin (2006)), the sliding span lengths used for SEATS adjustments within X-13A-S are calibrated to coincide with the span lengths used for the X-11 filters when the two types of filters are close. In this way, the span length specifications used for SEATS adjustments are anchored to those of the X-11 filters.

The table below gives the span length used by the program for a given value of Θ. Research of the type described in Feldpausch, Hood, and Wills (2004) showed that for simulated series with known components, using the sliding spans lengths based on the seasonal moving average parameter seemed to provide a more reliable indication of inaccuracy in the seasonal adjustment than other diagnostics commonly used with SEATS seasonal adjustments.

Seasonal MA	Length of Span (in years)
0.160	5
0.325	6
0.490	7
0.535	8
0.620	9
0.640	10
0.695	11
0.710	12
0.750	13
0.760	14
0.795	15
0.805	16
0.840	17
0.850	18
0.910	19

Table 4: Seasonal MA parameter greater than 0 at which the span length increases to the value indicated.

5 Future Plans

There are several areas of development considered for X-13A-S to be completed before its general release.

5.1 Alternate One Parameter Trading Day Regressor

The Weekend/Weekday contrast regressor shown in equation (3) of section 3.3 has been used in both the TRAMO and X-12-ARIMA for several years. While this is a reasonable simplification of the trading day effect, this type of constraint could be extended to other, more general ones. For example, one could include Friday with the weekend effects for a series measuring theater ticket sales.

Research at the Census Bureau has shown a number of possible patterns in economic time series; in particular, retail sales series. To assist in this research, a flexible way of specifying more general one-parameter trading day effects will be incorporated into the X-13A-S prototype.

5.2 Incorporating regCMPNT Modeling Capabilities

The `regCMPNT` modeling package will be made available for distribution soon, with revised documentation and new features. This software allows the fitting of regression models with error terms that are modeled as the sum of any number of components, each described by an ARIMA model.

The general form of the RegComponent time series model, taken from Bell (2004), is

$$y_t = x_t'\beta + \sum_{i=1}^{m} h_{i,t} z_{i,t} \tag{8}$$

where the first term is a regression mean function which is followed by a noise term that follows an ARIMA component model. The $h_{i,t}$ are series of known constants called `scale factors` and $z_{i,t}$ are independent unobserved component series following ARIMA models.

These models are referred to as regComponent models in Bell (2004), and have proven useful in a number of contexts, including utilizing sampling error information to improve seasonal adjustments for series with high sampling error variances (Bell and Nguyen, 2002), and modeling moving trading day effects in economic time series (Bell and Martin, 2005).

A possible future project is to incorporate signal extraction routines within the `regCMPNT` program, so that seasonal adjustments can be obtained from this software. This will make it possible to provide a means of estimating generalized airline models of the type developed in Findley, Martin, and Wills (2002) and Aston, Findley, Wills, and Martin (2004). These models expand the available models that can be used for model-based seasonal adjustment beyond simple ARIMA models and allow for more flexible specification of trend and seasonal effects.

The possibility of incorporating an object-oriented implementation of regCMPNT developed by Jean Palate at the National Bank of Belgium to incorporate models of type of equation (8), as well as the generalized airline models, into a future version of X-13A-S will be explored. These components are programmed into C♯ and Java, and offer the advantages of working in an object-oriented programming framework. An implementation of TRAMO/SEATS into reusable components is documented in Palate (2006).

5.3 XML output

Lefrançois and Mamay (2004) recommended that developers of software such as X-13A-S consider using XML as a way of better documenting input and specifications used between the different software and improve the integration of stand alone seasonal adjustment packages with other software systems.

Work will begin soon on examining how best to implement XML for the saved output of X-13A-S, both for the resulting series and components generated by the seasonal adjustment and for the modeling diagnostics that are produced. Different partners and software developers will need to agree on standards for this conversion; we hope to use the U. S. Census Bureau's experience in developing web based systems such as Ferret as well as other agencies' experiences to inform this effort.

5.4 Accessible Documentation

Section 508 is an amendment to the Disabilities Act that requires Federal agencies to make their electronic and information technology accessible to people with disabilities. As a start to making X-12-ARIMA and X-13A-S compliant with this act, an effort is currently underway to convert the X-12-ARIMA documentation to an accessible format.

The documentation was originally written in TeX; the documentation was converted into LaTeX to make it easier to convert it to HTML. Our goal is to create HTML such that users with commercial screen reading software (such as Jaws®) will be able to navigate the document successfully.

There are several open source programs that can convert simple LaTeX documents to HTML. These utilities deal with equations differently; many attempt to convert equations expressed in LaTeX to MathML, an extension to XML for rendering mathematics, while others create graphics files containing the equations. Since screen reading software does not currently process MathML in any meaningful way, testing was limited to those utilities that generated graphics.

Of these tools, only one was capable of converting a document as complex as the X-12-ARIMA documentation, and that required considerable reformatting of sections of the document. The HTML output from this utility still requires substantial changes to make it accessible.

Our long-term goal remains is to convert the LaTeX files into accessible HTML, using MathML to render the mathematical equations. Our current efforts are centered on rendering the PDF files generated for the Reference Manual and Quick References in such a way that they can be made accessible. The CommonLook Section 508 product for Adobe® Acrobat, developed by NetCentric™Technologies, is now being used for this task.

5.5 Other Features

Currently, the format of the SEATS output of the program is identical to that produced by the DOS version of SEATS, which is different than the X-12-ARIMA output format of the rest of the program. The tabular output of the program will be standardized, with labels assigned to each of the tables. The user will be given more control over which output tables can be stored or saved than SEATS currently offers.

SEATS produces a wide variety of growth rate estimates for the seasonally adjusted series, trend cycle, and other series. This facility will be expanded to provide growth rates for X-11 seasonal adjustments and trends.

6 Acknowledgements

The author thanks Pat Cantwell, Roxanne Feldpausch and David Findley for their careful reading of drafts of this document.

The author is also grateful for the assistance of Gianluca Caporello and Agustín Maravall, who made the source code of SEATS programs available for study and implementation and generously shared their expertise.

The graphs for this paper were generated using SAS software. Copyright, SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

References

Aston, J. A. D., Findley, D. F., Wills, K. C., and Martin, D. E. K. (2004), "Generalizations of the Box-Jenkins Airline Model With Frequency-Specific Seasonal Coefficients," *Proceeding of the NBER/NSF Time Series Conference*, also http://www.census.gov/ts/papers/findleynber2004.pdf.

Bell, W. R. (1984), "Seasonal Decomposition of Deterministic Effects," SRD Research Report No. 84/01, U. S. Census Bureau http://www.census.gov/srd/papers/pdf/rr84-1.pdf.

— (1995), "Correction to 'Seasonal Decomposition of Deterministic Effects'," SRD Research Report No. 95/01, U. S. Census Bureau http://www.census.gov/srd/papers/pdf/rr84-1.pdf.

— (2004), "On RegComponent time series models and their applications," in *State Space and Unobserved Component Models*, eds. Harvey, A., Koopman, S. J., and Shephard, N., Cambridge: Cambridge University Press, also http://www.census.gov/ts/regcmpnt/pc/.

Bell, W. R. and Hillmer, S. (1988), "A matrix approach to likelihood evaluation and signal extraction for ARIMA component time series models," Research Report Number 1988/22, Statistical Research Division, U.S. Census Bureau http://www.census.gov/srd/papers/pdf/rr88-22.pdf.

Bell, W. R. and Martin, D. E. K. (2005), "Modeling Time-Varying Trading Day Effects in Monthly Time Series," *Proceeding of the American Statistical Association, Business and Economic Statistics Section*, [CD-ROM] http://www.census.gov/ts/papers/jsm2004dem.pdf.

Bell, W. R. and Monsell, B. C. (1992), "X-11 Symmetric Linear Filters and their Transfer Functions," Research Report Number 1992/15, Statistical Research Division, U.S. Census Bureau http://www.census.gov/srd/papers/pdf/rr92-15.pdf.

Bell, W. R. and Nguyen, T. T. (2002), "Comparison of Time Series Characteristics for Seasonal Adjustments from SEATS and X-12-ARIMA," American Statistical Association, Proceedings of the Business and Economic Statistics Section [CD-ROM] http://www.census.gov/ts/papers/choodasa2002.pdf.

Box, G. E. P. and Tiao, G. C. (1975), "Intervention analysis with applications to economic and environmental problems," *Journal of the American Statistical Association*, 70, 70–79.

Burman, J. P. (1980), "Seasonal Adjustment by Signal Extraction," *Journal of Royal Statistical Society A*, 26, 321–337.

Buszuwski, J. A. and Scott, S. (1993), "Some Issues in Seasonal Adjustment when Modeling Interventions," American Statistical Association, Proceedings of the Business and Economic Statistical Section.

Census (2007), "X-12-ARIMA Reference Manual, Version 0.3," U.S. Census Bureau, U.S. Department of Commerce (http://www.census.gov/ts/x12a/final/v03/x12adocV03.pdf).

Feldpausch, R. M. (2006), "Windows® Interface to X-12-ARIMA," U.S. Census Bureau, U.S. Department of Commerce.

Feldpausch, R. M., Hood, C. C. H., and Wills, K. C. (2004), "Diagnostics for Model-Based Seasonal Adjustment," *Proceeding of the American Statistical Association, Business and Economic Statistics Section*, [CD-ROM] http://www.census.gov/ts/papers/jsm2004rmf.pdf.

Findley, D., McElroy, T. S., and Wills, K. C. (2005), "Modifications of SEATS Diagnostic for Detecting Over- and Underestimation of Seasonal Adjustment Components," *Proceeding of the American Statistical Association, Business and Economic Statistics Section*, [CD-ROM]. Also http://www.census.gov/ts/papers/findleymcelroywills2005.pdf.

Findley, D. F., Gagnon, R., and McElroy, T. S. (2006), "Evaluation of Finite-Sample Diagnostics for Model-Based Seasonal Adjustments and Trends," Proceedings of the Conference on Seasonality, Seasonal Adjustment and Their Implications for Short-term Analysis and Forecasting, Eurostat, Luxembourg.

Findley, D. F. and Martin, D. E. K. (2006), "Frequency Domain Analysis of SEATS and X-11/X-12-ARIMA Seasonal Adjustment Filters for Short and Moderate Length Time Series," *Journal of Official Statistics*, 22, 1–34.

Findley, D. F., Martin, D. E. K., and Wills, K. C. (2002), "Generalizations of the Box-Jenkins Airline Model," *Proceeding of the American Statistical Association, Business and Economic Statistics Section*, [CD-ROM] Also http://www.census.gov/ts/papers/findleynber2004.pdf.

Findley, D. F. and Monsell, B. C. (2007), "Modeling Stock Trading Day Effects Under Flow Day-of-Week Effect Constraints," Proceedings of the 2007 ISI Meetings (forthcoming).

Findley, D. F., Monsell, B. C., Bell, W. R., Otto, M. C., and Chen, B. C. (1998), "New capabilities of the X-12-ARIMA seasonal adjustment program (with discussion)," *Journal of Business and Economic Statistics*, 16, 127–77, http://www.census.gov/ts/papers/jbes98.pdf.

Findley, D. F., Monsell, B. C., Shulman, H. B., and Pugh, M. G. (1990), "Sliding Spans Diagnostics for Seasonal and Related Adjustments," *Journal of the American Statistical Association*, 85, 345–355.

Findley, D. F., Wills, K. C., Aston, J. A. D., Feldpausch, R., and Hood, C. C. H. (2003), "Diagnostics for ARIMA Model-Based Seasonal Adjustment," *Proceeding of the American Statistical Association, Business and Economic Statistics Section*, [CD-ROM].

Gómez, V. and Maravall, A. (1997), "Programs TRAMO and SEATS : Instructions for the User (Beta Version: June 1997)," Working Paper 97001, Ministerio de Economía y Hacienda, Dirrectión General de Análisis y Programación Presupuestaria, Madrid.

Hood, C. C. H. (2002), "X-12-Graph: A SAS/GRAPH Program for X-12-ARIMA Output, User's Guide for the X-12-Graph Batch for PC/Windows, Version 1.2," U. S. Census Bureau, U. S. Department of Commerce.

Kaiser, R. and Maravall, A. (2002), "Seasonal outliers in time series," Journal of the InterAmerican Statistical Institute, special issue on time series; http://www.bde.es/servicio/software/tramo/slsoutlier.pdf.

Lefrançois, B. and Mamay, C. (2004), "Presentation of Seasonally Adjusted Series," OECD Short-Term Economics Statistics Group Expert meeting, June 2004.

Lytras, D. P. (2006), "X-12-Graph: A SAS/GRAPH Program for X-12-ARIMA Output, User's Guide for the Batch Program on the PC, Version 1.4," U. S. Census Bureau, U. S. Department of Commerce http://www.census.gov/srd/www/x12a/x12gbat_doc.html.

Lytras, D. P., Feldpausch, R. M., and Bell, W. R. (2007), "Determining Seasonality: A Comparison of Diagnostics From X-12-ARIMA," (CD-ROM).

McElroy, T. S. (2005), "Matrix Formulas for Nonstationary Signal Extraction," Research Report No. RRS2005/04, Statistical Research Division, U.S. Census Bureau http://www.census.gov/srd/papers/pdf/rrs2005-04.pdf.

Monsell, B. C. (2002), "An Update on the Development of the X-12-ARIMA Seasonal Adjustment Program," in *Proceedings of the 3rd International Symposium on Frontiers of Time Series Modeling*, Tokyo: Institute of Statistical Mathematics, pp. 1–11.

— (2007), “Release Notes for Version 0.3 of X-12-ARIMA,” Research Report No. RRS2007/03, Statistical Research Division, U.S. Census Bureau http://www.census.gov/srd/papers/pdf/rrs2007-03.pdf.

Monsell, B. C., Aston, J. A. D., and Koopman, S. J. (2003), “Toward X-13,” *Proceeding of the American Statistical Association, Business and Economic Statistics Section*, [CD-ROM] http://www.census.gov/ts/papers/jsm2003bcm.pdf.

Palate, J. (2006), “Reusable components for seasonal adjustment: a new implementation of Tramo-Seats,” Proceedings of the Conference on Seasonality, Seasonal Adjustment and Their Implications for Short-term Analysis and Forecasting, Eurostat, Luxembourg.

Planas, C. and Depoutot, R. (2002), “Controlling Revisions in ARIMA-Model-Based Seasonal Adjustment,” *Journal of Time Series Analysis*, 23, 193–214.