

**stsplit** — Split and join time-span records
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## Description

`stsplit` with the `at(numlist)` or `every(#)` option splits episodes into two or more episodes at the implied time points since being at risk or after a time point specified by `after()`. Each resulting record contains the follow-up on one subject through one time band. Expansion on multiple time scales may be obtained by repeatedly using `stsplit`. *newvar* specifies the name of the variable to be created containing the observation's category. The new variable records the interval to which each new observation belongs and is bottom coded.

`stsplit, at(failures)` performs episode splitting at the failure times (per stratum).

`stjoin` performs the reverse operation, namely, joining episodes back together when such can be done without losing information.

## Quick start

Split episodes in `stset` data at analysis times 5, 10, and 15, and create new time category identifier `timecat`

```
stsplit timecat, at(5 10 15)
```

Join data that has been split after dropping variable created by `stsplit`

```
drop timecat
stjoin
```

Split episodes at the value in `startvar`

```
stsplit timecat, at(0) after(time=startvar)
```

Split data at 30, 40, and 50 time units after the value in `startvar`

```
stsplit timecat, at(30 40 50) after(time=startvar)
```

Split data every 10 time units after `startvar`

```
stsplit timecat, every(10) after(time=startvar)
```

Split data at failure times

```
stsplit, at(failures)
```

As above, and create risk-set identifier variable `riskvar`

```
stsplit, at(failures) riskset(riskvar)
```

## Menu

### stsplit

Statistics > Survival analysis > Setup and utilities > Split time-span records

### stjoin

Statistics > Survival analysis > Setup and utilities > Join time-span records

## Syntax

*Split at designated times*

```
stsplit newvar [if], {at(numlist) | every(#)} [stsplitDT_options]
```

*Split at failure times*

```
stsplit [if], at(failures) [stsplitFT_options]
```

*Join episodes*

```
stjoin [, censored(numlist)]
```

<i>stsplitDT_options</i>	Description
Main	
*at( <i>numlist</i> )	split records at specified analysis times
*every(#)	split records when analysis time is a multiple of #
<u>after</u> ( <i>spec</i> )	use time since <i>spec</i> for at() or every() rather than time since onset of risk; see <a href="#">Options</a>
trim	exclude observations outside of range
<u>nopreserve</u>	do not save original data; programmer's option

\*Either at(*numlist*) or every(#) is required with stsplit at designated times.

<i>stsplitFT_options</i>	Description
Main	
*at( <i>failures</i> )	split at observed failure times
<u>strata</u> ( <i>varlist</i> )	restrict splitting to failures within stratum defined by <i>varlist</i>
<u>riskset</u> ( <i>newvar</i> )	create a risk-set ID variable named <i>newvar</i>
<u>nopreserve</u>	do not save original data; programmer's option

\*at(*failures*) is required with stsplit at failure times.

You must stset your dataset by using the id() option before using stsplit or stjoin; see [\[ST\] stset](#).  
nopreserve does not appear in the dialog box.

## Options for stsplit

Main

`at(numlist)` or `every(#)` is required in syntax one; `at(failures)` is required for syntax two. These options specify the analysis times at which the records are to be split.

`at(5(5)20)` splits records at  $t = 5$ ,  $t = 10$ ,  $t = 15$ , and  $t = 20$ .

If `at([...] max)` is specified, `max` is replaced by a suitably large value. For instance, to split records every five analysis-time units from time zero to the largest follow-up time in our data, we could find out what the largest time value is by typing `summarize _t` and then explicitly typing it into the `at()` option, or we could just specify `at(0(5)max)`.

`every(#)` is a shorthand for `at(#(#)max)`; that is, episodes are split at each positive multiple of `#`.

`after(spec)` specifies the reference time for `at()` or `every()`. Syntax one can be thought of as corresponding to `after(time of onset of risk)`, although you cannot really type this. You could type, however, `after(time=birthdate)` or `after(time=marrydate)` or `after(marrydate)`.

*spec* has syntax

$$[\{\text{time} \mid \text{t} \mid \_t\} = ]\{\text{exp} \mid \min(\text{exp}) \mid \text{asis}(\text{exp})\}$$

where

`time` specifies that the expression be evaluated in the same time units as *timevar* in `stset timevar, ...`. This is the default.

`t` and `_t` specify that the expression be evaluated in units of analysis time. `t` and `_t` are synonyms; it makes no difference whether you specify one or the other.

*exp* specifies the reference time. For multiepisode data, *exp* should be constant within subject ID.

`min(exp)` specifies that for multiepisode data, the minimum of *exp* be taken within ID.

`asis(exp)` specifies that for multiepisode data, *exp* be allowed to vary within ID.

`trim` specifies that observations with values less than the minimum or greater than the maximum value listed in `at()` be excluded from subsequent analysis. Such observations are not dropped from the data; `trim` merely sets their value of variable `_st` to 0 so that they will not be used, yet they can still be retrieved the next time the dataset is `stset`.

`strata(varlist)` specifies up to five strata variables. Observations with equal values of the variables are assumed to be in the same stratum. `strata()` restricts episode splitting to failures that occur within the stratum, and memory requirements are reduced when strata are specified.

`riskset(newvar)` specifies the name for a new variable recording the unique risk set in which an episode occurs, and missing otherwise.

The following option is available with `stsplit` but is not shown in the dialog box:

`nopreserve` is intended for use by programmers. It speeds the transformation by not saving the original data, which can be restored should things go wrong or if you press *Break*. Programmers often specify this option when they have already preserved the original data. `nopreserve` does not affect the transformation.

## Option for stjoin

`censored(numlist)` specifies values of the failure variable, *failvar*, from `stset ...`, `failure(failvar=...)` that indicate “no event” (censoring).

If you are using `stjoin` to rejoin records after `stsplit`, you do not need to specify `censored()`. Just do not forget to drop the variable created by `stsplit` before typing `stjoin`. See [example 4](#) below.

Neither do you need to specify `censored()` if, when you `stset` your dataset, you specified `failure(failvar)` and not `failure(failvar=...)`. Then `stjoin` knows that *failvar* = 0 and *failvar* = . (missing) correspond to no event. Two records can be joined if they are contiguous and record the same data and the first record has *failvar* = 0 or *failvar* = ., meaning no event at that time.

You may need to specify `censored()`, and you probably do if, when you `stset` the dataset, you specified `failure(failvar=...)`. If `stjoin` is to join records, it needs to know what events do not count and can be discarded. If the only such event is *failvar* = ., you do not need to specify `censored()`.

## Remarks and examples

[stata.com](http://www.stata.com)

Remarks are presented under the following headings:

- [What stsplit does and why](#)
- [Using stsplit to split at designated times](#)
- [Time versus analysis time](#)
- [Splitting data on recorded ages](#)
- [Using stsplit to split at failure times](#)

## What stsplit does and why

`stsplit` splits records into two or more records on the basis of analysis time or on a variable that depends on analysis time, such as age. `stsplit` takes data like

id	_t0	_t	x1	x2	_d
1	0	18	12	11	1

and produces

id	_t0	_t	x1	x2	_d	tcat
1	0	5	12	11	0	0
1	5	10	12	11	0	5
1	10	18	12	11	1	10

or

id	_t0	_t	x1	x2	_d	agecat
1	0	7	12	11	0	30
1	7	17	12	11	0	40
1	17	18	12	11	1	50

The above alternatives record the same underlying data: subject 1 had  $x_1 = 12$  and  $x_2 = 11$  during  $0 < t \leq 18$ , and at  $t = 18$ , the subject failed.

The difference between the two alternatives is that the first breaks out the analysis times 0–5, 5–10, and 10–20 (although subject 1 failed before  $t = 20$ ). The second breaks out age 30–40, 40–50, and 50–60. You cannot tell from what is presented above, but at  $t = 0$ , subject 1 was 33 years old.

In our example, that the subject started with one record is not important. The original data on the subject might have been

```

id   _t0   _t   x1   x2   _d
1     0   14  12  11   0
1    14   18  12   9   1

```

and then we would have obtained

```

id   _t0   _t   x1   x2   _d   tcat
1     0     5  12  11   0     0
1     5    10  12  11   0     5
1    10    14  12  11   0    10
1    14    18  12   9   1    10

```

or

```

id   _t0   _t   x1   x2   _d   agecat
1     0     7  12  11   0     30
1     7    14  12  11   0     40
1    14    17  12   9   0     40
1    17    18  12   9   1     50

```

Also we could just as easily have produced records with analysis time or age recorded in single-year categories. That is, we could start with

```

id   _t0   _t   x1   x2   _d
1     0   14  12  11   0
1    14   18  12   9   1

```

and produce

```

id   _t0   _t   x1   x2   _d   tcat
1     0     1  12  11   0     0
1     1     2  12  11   0     1
1     2     3  12  11   0     2
...

```

or

```

id   _t0   _t   x1   x2   _d   agecat
1     0     1  12  11   0     30
1     1     2  12  11   0     31
1     2     3  12  11   0     32
...

```

Moreover, we can even do this splitting on more than one variable. Let's go back and start with

```

id   _t0   _t   x1   x2   _d
1     0   18  12  11   1

```

Let's split it into the analysis-time intervals 0–5, 5–10, and 10–20, and let's split it into 10-year age intervals 30–40, 40–50, and 50–60. The result would be

```

id   _t0   _t   x1   x2   _d   tcat   agecat
1     0     5  12  11   0     0     30
1     5     7  12  11   0     5     30
1     7    10  12  11   0     5     40
1    10    17  12  11   0    10     40
1    17    18  12  11   1    10     50

```

Why would we want to do any of this?

We might want to split on a time-dependent variable, such as age, if we want to estimate a Cox proportional hazards model and include current age among the regressors (although we could instead use `stcox`'s `tv` option) or if we want to make tables by age groups (see [ST] [strate](#)).

## Using `stsplit` to split at designated times

`stsplit`'s syntax to split at designated times is, ignoring other options,

```
stsplit newvar [if], at(numlist)
stsplit newvar [if], at(numlist) after(spec)
```

`at()` specifies the analysis times at which records are to be split. Typing `at(5 10 15)` splits records at the indicated analysis times and separates records into the four intervals 0–5, 5–10, 10–15, and 15+.

In the first syntax, the splitting is done on analysis time,  $t$ . In the second syntax, the splitting is done on 5, 10, and 15 analysis-time units after the time given by `after(spec)`.

In either case, `stsplit` also creates `newvar` containing the interval to which each observation belongs. Here `newvar` would contain 0, 5, 10, and 15; it would contain 0 if the observation occurred in the interval 0–5, 5 if the observation occurred in the interval 5–10, and so on. To be precise,

Category	Precise meaning	<code>newvar</code> value
0–5	$(-\infty, 5]$	0
5–10	$(5, 10]$	5
10–15	$(10, 15]$	10
15+	$(15, \infty)$	15

If any of the `at()` numbers are negative (which would be allowed only by specifying the `after()` option and would be unusual), the first category is labeled one less than the minimum value specified by `at()`.

Consider the data

```
id   yr0   yr1  yrborn  x1  event
1   1990  1995  1960    5   52
2   1993  1997  1964    3   47
```

In these data, subjects became at risk in `yr0`. The failure event of interest is `event = 47`, so we `stset` our dataset by typing

```
. stset yr1, id(id) origin(time yr0) failure(event==47)
(output omitted)
```

and that results in

```
id  _t0  _t   yr0   yr1  yrborn  x1  event  _d
1   0    5   1990  1995  1960    5   52    0
2   0    4   1993  1997  1964    3   47    1
```

In the jargon of `st`, variables `_t0` and `_t` record the span of each record in analysis-time ( $t$ ) units. Variables `yr0` and `yr1` also record the time span, but in time units. Variable `_d` records 1 for failure and 0 otherwise.

Typing `stsplit cat, at(2 4 6 8)` would split the records on the basis of analysis time:

```
. stsplit cat, at(2 4 6 8)
(3 observations (episodes) created)
. order id _t0 _t yr0 yr1 yrborn x1 event _d cat
. list id-cat
```

	id	_t0	_t	yr0	yr1	yrborn	x1	event	_d	cat
1.	1	0	2	1990	1992	1960	5	.	0	0
2.	1	2	4	1990	1994	1960	5	.	0	2
3.	1	4	5	1990	1995	1960	5	52	0	4
4.	2	0	2	1993	1995	1964	3	.	0	0
5.	2	2	4	1993	1997	1964	3	47	1	2

The first record, which represented the analysis-time span  $(0, 5]$ , was split into three records:  $(0, 2]$ ,  $(2, 4]$ , and  $(4, 5]$ . The `yrborn` and `x1` values from the single record were duplicated in  $(0, 2]$ ,  $(2, 4]$ , and  $(4, 5]$ . The original `event` variable was changed to missing at  $t = 2$  and  $t = 4$  because we do not know the value of `event`; all we know is that `event` is 52 at  $t = 5$ . The `_d` variable was correspondingly set to 0 for  $t = 2$  and  $t = 4$  because we do know, at least, that the subject did not fail.

`stsplit` also keeps your original time variables up to date in case you want to `streset` or `re-stset` your dataset. `yr1` was updated, too.

Now let's go back to our original dataset after we `stset` it but before we split it,

id	_t0	_t	yr0	yr1	yrborn	x1	event	_d
1	0	5	1990	1995	1960	5	52	0
2	0	4	1993	1997	1964	3	47	1

and consider splitting on age. In 1990, subject 1 is age  $1990 - \text{yrborn} = 1990 - 1960 = 30$ , and subject 2 is 29. If we type

```
. stsplit acat, at(30 32 34) after(time=yrborn)
```

we will split the data according to

```
age <= 30 (called acat=0)
30 < age <= 32 (called acat=30)
32 < age <= 34 (called acat=32)
34 < age (called acat=34)
```

The result will be

id	_t0	_t	yr0	yr1	yrborn	x1	event	_d	acat
1	0	2	1990	1992	1960	5	.	0	30
1	2	4	1990	1994	1960	5	.	0	32
1	4	5	1990	1995	1960	5	52	0	34
2	0	1	1993	1994	1964	3	.	0	0
2	1	3	1993	1996	1964	3	.	0	30
2	3	4	1993	1997	1964	3	47	1	32

The original record on subject 1 corresponding to  $(0, 5]$  was split into  $(0, 2]$ ,  $(2, 4]$ , and  $(4, 5]$  because those are the  $t$  values at which age becomes 32 and 34.

You can `stsplit` the data more than once. Now having these data, if we typed

```
. stsplit cat, at(2 4 6 8)
```

the result would be

id	_t0	_t	yr0	yr1	yrborn	x1	event	_d	acat	cat
1	0	2	1990	1992	1960	5	.	0	30	0
1	2	4	1990	1994	1960	5	.	0	32	2
1	4	5	1990	1995	1960	5	52	0	34	4
2	0	1	1993	1994	1964	3	.	0	0	0
2	1	2	1993	1995	1964	3	.	0	30	0
2	2	3	1993	1996	1964	3	.	0	30	2
2	3	4	1993	1997	1964	3	47	1	32	2

Whether we typed

```
. stsplit acat, at(30 32 34) after(time=yrborn)
. stsplit cat, at(2 4 6 8)
```

or

```
. stsplit cat, at(2 4 6 8)
. stsplit acat, at(30 32 34) after(time=yrborn)
```

would make no difference.

## Time versus analysis time

Be careful using the `after()` option if, when you `stset` your dataset, you specified `stset`'s `scale()` option. We say be careful, but actually we mean be appreciative, because `stsplit` will do just what you would expect if you did not think too hard.

When you split a record on a time-dependent variable, `at()` is still specified in analysis-time units, meaning units of `time/scale()`.

For instance, if your original data recorded time as Stata dates, that is, number of days since 1960,

```
id      date0      date1  birthdate  x1  event
  1  14apr1993  27mar1995  12jul1959  5   52
...
```

and you previously `stset` your dataset by typing

```
. stset date1, id(id) origin(time date0) scale(365.25) ...
```

and you now wanted to split on the age implied by `birthdate`, you would specify the split points in years since birth:

```
. stsplit agecat, at(20(5)60) after(time=birth)
```

`at(20(5)60)` means to split the records at the ages, measured in years, of 20, 25, ..., 60.

When you `stset` your dataset, you basically told `st` how you recorded times (you recorded them as dates) and how to map such times (dates) into analysis time. That was implied by what you typed, and all of `st` remembers that. Typing

```
. stsplit agecat, at(20(5)60) after(time=birth)
```

tells `stsplit` to split the data on 20, 25, ..., 60 analysis-time units after `birthdate` for each subject.



## Splitting data on recorded ages

Recorded ages can sometimes be tricky. Consider the data

```

id    yr0    yr1    age    x1    event
1     1980   1996    30     5     52
...

```

When was `age = 30` recorded—1980 or 1996? Put aside that question because things are about to get worse. Say that you `stset` this dataset so that `yr0` is the `origin()`,

```

id    _t0    _t    yr0    yr1    age    x1    event
1     0     16   1980   1996    30     5     52
...

```

and then split on analysis time by typing `stsplit cat, at(5(5)20)`. The result would be

```

id    _t0    _t    yr0    yr1    age    x1    event
1     0     5    1980   1985    30     5     .
1     5    10   1980   1990    30     5     .
1    10    15   1980   1995    30     5     .
1    15    16   1980   1996    30     5     52

```

Regardless of the answer to the question on when age was measured, `age` is most certainly not 30 in the newly created records, although you might argue that age at baseline was 30 and that is what you wanted, anyway.

The only truly safe way to deal with ages is to convert them back to birthdates at the outset. Here we would, early on, type

```

. generate bdate = yr1 - age           (if age was measured at yr1)
or
. generate bdate = yr0 - age           (if age was measured at yr0)

```

In fact, `stsplit` tries to protect you from making age errors. Suppose that you did not do as we just recommended. Say that age was measured at `yr1`, and you typed, knowing that `stsplit` wants a date,

```

. stsplit acat, at(20(5)50) after(time= yr1-age)

```

on these already `stsplit` data. `stsplit` will issue the error message “`after()` should be constant within `id`”. To use the earliest date, you need to type

```

. stsplit acat, at(20(5)50) after(time= min(yr1-age))

```

Nevertheless, be aware that when you `stsplit` data, if you have recorded ages in your data, and if the records were not already split to control for the range of those ages, then age values, just like all the other variables, are carried forward and no longer reflect the age of the newly created record.

### ► Example 1: Splitting on age

Consider the data from a heart disease and diet survey. The data arose from a study described more fully in [Morris, Marr, and Clayton \(1977\)](#) and analyzed in [Clayton and Hills \(1993\)](#). (Their results differ slightly from ours because the dataset has been updated.)

```
. use http://www.stata-press.com/data/r15/diet
(Diet data with dates)
. describe
Contains data from http://www.stata-press.com/data/r15/diet.dta
  obs:          337          Diet data with dates
  vars:         11          1 May 2016 19:01
  size:         8,088
```

---

variable name	storage type	display format	value label	variable label
id	int	%9.0g		Subject identity number
fail	byte	%8.0g		Outcome (CHD = 1 3 13)
job	byte	%8.0g		Occupation
month	byte	%8.0g		month of survey
energy	float	%9.0g		Total energy (1000kcal/day)
height	float	%9.0g		Height (cm)
weight	float	%9.0g		Weight (kg)
hienergy	byte	%9.0g		Indicator for high energy
doe	int	%td		Date of entry
dox	int	%td		Date of exit
dob	int	%td		Date of birth

---

Sorted by: id

In this dataset, the outcome variable, `fail`, has been coded as 0, 1, 3, 5, 12, 13, 14, and 15. Codes 1, 3, and 13 indicated coronary heart disease (CHD), other nonzero values code other events such as cancer, and 0 is used to mean “no event” at the end of the study.

The variable `hienergy` is coded 1 if the total energy consumption is more than 2.75 Mcal and 0 otherwise.

We would like to expand the data, using age as the time scale with 10-year age bands. We do this by first `stset`ting the dataset, specifying the date of birth as the origin.

```
. stset dox, failure(fail) origin(time dob) enter(time doe) scale(365.25) id(id)
      id: id
      failure event: fail != 0 & fail < .
obs. time interval: (dox[_n-1], dox]
enter on or after: time doe
exit on or before: failure
t for analysis: (time-origin)/365.25
origin: time dob
```

---

```
337 total observations
  0 exclusions
```

---

```
337 observations remaining, representing
337 subjects
  80 failures in single-failure-per-subject data
4,603.669 total analysis time at risk and under observation
              at risk from t = 0
              earliest observed entry t = 30.07529
              last observed exit t = 69.99863
```

The origin is set to date of birth, making time-since-birth analysis time, and the scale is set to 365.25, so that time since birth is measured in years.

Let's list a few records and verify that the analysis-time variables `_t0` and `_t` are indeed recorded as we expect:

```
. list id dob doe dox fail _t0 _t if id==1 | id==34
```

	id	dob	doe	dox	fail	_t0	_t
1.	1	04jan1915	16aug1964	01dec1976	0	49.615332	61.908282
34.	34	12jun1899	16apr1959	31dec1966	3	59.841205	67.550992

We see that patient 1 was 49.6 years old at time of entry into our study and left at age 61.9. Patient 34 entered the study at age 59.8 and exited the study with CHD at age 67.6.

Now we can split the data by age:

```
. stsplit ageband, at(40(10)70)
(418 observations (episodes) created)
```

`stsplit` added 418 observations to the dataset in memory and generated a new variable, `ageband`, which identifies each observation's age group.

```
. list id _t0 _t ageband fail height if id==1 | id==34
```

	id	_t0	_t	ageband	fail	height
1.	1	49.615332	50	40	.	175.387
2.	1	50	60	50	.	175.387
3.	1	60	61.908282	60	0	175.387
61.	34	59.841205	60	50	.	177.8
62.	34	60	67.550992	60	3	177.8

The single record for the subject with `id = 1` has expanded to three records. The first refers to the age band 40–49, coded 40, and the subject spends  $\_t - \_t0 = 0.384668$  years in this band. The second refers to the age band 50–59, coded 50, and the subject spends 10 years in this band, and so on. The follow-up in each of the three bands is censored (`fail = .`). The single record for the subject with `id = 34` is expanded to two age bands; the follow-up for the first band was censored (`fail = .`), and the follow-up for the second band ended in CHD (`fail = 3`).

The values for variables that do not change with time, such as `height`, are simply repeated in the new records. This can lead to much larger datasets after expansion. Dropping unneeded variables before using `split` may be necessary.

◀

## ► Example 2: Splitting on age and time in study

To use `stsplit` to expand the records on two time scales simultaneously, such as age and time in study, we can first expand on the age scale as described in [example 1](#), and then on the time-in-study scale with the command

```
. stsplit timeband, at(0(5)25) after(time=doe)
(767 observations (episodes) created)
. list id _t0 _t ageband fail if id==1 | id==34
```

	id	_t0	_t	ageband	fail
1.	1	49.615332	50	40	.
2.	1	50	54.615332	50	.
3.	1	54.615332	59.615332	50	.
4.	1	59.615332	60	50	.
5.	1	60	61.908282	60	0
111.	34	59.841205	60	50	.
112.	34	60	64.841205	60	.
113.	34	64.841205	67.550992	60	3

By splitting the data by using two time scales, we partitioned the data into time cells corresponding to a *Lexis diagram* as described, for example, in [Clayton and Hills \(1993\)](#). Also see [Keiding \(1998\)](#) for an overview of Lexis diagrams. Each new observation created by splitting the data records the time that the individual spent in a Lexis cell. We can obtain the time spent in the cell by calculating the difference  $\_t - \_t0$ . For example, the subject with  $id = 1$  spent 0.384668 years ( $50 - 49.615332$ ) in the cell corresponding to age 40–49 and study time 0–5, and 4.615332 years ( $54.615332 - 50$ ) in the cell for age 50–59 and study time 0–5.

We can also do these expansions in reverse order, that is, split first on study time and then on age.

◀

### ► Example 3: Explanatory variables that change with time

In the previous examples, time, in the form of age or time in study, is the explanatory variable to be studied or controlled for, but in some studies other explanatory variables also vary with time. The `stsplit` command can sometimes be used to expand the records so that in each new record such an explanatory variable is constant over time. For example, in the Stanford heart data (see [\[ST\] stset](#)), we would like to split the data and generate the explanatory variable `posttran`, which takes the value 0 before transplantation and 1 thereafter. The follow-up must therefore be divided into time before transplantation and time after.

We first generate for each observation an entry time and an exit time that preserve the correct follow-up time in such a way that the time of transplants is the same for all individuals. By summarizing `wait`, the time to transplant, we obtain its maximum value of 310. By selecting a value greater than this maximum, say, 320, we now generate two new variables:

```
. use http://www.stata-press.com/data/r15/stanford, clear
(Heart transplant data)
. generate enter = 320 - wait
. generate exit = 320 + stime
```

We have created a new artificial time scale where all transplants are coded as being performed at time 320. By defining `enter` and `exit` in this manner, we maintain the correct total follow-up time for each patient. We now `stset` and `stsplit` the data:

```

. stset exit, enter(time enter) failure(died) id(id)
      id: id
      failure event: died != 0 & died < .
obs. time interval: (exit[_n-1], exit]
enter on or after: time enter
exit on or before: failure

```

---

```

103 total observations
  0 exclusions

```

---

```

103 observations remaining, representing
103 subjects
  75 failures in single-failure-per-subject data
34,589.1 total analysis time at risk and under observation
      at risk from t = 0
earliest observed entry t = 10
last observed exit t = 2,119

```

```

. stsplsplit posttran, at(0,320)
(69 observations (episodes) created)
. replace posttran=0 if transplant==0
(34 real changes made)
. replace posttran=1 if posttran==320
(69 real changes made)

```

We replaced `posttran` in the last command so that it is now a 0/1 indicator variable. We can now generate our follow-up time, `t1`, as the difference between our analysis-time variables, list the data, and `stset` the dataset.

```

. generate t1 =_t - _t0
. list id enter exit _t0 _t posttran if id==16 | id==44

```

	id	enter	exit	_t0	_t	posttran
41.	44	320	360	320	360	0
110.	16	292	320	292	320	0
111.	16	292	628	320	628	1

```

. stset t1, failure(died) id(id)
      id: id
      failure event: died != 0 & died < .
obs. time interval: (t1[_n-1], t1]
exit on or before: failure

```

---

```

172 total observations
  0 exclusions

```

---

```

172 observations remaining, representing
103 subjects
  75 failures in single-failure-per-subject data
31,938.1 total analysis time at risk and under observation
      at risk from t = 0
earliest observed entry t = 0
last observed exit t = 1,799

```

## Using `stsplit` to split at failure times

To split data at failure times, you would use `stsplit` with the following syntax, ignoring other options:

```
stsplit [if] , at(failures)
```

This form of episode splitting is useful for Cox regression with time-varying covariates. Splitting at the failure times is useful because of a property of the maximum partial-likelihood estimator for a Cox regression model: the likelihood is evaluated only at the times at which failures occur in the data, and the computation depends only on the risk pools at those failure times. Changes in covariates between failure times do not affect estimates for a Cox regression model. Thus, to fit a model with time-varying covariates, all you have to do is define the values of these time-varying covariates at all failure times at which a subject was at risk (Collett 2015, chap. 8). After splitting at failure times, you define time-varying covariates by referring to the system variable `_t` (analysis time) or the *timevar* variable used to `stset` the data.

After splitting at failure times, all `st` commands still work fine and produce the same results as before splitting. To fit parametric models with time-varying covariates, it does not suffice to specify covariates at failure times. Stata can fit “piecewise constant” models by manipulating data using `stsplit`, `{at()|every()}`.

◀

### ▶ Example 4: Splitting on failure times to test the proportional-hazards assumption

Collett (2015, 187–190) presents data on 26 ovarian cancer patients who underwent two different chemotherapy protocols after a surgical intervention. Here are a few of the observations:

```
. use http://www.stata-press.com/data/r15/ocancer, clear
. list patient time cens treat age rdisea in 1/6, separator(0)
```

	patient	time	cens	treat	age	rdisea
1.	1	156	1	1	66	2
2.	2	1040	0	1	38	2
3.	3	59	1	1	72	2
4.	4	421	0	2	53	2
5.	5	329	1	1	43	2
6.	6	769	0	2	59	2

The `treat` variable indicates the chemotherapy protocol administered, `age` records the age of the patient at the beginning of the treatment, and `rdisea` records each patient’s residual disease after surgery. After `stsetting` this dataset, we fit a Cox proportional-hazards regression model on `age` and `treat` to ascertain the effect of treatment, controlling for `age`.

```
. stset time, failure(cens) id(patient)
           id: patient
           failure event:  cens != 0 & cens < .
obs. time interval:  (time[_n-1], time]
exit on or before:  failure
```

---

```
26 total observations
0 exclusions
```

---

```
26 observations remaining, representing
26 subjects
12 failures in single-failure-per-subject data
15,588 total analysis time at risk and under observation
           at risk from t = 0
           earliest observed entry t = 0
           last observed exit t = 1,227
```

```
. stcox age treat, nolog nohr
           failure _d: cens
           analysis time _t: time
           id: patient
```

Cox regression -- no ties

```
No. of subjects = 26           Number of obs = 26
No. of failures = 12
Time at risk = 15588
LR chi2(2) = 15.82
Log likelihood = -27.073767     Prob > chi2 = 0.0004
```

_t	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
age	.1465698	.0458537	3.20	0.001	.0566982	.2364415
treat	-.7959324	.6329411	-1.26	0.209	-2.036474	.4446094

One way to test the proportional-hazards assumption is to include in the model a term for the interaction between age and time at risk, which is a continuously varying covariate. This can be easily done by first splitting the data at the failure times and then generating the interaction term.

```
. stsplit, at(failures)
(12 failure times)
(218 observations (episodes) created)
```

```
. generate tage = age * _t
. stcox age treat tage, nolog nohr
           failure _d: cens
           analysis time _t: time
           id: patient
```

Cox regression -- no ties

```
No. of subjects = 26           Number of obs = 244
No. of failures = 12
Time at risk = 15588
LR chi2(3) = 16.36
Log likelihood = -26.806607     Prob > chi2 = 0.0010
```

_t	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
age	.2156499	.1126093	1.92	0.055	-.0050602	.43636
treat	-.6635945	.6695492	-0.99	0.322	-1.975887	.6486978
tage	-.0002031	.0002832	-0.72	0.473	-.0007582	.000352

Other time-varying interactions of age and time at risk could be generated. For instance,

```
. generate lntage = age * ln(_t)
. generate dage = age * (_t >= 500)
```

Although in most analyses in which we include interactions we also include main effects, if we include in a Cox regression a multiplicative interaction between analysis time (or any transformation) and some covariate, we should not include the analysis time as a covariate in `stcox`. The analysis time is constant within each risk set, and hence, its effect is not identified.

#### □ Technical note

If our interest really were just in performing this test of the proportional-hazards assumption, we would not have had to use `stsplit` at all. We could have just typed

```
. stcox age treat, tvc(age)
```

to have fit a model including  $t \cdot \text{age}$ , and if we wanted instead to include  $\ln(t) \cdot \text{age}$  or  $\text{age} \cdot t \geq 500$ , we could have typed

```
. stcox age treat, tvc(age) texp(ln(_t))
. cstoc age treat, tvc(age) texp(_t >= 500)
```

Still, it is worth understanding how `stsplit` could be used to obtain the same results for instances when `stcox`'s `tvc()` and `texp()` options are not rich enough to handle the desired specification. □

Assume that we want to control for `rdisea` as a stratification variable. If the data are already split at all failure times, we can proceed with

```
. stcox age treat tage, strata(rdisea)
```

If the data are not yet split, and memory is scarce, then we could just split the data at the failure times within the respective stratum. That is, with the original data in memory, we could type

```
. stset time, failure(cens) id(patient)
. stsplit, at(failures) strata(rdisea)
. generate tage = age * _t
. stcox treat age tage, strata(rdisea)
```

This would save memory by reducing the size of the split dataset. ◀

#### □ Technical note

Of course, the above model could also be obtained by typing

```
. stcox age treat, tvc(age) strata(rdisea)
```

without splitting the data. □



▷ Example 5: Cox regression versus conditional logistic regression

Cox regression with the “exact partial” method of handling ties is tightly related to conditional logistic regression. In fact, we can perform Cox regression via `clogit`, as illustrated in the following example using Stata’s cancer data. First, let’s fit the Cox model.

```
. use http://www.stata-press.com/data/r15/cancer, clear
(Patient Survival in Drug Trial)
. generate id =_n
. stset studytim, failure(died) id(id)
      id: id
      failure event: died != 0 & died < .
obs. time interval: (studytime[_n-1], studytime]
exit on or before: failure
```

---

48	total observations	
0	exclusions	

---

48	observations remaining, representing	
48	subjects	
31	failures in single-failure-per-subject data	
744	total analysis time at risk and under observation	
	at risk from t =	0
	earliest observed entry t =	0
	last observed exit t =	39

```
. stcox age drug, nolog nohr exactp
      failure _d: died
      analysis time _t: studytime
      id: id
```

Cox regression -- exact partial likelihood

No. of subjects =	48	Number of obs =	48
No. of failures =	31		
Time at risk =	744		
		LR chi2(2) =	38.13
Log likelihood =	-73.10556	Prob > chi2 =	0.0000

_t	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
age	.1169906	.0374955	3.12	0.002	.0435008	.1904805
drug	-1.664873	.3437487	-4.84	0.000	-2.338608	-.9911376

We will now perform the same analysis by using `clogit`. To do this, we first split the data at failure times, specifying the `riskset()` option so that a risk set identifier is added to each observation. We then fit the conditional logistic regression, using `_d` as the outcome variable and the risk set identifier as the grouping variable.

```
. stsplit, at(failures) riskset(RS)
(21 failure times)
(534 observations (episodes) created)
. clogit _d age drug, group(RS) nolog
note: multiple positive outcomes within groups encountered.
Conditional (fixed-effects) logistic regression
```

	Number of obs	=	573
	LR chi2(2)	=	38.13
	Prob > chi2	=	0.0000
	Pseudo R2	=	0.2069

Log likelihood = -73.10556

	_d	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
	age	.1169906	.0374955	3.12	0.002	.0435008 .1904805
	drug	-1.664873	.3437487	-4.84	0.000	-2.338608 -.9911376

◀

### ▶ Example 6: Joining data that have been split with stsplit

Let's return to the [first example](#). We split the diet data into age bands, using the following commands:

```
. use http://www.stata-press.com/data/r15/diet, clear
(Diet data with dates)
. stset dox, failure(fail) origin(time dob) enter(time doe) scale(365.25) id(id)
(output omitted)
. stsplit ageband, at(40(10)70)
(418 observations (episodes) created)
```

We can rejoin the data by typing `stjoin`:

```
. stjoin
(option censored(0) assumed)
(0 obs. eliminated)
```

Nothing happened! `stjoin` will combine records that are contiguous and record the same data. Here, when we split the data, `stsplit` created the new variable `ageband`, and that variable takes on different values across the split observations. Remember to drop the variable that `stsplit` creates:

```
. drop ageband
. stjoin
(option censored(0) assumed)
(418 obs. eliminated)
```

◀

Wilhelm Lexis (1837–1914) was born near Aachen in Germany. He studied law, mathematics, and science at the University of Bonn and developed interests in the social sciences during a period in Paris. Lexis held posts at universities in Strassburg (now Strasbourg, in France), Dorpat (now Tartu, in Estonia), Freiburg, Breslau (now Wroclaw, in Poland), and Göttingen. During this peripatetic career, he carried out original work in statistics on the analysis of dispersion, foreshadowing the later development of chi-squared and analysis of variance.

## Acknowledgments

`stsplit` and `stjoin` are extensions of `lexis` by David Clayton (retired) of the Cambridge Institute for Medical Research and Michael Hills (retired) of the London School of Hygiene and Tropical Medicine (Clayton and Hills 1995). The original `stsplit` and `stjoin` commands were written by Jeroen Weesie of the Department of Sociology at Utrecht University, The Netherlands (Weesie 1998a, 1998b), as was the revised `stsplit` command.

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## Also see

[ST] `stset` — Declare data to be survival-time data