

Single Transferable Vote (STV)

1. What is it?

STV is a proportional representation system well suited to electing representatives to sit on a committee where several seats fall vacant simultaneously, such as the Industrial Internet Consortium Steering Committee. This note outlines the system from the voter's point of view, using the procedures laid down by the Electoral Reform Society, a non-partisan British organization involved in running public elections for over 100 years.

2. How to cast a vote in STV

From the voter's point of view, using STV is simple; instead of voting for only one candidate, each voter numbers his choices in order; 1 for his or her most preferred candidate, 2 for the next favorite, and so on. Any candidates for which the voter does not wish to vote at all are left un-numbered.

3. How the votes are counted

In counting the votes, the general principle is also simple: each ballot paper initially counts as a vote for the candidate marked by that voter as his or her first preference. However, it's possible that such a vote cannot help to elect that candidate, either because he or she has enough first preference votes to be elected without it, or so few as to be without hope of being elected. In these cases, the vote is not wasted; the ballot paper is passed on to the candidate marked by that voter as his or her second choice amongst the remaining candidates; if it cannot help that candidate either, it's passed on to the next choice, and so on. If a particular ballot paper runs through all its preferences in this way, then it is not counted towards any candidate, so that an individual's vote will never help elect a candidate for whom they did not express a numbered preference.

The measure of "enough votes to be elected" is termed the "quota", and is calculated as:

$$\frac{\text{(Total votes cast)}}{\text{(Number of seats to be filled + 1)}}$$

Thus, if there is only one seat available, the quota is half the votes cast, as would be expected. To be elected to one of two seats, a candidate must attract at least one third of the votes cast (either as the first choice, or through transfer), and so on.

The exact procedure for counting the votes is actually slightly more complex than this; in particular, since it wouldn't be fair to transfer only a random section of ballot papers that exceed a quota, all the ballots are transferred from an elected candidate, but with a fractional vote value calculated by sharing that candidate's surplus of votes over the quota equally between all the transferred ballot papers.

The transfers of votes from elected candidates and exclusion of candidates who cannot be elected continues until all the posts have been filled.

However, there are optimizations which eliminate counting and transfers, and which are useful when the counting must be done by hand. Fortunately, the ERS has produced a program to do the hard work of transferring votes and eliminating candidates.

4. A worked example

The following illustration of STV in action for an election of a committee of 5 is taken from the ERS leaflet "What is STV?":

There are 9 candidates:

Alan STEWART
Mary VINE
Philip AUGUSTINE

Monty COHEN
 Michael LENNON
 Peter EVANS
 Sheila WILCOCKS
 Tony HARLEY
 Frank PEARSON

First stage: In the example, 647 votes are cast, so the quota is $647/(5+1) = 108$ (when rounded up to the next whole number). The tally of first preference votes is:

1st Stage	
Alan STEWART	66
Mary VINE	48
Philip AUGUSTINE	95
Monty COHEN	55
Michael LENNON	58
Peter EVANS	144
Sheila WILCOCKS	60
Tony HARLEY	91
Frank PEARSON	30

	647

Only one candidate, Evans, exceeds the quota at this stage. He is therefore declared elected.

Second stage: Evans's surplus of $(144 - 108) = 36$ votes must now be transferred with a transfer value of $36/144 = 0.25$ votes each.

When Evans' first choice ballots are re-counted on their second preferences, the results are:

	Second preference votes	Transfers as
VINE	80	20
COHEN	36	9
PEARSON	16	4
STEWART	8	2
HEARLEY	4	1
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	144	36

By transferring Evans' surplus, his vote has been reduced to 108, and the others increased by the above transfer values, giving a new count:

	1st Stage	2nd Stage
Alan STEWART	66 + 2 =	68
Mary VINE	48 + 20 =	68
Philip AUGUSTINE	95	95
Monty COHEN	55 + 9 =	64
Michael LENNON	58	58
Peter EVANS	144 - 36 =	108
Sheila WILCOCKS	60	60
Tony HARLEY	91 + 1 =	92
Frank PEARSON	30 + 4 =	34
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	647	647

At the next stage, the candidate with fewest votes (Pearson) is excluded. His 30 first choice papers are transferred with their full values to their second preferences (or third preferences in the case of any showing Evans as the second choice), and the 16 papers just transferred with value 0.25 are transferred to their third choice candidate. Vine and Cohen receive the equivalent of 23 and 5 votes respectively; Augustine, Harley and Stewart each receive one vote. The equivalent of three votes show no further preference, or preferences only for Evans, already elected, and so are not transferable. This completes the third stage:

	1st Stage	2nd Stage	3rd Stage
Alan STEWART	66 + 2 =	68 + 1 =	69
Mary VINE	48 + 20 =	68 + 23 =	91
Philip AUGUSTINE	95	95 + 1 =	96
Monty COHEN	55 + 9 =	64 + 5 =	69
Michael LENNON	58	58	58
Peter EVANS	144 - 36 =	108	108
Sheila WILCOCKS	60	60	60
Tony HARLEY	91 + 1 =	92 + 1 =	93
Frank PEARSON	30 + 4 =	34 - 34 =	0
Non-transferable			3
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	647	647	647

At the next stage, the candidate with fewest votes (Lennon) is once again eliminated. Of those who listed him as first choice, 46 have chosen Stewart as their next available preference, 6 have chosen Vine, 2 Cohen, and 4 show no available next preference. After the transfer, the tallies now stand at:

	1st Stage	2nd Stage	3rd Stage	4th Stage
Alan STEWART	66 + 2 =	68 + 1 =	69 + 46 =	115
Mary VINE	48 + 20 =	68 + 23 =	91 + 6 =	97
Philip AUGUSTINE	95	95 + 1 =	96	96
Monty COHEN	55 + 9 =	64 + 5 =	69 + 2 =	71
Michael LENNON	58	58	58 - 58 =	0
Peter EVANS	144 - 36 =	108	108	108
Sheila WILCOCKS	60	60	60	60
Tony HARLEY	91 + 1 =	92 + 1 =	93	93
Frank PEARSON	30 + 4 =	34 - 34 =	0	0
Non-transferable			3 + 4 =	7
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	647	647	647	647

Since Stewart's total exceeds the quota, he has been elected.

At first sight, the next action should be to transfer Stewart's surplus, but since it's only $(115-108) = 7$, and thus smaller than the difference between the two candidates with the fewest votes, it cannot affect the outcome, and so this transfer can be skipped, and the lowest polling candidate (Wilcocks) is instead excluded. Her 60 votes go to Augustine (32), Harley (15), Vine (7) and Cohen (1), with five showing no further preference. After the transfer, the tallies now stand at:

	1st Stage	2nd Stage	3rd Stage	4th Stage	5th Stage
Alan STEWART	$66 + 2 =$	$68 + 1 =$	$69 + 46 =$	115	115
Mary VINE	$48 + 20 =$	$68 + 23 =$	$91 + 6 =$	$97 + 7 =$	104
Philip AUGUSTINE	95	$95 + 1 =$	96	$96 + 32 =$	128
Monty COHEN	$55 + 9 =$	$64 + 5 =$	$69 + 2 =$	$71 + 1 =$	72
Michael LENNON	58	58	$58 - 58 =$	0	0
Peter EVANS	$144 - 36 =$	108	108	108	108
Sheila WILCOCKS	60	60	60	$60 - 60 =$	0
Tony HARLEY	$91 + 1 =$	$92 + 1 =$	93	$93 + 15 =$	108
Frank PEARSON	$30 + 4 =$	$34 - 34 =$	0	0	0
Non-transferable			$3 + 4 =$	$7 + 5 =$	12
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	647	647	647	647	647

Both Augustine and Harley have now achieved the quota of 108, and are elected. Their combined surplus (27) is not enough to make any difference to the order of the two remaining candidates, Cohen (72) and Vine (104), so there is nothing to be gained by transferring them, and Cohen can be declared to be excluded and Vine elected with doing any further counting.

5. Further Information

The exact counting procedure is fully described in the ERS manual "How to Conduct an Election by the Single Transferable Vote", which is available at <http://www.electoral-reform.org.uk/votingsystems/stvrules.htm>.