Executive Summary

Purpose:
As part of the Simulation Modeling for an Immersive Learning Experience (SMILE) project, the Alleviating Long Lines module investigates several methods for reducing voter wait times due to long lines in three-step and two-step voting processes and under different arrival patterns. Through computer simulation, voter wait times are estimated for three line alleviation strategies of shortening long lines and voter wait times when implemented individually and in combination.

Voting Processes:
1. Two-Step Voting Process: consists of a check-in step using electronic poll books (i.e., 3 devices) and a ballot marking and casting step at a digital ballot marking device (i.e., 10 devices).
2. Three-Step Voting Process: consists of a check-in step using electronic poll books (i.e., 2 devices), ballot marking using pen and paper at a voting booth (i.e., 8 booths), and ballot scanning at a digital ballot scanner (i.e., 1 device).

Voter Arrival Patterns:
1. Two-Peak Arrivals: a large proportion of voters arrive in the morning (7 AM – 10 AM) and afternoon (4 PM – 6 PM).
2. Morning Arrivals: a large proportion of voters arrive in the morning (7 AM – 10 AM).
3. Afternoon Arrivals: a large proportion of voters arrive in the afternoon (4 PM – 7 PM).

Line Alleviation Strategies:
1. Voter Preparation: an additional poll worker acts as a greeter at the entrance of the polling location to prepare voters for the check-in process. This aims to reduce the time required to check in by up to 10 seconds per voter.
2. Line Separation: check-ins are separated into two stations with individual lines to form, one for each check-in station.
3. Resource Allocation: voting resources are increased to determine if additional resources reduce voter waits.

Results:
Using simulated voter wait times, the effect of strategies for reducing long lines and voter waits are determined for each voting process and arrival pattern. Below are six tables showing the effect of each strategy on voter wait times per voting process and per voter arrival pattern.

Two-Step Voting Process per Voter Arrival Pattern: Table 1 and Table 2 findings show that the best individual strategy for alleviating long lines, in the simulated two-step voting process, is the *allocation of an additional ballot marking device*, regardless of the voter arrival pattern. With an *additional ballot marking device*, the average voter wait time is reduced by 36.4-48.8%, while the longest voter wait is reduced by 3.6-8.8%. These findings indicate that the voting process' bottleneck is the ballot marking and casting step.

Three-Step Voting Process per Voter Arrival Pattern: Table 3 and Table 4 findings show that the best individual strategies for alleviating long lines, in the simulated three-step voting process, are the *voter preparation strategy* and the *allocation of an additional check-in device*, regardless of the voter arrival pattern. Implementing the *voter preparation strategy* results in a 27.2-45.2% reduction in the average voter wait times and an 18.1-33.6% reduction in the longest voter wait time. With an *additional check-in device*, the average voter wait time was reduced by 53.4-68.4%, while the longest voter wait was reduced by 40.5-42.8%. These findings indicate that the voting process' bottleneck is the check-in step.

Combining Line Alleviation Strategies: Tables 5 and 6, indicate that there may be an added benefit of implementing line alleviation strategies in combination. For both the two-step and three-step voting processes, implementing the voter preparation and resource allocation strategies in combination as well as the line separation and resource allocation strategies in combination, result in reduced voter wait times. Within the two-step voting process, combining the *voter preparation* and the *allocation of an additional ballot marking device* or combining the *line separation strategy* with the *allocation of an additional ballot marking device* reduces both the average and longest voter wait times. Within the three-step voting process, combining the *voter preparation* and the *allocation of an additional check-in device* or *line separation strategy* with the *allocation of an additional check-in device* reduces both average and longest voter wait times.

As demonstrated by the negative values in Tables 5 and 6, implementing these strategies may lead to an increase in voter wait times. This occurs when a strategy speeds up a part of the voting process that is not the bottleneck of the process. For example, the ballot marking and casting step in the two-step voting process represents the bottleneck of the process. Therefore, implementing the *voter preparation strategy* or *line separation strategy*, which are intended to speed up the check-in process, leads to increases in average and longest voter wait times in certain cases.

Each line alleviation strategy has pros and cons:

- ➔ *The Voter preparation strategy* may require an additional election worker to prepare voters in line for the check-in and voting processes. This strategy may also depend on the experience of and effective communication by the election worker. However, the *voter preparation strategy* is simple to implement and can effectively shorten voter waits.
- ➔ *The Line separation strategy* requires additional space within a polling location to allow room for the separated check-in stations and the two check-in lines. Therefore, this strategy may not be suitable for particularly small in-person polling locations. Additionally, the *line separation strategy* offers little reduction in voter wait time when implemented individually and may confuse voters or result in line jumping. However, *line separation* requires no additional staff to implement.
- ➔ *The resource allocation strategy* consistently reduces voter wait times so long as the appropriate resource is increased. While *resource allocation* is the most effective individual strategy, allocating voting equipment may be costly, require additional space, and depends on appropriately balancing voting equipment at each step of the voting process.

Table 1

Estimated Voter Wait Times for the Two-Step Voting Process per Voter Arrival Pattern

Voter Wait Time (minutes)	Line Alleviation Strategy				
	No Alleviation Method	Voter Preparation	Line Separation	Resource Allocation	
				Check-in	Ballot Marking Device
Two-Peak Arrivals					
Average Wait Time	59	57	59	58	31
Longest Wait Time	152	132	143	152	146
Morning Arrivals					
Average Wait Time	72	73	70	70	37
Longest Wait Time	128	139	132	129	121
Afternoon Arrivals					
Average Wait Time	29	29	30	31	18
Longest Wait Time	139	128	137	134	127

Table 2

Change in Voter Wait Times for the Two-Step Voting Process per Voter Arrival Pattern

Voter Wait Time (minutes, percent)	Line Alleviation Strategy				
	No Alleviation Method	Voter Preparation	Line Separation	Resource Allocation	
				Check-in	Ballot Marking Device
Two-Peak Arrivals					
Average Wait Time	-	2.2 (3.7%)	0.2 (0.4%)	1 (1.7%)	28.4 (47.7%)
Longest Wait Time	-	20 (13.1%)	9.1 (6%)	-0.6 (-0.4%)	5.5 (3.6%)
Morning Arrivals					
Average Wait Time	-	-1.4 (-1.9%)	1.3 (1.9%)	1.3 (1.8%)	35 (48.8%)
Longest Wait Time	-	-11 (-8.6%)	-4 (-3.1%)	-0.6 (-0.5%)	7.7 (6%)
Afternoon Arrivals					
Average Wait Time	-	-0.4 (-1.2%)	-1 (-3.6%)	-1.5 (-5.3%)	10.6 (36.4%)
Longest Wait Time	-	11.3 (8.1%)	2 (1.4%)	5.1 (3.7%)	12.2 (8.8%)

**Note.* Positive values indicate a decrease in wait time while negative values indicate an increase in wait time.

Table 3

Estimated Voter Wait Times for the Three-Step Voting Process per Voter Arrival Pattern

Voter Wait Time (minutes)	Line Alleviation Strategy					
	No Alleviation Method	Voter Preparation	Line Separation	Resource Allocation		
				Check-in	Voting Booth	Ballot Scanner
Two-Peak Arrivals						
Average Wait Time	44	25	44	16	43	44
Longest Wait Time	103	69	107	62	107	105
Morning Arrivals						
Average Wait Time	54	29	54	17	50	52
Longest Wait Time	100	82	117	60	98	98
Afternoon Arrivals						
Average Wait Time	21	15	23	10	21	22
Longest Wait Time	96	78	106	55	96	99

Table 4

Change in Voter Wait Times for the Three-Step Voting Process per Voter Arrival Pattern

Voter Wait Time (minutes, percent)	Line Alleviation Strategy					
	No Alleviation Method	Voter Preparation	Line Separation	Resource Allocation		
				Check-in	Voting Booth	Ballot Scanner
Two-Peak Arrivals						
Average Wait Time	-	18.3 (41.8%)	-0.5 (-1.1%)	27.3 (62.4%)	0.7 (1.5%)	-0.4 (-1%)
Longest Wait Time	-	34.7 (33.6%)	-3.8 (-3.7%)	41.8 (40.5%)	-3.3 (-3.2%)	-1.9 (-1.9%)
Morning Arrivals						
Average Wait Time	-	24.4 (45.2%)	0.1 (0.2%)	36.8 (68.4%)	3.9 (7.3%)	1.8 (3.3%)
Longest Wait Time	-	18.1 (18.1%)	-16.4 (-16.4%)	40.8 (40.7%)	2.5 (2.5%)	2 (2%)
Afternoon Arrivals						
Average Wait Time	-	5.8 (27.2%)	-2 (-9.3%)	11.4 (53.4%)	0.3 (1.3%)	-0.9 (-4.4%)
Longest Wait Time	-	17.8 (18.6%)	-9.8 (-10.3%)	41 (42.8%)	-0.5 (-0.5%)	-3.5 (-3.7%)

**Note.* Positive values indicate a decrease in wait time while negative values indicate an increase in wait time.

Table 5

Effective Strategy Combinations: Estimated Voter Wait Times for the Two-Step Voting Process per Voter Arrival Pattern

Voter Wait Time (minutes)	Line Alleviation Strategy		
	No Alleviation Method	Voter Preparation & Additional Ballot Marking Device	Line Separation & Additional Ballot Marking Device
Two-Peak Arrivals			
Average Wait Time	59	32	32
Longest Wait Time	152	119	117
Morning Arrivals			
Average Wait Time	72	34	35
Longest Wait Time	128	106	104
Afternoon Arrivals			
Average Wait Time	29	18	18
Longest Wait Time	139	130	123

Table 6

Effective Strategy Combinations: Estimated Voter Wait Times for the Three-Step Voting Process per Voter Arrival Pattern

Voter Wait Time (minutes)	Line Alleviation Strategy		
	No Alleviation Method	Voter Preparation & Additional Check-in	Line Separation & Additional Check-in
Two-Peak Arrivals			
Average Wait Time	44	15	17
Longest Wait Time	103	46	55
Morning Arrivals			
Average Wait Time	54	17	16
Longest Wait Time	100	54	58
Afternoon Arrivals			
Average Wait Time	21	10	10
Longest Wait Time	96	55	58

**These results are determined from simulated two-step and three-step voting processes. While real election data were used, these results may not directly apply to voting processes that include more or fewer steps to vote or contain processes that are particularly quick or slow to complete (e.g., ballots with many questions or ballots with few questions). The effectiveness of implementing these strategies also depends on the starting resource allocation. As demonstrated in the results, the two-step process resource bottleneck occurred at the ballot marking devices while the bottleneck of the three-step process occurred at the check-ins. If the check-in step is not the bottleneck of the system, then strategies that speed up the check-in process may result in longer voter wait times. Additionally, precincts that expect a large number of in-person voters may experience different outcomes than those presented.*