Crew scheduling

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Introduction

Definition (Crew scheduling (runcutting) (TCRP 135)). The process of converting (or cutting) vehicle blocks into work assignments (or runs) for operators.

Definition (Run (TCRP 135)). A work assignment for an operator. Most often, run refers to a whole day's work assignment.

- A run may consist of all or part of a vehicle block, and may have single or multiple pieces.

Importance

- Operator wages consists of $\sim$60-70% of total operating costs.
- Even small reduction in number of operators or saving in operating hours can result in huge savings for the agency.

Challenges

- Extremely complex problem as it has take into account a range of qualitative and quantitative factors.
- Operator assignment has to be "legal" (satisfying the written rules of labor contract/agreement).
- It should be efficient (various ways of measuring efficiency?)

Types of runs

1. **Straight runs**: Usually, a straight run has consisted of a single piece of work, where the operator stays on the same vehicle for the whole day.
   - A second type of straight run involves a break (often required by labor agreement or legislation) between two pieces of work. This break (∼30-60 min) may be paid or unpaid.

Figure: Straight run[1]

[1] Figure taken from TCRP 135

Types of runs

2. **Split Runs**: Split (or swing) runs refer to runs that have two pieces, with a (usually) longer unpaid break (also called swing time) ($>$90 min) between those pieces.
   - The operator is not on duty between the pieces of work, and typically all pieces start and finish at the home garage.

Figure: Split run[2]

3. **Trippers**: Trippers are almost always short one-piece straight runs, and are often used in peak periods. Trippers are sometimes known as "part-time runs."

Figure: Tripper[3]

[2]Figure taken from TCRP 135

Components of Runs

1-Piece Straight Run

Report 0:15	Travel / Pull 0:20	Revenue Time 7:15	Travel / Pull 0:18	Sign Off 0:10

Total Hours = 8:18

Split Run

Report 0:15	Travel / Pull 0:15	Revenue Time 3:15	Travel / Pull 0:20	Sign Off 0:05	Unpaid Break (Swing) 3:00	Report 0:10	Travel / Pull 0:20	Revenue Time 3:00	Travel / Pull 0:18	Sign Off 0:10

Total Hours = 8:08

Total Spread = 11:08

Figure: Components of run[4]

[4] Figure taken from TCRP 135

Measuring the success of a runcut

Definition (Pay-to-platform ratio (TCRP 135)). The ratio of pay hours to platform time.

- e.g., if an operator receives 9:00 in pay for 8:00 of platform time, the pay-to-platform ratio is 1.125 (9:00/8:00).

Definition (Pay hours). The number of hours for which an operator is paid at his/her rate. Pay hours include work hours, make-up time, overtime premium, spread premium[5], and any other adjustments called for in the contract.

[5] Pay equal to one-half or more of all minutes in excess of a specified maximum spread time, in addition to regular straight pay.

Inputs to runcutting

- A complete set of trips and vehicle blocks
- All relevant defined rules (usually given in labor agreement)
- Defined relief time, relief locations, and travel times
- Other constraints–cost, work rule preferences, etc.

Service curve

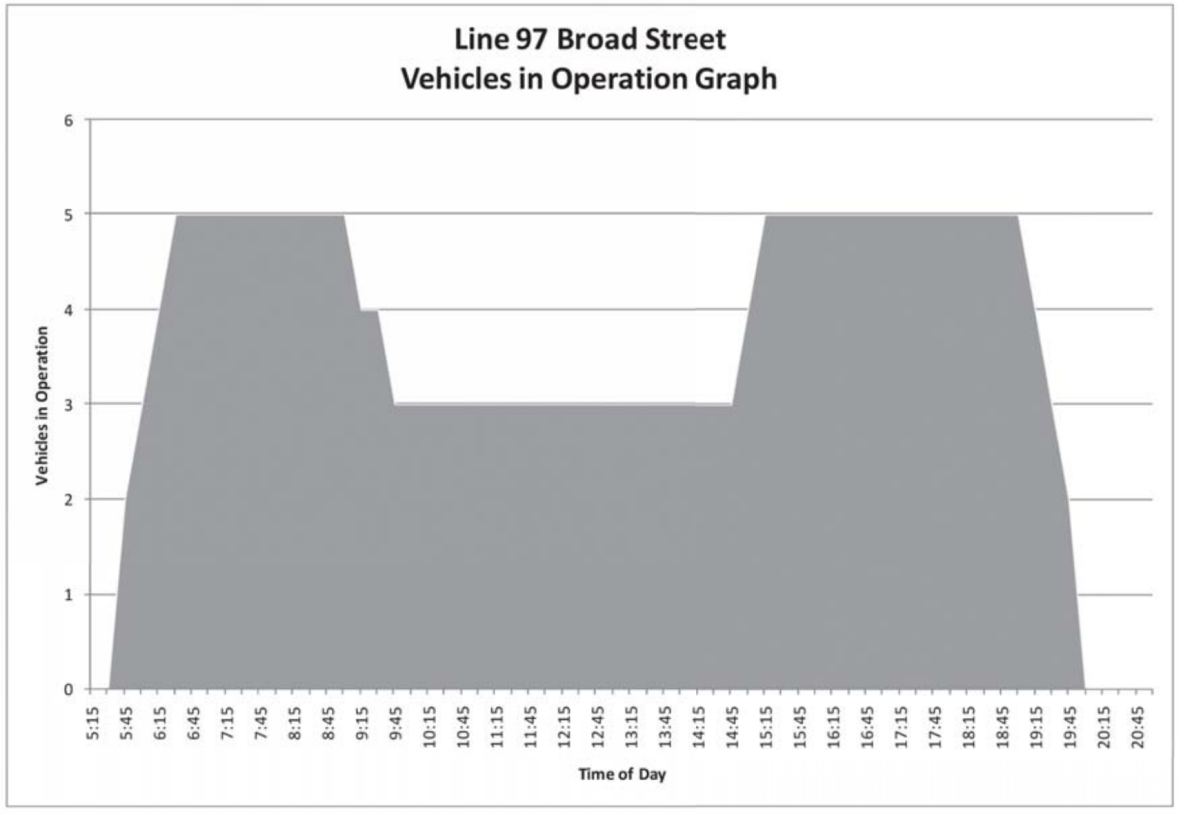

Figure: Service curve[6]

- Many blocks are around 14 hours, so cut them into two pieces, each as a single run.
- AM peak blocks (3:30) are smaller than the PM peak blocks (4:30). This can be served using two 8:00 split runs.
- Two additional runs are required during peaks.

[6] Figure taken from TCRP 135

Possible objectives[7]

- To minimize operating costs
- To minimize the number of split runs
- To minimize the number of trippers
- To evenly distribute the work among the operators
- To ensure all reliefs are at one particular location
- To maximize long runs for AM starts
- To make the runcuts more "operations-friendly"
- To ensure all runs are legal (this is often overlooked)
- To achieve a target distribution of full-time and part-time work based upon labor agree- ments and/or current manpower availability

[7] Taken from TCRP 135

Simple runcutting exercise

Work rules

Work Rule	Requirement
Minimum Platform Time (full-time run)	6:00
Maximum Platform Time	10:00
Minimum Platform Time (tripper)	2:00
Maximum Platform Time (tripper)	5:59
Report Allowance (start of run)	0:15
Clear Allowance (end of run)	0:15
Clear Allowance (end of first half of split run)	0:05
Report Allowance (start of second half of split run)	0:15
Maximum Spread	13:00
Run Type Limits	50% minimum straight runs 25% maximum split runs 25% maximum trippers
Guarantee (Daily)	8:00
Overtime (Daily)	Time and a half over 8:00
Spread Penalty	Time and a half over 10:00
Reliefs	Must be at "Point A" All reliefs are taken as travels using a car 0:10 travel time from garage to Point A

Figure: Work rules[8]

[8] Figure taken from TCRP 135

Basic calculations

- Non-platform time is at least 40 minutes
  - Garage is 10 minutes from point "A" (relief point)
  - 15 min report allowance
  - 15 min clear allowance
- We need to cut our runs somewhere around 8:00 - 0:40 = 7:20 platform time.
- # of runs = 54:32/7:20 $\approx$ 8.

Hour Summary			
Block	Garage Depart	Garage Arrival	Platform Hours
1	5:46	9:19	3:33
2	6:01	18:38	12:37
3	5:50	18:19	12:29
4	6:05	9:38	3:33
5	6:20	19:53	13:33
6	15:01	19:49	4:48
7	15:20	19:19	3:59
Total			54:32:00

Basic calculations

- The figure below suggests blocks 2,3, and 5 can be served using two straight runs each.
- Blocks 1,4, 6, and 7 can be served using two split or four trippers.

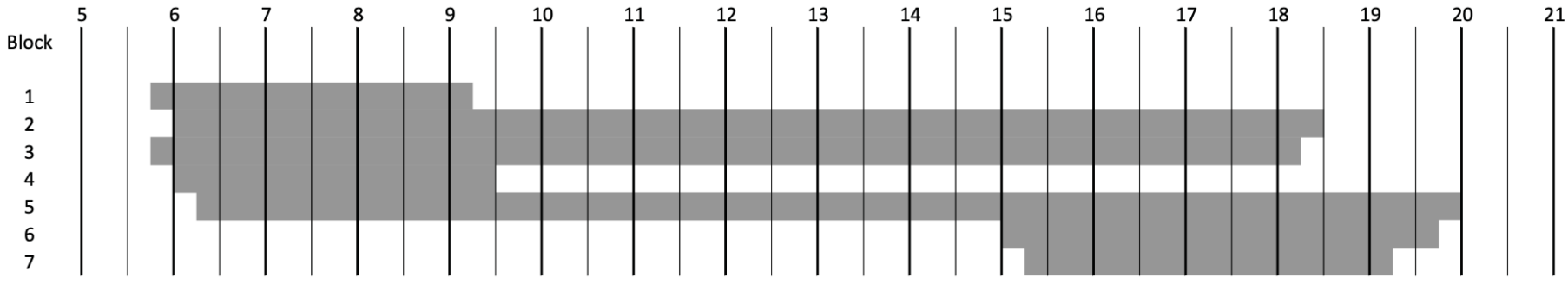

Figure: Vehicle blocks[9]

[9]Figure taken from TCRP 135

First create the straight runs

Output should look like...

Run #	Type	Block #	Report time	Start			End			Sign off time	Plat Hours	Report Hours	Travel Hours	Total Hours	Spread	Guarantee	Overtime	Spread Penalty	Paid Hours	Pay/Plat ratio
				Time	Place	Type	Time	Place	Type											
1	Str	2	5:46	6:01	Garage	Pull	12:09	A	Street	12:34	6:08	0:30	0:10	6:48	6:48	1:12	0:00	0:00	8:00	1.304
2	Str	2	11:44	12:09	A	Street	18:38	Garage	Pull	18:53	6:29	0:30	0:10	7:09	7:09	0:51	0:00	0:00	8:00	1.234
3	Str	3	5:35	5:50	Garage	Pull	12:39	A	Street	13:04	6:49	0:30	0:10	7:29	7:29	0:31	0:00	0:00	8:00	1.174
4	Str	3	12:14	12:39	A	Street	18:19	Garage	Pull	18:34	5:40	0:30	0:10	6:20	6:20	1:40	0:00	0:00	8:00	1.412
5	Str	5	6:05	6:20	Garage	Pull	13:09	A	Street	13:34	6:49	0:30	0:10	7:29	7:29	0:31	0:00	0:00	8:00	1.174
6	Str	5	12:44	13:09	A	Street	19:53	Garage	Pull	20:08	6:44	0:30	0:10	7:24	7:24	0:36	0:00	0:00	8:00	1.188

Figure: Straight runs[10]

[10] Figure taken from TCRP 135

If we choose to use split runs for blocks 1,4,6, and 7

Let's try to combine Block 1 with 6 and Block 4 with 7 using split runs, we have following estimate of spread and work hours.

Block	Garage Depart	Garage Arrive	Hours
1	5:46	9:19	3:33
6	15:01	19:49	4:48
	Spread	14:33	
	Work hours	9:11	

Block	Garage Depart	Garage Arrive	Hours
4	6:05	9:38	3:33
7	15:20	19:19	3:59
	Spread	13:44	
	Work hours	8:22	

Figure: Split runs[11]

But these are not "legal" according to our work rules. Should we just use trippers then? But the rules only allow 25% maximum trippers.
In our case, we allow Block 4 and 7 to be served using split runs and Block 1 and 6 to be served using trippers.

[11] Figure taken from TCRP 135

Final output should look like this ...

Run #	Type	Block #	Report time	Start			End			Sign off time	Plat Hours	Report Hours	Travel Hours	Total Hours	Spread	Guarantee	Overtime	Spread Penalty
				Time	Place	Type	Time	Place	Type									
1	Str	2	5:46	6:01	Garage	Pull	12:09	A	Street	12:34	6:08	0:30	0:10	6:48	6:48	1:12	0:00	0:00
2	Str	2	11:44	12:09	A	Street	18:38	Garage	Pull	18:53	6:29	0:30	0:10	7:09	7:09	0:51	0:00	0:00
3	Str	3	5:35	5:50	Garage	Pull	12:39	A	Street	13:04	6:49	0:30	0:10	7:29	7:29	0:31	0:00	0:00
4	Str	3	12:14	12:39	A	Street	18:19	Garage	Pull	18:34	5:40	0:30	0:10	6:20	6:20	1:40	0:00	0:00
5	Str	5	6:05	6:20	Garage	Pull	13:09	A	Street	13:34	6:49	0:30	0:10	7:29	7:29	0:31	0:00	0:00
6	Str	5	12:44	13:09	A	Street	19:53	Garage	Pull	20:08	6:44	0:30	0:10	7:24	7:24	0:36	0:00	0:00
7	Spl	1	5:31	5:46	Garage	Pull	9:19	Garage	Pull	9:24								
											8:21	0:50	0:00	9:11	14:18	0:00	0:35	2:09
		6	14:46	15:01	Garage	Pull	19:49	Garage	Pull	20:04								
8	Pt	4	5:50	6:05	Garage	Pull	9:38	Garage	Pull	9:53	3:33	0:30	0:00	4:03	4:03	0:00	0:00	0:00
9	Pt	7	15:05	15:20	Garage	Pull	19:19	Garage	Pull	19:34	3:59	0:30	0:00	4:29	4:29	0:00	0:00	0:00
											54:32:00	**4:50**	**1:00**	**60:21:00**		**5:21**	**0:35**	**2:09**

Figure: Completed runcut[12]

Total paid hours = 68.5 and total platform hours = 54.5
Pay/plat ratio = 1.25

[12] Figure taken from TCRP 135

Final thoughts

- One might have to go back and improve blocks or even adjust the schedule to get better runcutting.
- We did not cover rostering which is the process of grouping daily operator runs into packages of weekly work assignments. I recommend reading this from the book.

Suggested reading

- TCRP Report 135
- Gkiotsalitis, Konstantinos. Public transport optimization, Chapter 11.

Thank you!