Measurement & Evaluation

- Determine criteria
  - depends on values
  - endless
- Measure each criterion
  - scales
- Combine measures
  - logics

Criteria

Where do criteria come from?

- Criteria
- Constraint
- Requirement
- Preference
- Examples: space layout programs, Old People's Housing

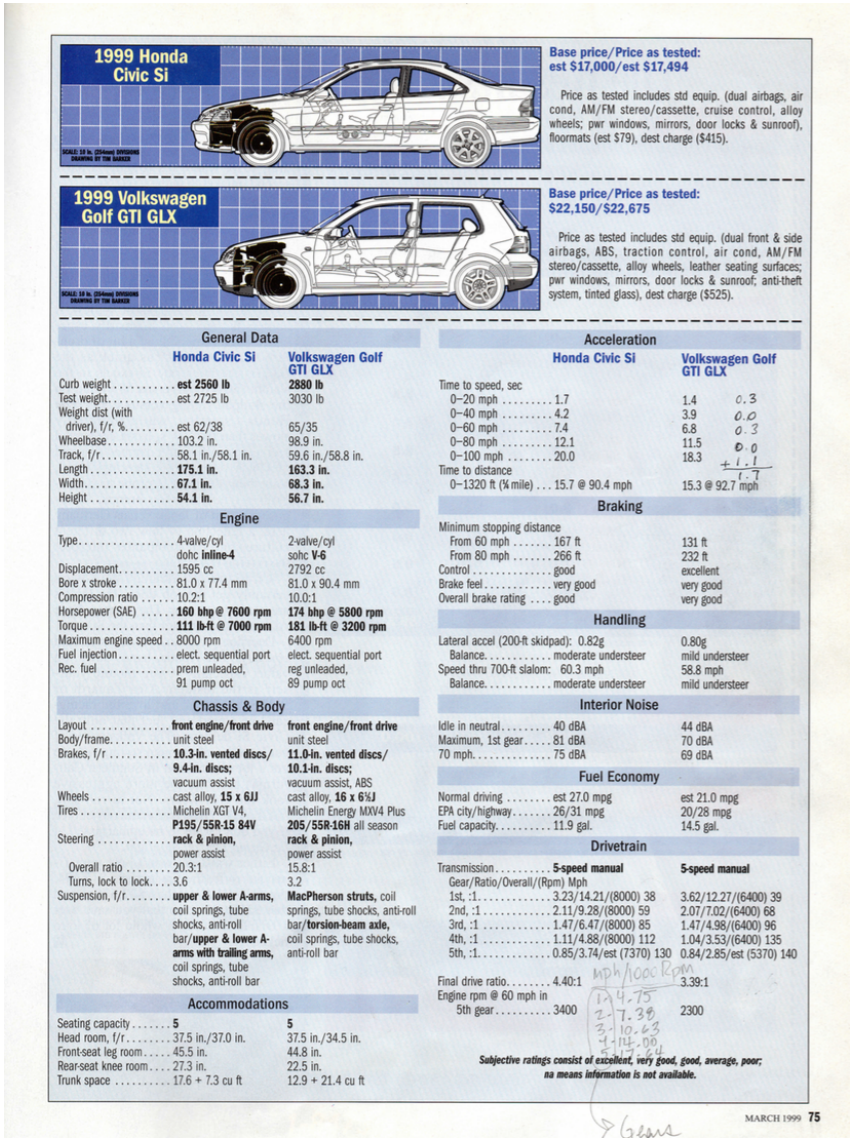
Constraints

- Realizability constraint
- Performance constraint
- Style constraint

Measurement

- Measurement is for making comparisons
- Measurement is collecting data
- Standard measures: cm, kg
- Direct comparisons: bigger, lighter
- Complex test, i.e. Does it have a balcony?

Evaluation Example



1999 Honda Civic Si

Base price/Price as tested:
est $17,000/est $17,494

Price as tested includes std equip. (dual airbags, air cond, AM/FM stereo/cassette, cruise control, alloy wheels; pwr windows, mirrors, door locks & sunroof), floormats (est $79), dest charge ($415).

1999 Volkswagen Golf GTI GLX

Base price/Price as tested:
$22,150/$22,675

Price as tested includes std equip. (dual front & side airbags, ABS, traction control, air cond, AM/FM stereo/cassette, alloy wheels, leather seating surfaces; pwr windows, mirrors, door locks & sunroof; anti-theft system, tinted glass), dest charge ($525).

General Data

	Honda Civic Si	Volkswagen Golf GTI GLX
Curb weight	**est 2560 lb**	**2880 lb**
Test weight	est 2725 lb	3030 lb
Weight dist (with driver), f/r, %	est 62/38	65/35
Wheelbase	103.2 in.	98.9 in.
Track, f/r	58.1 in./58.1 in.	59.6 in./58.8 in.
Length	**175.1 in.**	**163.3 in.**
Width	**67.1 in.**	**68.3 in.**
Height	**54.1 in.**	**56.7 in.**

Engine

Type	4-valve/cyl dohc **inline-4**	2-valve/cyl sohc **V-6**
Displacement	1595 cc	2792 cc
Bore x stroke	81.0 x 77.4 mm	81.0 x 90.4 mm
Compression ratio	10.2:1	10.0:1
Horsepower (SAE)	**160 bhp @ 7600 rpm**	**174 bhp @ 5800 rpm**
Torque	**111 lb-ft @ 7000 rpm**	**181 lb-ft @ 3200 rpm**
Maximum engine speed	8000 rpm	6400 rpm
Fuel injection	elect. sequential port	elect. sequential port
Rec. fuel	prem unleaded, 91 pump oct	reg unleaded, 89 pump oct

Chassis & Body

Layout	**front engine/front drive**	**front engine/front drive**
Body/frame	unit steel	unit steel
Brakes, f/r	**10.3-in. vented discs/ 9.4-in. discs;** vacuum assist	**11.0-in. vented discs/ 10.1-in. discs;** vacuum assist, ABS
Wheels	cast alloy, **15 x 6JJ**	cast alloy, **16 x 6½J**
Tires	Michelin XGT V4, **P195/55R-15 84V**	Michelin Energy MXV4 Plus **205/55R-16H** all season
Steering	**rack & pinion,** power assist	**rack & pinion,** power assist
Overall ratio	20.3:1	15.8:1
Turns, lock to lock	3.6	3.2
Suspension, f/r	**upper & lower A-arms,** coil springs, tube shocks, anti-roll bar/**upper & lower A-arms with trailing arms,** coil springs, tube shocks, anti-roll bar	**MacPherson struts,** coil springs, tube shocks, anti-roll bar/**torsion-beam axle,** coil springs, tube shocks, anti-roll bar

Accommodations

Seating capacity	**5**	**5**
Head room, f/r	37.5 in./37.0 in.	37.5 in./34.5 in.
Front-seat leg room	45.5 in.	44.8 in.
Rear-seat knee room	27.3 in.	22.5 in.
Trunk space	17.6 + 7.3 cu ft	12.9 + 21.4 cu ft

Acceleration

	Honda Civic Si	Volkswagen Golf GTI GLX
Time to speed, sec		
0–20 mph	1.7	1.4
0–40 mph	4.2	3.9
0–60 mph	7.4	6.8
0–80 mph	12.1	11.5
0–100 mph	20.0	18.3
Time to distance		
0–1320 ft (¼ mile)	15.7 @ 90.4 mph	15.3 @ 92.7 mph

Braking

Minimum stopping distance		
From 60 mph	167 ft	131 ft
From 80 mph	266 ft	232 ft
Control	good	excellent
Brake feel	very good	very good
Overall brake rating	good	good

Handling

Lateral accel (200-ft skidpad):	0.82g	0.80g
Balance	moderate understeer	mild understeer
Speed thru 700-ft slalom:	60.3 mph	58.8 mph
Balance	moderate understeer	mild understeer

Interior Noise

Idle in neutral	40 dBA	44 dBA
Maximum, 1st gear	81 dBA	70 dBA
70 mph	75 dBA	69 dBA

Fuel Economy

Normal driving	est 27.0 mpg	est 21.0 mpg
EPA city/highway	26/31 mpg	20/28 mpg
Fuel capacity	11.9 gal.	14.5 gal.

Drivetrain

	Honda Civic Si	Volkswagen Golf GTI GLX
Transmission	**5-speed manual**	**5-speed manual**
Gear/Ratio/Overall/(Rpm) Mph		
1st, :1	3.23/14.21/(8000) 38	3.62/12.27/(6400) 39
2nd, :1	2.11/9.28/(8000) 59	2.07/7.02/(6400) 68
3rd, :1	1.47/6.47/(8000) 85	1.47/4.98/(6400) 96
4th, :1	1.11/4.88/(8000) 112	1.04/3.53/(6400) 135
5th, :1	0.85/3.74/est (7370) 130	0.84/2.85/est (5370) 140
Final drive ratio	4.40:1	3.39:1
Engine rpm @ 60 mph in 5th gear	3400	2300

Subjective ratings consist of excellent, very good, good, average, poor; na means information is not available.

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The Results...

Performance		Honda Civic Si	Volkswagen Golf GTI GLX
0–60 mph	40 pts.	36.8	40.0
60–0 mph	40 pts.	31.4	40.0
Slalom	35 pts.	35.0	34.1
Skidpad	35 pts.	35.0	34.1
TOTAL	150 pts.	138.2	148.2

Performance points based on proportional scale.

Subjective Ratings			
Engine	10 pts.	8.0	9.0
Gearbox	10 pts.	9.0	7.5
Steering	10 pts.	7.5	8.5
Brakes	10 pts.	8.5	9.0
Ride	10 pts.	8.5	8.5
Handling	10 pts.	9.0	8.5
Ergonomics	10 pts.	9.0	8.0
Build quality	10 pts.	9.5	9.5
Exterior styling	10 pts.	7.0	9.5
Interior styling	10 pts.	9.0	8.5
TOTAL	100 pts.	85.0	86.5

Subjective ratings based on points awarded in each of 10 categories, by two editors.

Lap Times			
One Lap	100 pts.	98.3	100.0

Lap times based on proportional scale.

Price			
Price as Tested	150 pts.	150.0	145.6

Points-range for price equals average points-range of other categories, with less expensive car receiving 150 points.

Results			
Total points	500 pts.	471.5	480.3
(Total Points ÷ 5)		94.3	96.1
STANDINGS		2 Honda Civic Si	1 Volkswagen Golf GTI GLX

cated as the Honda's four, it is bigger. So, with the chant of "no replacement for displacement" ringing in our ears, we award the Hot Shot Oscar for "Best Performance by a Moderately Priced, Fun-to-Drive Sedan" to the GTI. Not just for its spirited showing on the race-track, but for its lively lunge down the drag strip, where it's roughly a half-second quicker than the Civic Si.

Now then, on to handling, steering, road feel and other things related to keeping these rascals on the pavement. Based on our objective (numbers) and subjective (what *we* think) evaluations, the prize for "Keeping the Shiny Side Up, Black Side Down" goes to the Civic Si. On the Streets of Willow, it corners flat and turns in smartly, especially when prompted by a bit of drop-throttle. Though not as quick as the GTI on the track, the Si excels in the slalom (60.3 mph versus 58.8) and on the skidpad (0.82g versus 0.80). The Honda's steering, while admittedly slower than the VW's, has a connected feel, yet is sufficiently damped to avoid kickback through the steering wheel, something the Golf is prone to—especially when traversing bumps. I suppose it's a bit of Japan versus Germany here, a reflection of how two different cultures and car companies interpret the driving experience.

On to brakes. Although the Civic's certainly get the job done, the Golf's are clearly superior. They're big, have ABS and stop shorter than the Si's.

Decision time. So, which car should *you* buy? The Honda, hands down, on value, especially if you picture yourself as the resident Alex Zanardi or Ralf Schumacher and love the racing-car-like sound and feel that only the Civic Si delivers. The Volkswagen if you're a fan of German styling (it sure got a lot of attention in Southern California) and like the more aggressive look the GTI wears. Not to rub salt, but the GTI GLX is the obvious choice if you don't want to be embarrassed at *Le Grand Prix du Stoplight*.

Either way, you won't bust your financial duff (the Civic costs $17,494, the GTI GLX fetches $22,675). And that $210,000 or so that you save over a Diablo will buy a whole lot of lotto tickets.

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Scales

from Lawson, Chapter 5

- Ratio
  - i.e. speed, distance, time,
- Interval
  - i.e. subjective ratings: comfort, style; C^{o}
- Ordinal
  - i.e. race result; 1^{st}, 2^{nd},
- Nominal
  - number used as a name

The operations that can be done on each scale are different

Evaluation

- Satisficing
- Lexicographic Ordering
- Pareto Optimality
- Multi-criteria optimization
- Bayesian decision making
- ...

Satisficing

- Find a solution satisfying all constraints
  - binary constraints: [0 , 1] defined by a threshold
- If problem is too easy
  - change threshold to make a constraint harder
  - add a new constraint
- If problem is too hard
  - change threshold to make a constraint easier
  - remove a constraint

Lexicographic Ordering

a.k.a. dictionary order, alphabetical order or lexicographic(al) product

- A generalization of the way the alphabetical order of words is based on the alphabetical order of their component letters
- Criteria are listed in importance, only the most important criterion is considered first, the next criterion is considered in case the alternatives are equal w.r.t. previous criteria

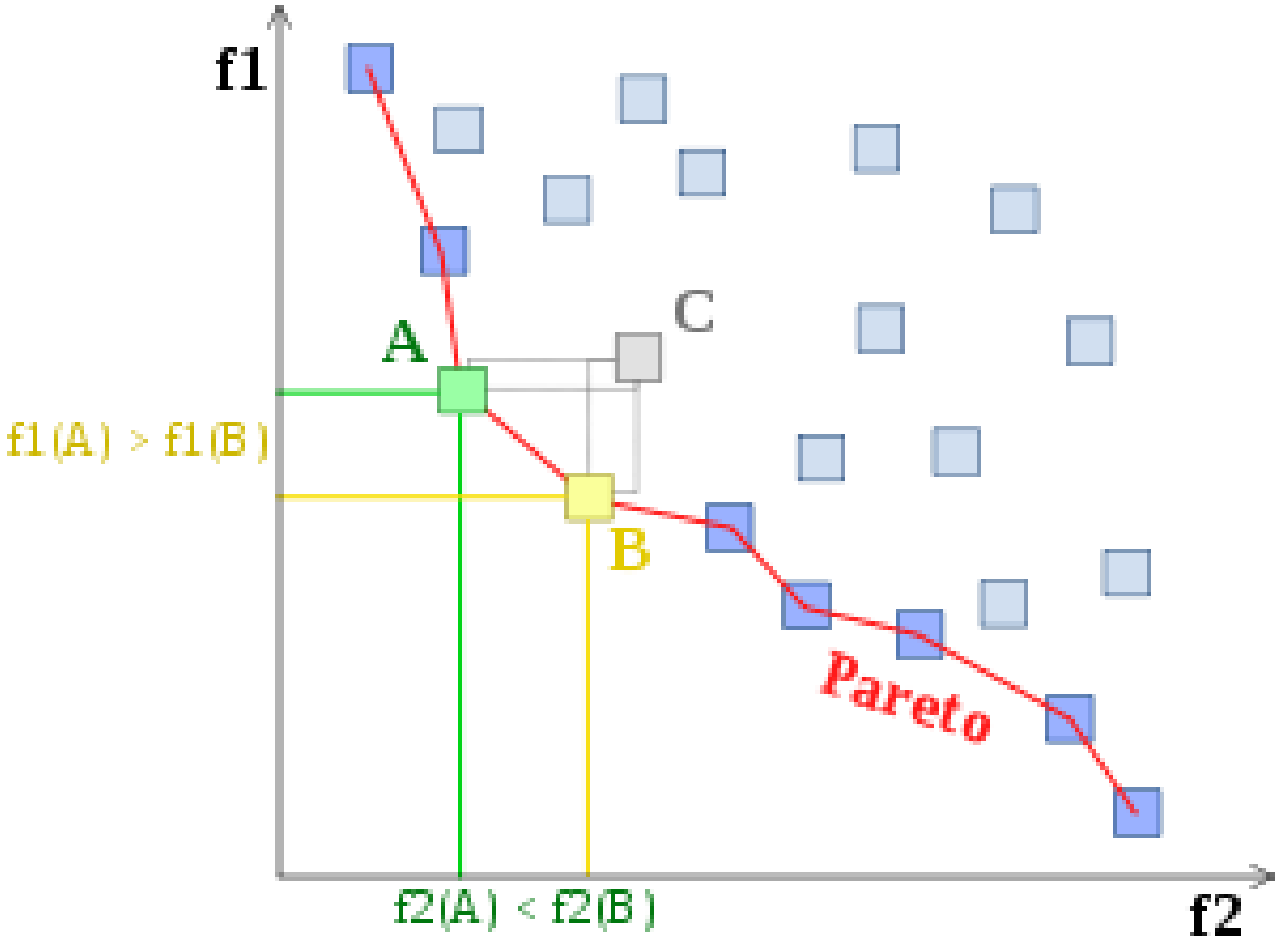
Pareto Optimality

named after Vilfredo Pareto (1848–1923), an Italian economist

- Applied to engineering; improve one criterion w/o making other criteria worse

Pareto Optimality

A Pareto Optimal solution does not always exist



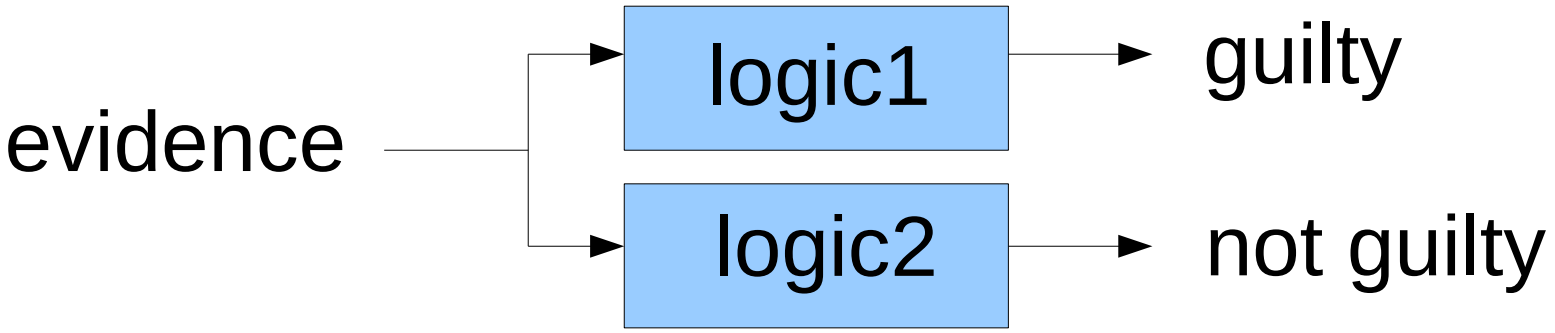
Optimization

- One variable, i.e. cost as in QAP
- Many variables, as in Road & Track article

Logic

Process by which data is transformed into decisions

i.e. in court: maximal logics



Deliberation

Process of coming to a judgement

Deliberation involves listening carefully to other logics (to both sides) and properly weighing the evidence

Processing data thru opposite logics, i.e. [personal logic + maximal pro + maximal con] is better than just personal logic

Deliberation

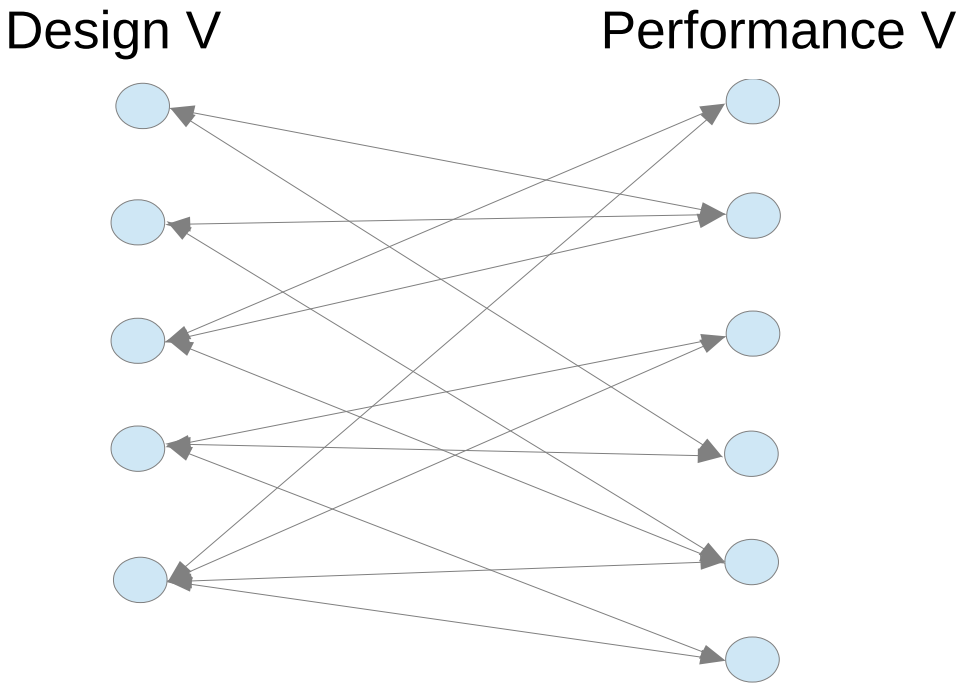
- deliberation is better than subjective opinion
- shortcomings of personal logic
  - ignoring alternatives
  - pre-weighting alternatives (ignores data)
  - ignoring information (limits inputs)
  - ignoring goals

Evaluation Traps

- Overprecision
- Value judgements – necessary because we can't measure everything on same scale
- Human values
- Design rationale

Design Performance

Many to many relations between design & performance variables



Performance Specification

- Solution oriented,
  - i.e. 25 cm cavity wall
- Performance oriented,
  - i.e. heat transfer coefficient <= 0.234

Performance Oriented Specs.

- Increase range of possible solutions
- Promote innovation
- Opportunity for better quality control
- Better fit between building and its intent
- Spur to cost effectiveness
- Responsibility of design decisions further down in the design process
- Requires test method
- Requires better educated users

Design Rationale

Issues unforeseen during design

- Airtight house – radon levels, moisture deterioration
- St.Louis housing