

SE101: 2018-09-18

Engineering Disasters

This Week's LKML News

Linus Torvalds wrote this Sunday (16 Sep 2018):

[...]

“This is my reality. I am not an emotionally empathetic kind of person and that probably doesn't come as a big surprise to anybody. Least of all me. The fact that I then misread people and don't realize (for years) how badly I've judged a situation and contributed to an unprofessional environment is not good.

This Week's LKML News

This week people in our community confronted me about my lifetime of not understanding emotions. My flippant attacks in emails have been both unprofessional and uncalled for. Especially at times when I made it personal. In my quest for a better patch, this made sense to me. I know now this was not OK and I am truly sorry.

This Week's LKML News

The above is basically a long-winded way to get to the somewhat painful personal admission that hey, I need to change some of my behavior, and I want to apologize to the people that my personal behavior hurt and possibly drove away from kernel development entirely.”

Pont de Québec

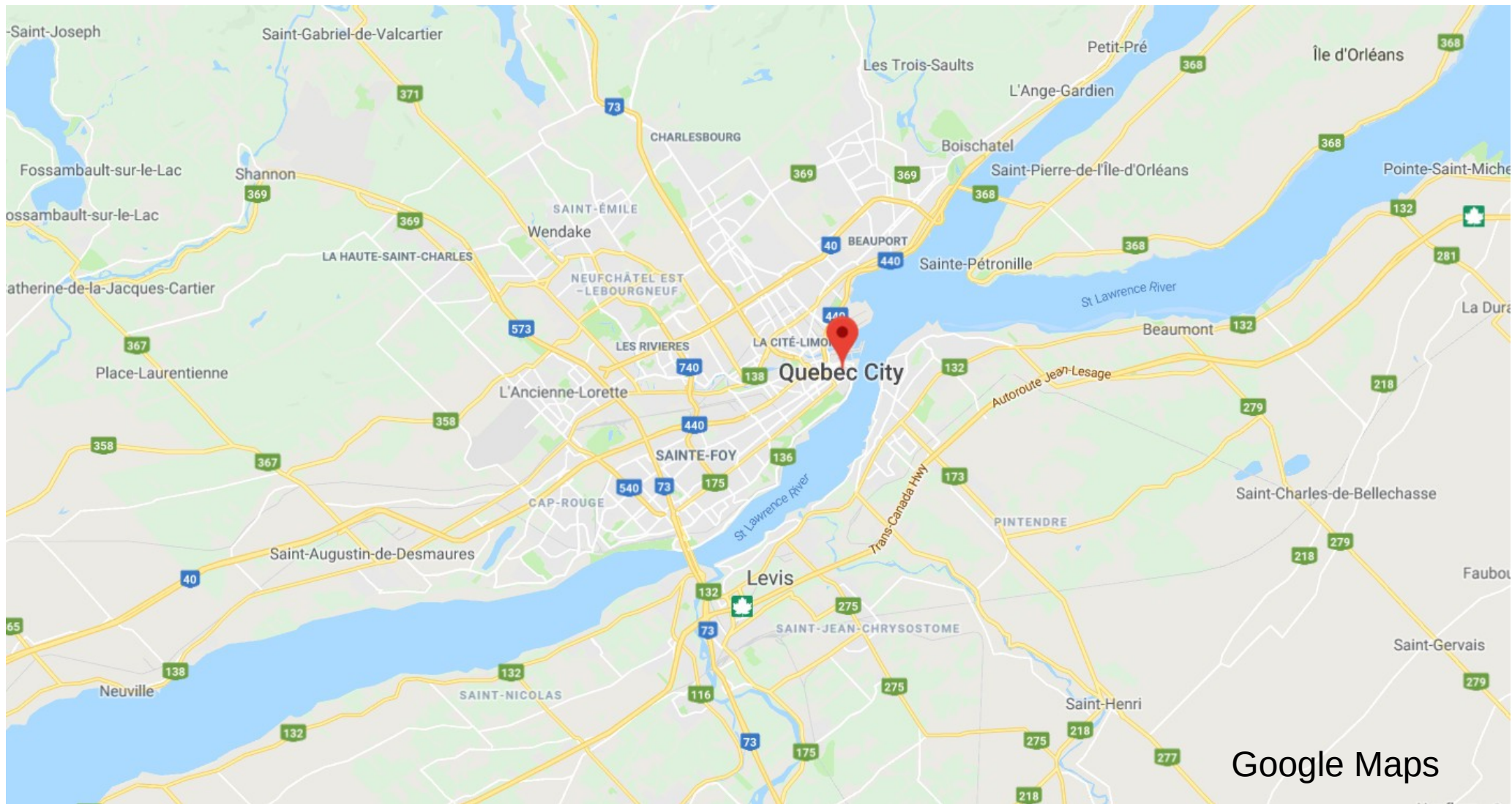


credit: Canonica, Wikimedia Commons, CC BY-SA 3.0

Quebec City Bridge

549m between piers, 987m total length

- Longest cantilever bridge in the world (still)
- Was longest bridge in the world until 1929
- National Historic Site of Canada (1995)



Quebec City Bridge, 1907



Canada

ROYAL COMMISSION

QUEBEC BRIDGE INQUIRY

REPORT

ALSO

REPORT ON DESIGN OF QUEBEC BRIDGE

BY

C. C. SCHNEIDER

PRINTED BY ORDER OF PARLIAMENT



OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST
EXCELLENT MAJESTY

1908

[No. 154—Vol. I—1908]

TRANSMISSION

Royal Commission Conclusions

Causes of the collapse:

- “Failure of the lower chords in the anchor arm near main pier... due to their defective design”
- “Failure cannot be attributed directly to any cause other than errors in judgment on the part of engineers [Cooper and Szlapka]”

Royal Commission Conclusions

“The ability of the two engineers was tried in one of the most difficult professional problems of the day and proved to be insufficient for the task.”

“The failure to appoint an experienced bridge engineer to the position of chief engineer was a mistake.”

What Happened?

Consulting engineer: Theodore Cooper of New York

- “few equals on the continent”
- worked remotely from New York
- didn't charge enough to support a staff

Responsibility and Requirements

Cooper had ultimate responsibility for the bridge.
[extensive correspondence w/government]

Changed length of center span from 1600' to 1800'.

Engineering Calculations

Load calculations done by engineer
Peter L. Szlapka

Actual weight exceeded estimated weight by 8MM lbs
[bad data informed estimates]

Cooper gave go-ahead anyway: used safety margin.

What happened on-site

Chief engineer on-site (EA Hoare) was good manager, but not an experienced bridge engineer.

Workers observed misalignment in chord splices.
(on several occasions)

Final stop-work order didn't make it in time.

Bridge Collapse

Cantilever arm and partially-constructed span fell into the St. Lawrence River in 15 seconds.

75 of 86 workmen on-site died,
33 Mohawk steelworkers from Kanhawake.

Damage over \$1.5MM (\$40MM in 2018 dollars)

Quebec City Bridge, 1916



Different Day, Different Story

1916 design was still cantilevered and still at 549m.

More steel in plan, plus invention of K-trusses.

100,000 spectators for span-raising day.

Second Failure

While lifting the span,
it broke off its supports and fell into the river.

13 worker deaths, 14 injuries.

Cause:

Failure of the concrete in the erection equipment.

[First guess—buckled span—was wrong.]

Hyatt Hotel Lobby Walkway, 1981

- Worst structural failure in US history
- 114 fatalities
- Builder didn't follow design
- Engineer failed to supervise
- Collapsed on opening day



Eventual success

This time, much less collateral damage.
Plan was still sound.

One year later, bridge successfully completed.
125,000 people came to the span-raising.

Postscript: Rust

Bridge is currently owned by CN.

Some media reports about rust concerns.

FIU Pedestrian Bridge, March '18

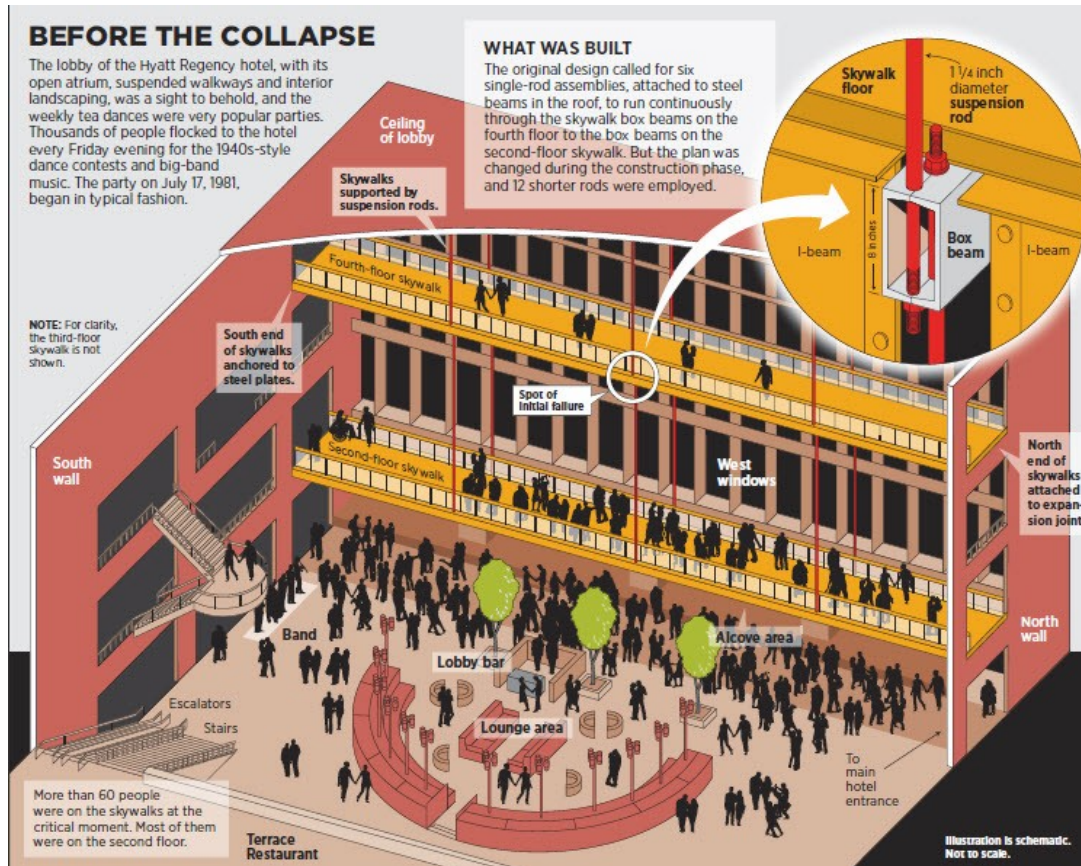


Links Florida Intl U campus
to town of Sweetwater.

Collapsed during construction
4 deaths, 10 injuries.

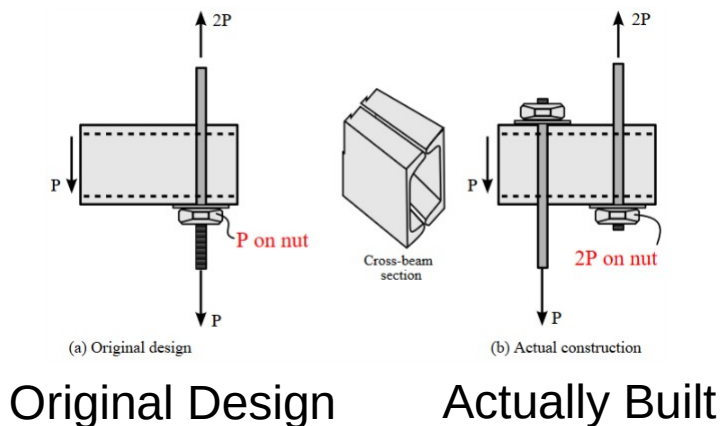
Under NTSB investigation.

Hyatt Hotel Lobby Walkway (Kansas City), 1981



114 dead,
over 200 injured

Design Changes



Problem: fastener overloaded
(though even original design didn't meet code)

Communication Issues

Contributing to the disaster:
design changes
poor communications
poor/no calculations
general negligence

No record of consultation re: changes
(maybe approved over phone).

Diagnose: Playground Bubble

- What is wrong with this design?
- How could it be better?

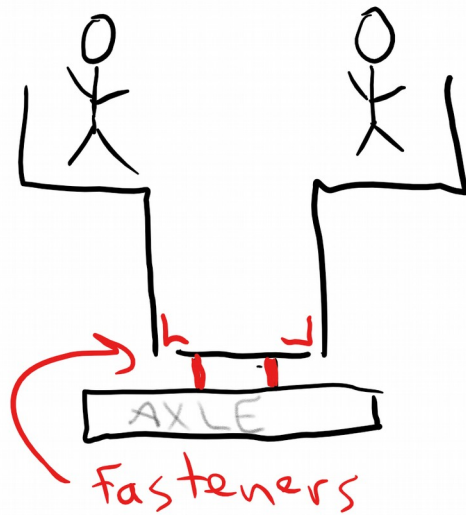


Bike Bus: a joyous ride to daycare

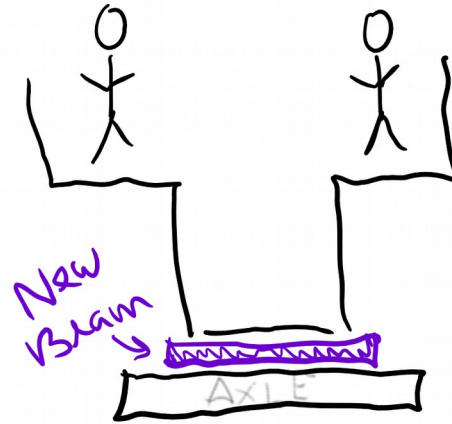
- Seats 6 kids
- Fun!
- Design flaw ...



Bike Bus – Original + Re-built



ORIGINAL



RE-BUILT

Engineering Mistakes Everywhere

- Keep your eyes open
- Design it right
- Build it right
- Analyze
- Review
- Test
- Verify

Software Disasters ...

- Concurrency
 - Therac 25 radiation machine (1985)
 - Power grid 50M people (2003)
- Correctness
 - Intel Pentium division bug, \$500M (1994)
 - California releases 450 violent inmates (2011)
 - Mars Orbiter (1998)
- Data breaches
 - Equifax (2017)
 - Yahoo (2016)
 - Ashley Madison (2015)
 - Home Depot (2014)
 - Target (2014)
 - Etc.

Harms caused by software

- Volkswagen scandal
- Facebook-mediated election meddling
- 911 system outages

The Future ...

- More software
 - Cars
 - Stock exchanges
 - Businesses
 - Government
 - Medical devices
 - Etc.
- You!
 - Responsibility
 - Professionalism
 - Do the right thing