

Classic Examples

Intro to Data Visualization

Gaston Sanchez

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Minard's Map



Napoleon crossing the Alps by Jacques Louis David. (The horse is believed to be Marengo)

EUROPE IN 1812



Some historical background

- ▶ 1776: Declaration of independence (USA)
- ▶ 1789: French Revolution
- ▶ 1792: French First Republic
- ▶ 1804: French First Empire (Napoleon becomes emperor)
- ▶ 1803–1815: Napoleonic Wars
- ▶ 1812: War between US and United Kingdom

Some historical background

French Invasion of Russia

June 1812

Grand Armee (500,000 aprox)

https://en.wikipedia.org/wiki/French_invasion_of_Russia

C.J. Minard



- ▶ Charles Joseph Minard
(1781 - 1870)
- ▶ French Civil Engineer
- ▶ Created very novel and sophisticated graphics

https://en.wikipedia.org/wiki/Charles_Joseph_Minard

Carte Figurative des pertes successives en hommes de l'Armée Française dans la Campagne de Russie 1812-1813.
 Dressée par M. Minard, Inspecteur Général des Ponts et Chaussées au décret.

Les nombres d'hommes perdus sont représentés par les longueurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en tracés des zones. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. — Les renseignements qui ont servi à dresser la carte ont été pris dans les ouvrages de M. M. Chiat, de Léger, de Feronat, de Chambry et le journal médical de Jacob, pharmacien de l'Armée depuis le 28 Octobre. Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Napoléon et du Maréchal Davout, qui avaient été détachés sur Malibor et Malibor en leur rejoindre vers Orsha en Malibor, avaient marché avec l'armée.

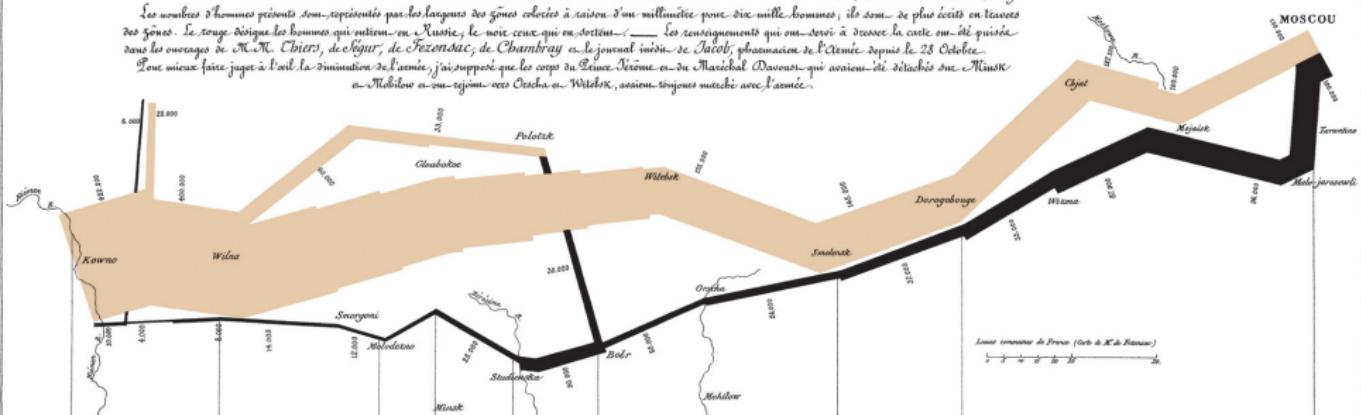


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.

Les Campagnes passent au gelé
le Nil est gelé.



Avec un Registre, 1. Feu. 1^{re} Mar. 31 1813 à Paris.

Imp. Lib. Registre et Diviseur.

Ligne commune de France (Globe de M. de Russie)

Zéro le 18 X^{me}

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Plaine 24 8^{me}

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Degrés

About Minard's map

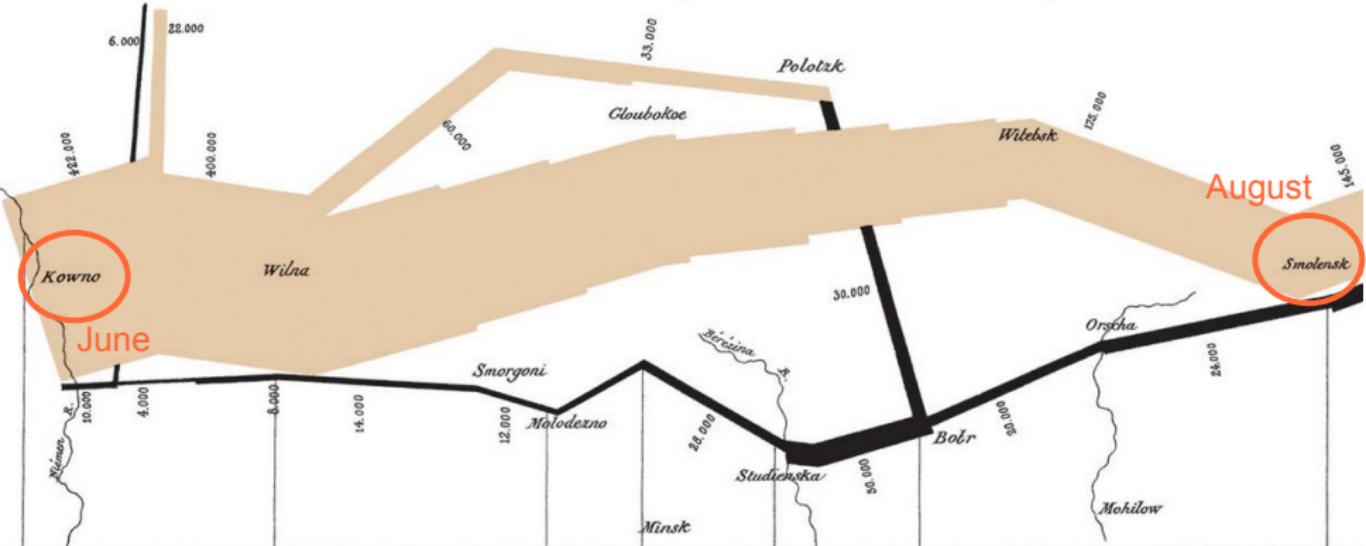
Seven variables in one chart

- ▶ number of troops
- ▶ traveled distance
- ▶ temperature
- ▶ latitude
- ▶ longitude
- ▶ direction of travel
- ▶ location relative to specific dates

Tours,

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; il y a deux zones. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. — Les renseignements qui ont servi à ce tableau sont tirés des ouvrages de M. Chier, de Ségur, de Fézensac, de Chambray et le journal médical de Jacob, pharmacien de l'Armée.

Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout qui avaient été à Mohilow et qui rejoignirent Oroscha et Witelsk, avaient toujours marché avec l'armée.

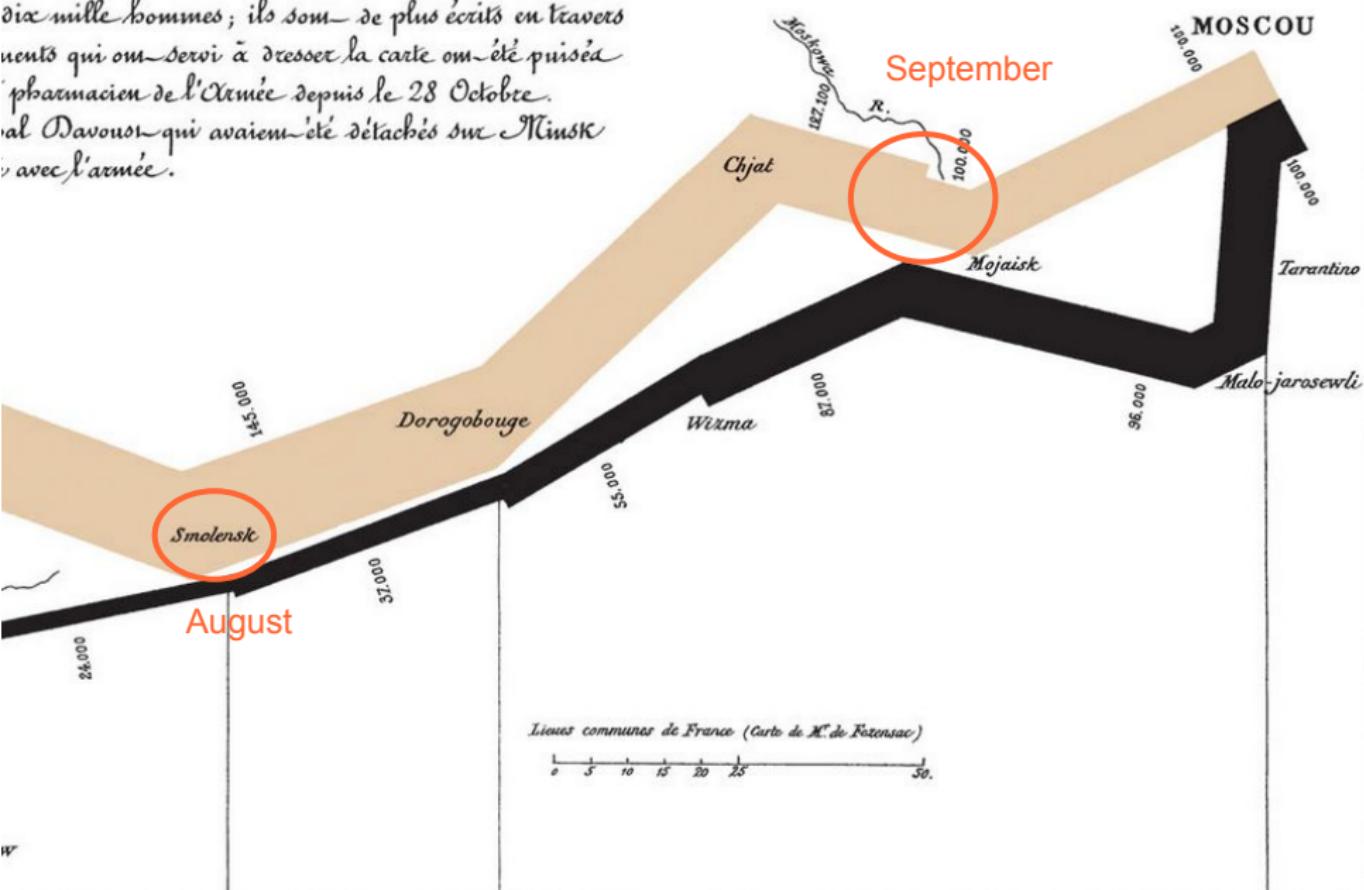


Russian Field Marshal Mikhail Kutuzov



Paris, le 20 Novembre 1869.

dix mille hommes; ils sont de plus écrits en travers
uents qui ont servi à dresser la carte ont été puisés à
pharmacien de l'Armée depuis le 28 Octobre.
al Davout qui avaient été détachés sur Minsk
avec l'armée.





The Russian Army and residents of Moscow abandon the city in 1812, by A. Semyonov and A. Sokolov.

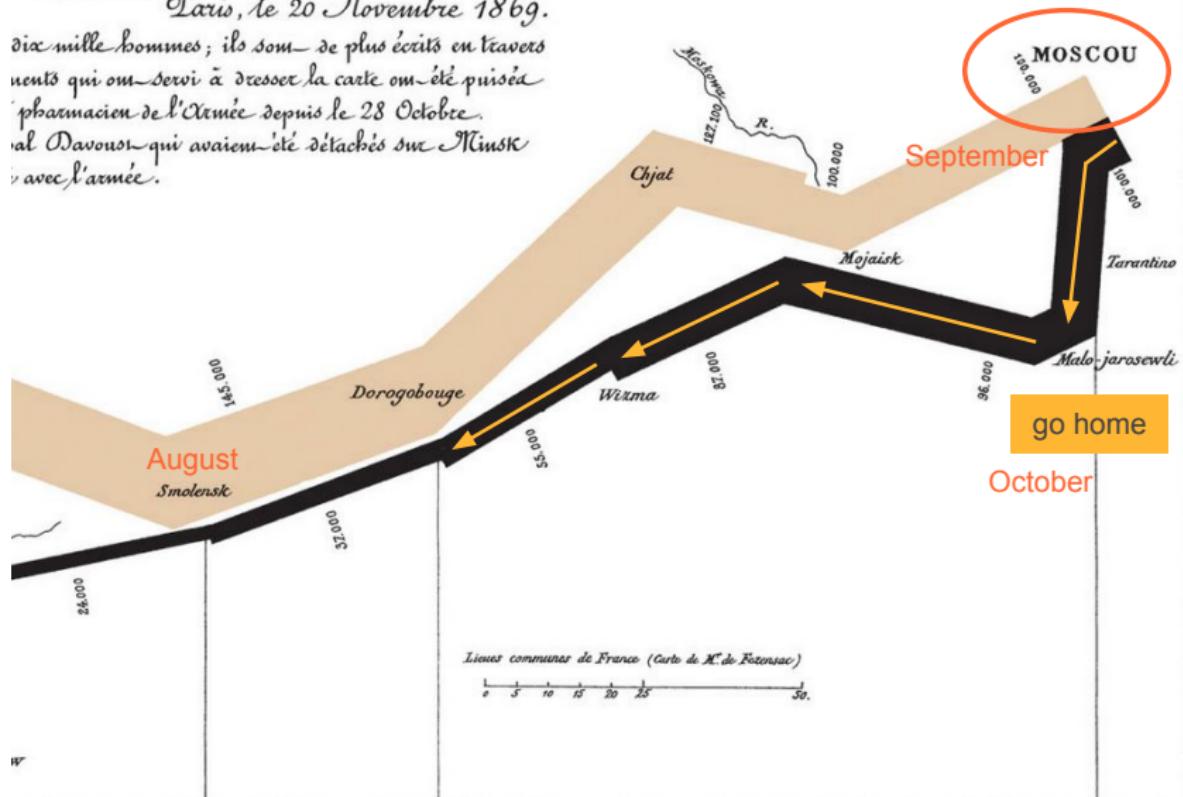
Some historical background

Capture of Moscow

September 1812

(not so) Grand Armee (100,000 aprox)

Taxis, le 20 Novembre 1869.
 dix mille hommes; ils sont de plus écrits en trave
 nents qui ont servi à dresser la carte ont été puisés
 pharmacien de l'Armée depuis le 28 Octobre.
 al Davous qui avaient été détachés sur Minsk
 avec l'armée.





Napoleon's retreat from Moscow, by Viktor Mazurovsky.



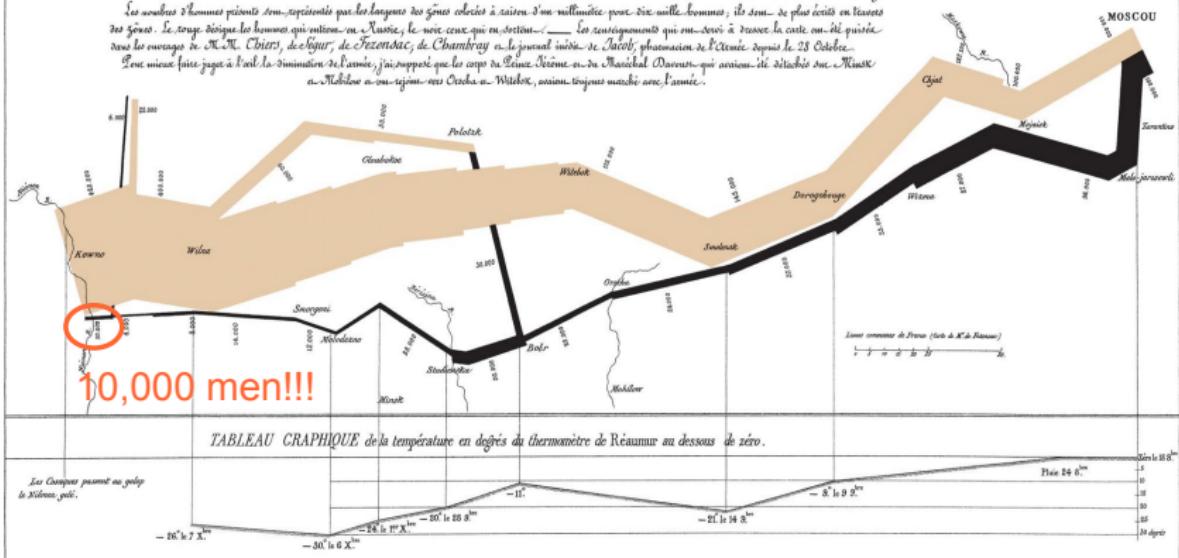
La retraite de Russie

Carte Figurative des pertes successives en hommes de l'Armée Française dans la Campagne de Russie 1812-1813.

Dessiné par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite.

$\overline{R} : \ell_2(\mathbb{N}) \rightarrow \ell_\infty(\mathbb{C})$

Les audibles d'hommes peuvent être représentés par les longues récitations des gosses coloqués à laisser. J'en mélangeais pour dire toute l'heure, ils sont... de plus en plus en faveur de Séneca. Le temps dégoûte les hommes... ou... Xerxes, le seul que je retiens... *Les enseignements qui me sont à donner la carte où il devra être envoyé de M. le Chevalier de Fézézet, de Chambry ou... le journal intime de Talley, phonogramme de l'époque vers le 28 Octobre. Son mieux fait je juge à l'œil la diminution de l'amour... j'ai supposé que les corps de Xerxes et de Machabel Dourou, qui avaient été détruits sur l'île de Melibée auquel je suis venu, étaient toujours dans l'île.*



Challenger Explosion (1986)



A bit of context

Some Remarks

- ▶ Space Race
- ▶ Cold War (USA -vs- URSS)
- ▶ Many launching delays
- ▶ First civilian as part of the crew
- ▶ Reagan's "State of the Union"
planned the same day

A major malfunction

Challenger's brief flight

.678 seconds

Following Challenger's liftoff, a puff of black smoke — seen only by automatic launch cameras — indicates a problem with one of the O-ring seals at the joint between segments of the shuttle's right-hand solid rocket booster.

No human eyes see the smoke, and there would have been no way to abort the flight if they had.

58 seconds

A small jet of smoke and flame bursts through the side of the booster and quickly grows.

73 seconds

The flame burns through the strut attaching the solid rocket booster to the external fuel tank, causing the booster to swirl into the side of the tank. The resulting massive explosion destroys the space shuttle.

Full thrust

Once the boosters ignite, there is no way to shut them off.

3 minutes, 58 seconds

Challenger's crew compartment, which appeared to come away from the exploding shuttle more or less intact, smashes into the Atlantic Ocean at 200 mph.

Officials never determined whether the shuttle's explosion or the impact with the ocean killed the crew.

External fuel tank

Holds about 143,000 gallons of liquid oxygen and 385,000 gallons of liquid hydrogen.

Solid rocket booster

Manufactured in segments, which are then stacked.

Liquid hydrogen

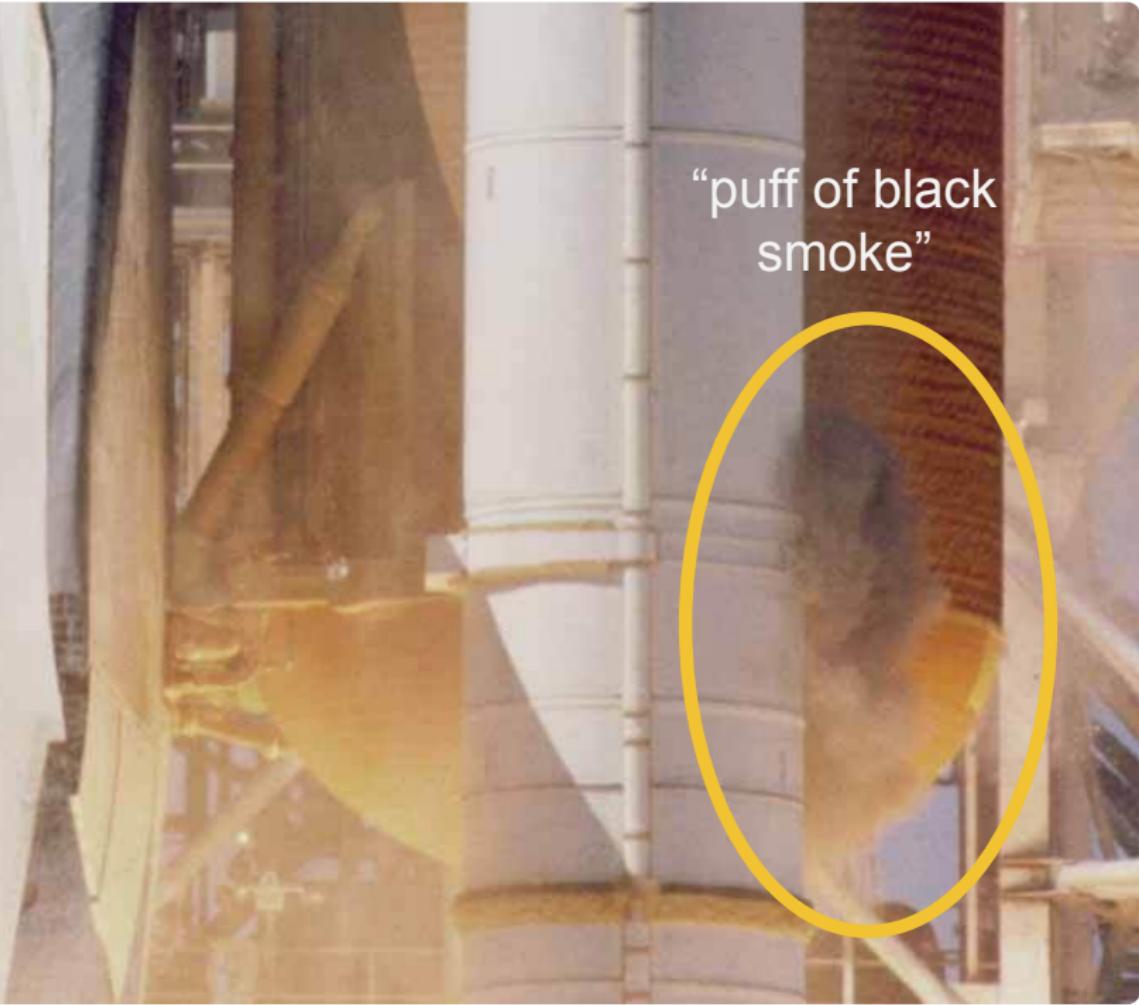
Crew compartment

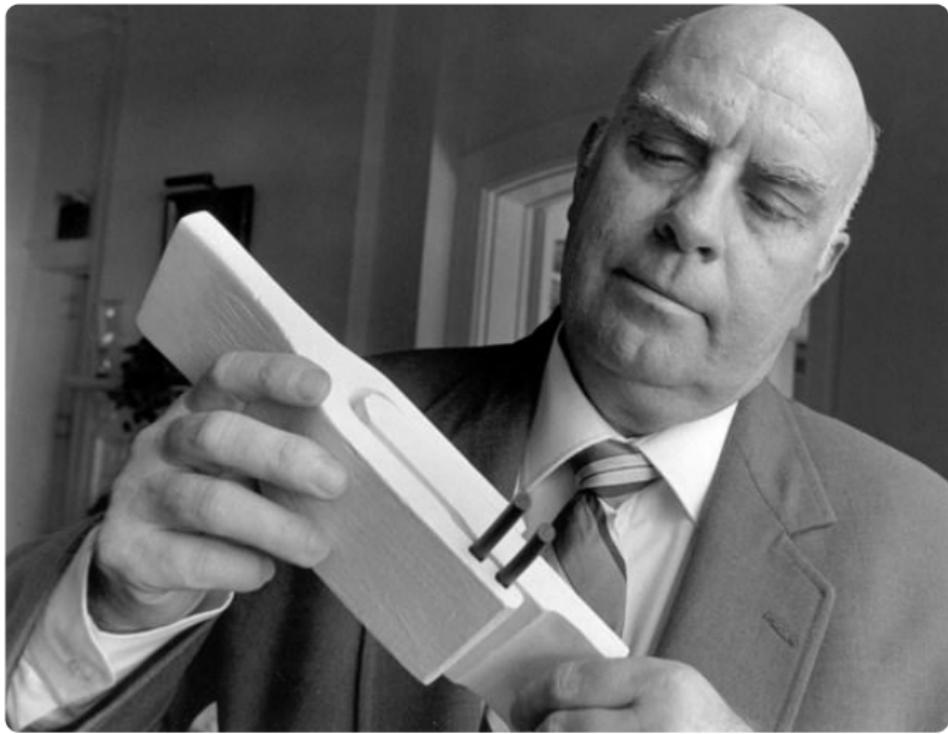
Main shuttle engines

SOURCE: NASA
THE PLAIN DEALER

<https://www.awesomestories.com/asset/view/Challenger-and-the-Major-Malfunction//1>

United States

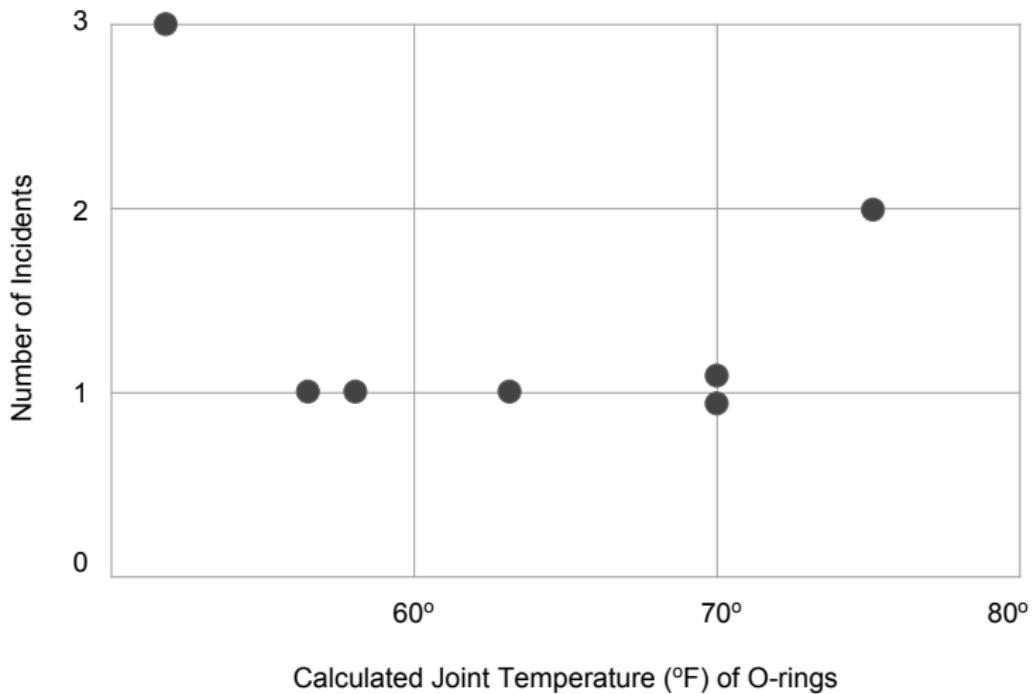




Roger Boisjoly, c. 1991 (former Morton-Thiokol engineer)

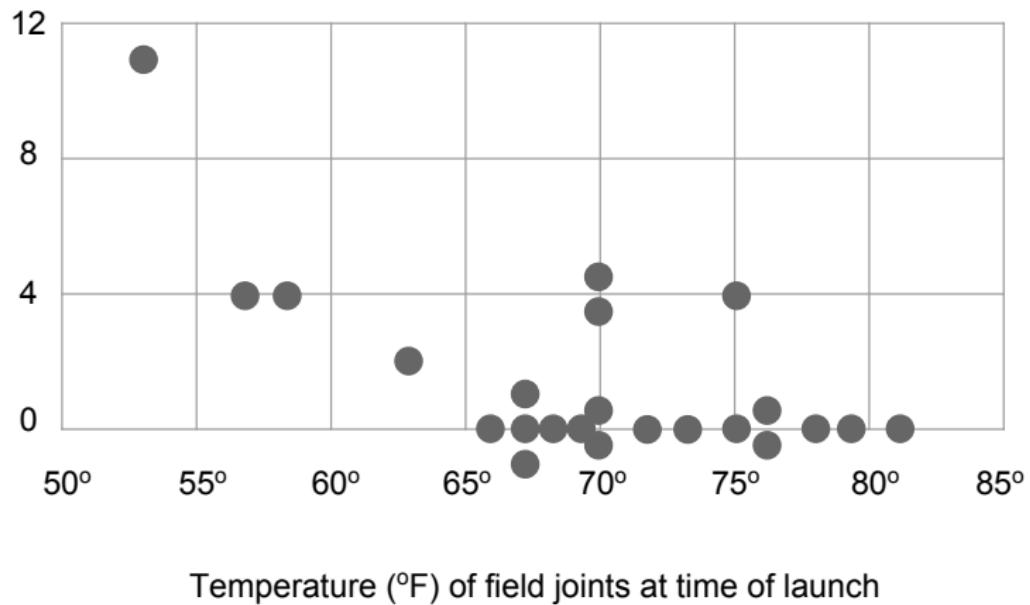


Bob Ebeling, c. 2016 (former Morton-Thiokol engineer)



(24 launches with affected O-rings prior to the Challenger)

O-ring damage
index, each launch



Temperature (°F) of field joints at time of launch

(Published in shuttle commission report; unknown date of creation)

Flight	Date	Temp	Erosion Incidents	Blow-by Incidents	Damage Index	O-ring Damage
51-C	01.24.85	53	3	2	11	yes
41-B	02.03.84	57	1		4	yes
61-C	01.12.86	58	1		4	yes
41-C	04.06.84	63	1		2	yes
1	04.12.81	66			0	no
6	04.04.83	67			0	no
51-A	11.08.84	67			0	no
51-D	04.12.85	67			0	no
5	11.11.82	68			0	no
3	03.22.82	69			0	no
2	11.12.81	70	1		4	unknown
9	11.28.83	70			0	
41-D	08.30.84	70	1		4	no
51-G	06.17.85	70			0	no
7	06.18.83	72			0	no
8	08.30.83	73			0	no
51-B	04.39.85	75			0	no
61-A	10.30.85	75		2	4	yes
51-I	08.27.85	76			0	no
61-B	11.26.85	76			0	no
41-G	10.05.84	78			0	no
51-J	10.03.85	79			0	no
	06.27.82	80			?	unknown
51-F	07.29.85	81			0	

Values in red were exhibited at some point in the 13 pre-launch charts; those in black were not included

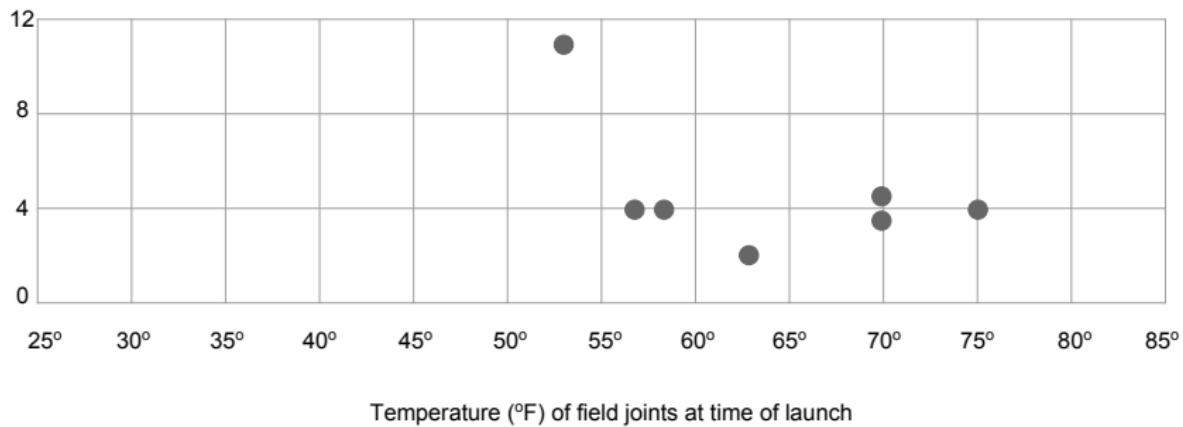
(based on Tufte)

Some Remarks

- ▶ 13 charts were prepared for making the decision to launch
- ▶ 6 charts contained no tabled data about either O-ring temp, blow-by, or damage.
- ▶ The rest of charts contained no info about relation between temp and O-ring anomalies
- ▶ They all failed to reveal the risks of launching at very low temperatures

7 launches with affected O-rings prior to the Challenger

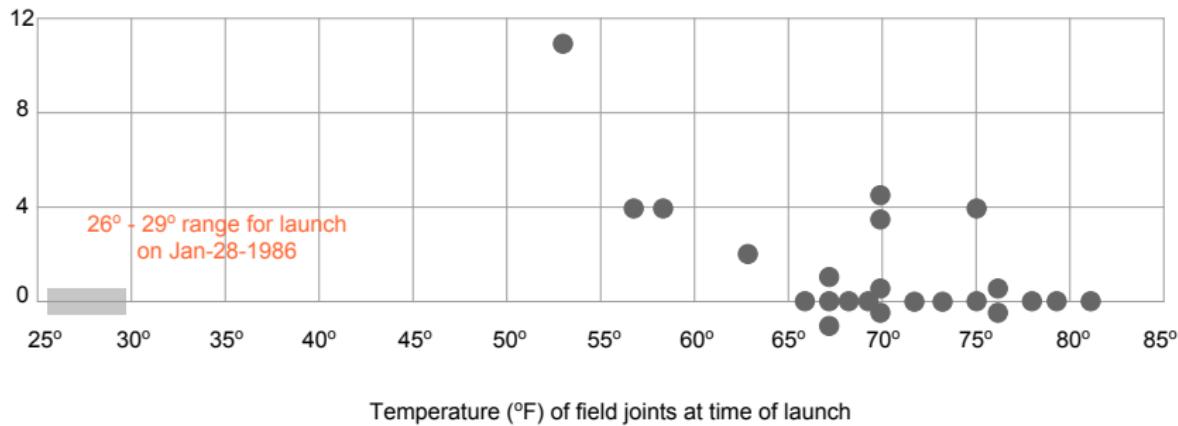
O-ring damage
index, each launch



24 launches prior to the Challenger

O-ring damage
index, each launch

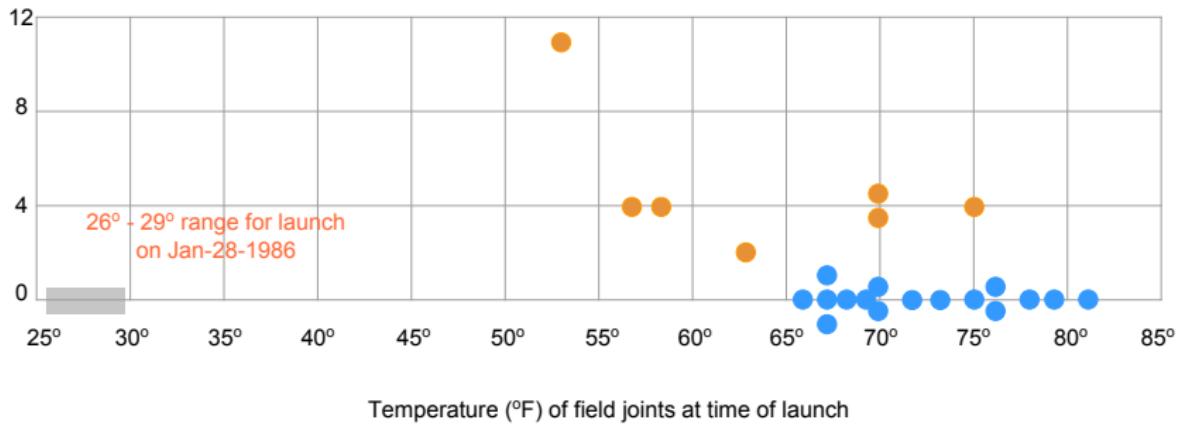
$$r = -0.6415$$



24 launches prior to the Challenger

O-ring damage
index, each launch

$$r = -0.6415$$

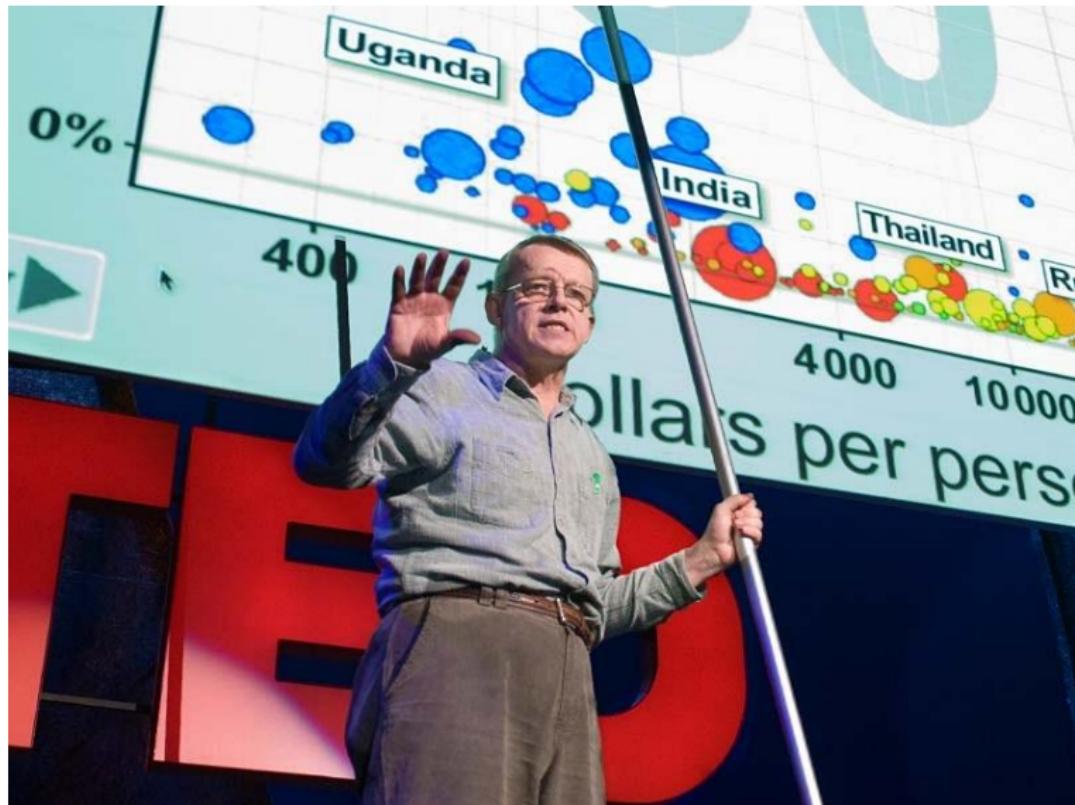


Some resources

- ▶ Space Shuttle Challenger Accident
<https://www.youtube.com/watch?v=fSTrmJtHLFU>
- ▶ Inside Space Shuttle Challenger STS-51L During The Accident
<https://www.youtube.com/watch?v=NnmSdVbgQ4M>
- ▶ NPR article about Bob Ebeling
[http://www.npr.org/sections/thetwo-way/2016/01/28/464744781/
30-years-after-disaster-challenger-engineer-still-blames-himself](http://www.npr.org/sections/thetwo-way/2016/01/28/464744781/30-years-after-disaster-challenger-engineer-still-blames-himself)
- ▶ Challenger Engineer Who Warned Of Shuttle Disaster Dies
[http://www.npr.org/sections/thetwo-way/2016/03/21/470870426/
challenger-engineer-who-warned-of-shuttle-disaster-dies](http://www.npr.org/sections/thetwo-way/2016/03/21/470870426/challenger-engineer-who-warned-of-shuttle-disaster-dies)

Hans Rosling's Talks

Communicate: Hans Rosling



Watch any (or better: all) of Hans Rosling videos
and TED talks

Hans Rosling

Hans Rosling: The best stats you've ever seen | TED Talk | TED.com
 19:50

https://www.ted.com/talks/hans_rosling_shows_the_best_stats_yo... ▾
You've never seen data presented like this. With the drama and urgency of a sportscaster, statistics guru **Hans** ...

Hans Rosling: Global population growth, box by box | TED Talk | TED ...
 10:04

https://www.ted.com/talks/hans_rosling_on_global_population_g... ▾
This is the paradoxical answer that **Hans Rosling** unveils at TED@Cannes using ... Poverty is an ...

Hans Rosling: New insights on poverty | TED Talk | TED.com
 18:57

https://www.ted.com/talks/hans_rosling_reveals_new_insights_on... ▾
Researcher **Hans Rosling** uses his cool data tools to show how countries are pulling themselves out of ...

Hans and Ola Rosling: How not to be ignorant about the world | TED ...
 19:05

https://www.ted.com/talks/hans_and_ola_rosling_how_not_to_be... ▾
Sep 11, 2014
How much do you know about the world? **Hans Rosling**, with his famous charts of global population, health and ...

Hans Rosling: Let my dataset change your mindset | TED Talk | TED.com
 19:56

https://www.ted.com/talks/hans_rosling_at_state ▾
Talking at the US State Department this summer, **Hans Rosling** uses his fascinating data-bubble software to ...

Hans Rosling: The magic washing machine | TED Talk | TED.com
 9:15

www.ted.com/talks/hans_rosling_and_the_magic_washing_mach... ▾
What was the greatest invention of the industrial revolution? **Hans Rosling** makes the case for the washing ...

The best stats you've ever seen | Hans Rosling - YouTube
 19:56

<https://www.youtube.com/watch?v=hVlmVzgtD6w> ▾
Jan 16, 2007 - Uploaded by TED
<http://www.ted.com> With the drama and urgency of a sportscaster, statistics guru **Hans Rosling** uses an ...

Hans Rosling: Asia's rise – how and when | TED Talk | TED.com
 15:50

https://www.ted.com/talks/hans_rosling_asia_s_rise_how_and_w... ▾
Hans Rosling was a young guest student in India when he first realized that Asia had all the capacities to ...