It is the assumption that kills you

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KIVI - RBT

Delft University of Technology

A retrospection on safety and risk

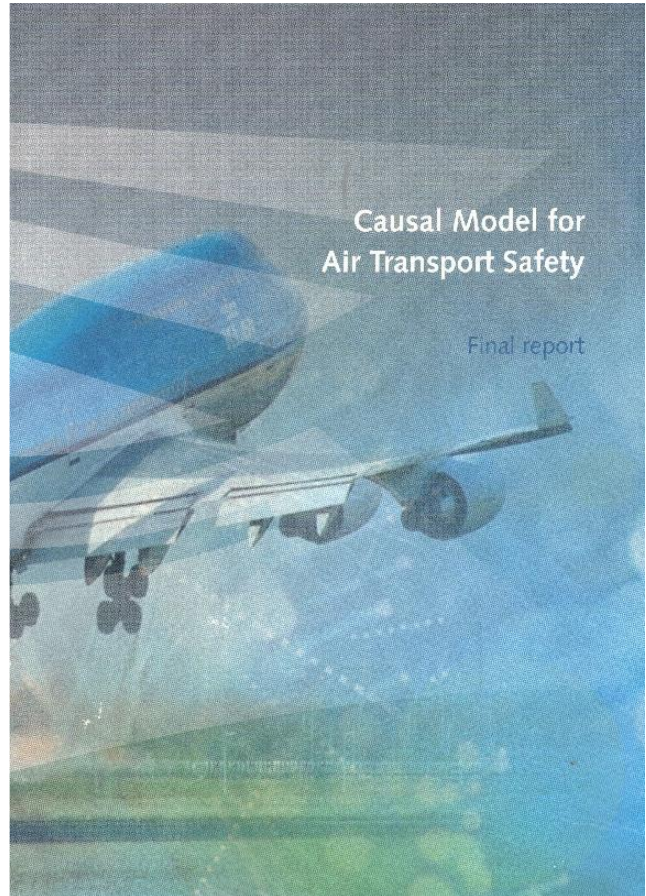
A paradigm shift (1978 – 2025):

- From Accident Investigation towards Safety Management
- From deficiencies in design towards emergent operational practices
- From technology towards organisation and governance
- From qualified and independent investigation to operational excellence
- From learning by failure towards evaluating success

Consequences of this shift:

- Focus transfer from investigation feedback towards operational best practices (Farrier)
- Replacing notions of cause, prevention and precaution by resilience (Hollnagel)
- Introduction of ‘belief’ systems: system complexity, chaos model (Cynefin)
- Individualized subjectivity of human error: Work as Done/Work as Imagined (Reason)
- Creating new tools and operating parameters:
  - = Key Performance Indicators
  - = socio-organisational networks: the FRAM model
  - = system modelling: the CATS model
  - = big data analysis, algorithms, AI, Chat gpt
  - = democratic participation

“CATS is the second best representation of reality, reality itself being the best”



A shift in context and operational environment

A new socio-economical environment: post-neoliberalism
= new market relations: privatisation, delegation, the Boeing 737 case
= organisational learning potential: suppressing 'weak' signals
= reinstalling liability, accountability and oversight

But most of all

Legitimized by 'scientific' theories at higher systems levels:
Turner, Reason, Rasmussen, Perrow
'New school' paradigms in socio-technical systems engineering and emerging policy analysis:
= process overrules content
= market overrules knowledge
= participation overrules expertise

and 'scientific battles' for recognition of extrapolated adaptations

Conclusion 1:

A dialectic stall in scientific development occurs
Derivative approaches provide thesis and antithesis, but do not deliver a synthesis

An ESReDA remedial response

According to Vincenti (1990):

Given changes in the socio-economical and technological environment, disruptive adaptations might perform better than derivative extrapolations

What are these changes:

Technological innovations, market developments, governmental arrangements, policy demands on sustainability, circular economy, climate responsive and resilience capacity

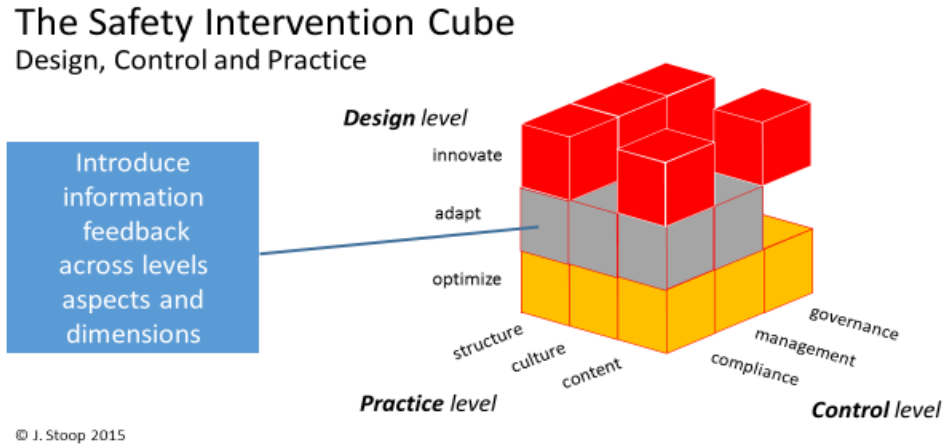
A remedy in 4 steps?

= understanding investigative notions and methodology: forensic sciences

= future proof systems change and transition: foresight by hindsight and insight

= applying a systems architecture: the ESReDA Cube and

= system dynamics: the MCIM model



For safety, this means:

A disruptive approach in focus: innovate rather than extrapolate

A stepwise approach: first understand, then comprehend

Explore beyond the event: add the system to the scope

Provide a timely transparency in the factual functioning of complex systems

Diagnosing (sub)system problems to identify solution spaces in a system safety landscape

Conclusion 2:

Develop a new system methodologies: Safety Investigations, Knowledge Based and Value Based system design and operations

The ESReDA Safety Investigation Methodology

The investigation processes contains 3 steps from insight, to oversight, to foresight

1. The investigative reconstruction of the event in its environment

factual description of the system components, aspects and dimensions to facilitate the step from description to explanation of the event in its context, given the available data and conditions

2. The analytic interpretation of facts and findings

Mobilizing knowledge and expertise about states, defciencies, design and operational assumptions, models, simplifications, interactions to facilitate the step from understanding to sustainable change and performance enhancement

3. The adaptive intervention by learning, recommending and change

Categorizing change options in the event and the system as derivative, disruptive or prospective adaptations, applying system engineering design and change management principles to facilitate the step from recommending to implementing knowledge based solution spaces

How to achieve change and transition?

Change the focus to conceptual change rather than form adaptation and function variation
Identify and validate system boundaries: technological, social, institutional, ecosystem
Identify knowledge deficiencies in expertise and experience
Apply the full information paradigm: combine feedforward and feedback
Identify the operating envelope, also on the long term
Identify assumptions, simplifications and extrapolations
Lessons learned or lessons forgotten, denied or dismissed
Identify change agents, change drivers and bifurcation points

From wind mills to wind turbines
what are the assumptions?

Conclusion 3:
Develop a Prospective, Future Proof approach,
by combining Hindsight, Insight and Foresight
by applying ~~a~~ Generative Design Methodology

How does this apply in a case based practice?

The Wind turbine energy transition case

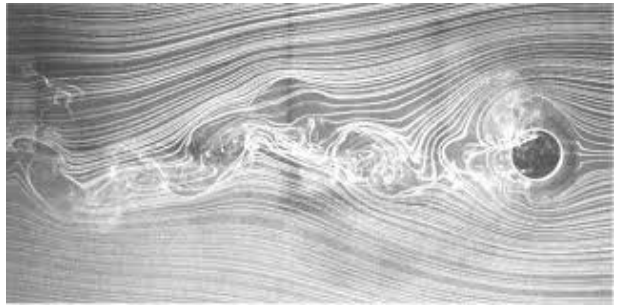
The atmosphere

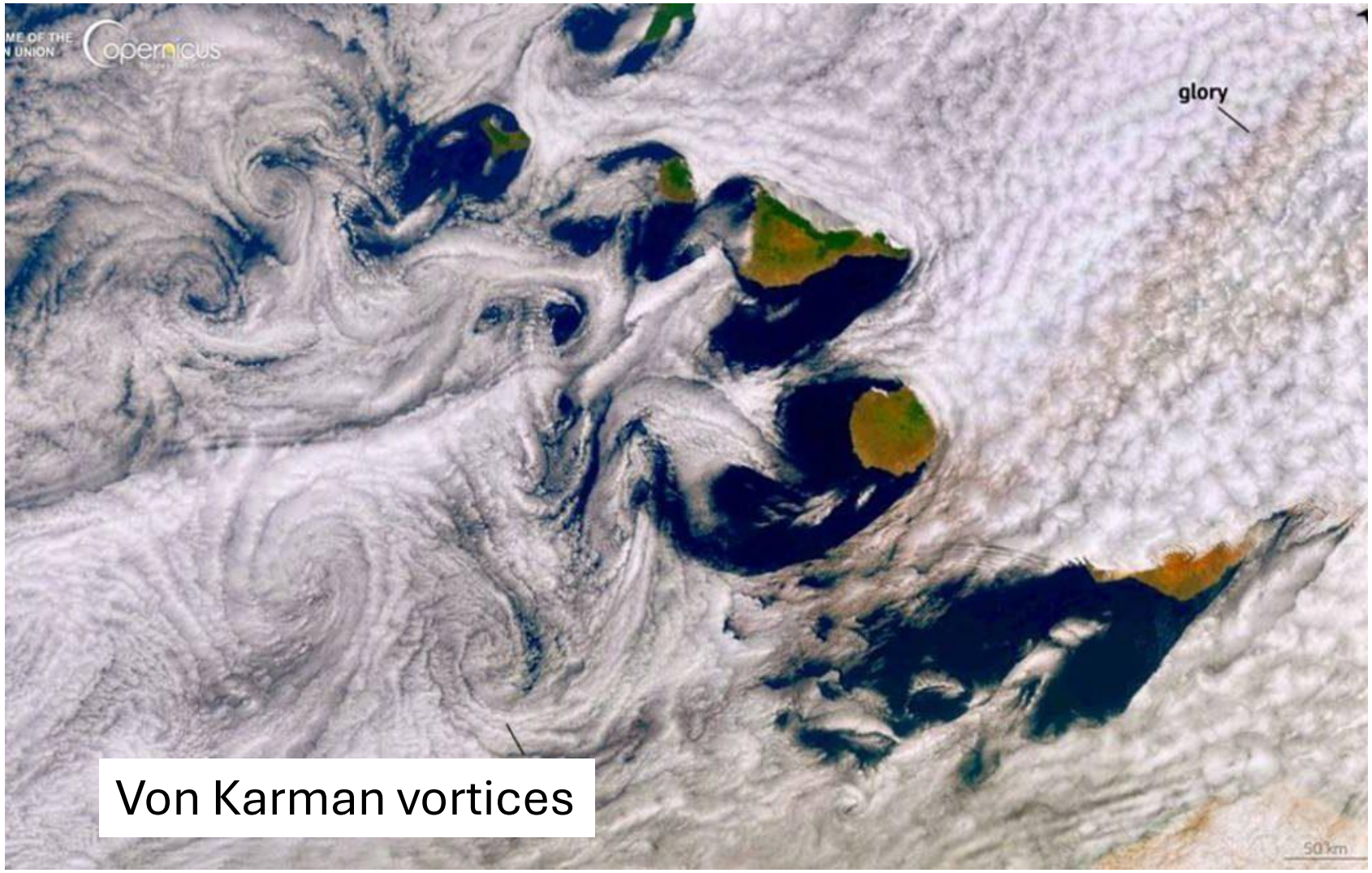
1. What about the nature of the beast

Characteristic vortices by satellite observations of the Canary Islands

Von Karman vortices

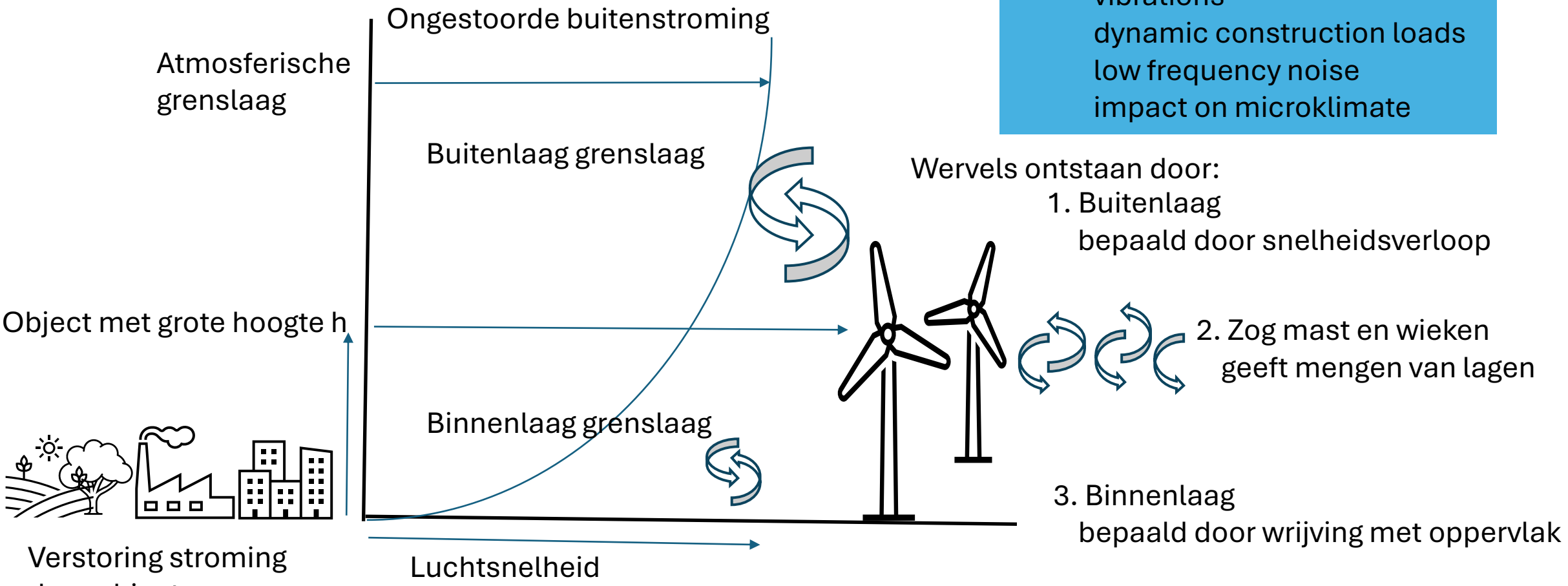
In theory
In windtunnels
and in praktice





2. What about atmosferic boundary layer structure

Vortices create disturbances:
- vibrations
- dynamic construction loads
- low frequency noise
- impact on microklimate



Wervels ontstaan door:

1. Buitenlaag
   bepaald door snelheidsverloop
2. Zog mast en wieken
   geeft mengen van lagen
3. Binnenlaag
   bepaald door wrijving met oppervlak

Verstoring stroming na 14 maal de hoogte h uitgedempt

3. We know the Waterwolf, but what about the Windwolf?

On a beautiful summer day……

Oftewel,

Extreem weer,
onvoorspelbare
klimaatveranderingen,
zeespiegelstijgingen
en hun interacties

Stormvloeden: *eens per 50 jaar!*
60 keer van 838 tot 2021, o.a.
1421 Elizabethsvloed
1916 Zuiderzee
1953 Zeeland

Windhozen in Nederland:
met doden en gewonden:
10 in afgelopen 100 jaar
1925 in Borculo;
1927 bij Neede (F4)
1950 Veluwe (F4/F5)
1967 Chaam en Tricht
1972 Ameland
1981 Moerdijk
1992 Ameland
2021 ‘s Heerenberg
2022 Zierikzee
2022 Beek

Sinds 1910:
67 zware stormen met
Windkracht 10 of meer

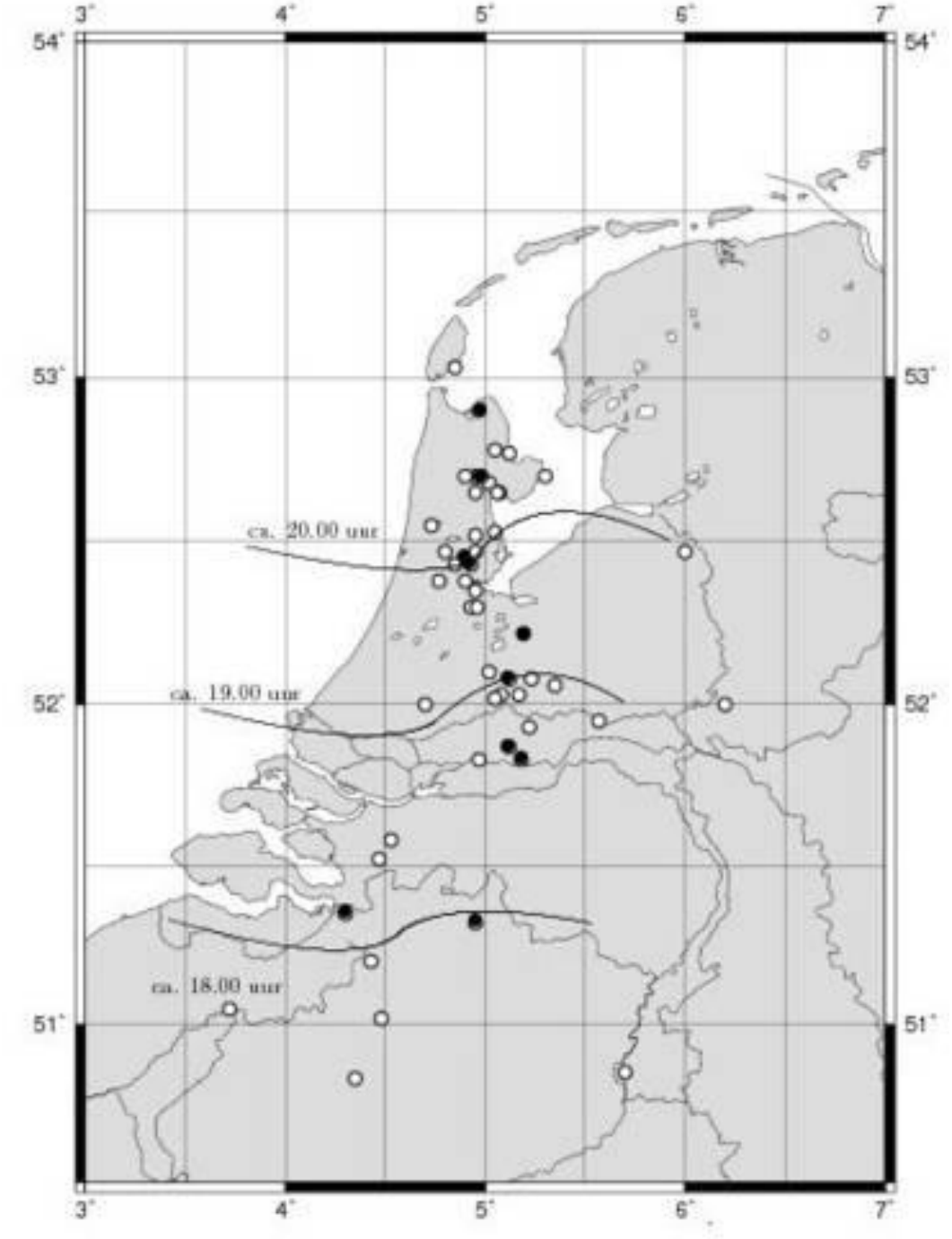
Low probability
Major consequences?
Negligible risc?

Het rampjaar was 1672 of was het 1674?

Het Schrickelik Tempeest

van Fontainebleau tot Hamburg
Woensdag 1 augustus 1674

Unpredictable coincide
or foreseeable?



Due to a horrific thunderstorm, the transept of the Gothic cathedral in Utrecht collapsed, unimaginable damage throughout the country

A contemporary explanaton of th phenomenon

Quote from: www.knmi.nl/kennis-en-datacentrum/achtergrond/zomerstorm-van-1674-domkerk-utrecht-stort-in

"'Op woensdag 1 augustus trekt een koudefront over de lage landen die de drukkende hitte van die dag verdringt door koel zomerweer. De onweerscomplexen die hiermee gepaard gaan zijn echter bijzonder actief. De wind wakkert sterk aan en samen met sterke rukwinden geeft dat aanleiding tot aanzienlijke schade op grote schaal in Europa, van Noord-Frankrijk (Fontainebleau), Belgie en Nederland tot aan Noord-Duitsland (Hamburg). De schade is overweldigend.

De treksnelheid van het front is ca.70km/h; Het deel van het front wat zich over Utrecht bewoog versneld t.o.v. het deel wat over Zuid- en Noord-Holland trok. De vervorming van het front geeft de karakteristieke boog structuur van het front. De snelheden van dit versnelde deel van het front kunnen oplopen tot 80-85 km/h. Deze mesoschaal structuur wordt `boog-echo' genoemd, naar de boogvorm van de echo op het radarbeeld.

De hoge snelheid duidt ook op een forse verticale snelheidsschering; Ten westen van de boog-echo is een gebied waarbij de passage van het front gepaard gaat met minder sterke rukwinden met beduidend minder schade, Dit is consistent met de afwezigheid van schade in het meest oostelijke deel van Noord-Holland.

Een ander argument zijn de observaties van hevige regen en uit de kluiten gewassen hagelstenen. Die duiden op het bestaan van een supercell. Hoe sterker de supercell, des te groter de hagelstenen. Een supercell ontstaat als deel van de boog-echo structuur. Verder duidt de plaatselijkheid van de schade op een sterk gelocaliseerd fenomeen als een tornado. De extreme liftkracht die meerdere getuigen verstelt deed staan is een andere karakteristieke eigenschap van een tornado.

Als we de balans opmaken, dan kunnen we zeggen dat op 1 augustus 1674 een zeer actieve buienlijn over ons land trok. Tijdens de passage van het front trad een opvallende mesoschaalstructuur op, de z.g. boog-echo. Het is waarschijnlijk dat op deze boog-echo zich twee tornado's ontwikkelen. Het extreme weer van deze dag heeft het maatschappelijk leven anno 1674 sterk ontwricht.

Tegelijkertijd werpt deze gebeurtenis zijn schaduw vooruit;
een herhaling van een dergelijke front passage over de huidige randstad zal ronduit desastreus zijn voor de Nederlandse samenleving"

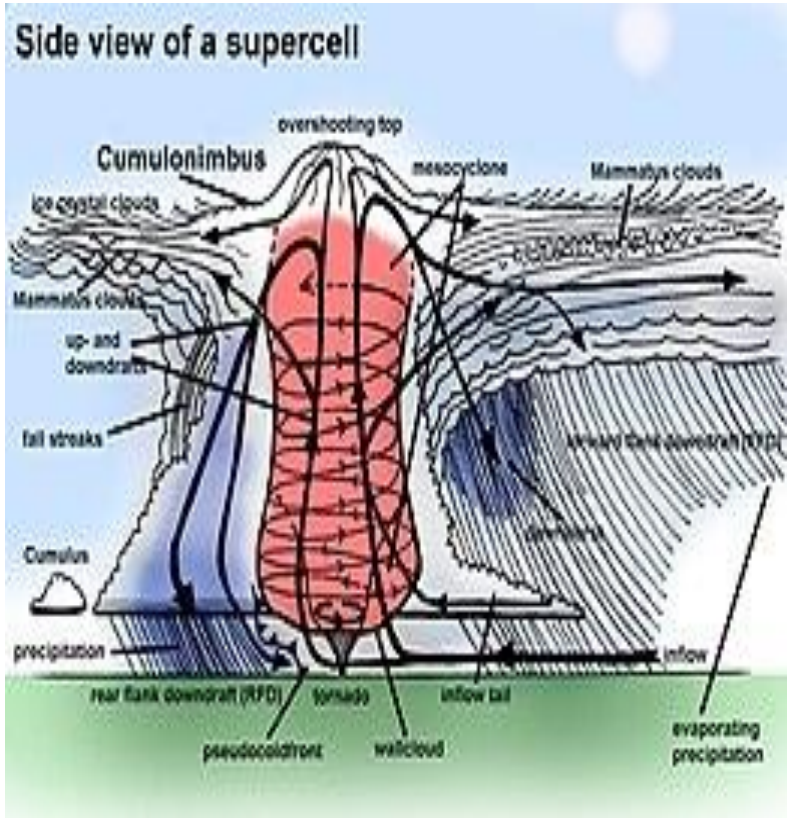
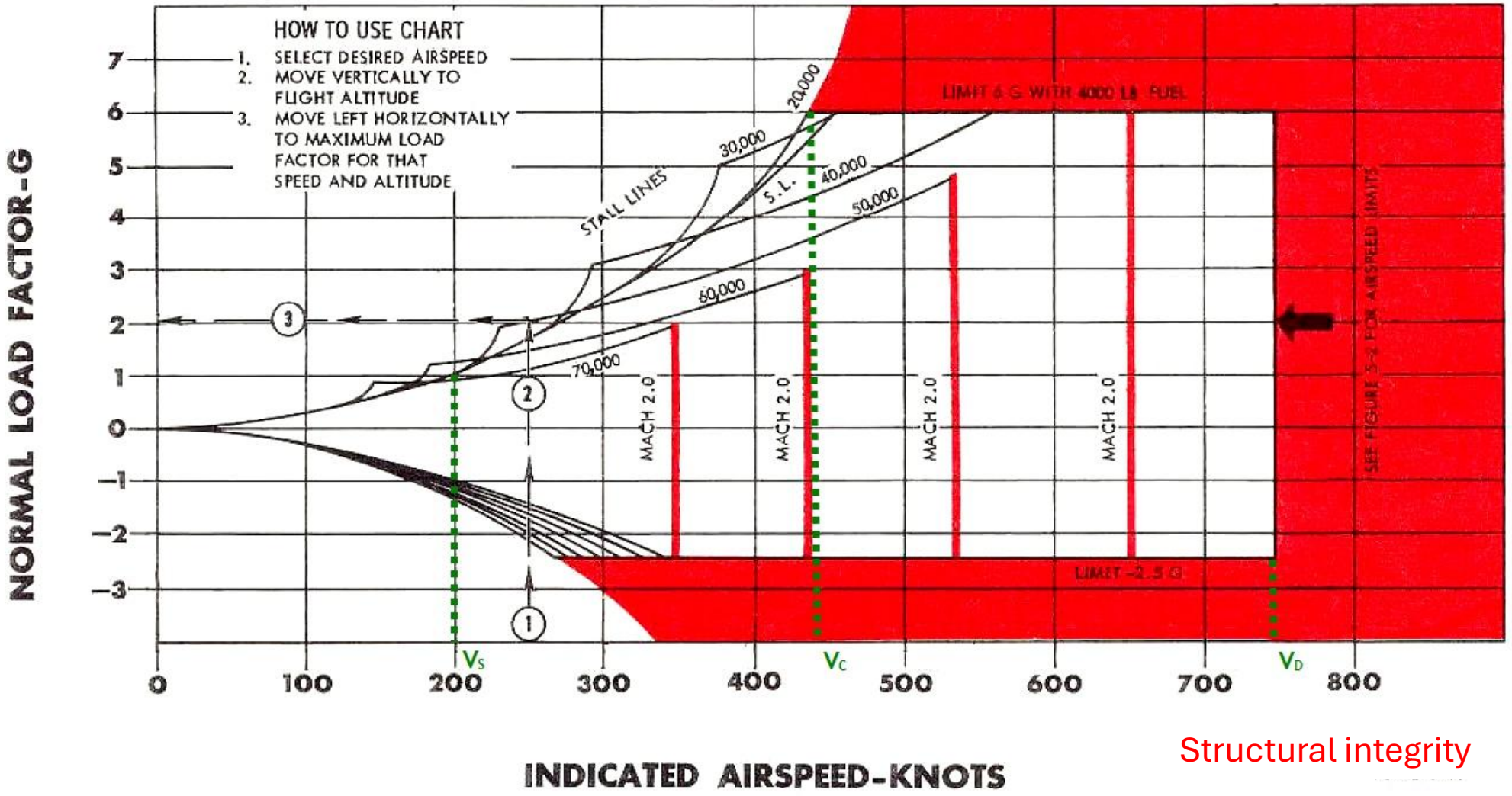


Fig reference Wikipedia

4. What about the operating envelope?

Propulsion power limitations

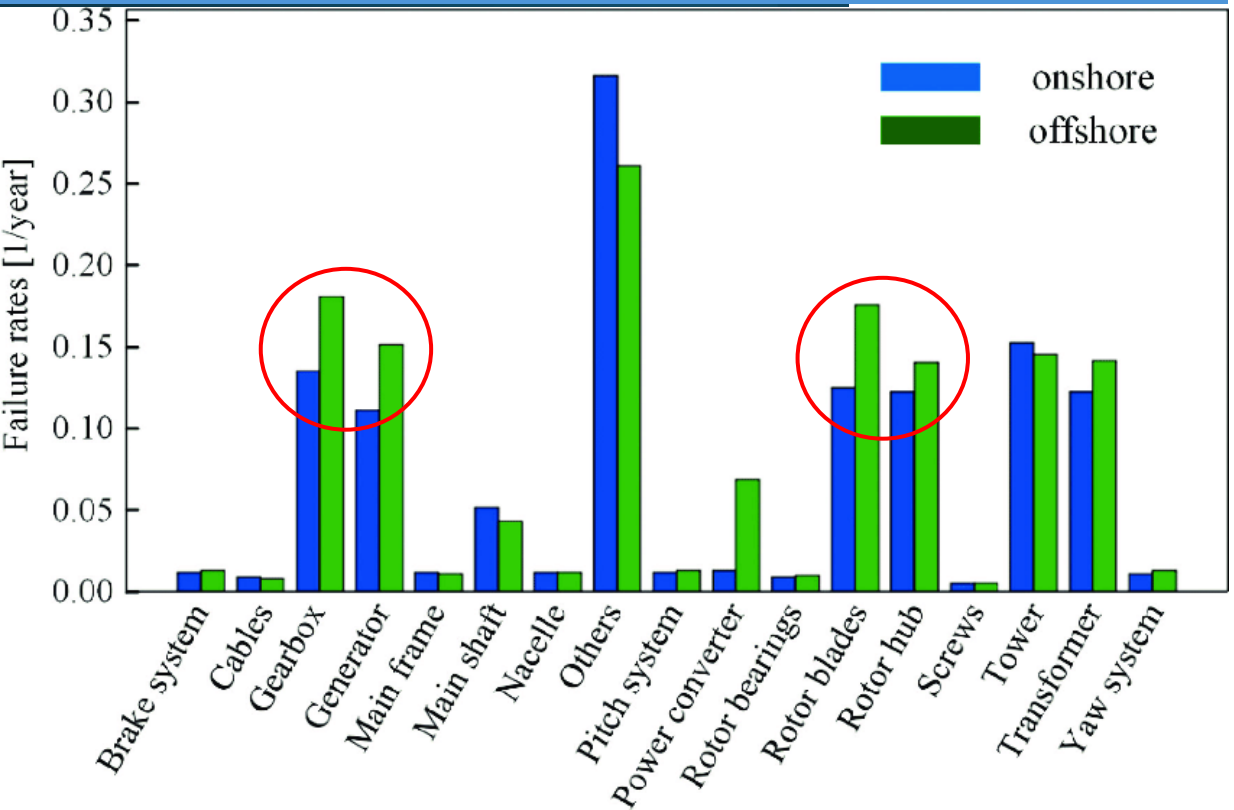


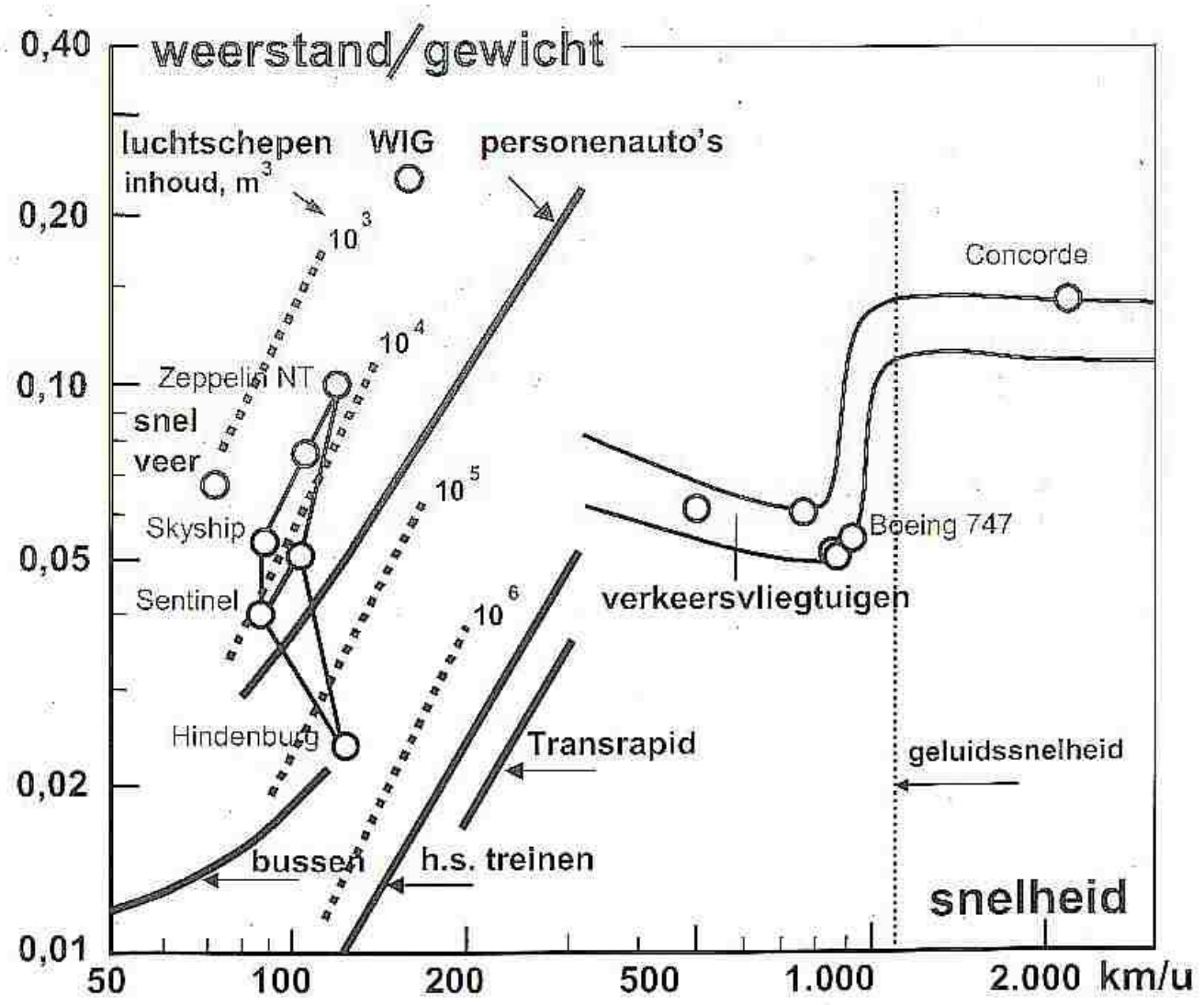
Sound barrier

Structural integrity

5. What about inherent failure modes

6. What about system intrinsic properties, performance boundaries, component failures, operating environment?





Vehicle specific drag characteristics

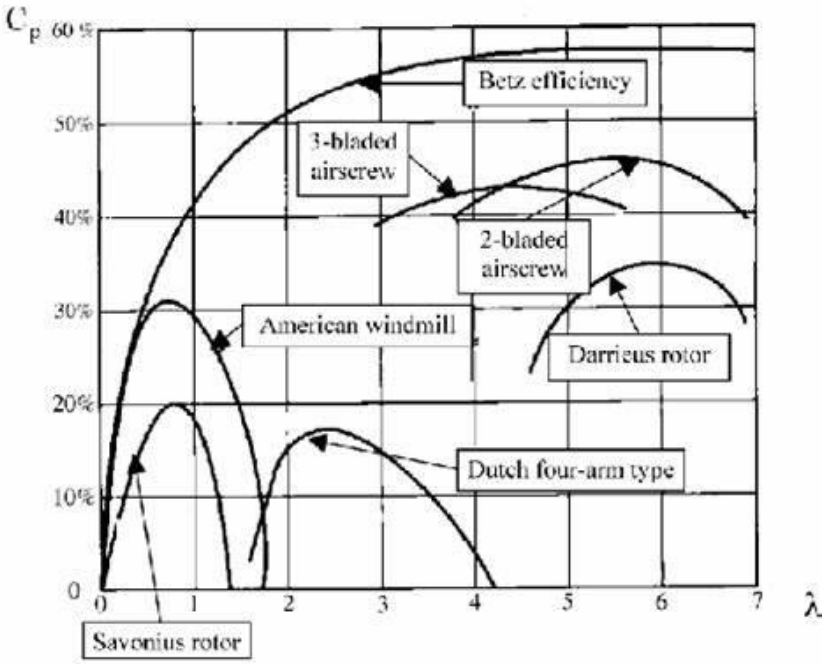
7. What about literature on

Theoretical maximum, vortices, vibrations, groundeffect, wake interaction, flutter

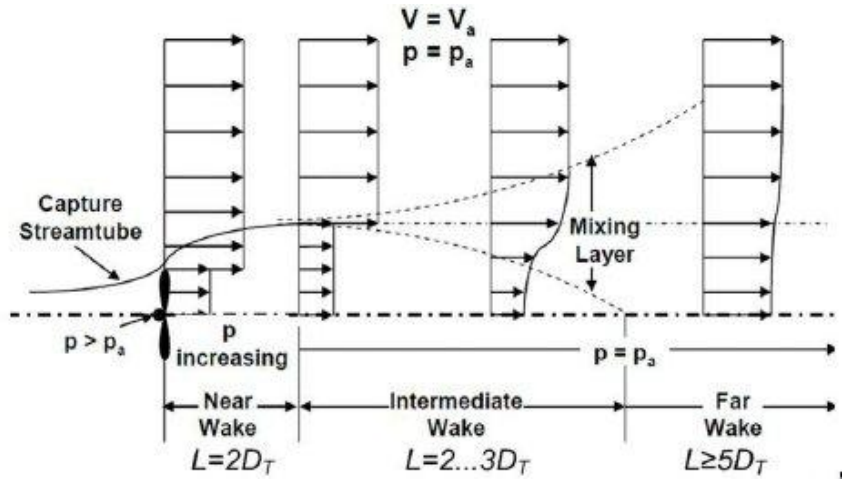
Theoretical maximum power:
Betz law 1919, 59.3%

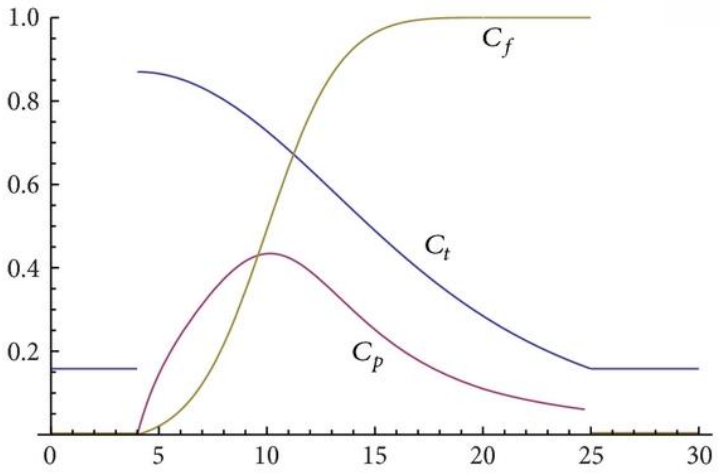
Push or pull rotor: TSR = 1
Windmill (disk drag, TSR < 1)
or windturbine (disk lift, TSR > 1)

capacity factor *Cf*
thrust coefficient *Ct*
power coefficient *Cp*

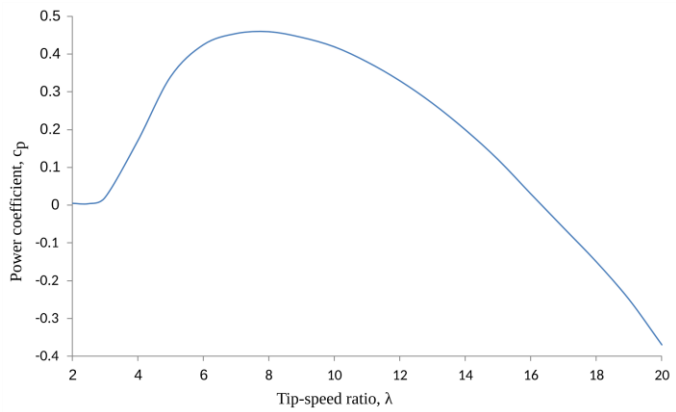


Zogstructuur bij schroefwerking

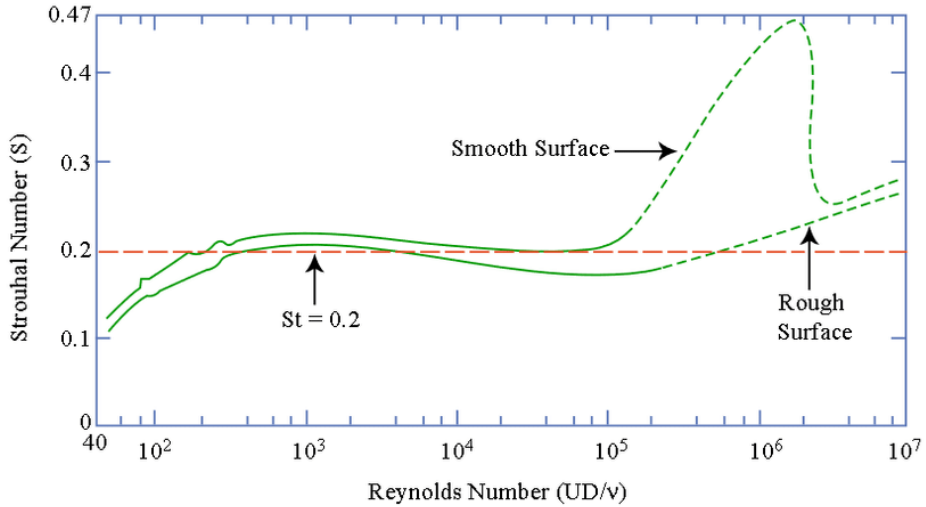




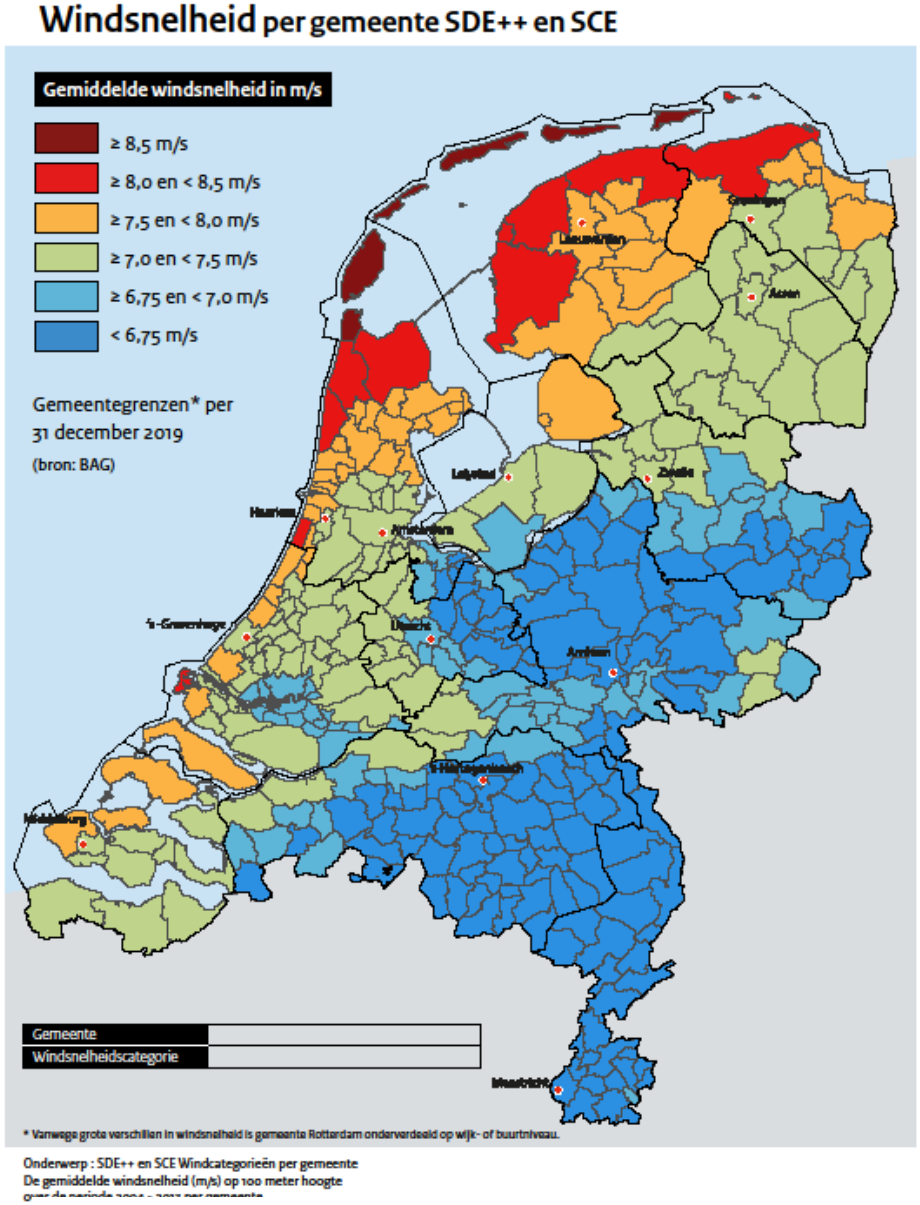
Tip Speed Ratio TSR

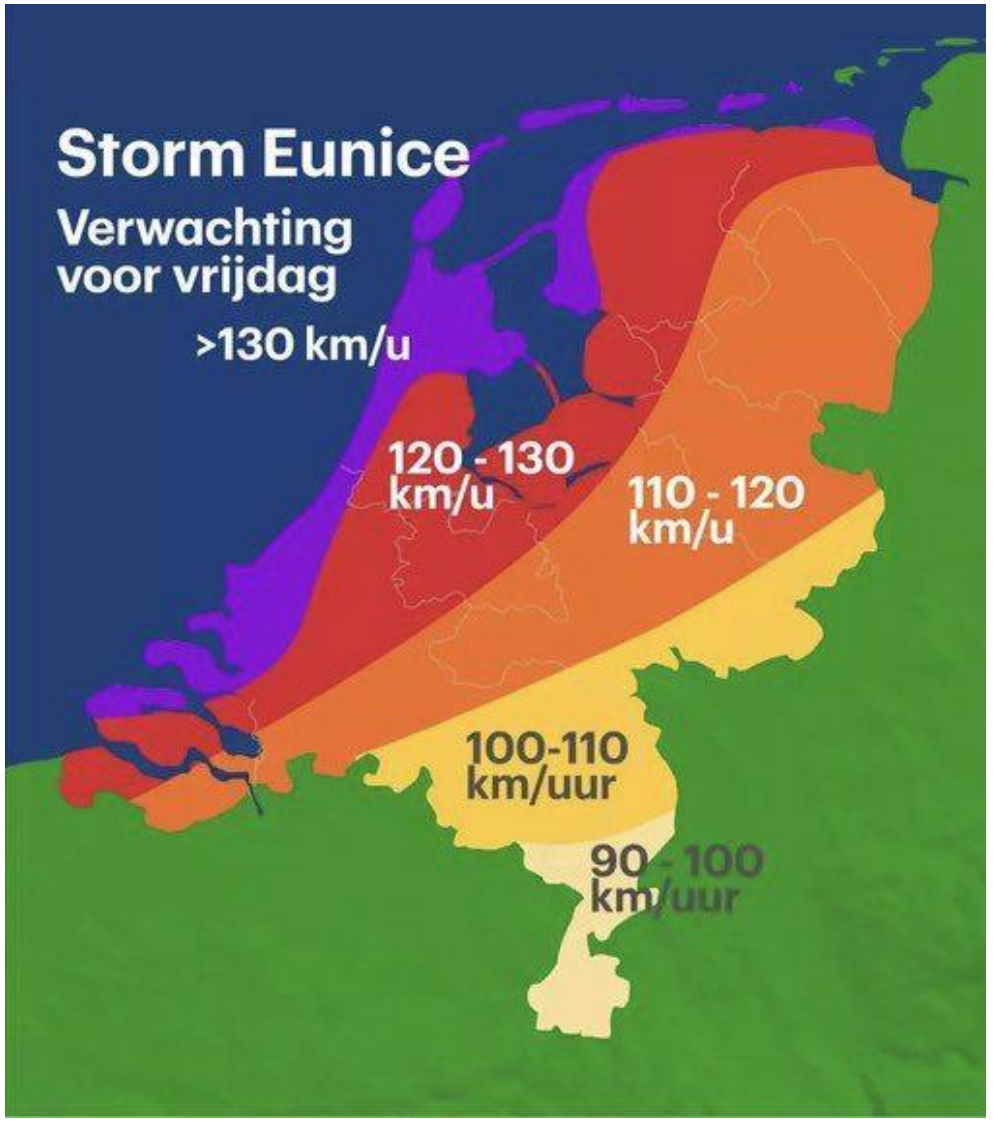


Wervels, trillingsgedrag en Strouhal getal



8. What about design for nominal wind loads or limit state conditions (1 to 25 !)





- Average windspeed: 25 km/hr (7 m/sec)

Peakload in km/hr: 130 km/hr (36 m/sec)

The Wind turbine energy transition, a summary

Information provided:

525 Newspapers articles , scientific and professional papers, Participation sessions on Energy Transition

Lacking information from: turbine manufacturers, consultants, market share holders, project management teams

Scientific literature, dedicated knowledge domains and disciplines: aerodynamics, geophysics, meteorology

Observations insurance company Gcube, observations on pilot holes and windfarm anomalies

Open questions on the 8 What Abouts:

Existing knowledge and experience in the participation process, lessons learned and forgotten

Assessing the nature of information: specific or generic, factual/empirical or 'belief' based

Operating environment, local and regional land use and maritime conditions

Micro, meso and macro impact: wind profile, weather change, climate change

Preferred design options: big, bigger, biggest, maximizing performance by linear extrapolation

Balancing of primary design pillars: power generation, storage, transport, consumers

Primary Design Knowledge domains: materials, aerodynamics, geofysics, meteorology

Risk and impact assessment: event data, population at risk, catastrophic failure rate, accident scenarios

Sustainability and life cycle demands: carbon footprint, upcycling waste, rescue and emergency

Operational excellence: occupational hazards, fully automated stability and control

Incident reporting, alerting and response, operating limits, corporate inspections and governance oversight

Business model: network configuration, return on investments, insurance, upgrades, decommission and disposal

Unknown unknowns: atmospheric abberations. Pilot holes and windturbine farm anomalies

Conclusion 4:

Each of these aspects contain knowledge deficiencies, unvidated assumptions and undisclosed correlations

9. Points to ponder
Gaining Insight, Oversight, Foresight
First Time Right, Triple Zero

1. Understanding the dynamics of the atmosphere

Offshore and onshore

The layered structure of the atmosphere: three regions, three perspectives

Managing knowledge domains: aerodynamics, meteorology, geophysics, oceanography

2. Impact of the design concepts and assumptions:

Performance, process, procedures, design standards and EU Directives

Derivative, disruptive or prospective solution domains, design limits and operating envelope

Generating R&D issues, based on knowledge deficiencies and assumptions

Safety and risk assessment: analysis versus perception, imagination versus intervention

3. The nature and wealth of data: collection techniques, observation, modeling, simulation, interpretation

4. Information bias: the role of whistle blowers versus influencers; empirical or ideological?

The role of influencers

1. With respect to causality

Trump hint op diversiteitsbeleid als oorzaak van crash vliegtuig met legerhelikopter, nos.nl

A pilot response: If safety is turned into politics in the ugliest way, we have a problem. No research. No context. Deeply concerning and sickening.

2. With respect to information dissemination

Artikel op Linkedin: Grote gevolgen voor de atmosfeer door toenemend aantal windturbines (Bert Weteringe & John Stoop)

Gerrit Hiemstra: Former weather presenter at NOS | Weather, climate and consultancy

Het artikel is echter niets meer dan een doorzichtige poging van de clintelletjes om twijfel te zaaien over klimaatverandering. Het staat bol van onzin, drogredenen en onterechte verbanden.

Twee klimaatkwakzalvers uit de luchtvaartsector hebben een artikel in elkaar geknutseld en beweren dat windturbines "een bijdrage kunnen leveren aan klimaatverandering".

Het wás al duidelijk dat verspreiden van hashtag#desinformatie de core-business is van klimaatontkennersorganisatie Clinte. Weer een artikel dat laat zien hoe mensen voor de gek worden gehouden.

Daarbij worden kwakzalverstactieken niet geschuwd: net doen alsof je een wetenschappelijk bezig bent.

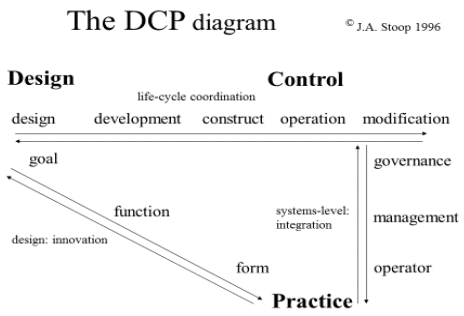
Trek een witte jas aan en hang een stethoscoop om je nek en iedereen denkt dat je een arts bent.

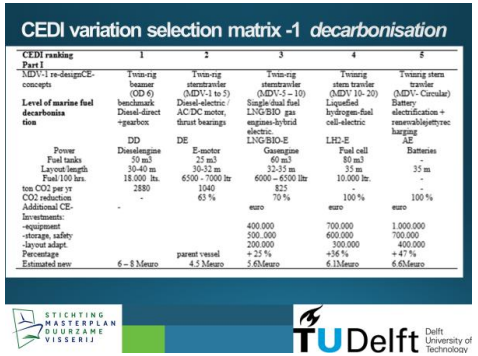
Ook deze keer wordt er weer een voormalige professor van stal gehaald om het verhaal van een wetenschappelijk sausje te voorzien.

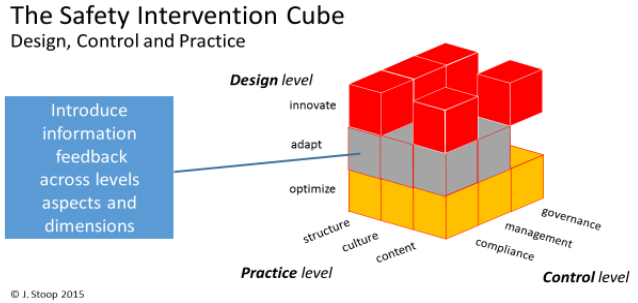
Or: empirical evidence?

New analytic tools at the systems level:

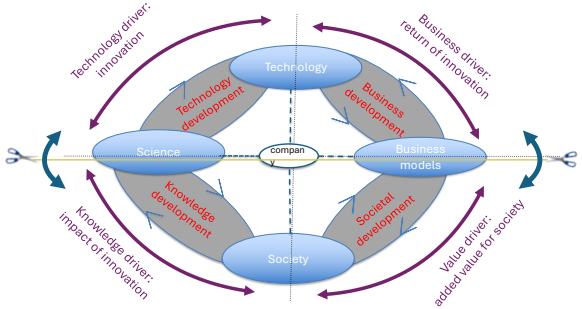
1. The Design – Control – Practice diagram
2. Performance indicators, both soft and hard. The CEDI matrix: Circular Economy Design Index
3. System architecture and dynamic interaction across level: the ESReDA Cube reference framework
4. Innovation and transition change triggers and drivers: the MCIM model, intervention potential







Modified CIM



and key success factors

The systems engineering design process level:

1. A sustainability and safety problem oriented approach
2. Sharing knowledge with participatory choices regarding modeling, functionality and goals
3. Clarify assumptions, limitations and simplifications
4. Communication with users and multi-stakeholders
5. Generation of component innovation, subsystem optimization and overall system concept integration
6. Safety investigators are the system architect counterparts

Conclusion 5:

The future begins by investigations and conceptual design assumptions

Towards a Generative Design Perspective

Towards a Generative Design Perspective

Forensic Engineering and Safety Investigation; enablers of Foresight

A stepwise upgrade of the design perspective from events towards socio-technical systems

1. Single issue safety: OSHE aspects, data driven and derivative form variation
2. Multiple issues: business driven Triple P by People, Planet, Profit and disruptive functional integration
3. Value chain driven: prospective foresight by Triple Zero. Zero accidents, Zero emission and Zero waste, goal based concepts, future proof and climate change compatible

A broadening of the design focus:

1. Technical optimization, design parameters, integrating safety performance indicators
2. Flexible modular design, primary design pillars, short term change potential
3. Transfer from static towards dynamic adaptation, anticipating future priorities and social values

Questions, any questions?