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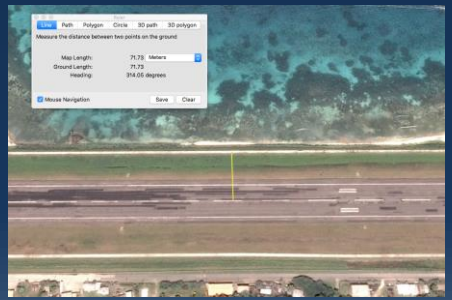
Runway Excursions

Risk analysis and potential mitigation strategies

Your flight to paradise…..



Weno –Chuuk international airport, PTKK

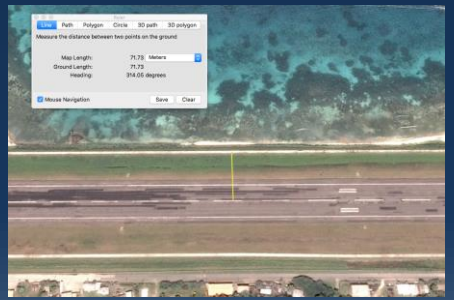
- 04-22 1831 meter
- Uncontrolled airspace < 5 500’
- RNAV and NDB approach

- Runway strip: 60 x 70 meters << ICAO SARPS
- RESA: None (!) << ICAO SARPS

- With an ICAO RESA: LDA would be
  - (1831-2 x 90)= 1651 meter (standard) /
  - (1831-2 x 240)= 1351 meter (recommended)

- Weight penalties for B737-800 wet runway landing

Your flight to paradise…..



Weno –Chuuk international airport, PTKK

- Q: Why does an airline operate to an airport well below ICAO standards ?
- A Do they perhaps believe that the revenues supersedes the costs of the runway excursion risk?

- Q Why does the airport not provide adequate mitigations?
- A Did they perhaps believe that mitigation is too expensive?

- → $$$ → express risk also in $

The consequence: Underrun or Overrun at PTKK

Air Niugini

22-09-2018

B 737-800
Destroyed

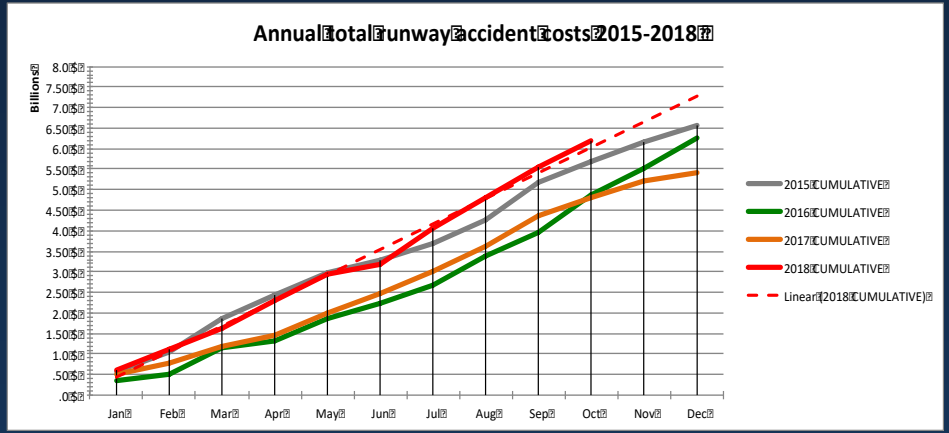
Accident costs estimated at: $ 102 Million (Purchasing power corrected); 1 fatality

Overrun Recommended RESA or EMAS would have safely stopped the aircraft
Underrun Recommended RESA would have prevented the high damage.

Does accepting continuous none-ICAO adherence justify the additional risk?

Runway related events risk in costs

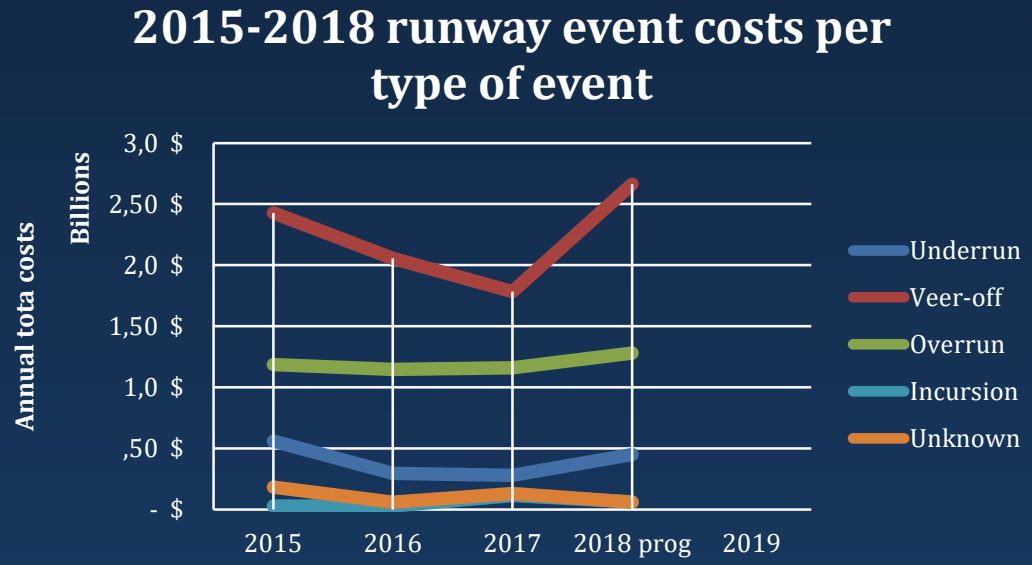
- 2600 Runway events 2015-2018 YTD
- Average $ 500 Million / Month
- Global, All types, All aerodromes
- Purchasing power corrected, underreporting not compensated, estimates are conservative



2015	$ 6.5 Billion
2016	$ 6.2 Billion
2017	$ 5.4 Billion
2018 1 Nov	$ 6.2 Billion ($7.3 prog)

EARLY COST SAFETY ANALYSIS OF RUNWAY EVENTS
Rob van Eekeren, Stephen Wright, Olja Čokorilo
DOI: 10.7708/ijtte.2018.8(3).01

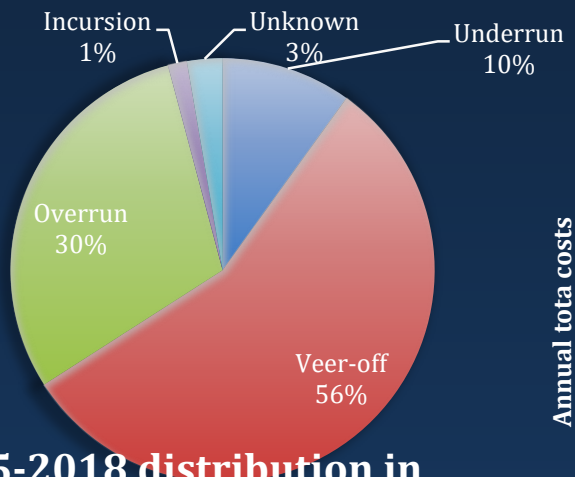
Runway excursion risk costs (4 years)



4 year period (in Million $)
(Purchasing power corrected; all types; all regions):

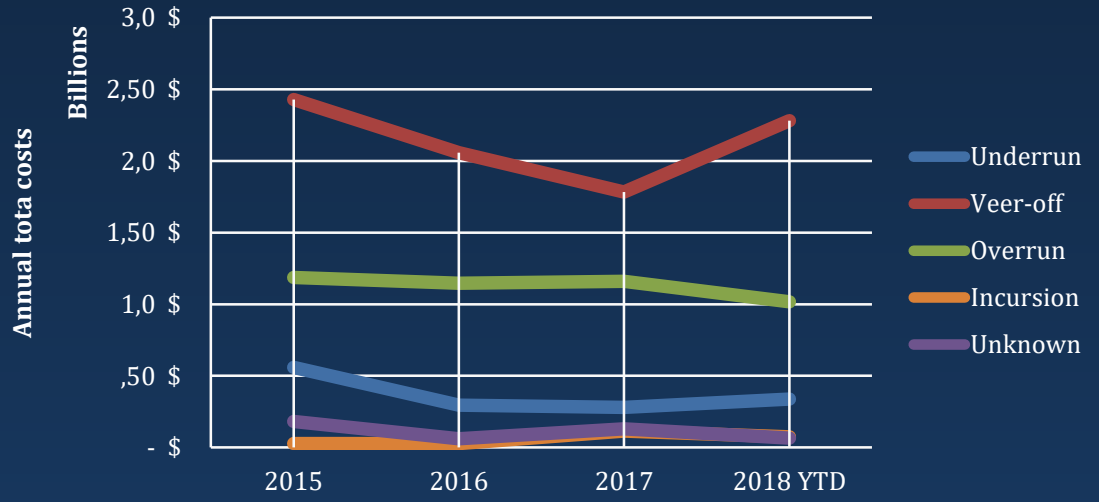
- Incursions: $ 0 200 / $ 50/yr
- Underruns: $ 1 600 / $ 400/yr
- Overruns : $ 4 800 / $ 1 200/yr
- Veer offs: $ 9 900 / $ 2 500/yr

Runway excursion risk costs



2015-2018 distribution in /excursion costs

2015-2018 runway event costs per type of event



Veer-offs highest costs and Rising……

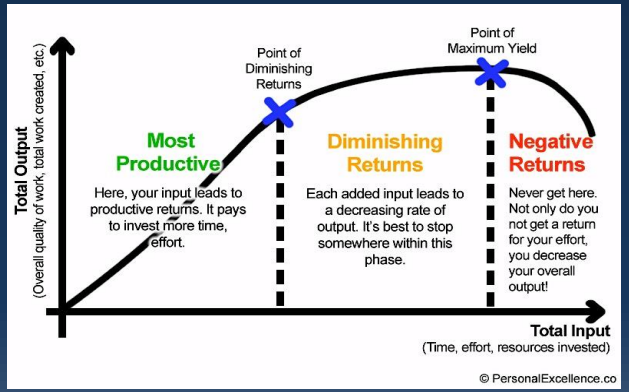
How to reduce the runway event costs?

Risk=f [Probability, Severity]

1. What is the highest risk / costs?
   1. Runway veer offs
   2. Runway overruns
   3. Runway underruns
   4. Runway incursions

- What are the costs of mitigations?
  1. Reduce numbers
  2. Reduce Risk of damage

- What is the ROI and best cost-benefit equation?



Reducing runway events RISK

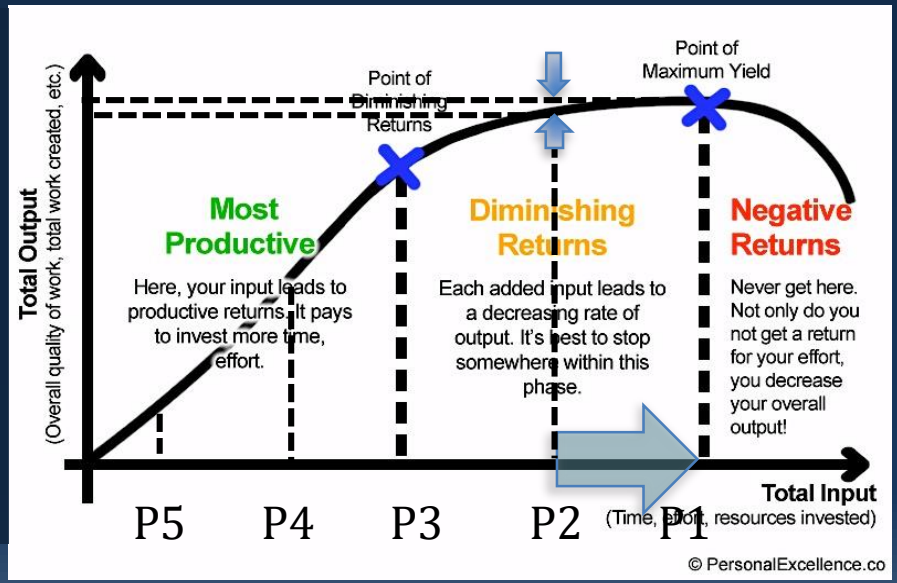
Risk=f [Probability, Severity]

Probability	Severity: Negligible (1)	Marginal (2)	Moderate (3)	Critical (4)	Catastrophic (5)
Almost certain (5)	Medium (5)	High (10)	High (15)	High (20)	High (25)
Likely (4)	Low (4)	Medium (8)	High (12)	High (16)	High (20)
Possible (3)	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
Unlikely (2)	Low (2)	Low (4)	Medium (6)	Medium (8)	High (10)
Rare (1)	Low (1)	Low (2)	L… (3)	…ow (4)	Medium (5)

Law of diminishing returns → limits $

Probability →

- Fewer tools available.
- Increasingly more challenging.
- Mitigation costs rise.



Runway veer off: damage high, fatal low

70% of Runway excursions ≥ Moderate damage
Avg 10 fatalities/year

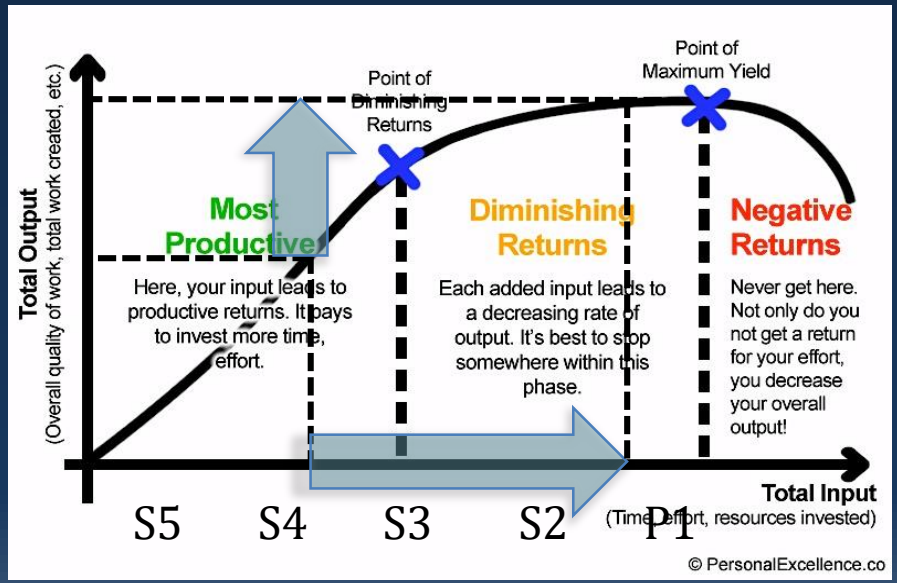
Reducing runway events RISK

Risk=f [Probability, Severity]

Probability	Negligible (1)	Marginal (2)	Moderate (3)	Critical (4)	Catastrophic (5)
	Severity				
Almost certain (5)	Medium (5)	High (10)	High (15)	High (20)	High (25)
Likely (4)	Low (4)	Medium (8)	High (12)	High (16)	High (20)
Possible (3)	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
Unlikely (2)	Low (2)	ow (4)	Medium (6)	Medium	High (10)
Rare (1)	Low (1)	2)	(3)	(4)	Medium (5)

Severity → Hardware

- Adherence to current SARPS
- Go BOYOND
- Cost effective approach



Avoiding the law of diminishing returns

Reducing runway events RISK

Risk=f [Probability, Severity]

Avg. one excursion per day

Avg. ≥ substantial damage

Probability	Severity: Negligible (1)	Marginal (2)	Moderate (3)	Critical (4)	Catastrophic (5)
Almost certain (5)	Medium (5)	High (10)	High (15)	High (20)	High (25)
Likely (4)	Low (4)	Medium (8)	High (12)	High (16)	High (20)
Possible (3)	Low (3)	Medium (6)	Medium (9)	High (12)	High (15)
Unlikely (2)	Low (2)	Low (4)	Medium (6)	Medium (8)	High (10)
Rare (1)	Low (1)	Low (2)	Low (3)	Low (4)	Medium (5)

Reducing likelihood at unlikely events is very challenging and increasingly cost in-efficient

Probability	Severity: Negligible (1)	Marginal (2)	Moderate (3)	Critical (4)	Catastrophic (5)
Almost certain (5)	Medium (5)	High (10)	High (15)	High (20)	High (25)
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Rare (1)	Low (1)	Low (2)	Low (3)	Low (4)	Medium (5)

Reducing severity of high damage events could be effective

Overruns

Severity reduction possible mitigations

Aircraft

- Undercarriage construction (very strong)
- Soft tires and large wheels (tractor)
- Engine mounting (high, above wings)
- Cage construction (car safety)

Highly unlikely for CAT ops.

Aerodrome

- Runway strip: (size, bearing capacity and friction).
- RESA: (size, bearing capacity and friction).
- EMAS

Shall already be i.a.w. ICAO 14 → achievable!

Risk flexible cost effective-> Option

Examples successful overrun mitigations

VTSB B747-4 Oct 2018

Adequate runway strip & RESA

Runway end safety area (RESA).

An area symmetrical about the extended runway centre line and adjacent to the end of the strip primarily intended to reduce the risk of damage to an aeroplane undershooting or overrunning the runway.

ICAO annex 14

EMAS
KLGA B737-7 Oct 2016, vice president (elect) Pence.

Future new systems?

Veer-offs

Severity reduction possible mitigations

Aircraft

- Undercarriage construction (very strong; Russian military)
- Soft tires and large wheels (e.g. tractor)
- Engine mounting (high, above wings)
- Safety Cage construction (cars)

Highly unlikely for CAT ops.

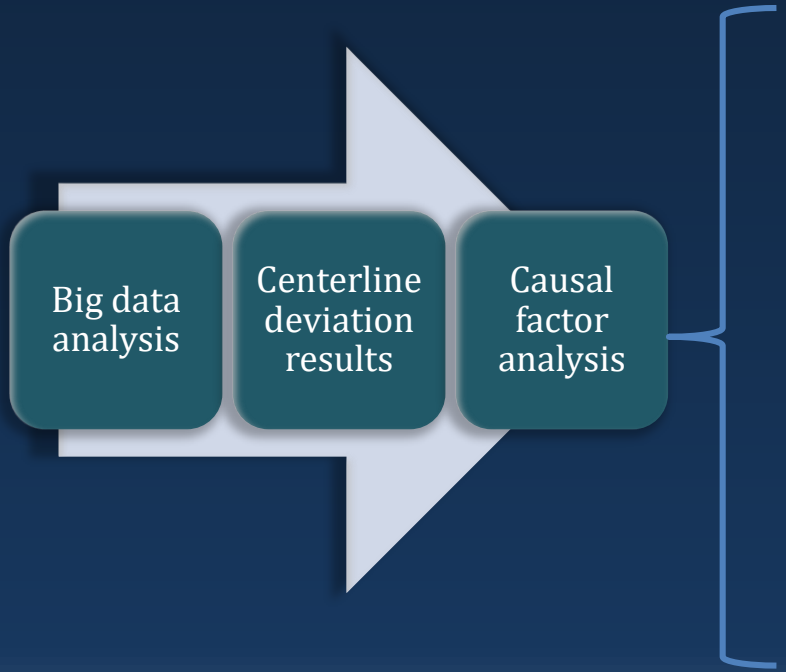
Aerodrome

- Runway strip: (size, bearing capacity and friction).

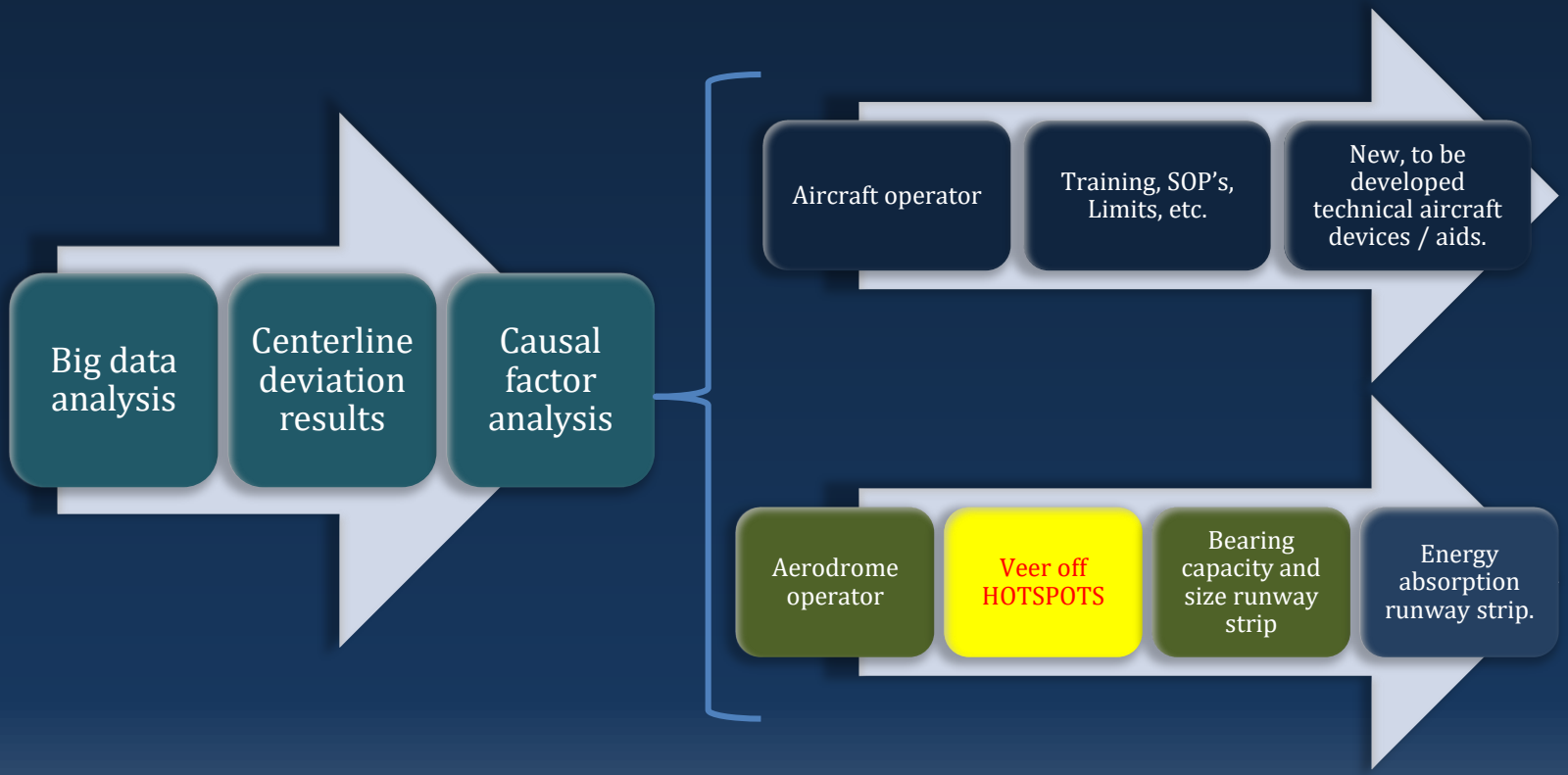
Should already be i.a.w. ICAO annex 14 or better → achievable!

- Alternatives for runway strip
  - New legal framework ? (cost effective risk management)

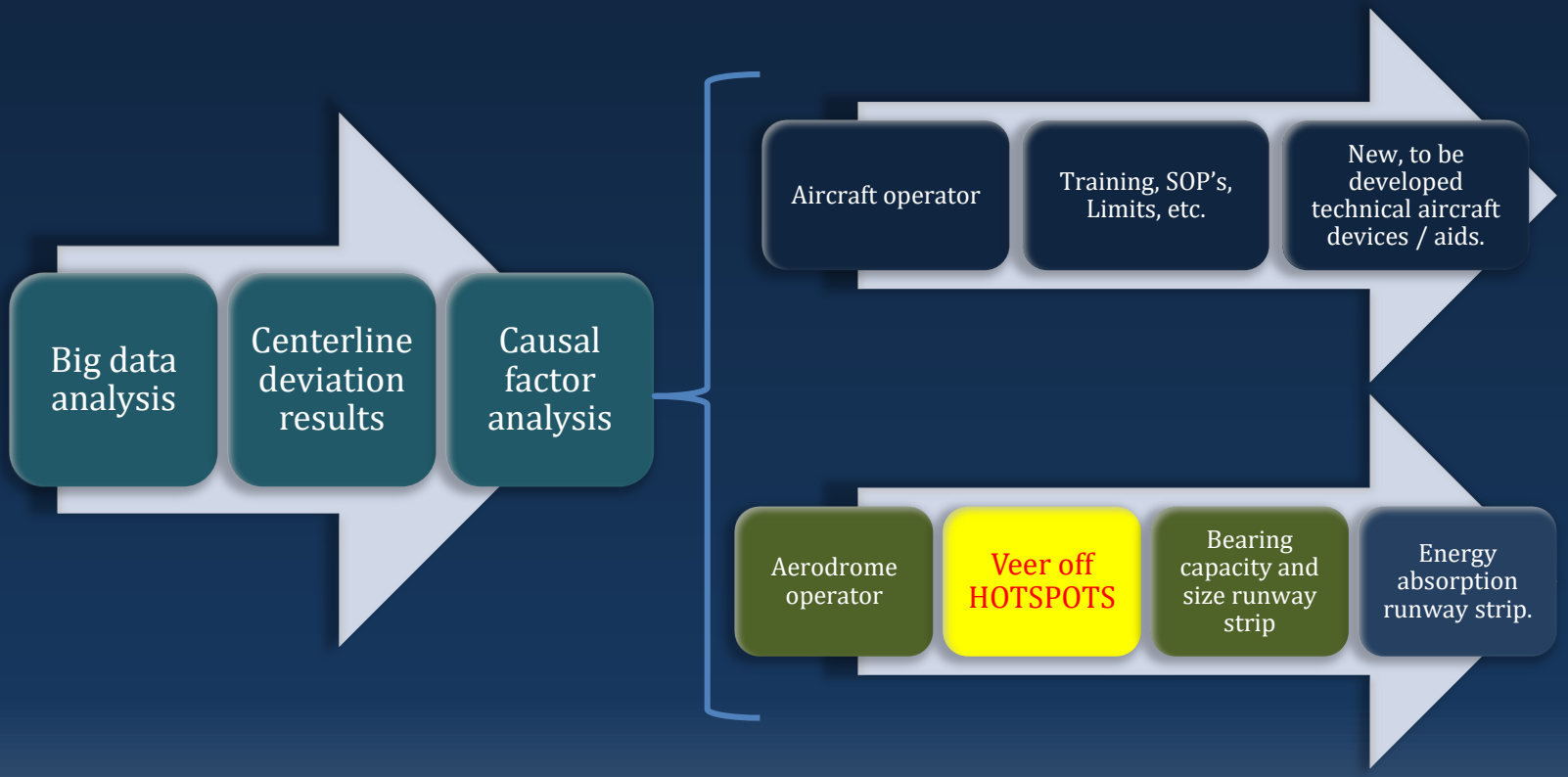
Imagine a future with:



Imagine a future with:

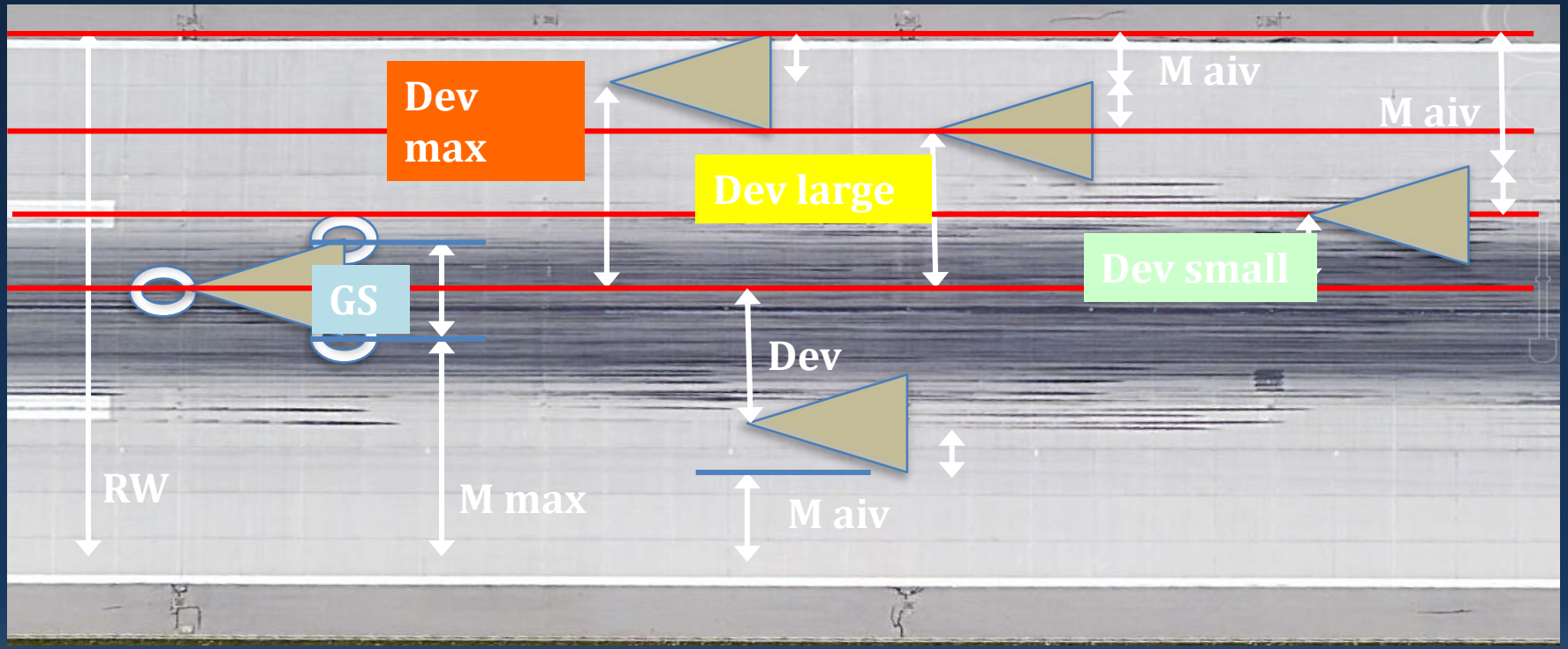


Imagine a future with:

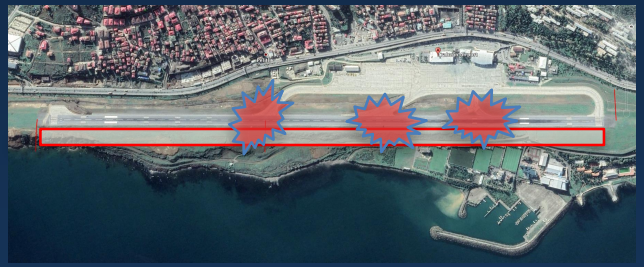


- Veer-off likelihood reduced
- Veer-off hotspots identified
- Veer-off hotspots mitigated
- Veer-off severity reduced

Principle center line deviation



Runway strip reduction risk of damage



- A deviation on to the runway shoulder should be regarded as an incident; lessons learned needed.
- The runway strip < 75 meters from centerline should be re-enforced to assure a high bearing capacity enabling risk reduction and adequate controllability to aircraft veering off.
- Runway exits and entry's should not pose an extra risk of damage for aircraft running off (no sinking in).

Example: Trabzon:
Veer-off severity and Risk is extremely high

CAT operations to these types of aerodromes should be postponed until the aerodrome has provided adequate HOTSPOT mitigations. ……

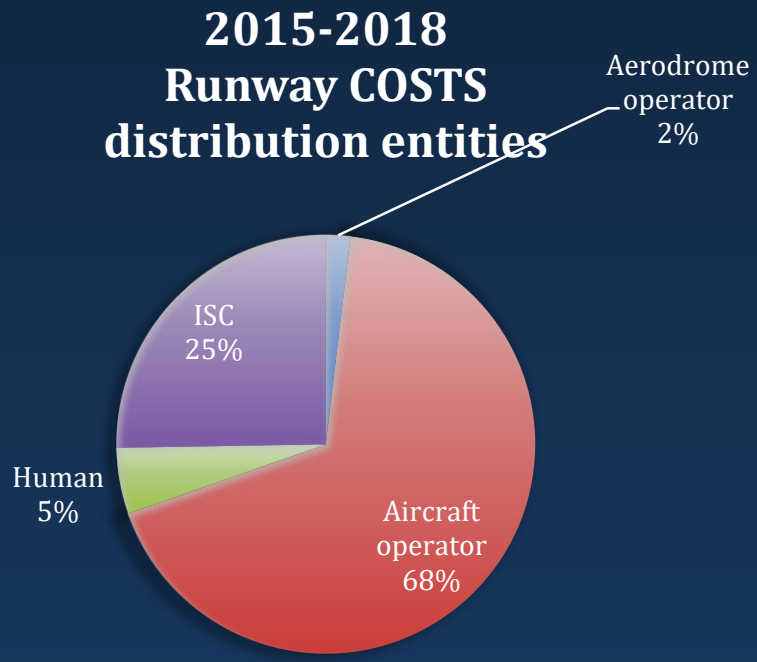
(Potential) veer off mitigation for runway strip.

- New product (GEMSS) by consortium
- Low price per m2 allows cost effective runway strip improvements.
- Low carbon footprint, excellent drainage, reduces wildlife hazard, improves controllability of veering off aircraft and reduces risk of damage, not same performance as an EMAS

Thus: cost effective alternatives are available for RESA and for runway strip safety

What is restricting these type of mitigations?

The KEY ISSUE:



Why would an aerodrome operator, even with an inadequate runway strip or RESA, invest in runway safety when the (financial) risks are very limited for the aerodrome?

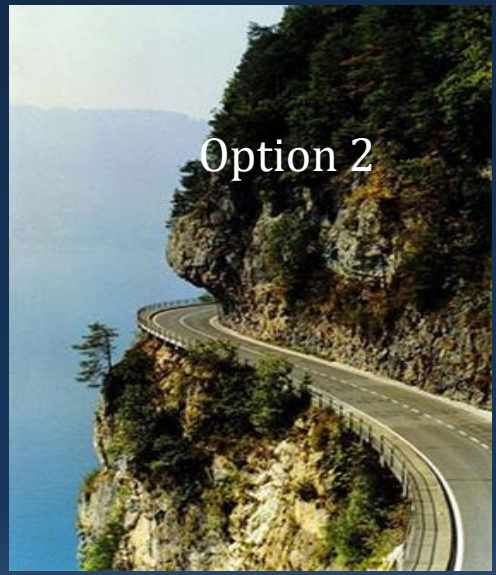
XXRA; wind Variable 25ktsG30

Poor maintained road with no barrier in a minibus with all safety options.

What would you choose?

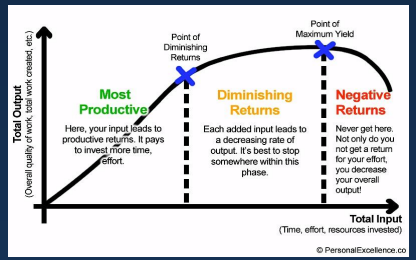
Well maintained road with barrier in a minibus with passive safety options only.

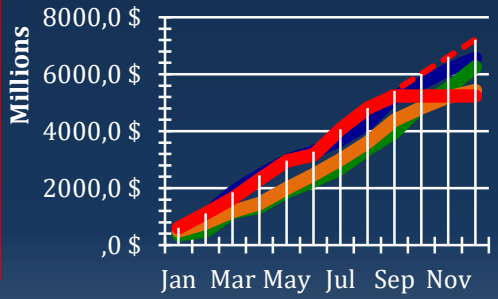
LEFT	Active system	Right
Yes	Speed limiter	No
Yes	Cruise control	No
Yes	Oncoming Lane Mitigation	No
Yes	Lane Keeping Aid	No
Yes	Rear park assist	No
Yes	Brakes with Hill Start Assist and Automatic Hold	No
Yes	Hill Descent Control	No
Yes	Rain sensor	No
Yes	High positioned rear brake lights	No
Yes	Intelligent Driver Information System	No
Yes	Steering wheel remote control	No
Yes	Road Sign Information	No
Yes	Voice control	No
	Passive systems	
Yes	Dual-stage airbags, driver and front passenger	Yes
Yes	Knee airbag driver side	Yes
Yes	side impact protection system	Yes
Yes	Inflatable Curtain	Yes
Yes	whiplash injury protection system	Yes
Yes	Belt minder all seats	Yes
Yes	Safety belts with pre-tensioners and load limiters	Yes
Yes	ISOFIX	Yes



Conclusions

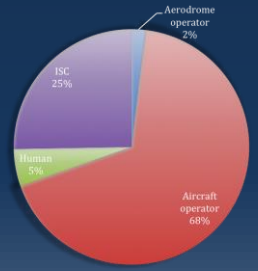
- OVERSIGHT
  - Not all RESA or runway strips are to equivalent to ICAO SARPS
  - Some even increase the risk of damage rather than reducing it
  - Which is apparently acceptable for a number of CAA's.
- SMS
  - Aircraft operators operate to these aerodromes, despite the increased runway excursion risk and thus its accidents costs.
- RISK
  - The law of diminishing returns set limits to the likelihood reduction. As a result will the risk of runway excursions increase .
  - An objective cost-benefit approach could help.





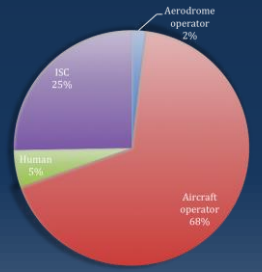
Conclusions & recommendations Overruns

- Overruns; $ 1.2 B/year. (all types)
- RESA size and bearing should become coherent with the type of operation.
  - Eg. 3000 meter runway with STOL aircraft : No need RESA
  - Eg. 1800 meter runway, B737-A320 operations: 60+240 meter RESA with ++ good bearing capacity
  - Eg. Same and terrain / wx issues: 60+ >>240++ meters RESA , +++ good bearing capacity and improved friction.
- -OR- adequate mitigation such as EMAS or equivalent system(s).
- Cost-Benefit apprach to mitigation(s)



Conclusions & recommendations Veer-offs

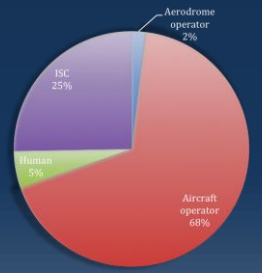
- Costs $ 2.5B/year….and rising…
- Veer-off risk reduction shall become highest priority of runway safety.
- Systematic and joined approach required, stimulated by Authority.
- Task force suggested.



Conclusions & recommendations Veer-offs

Reducing numbers:

1. (Big) data analysis for likelihood and location
2. Weather and aircraft controllability analysis
3. Aircraft operator related
   a) On board systems technology
   b) Training, SOP's, limits, etc.
4. Aerodrome operator related: HOTSPOTS
5. Cost / benefit of mitigation(s) analysis



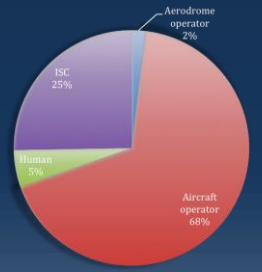
Conclusions & recommendations Veer-offs

Reducing severity:

① Improve off-runway controllability
   a) Extended runway shoulders principle
   b) Bearing capacity improvement (75 meters)
   c) Water drainage improvement

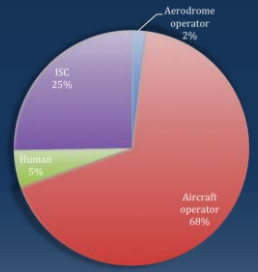
② Improved risk of damage reduction (risk orientated)
   a) Flexible runway strip size
   b) Flexible bearing capacity (increase near in ground obstacles)
   c) In pavement obstacles mitigation

③ Cost / benefit of mitigation(s) analysis



Conclusions & recommendations cost-benefit

- COST EFFECTIVE
  - Disproportional risk distribution between aerodrome and aircraft operators blocks cost effective mitigations.
  - An objective cost-benefit system should indicate the ALARP limits of the various runway risks mitigations.
  - An EU or national safety fund (e.g security charges) (fuel tax?) should be established, stimulating cost effective runway safety improvements benefitting all EU/national passengers and its aviation sector as a whole.



Conclusion and recommendations

① Make runway veer-off risk reduction the highest priority.

② Establish TASK FORCE veer-off risk reduction.

③ Research on big data analysis for veer-off likelihood indication.

④ Develop system to identify veer-off HOTSPOTS.

⑤ Develop system of objective cost-benefit analysis of mitigations.

⑥ Solve disproportional issue of aerodromes costs versus. aircraft operators cost in runway excursions, which blocks cost effective mitigations . (E.g. common runway safety fund).

FSS Runway Excursion

Risk analysis and potential mitigations

Questions / Suggestions / Discussion / Debate ?

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