Groningen Region
Falling Hazards Risk Assessment

Gemeente Groningen

Rijksuniversiteit Groningen

Hanzehogeschool Groningen

Universitair Medisch Centrum Groningen

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5.1.2e *(TTAC Ltd) &* 5.1.2e *(NAM)*

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   (with demonstration)
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1. Risk model overview

- what are “Falling Hazards”?

- purpose of the model

- scope of the model

- how the model works

2. Falling hazards survey (with demonstration)

3. Measuring “Risk”

4. Risk assessment results

5. Observations & Conclusions

What are "Falling Hazards"?

- Non-structural building elements
- Attached to a building, but not part of the structure
- May be dislodged by high winds or shaking
- Failure does NOT cause building collapse
- But MAY create hazard for people below

Falling Hazards - examples

Chimney (Schoorsteen)
Folkestone, UK, 2007
Magnitude 4.2
Depth 5km

Gable (Kopgevel)
Liège, Belgium, 1983
Magnitude 4.6
Depth 5km

Parapet (Borstwering)
Kalgoorlie, Australia 2010
Magnitude 5
Depth 2km

Falling Hazards Risk Model - Aim

- Prioritise **areas** for inspection
- Help develop practical rules to manage risk

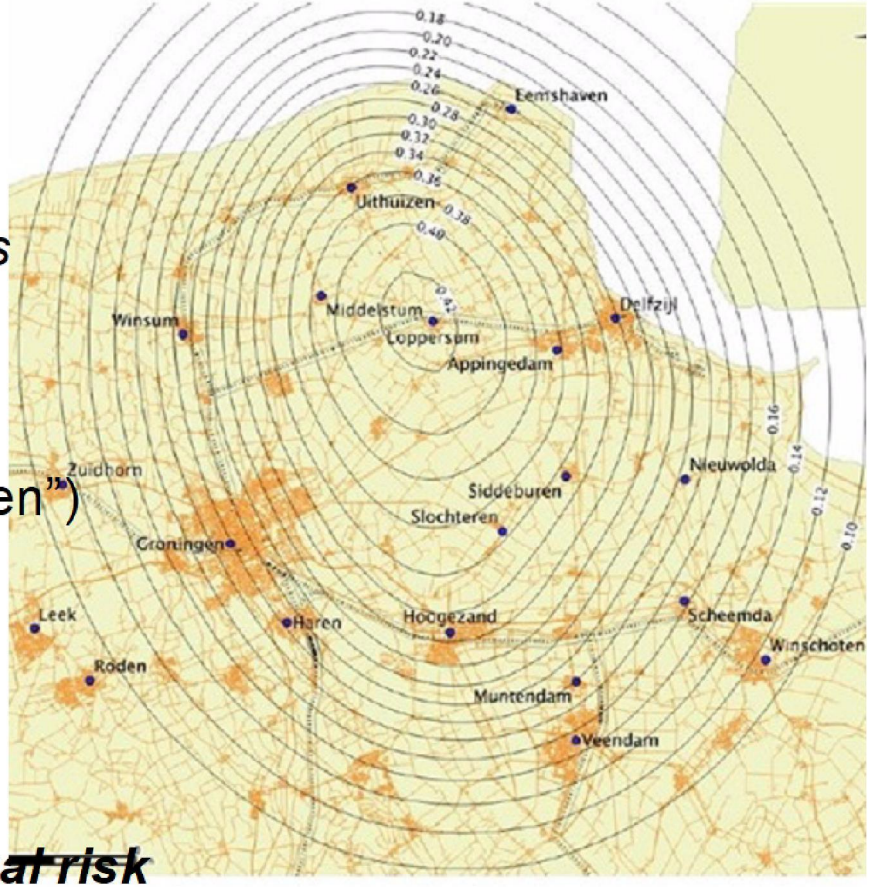
NOT

- Definitive risk estimates for individual objects

Falling Hazards Risk Model - Scope

- Non-structural building elements
  - *above doorways*
  - *into public space around buildings*
  - *through roofs*

  within the 0.1g PGA contour (NEN-NPR map, KNMI 2013) (excluding small "notverblijfsobjecten")



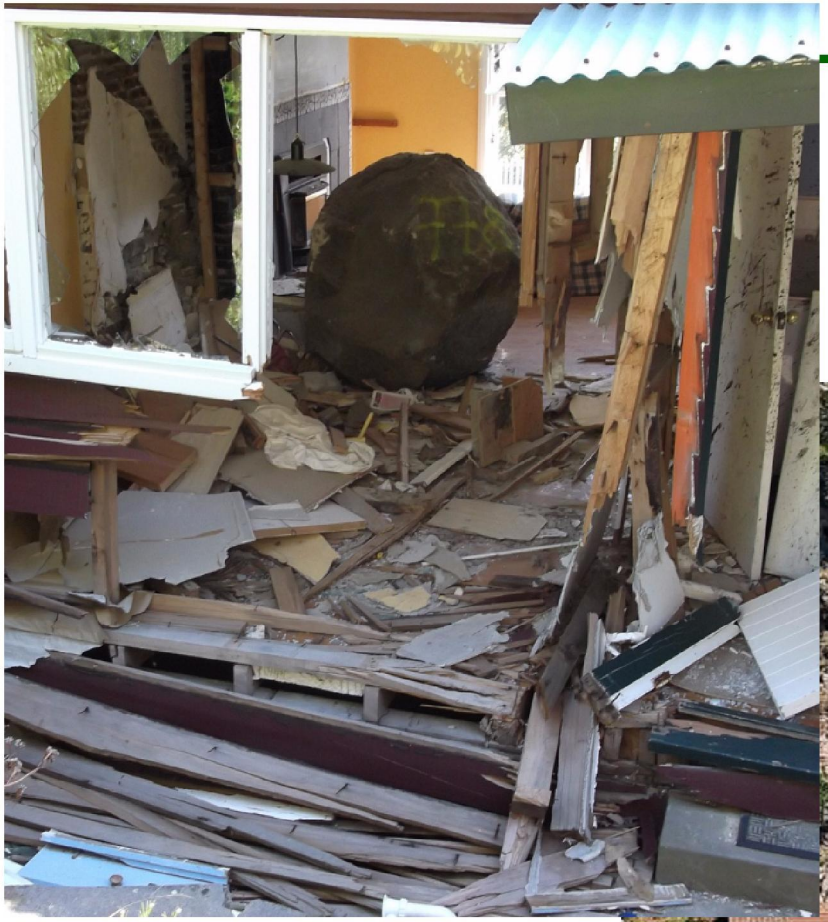
- Output: ***Community Risk***

  (CR =Local Personal Risk x average N people present in at-risk area)

  & Occupancy-weighted individual risk

  (OIA = LPR x % time a representative individual is present – after CM advice)

Falling Hazard Model Inspiration



GNS Science New Zealand: Rockfall and Cliff Collapse Risk after the Christchurch 2010/11 earthquakes

C Massey, M McSaveney et al "Canterbury Earthquakes 2010/11 Port Hills Slope Stability: Life Safety Risk from Rockfalls (Boulder Rolls) in the Port Hills (2012)", GNS Science report 2012/123

Falling Hazards Model Overview

(& New Zealand Rockfall model)

Earthquake shaking scenarios	How often shaking happens	Falling object sources	Falling object travel	Probability of death if present	Probability or number of people present
New Zealand Rockfalls					
0.1-0.4g 0.4-1g 1-2g >2g	NZ Seismic Hazard Model (time dependent)	Cliff studies + Previous experience	Previous debris runout experience	Literature + experience + simple assumptions	Simple assumptions
Groningen Falling Hazard from non-structural building elements					
0.05-0.1g 0.1-0.2g 0.2-0.3g 0.3-0.4g (etc) to 0.9-1g	KNMI 2015 PSHA (others can be included quickly)	Hazardous object details **(Survey)** + Hazardous object failure probabilities **(Research)**	Study of hazard range of masonry fallen from buildings	Simple model based on dimensions of falling object (substantiated by research)	$P_{(present)}$ = 1 (LPR) x $N_{(present)}$ ➔ CR a) passers-by b) runners-out c) in buildings x % time present ➔ OIA

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Falling Hazards Survey - Overview

- ~160k buildings surveyed using Google Street View
  - successful pilots in Bedum and Groningen centrum
  - team of 20 people (mainly students) over ~5 months
  - structured QA/QC process tailored to priority of Gemeenten

- Scope:
  - chimneys, parapets, gables, dormers, canopies, balconies etc
  - above doorways, public spaces, roofs of occupied buildings
  - object dimensions plus situational/exposure information
- Does NOT include
  - buildings obscured or otherwise not on Street View
  - rears of buildings
  - hazardous objects NOT presenting specific hazards
- Fitness for purpose
  - prioritisation for inspection ✓
  - understanding key risk factors ✓
  - decisions on individual objects/buildings ✗ ***Need to inspect 1st***

Survey Scope:

2. Falling Hazards Survey

WHERE

High Priority
Appingedam
Bedum
Delfzijl
Groningen (x10 Wijken)
Loppersum
Slochteren
Ten Boer
Winsum

Medium Priority
Eemsmond
Haren
Hoogezand-Sappemeer
Menterwolde
Oldambt
Veendam

Lower Priority
Aa en Hunze
Assen
Bellingwedde
De Marne
Grootegast
Leek
Noordenveld
Pekela
Tynaarlo
Zuidhorn

WHAT

Info for each building		
Footfall category		
	1	Remote; residents/postman only
	⋮	
	10	Busiest city street
Survey classification		
	P	facade within 5m of public space
	D	hazard within 1m of doorway
	N	clearly visible; no identifiable hazards
	O	obscured or otherwise not visible
	T	not built at time of StreetView photo
	X	out of scope building type
Facade lengths (where public access)		

Object Type
Chimney
Decorative feature
Pinnacle
Parapet
Balustrade
Free standing wall
Gable
DG-parapet
DG-gable
Dormer
Canopy-supported
Canopy-unsupported
Balcony
Bay window
Large glass area
Sign - vert
Sign - horiz
Industrial object
Flagpole

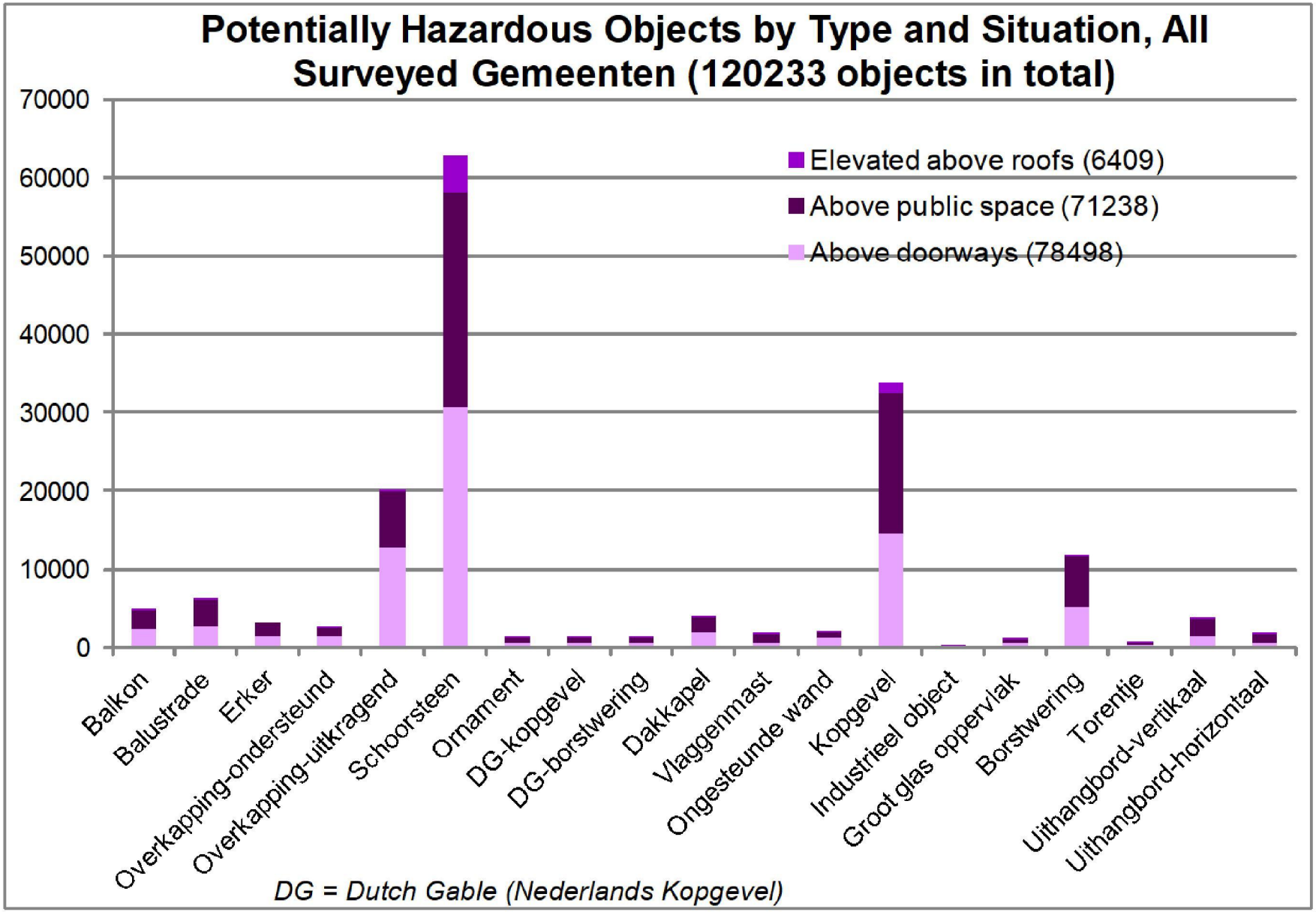
Info for each Building Element		
Dimensions (H, W, D)		
Hazard category		
	D	above doorway (within 1m)
	D*	presumed above doorway
	P	above public space on street
	P*	above public space, off street
	R	particular fall through roof hazard
Direction of fall		
	%	towards each facade (F,R,L,B)
	F	extra risk of fall thru' own roof
	N	risk of fall thru' neighbouring roof
Shape (from menu)		
Construction material (from menu)		
Special features		
	E	extended potential area at risk
	R	restraints in place
	T	wall ties in place
Condition (by exception only)		

PLACEHOLDER – Live Demo

Intent, given an Internet connection available at the meeting:

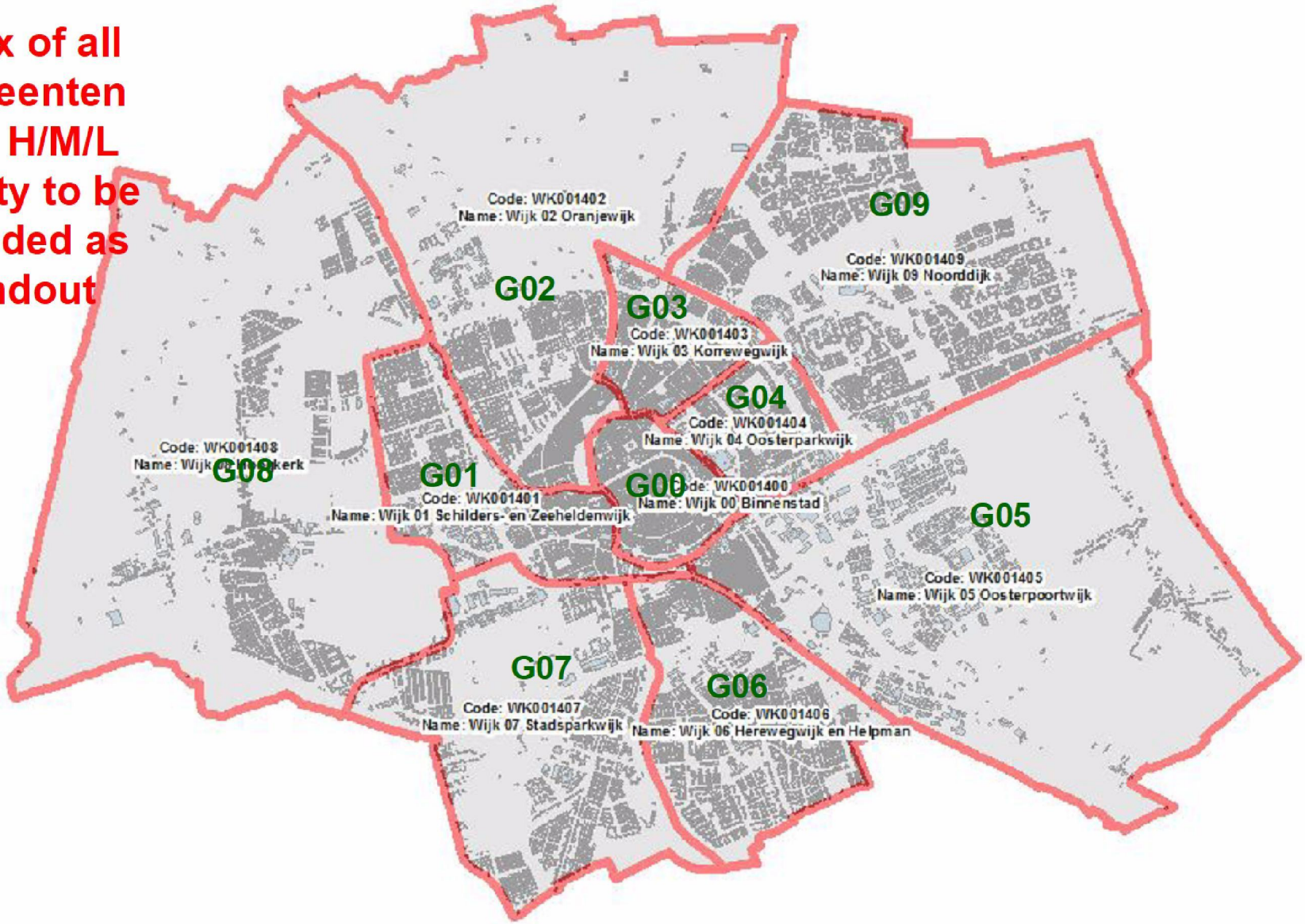
1. Select a place/building we know (can be in Groningen or elsewhere)
2. Demonstrate use of BAGViewer for positive ID of building
3. Demonstrate use of StreetView to find and characterise potential falling hazards
4. Walk through the data fields that are recorded in the Survey

Falling Hazards Survey – Results (1)

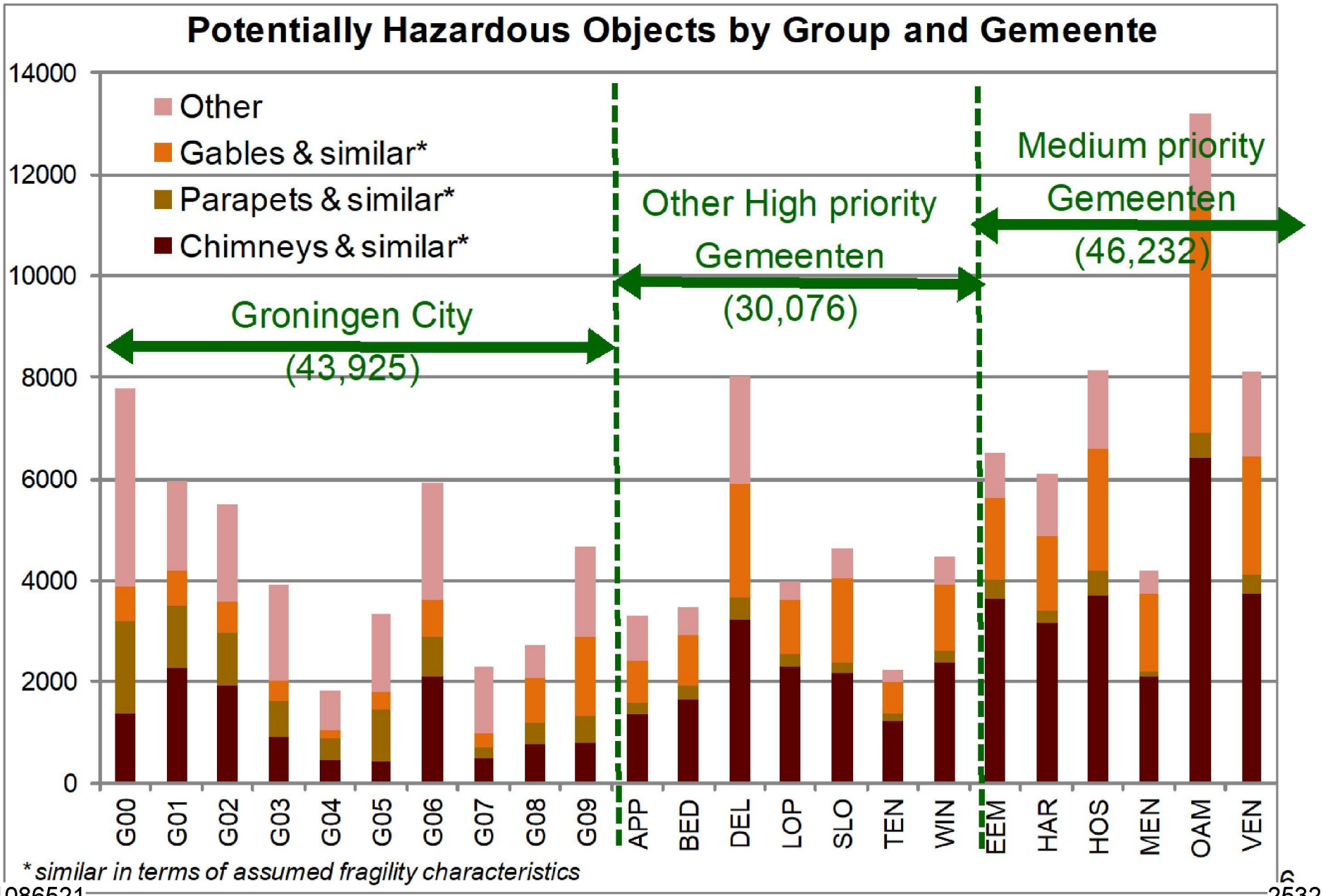


Locations: Groningen Wijken

Index of all Gemeenten plus H/M/L priority to be provided as handout



Falling Hazards Survey – Results (2)



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Individual vs Aggregate Risk

Simple example, for illustrative purposes:

Source of data:
http://ec.europa.eu/transport/road_safety/specialist/statistics/index_en.htm

2013 Netherlands Road Traffic Accident Data

- Fatalities - 476/yr } **Aggregate risk** ("Community Risk")
- Population ~16.8 Million*
- Average individual fatality risk* ~ 1 in 35,000 / yr } **Individual risk**

** This simple example assumes all people in Netherlands are exposed to the risk from road traffic accidents*

Falling Hazards: Risk Metrics

- Local Personal Risk (LPR)
  - Probability of fatality for hypothetical person present 100% of time in the at-risk area (does not consider likelihood of person being present)
  - Individual risk metric
  - Intermediate step in risk calculation – **not model output**
- Community Risk (CR)
  - LPR x average number of people present in at-risk area
  - Aggregate risk metric; units are fatalities per year
  - **Model output – used for prioritization**
- Occupancy-adjusted individual risk (OIA)
  - LPR x % time at-risk area is occupied by representative person
  - Individual risk metric, introduced by Commissie Meijdam
  - **Model output – indicator of "how safe is safe enough", and also used for prioritization**

Commissie Meijdam Advice (1)

- Normative Standard for Basic Safety (accepted by EZ)
  - Standard for basic safety is overall individual risk of 10^{-5} / year; taking into account all earthquake-related risks (collapse, falling objects etc.)
  - Where overall individual risk exceeds 10^{-5}/ year, address within ~ 5 years
  - Overall individual risk of 10^{-4} / year is "limit value" / highest priority

- Occupancy-adjusted individual risk (OIA)
  - Meijdam recommend OIA to measure individual risk for falling objects:

    "Voor gebouwen waar men normaal gesproken slechts een paar uur per week doorbrengt, en vooral voor het risico van vallende objecten waar de gemiddelde dagelijkse blootstelling uiterst kort is, adviseert de commissie om de tijd van blootstelling mee te nemen in de berekening van het risico. Het door de commissie gedefinieerde OIA voorziet in deze mogelijkheid."

  - OIA recommended to be used both for prioritization and for determination of "Basic Safety" (how safe is safe enough?)

Commissie Meijdam Advice (2)

- "Basic Safety" standard for falling objects
  - Basic Safety defined as 10-5 overall Individual Risk (IR)
  - OIA = contribution to overall individual risk from a building/object

Example of overall IR from Meijdam advice -→

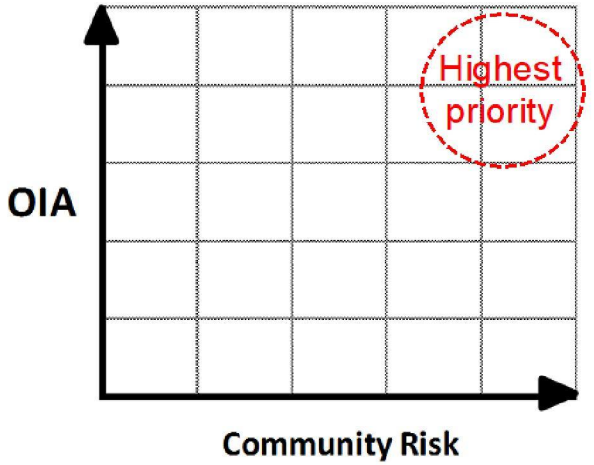
Voorbeeld risicobudget voor een representatieve Nederlandse persoon			
Waar	% van de tijd	Plaatsgebonden risico	OIA
Thuis	60%	$1,0E^{-05}$	$6,0E^{-06}$
Werk / educatie	25%	$1,0E^{-05}$	$2,5E^{-06}$
Gebouwen waar men normaal gesproken slechts een klein deel van de tijd doorbrengt (bijvoorbeeld een kerk)	1%	$5,00E^{-05}$	$5,0E^{-07}$
Blootstaan aan potentieel vallende objecten	1%	$1,00E^{-04}$	$1,0E^{-06}$
Buiten gevaar van aardbevingen (weg van gebouwen)*	13%	0	0
Totaal individueel risico	**100%**	-	**$1,0E^{-05}$**

- Acceptable OIA (threshold for Basic Safety) not yet defined – somewhere less than or equal to 10^{-5}
- If OIA significantly below 10^{-5}, contribution to overall Individual Risk is not significant, so we can be confident Basic safety has been achieved

Commissie Meijdam Advice (3) / Recommended Prioritization Strategy

- Aggregate risk
  - Commissie Meijdam propose new aggregate risk metric – "Social Risk" *(Maatschappelijk veiligheidsrisico)* to help prioritization and to consider additional measures beyond "basic safety' (if cost effective)
  - Further discussion required with Meijdam/SodM to define "Social Risk"
  - In meantime, Community Risk provides appropriate aggregate risk metric for prioritization

- Prioritization Strategy in light of Meijdam advice
  - Recommend prioritizing objects with highest OIA and highest Community Risk first
    - Considers both individual and aggregate risk
    - Reduces risk to Community as fast as possible
    - Minimizes chance of regrets



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What makes an object higher risk?

How many higher risk objects are there?

What are they?

Where are they?

5. Observations & Conclusions

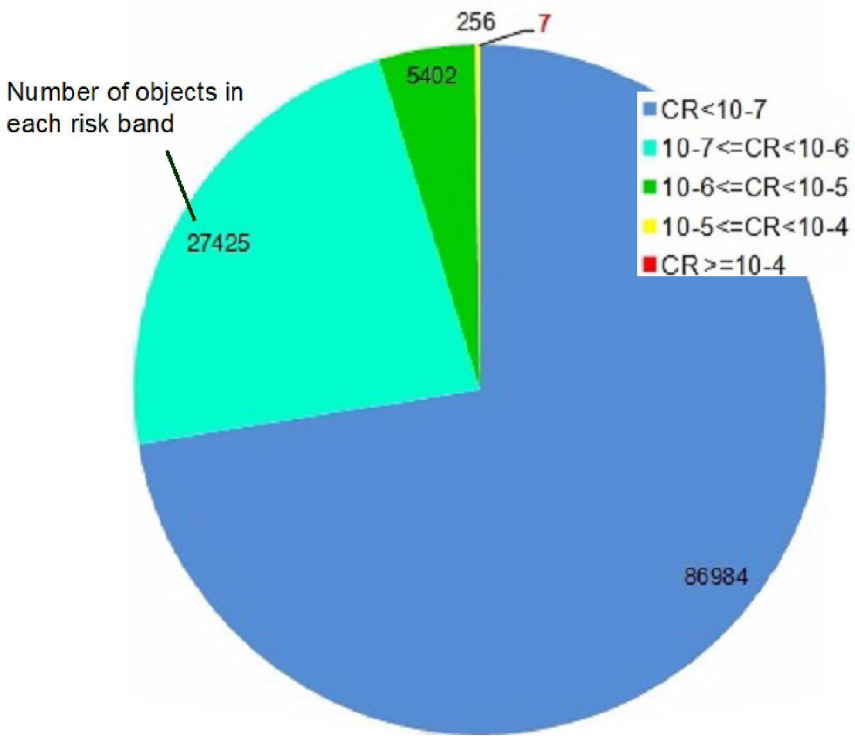
What makes an object "higher risk?"

- Seismicity
- Type (e.g. Chimney vs Gable)
- Size (big objects > little ones)
- Situation
  - above doorways (building occupants)
  - above public space (people outside)
  - high above roofs (building occupants)
  - elsewhere (occasional)

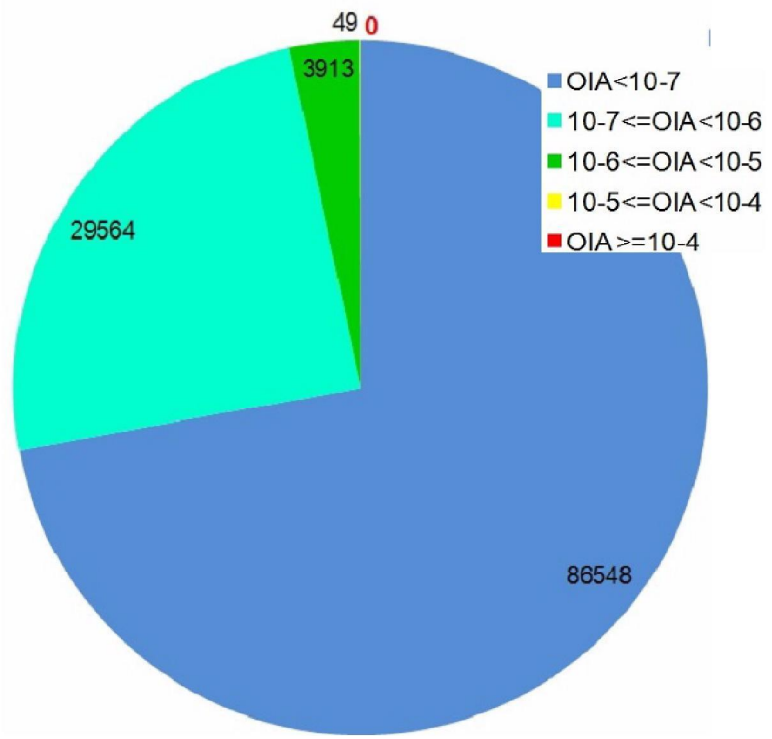
➔ **DEMONSTRATION**

How many "higher risk" objects are there?

(a) Community Risk (CR)

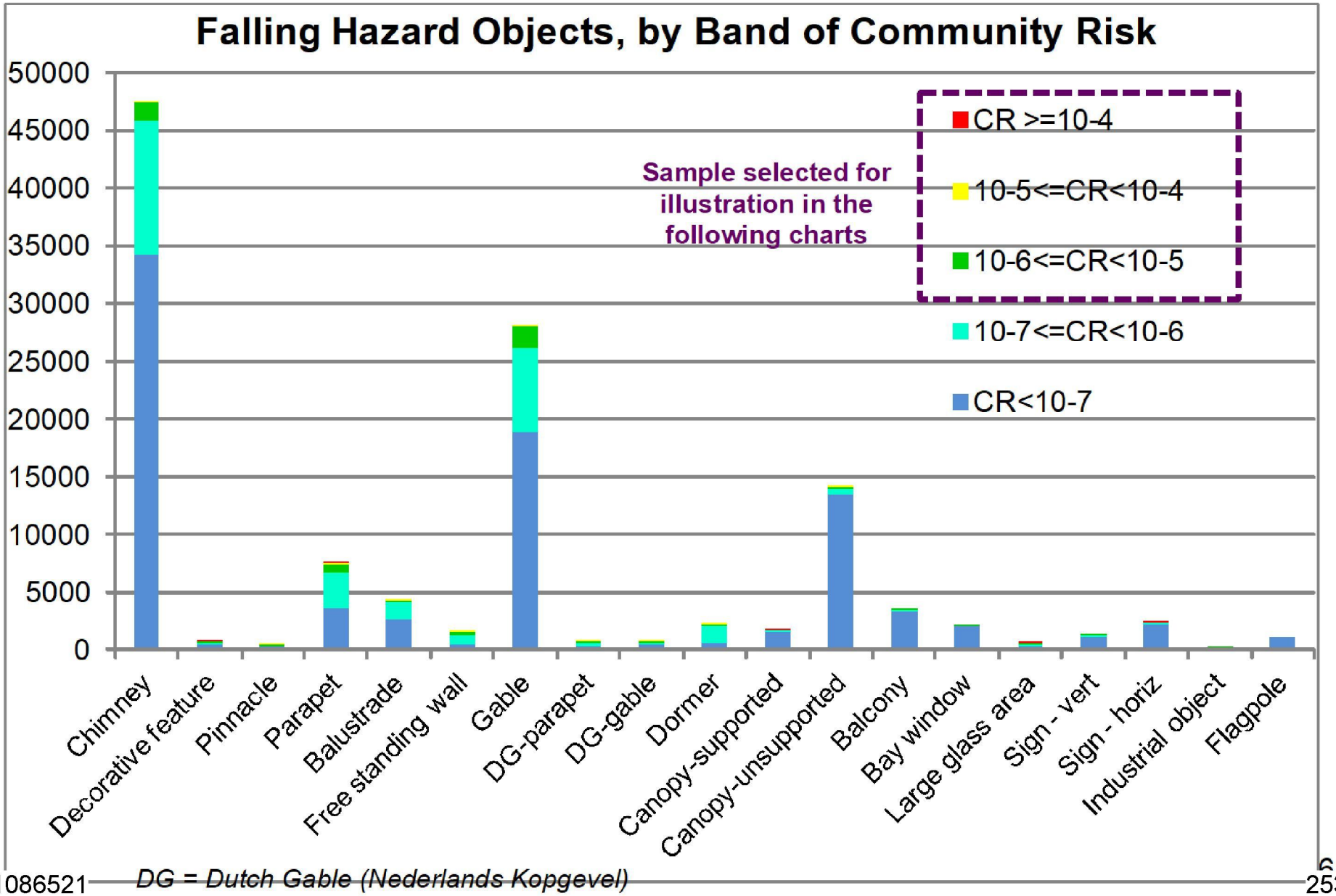


(b) Individual Risk (OIA)



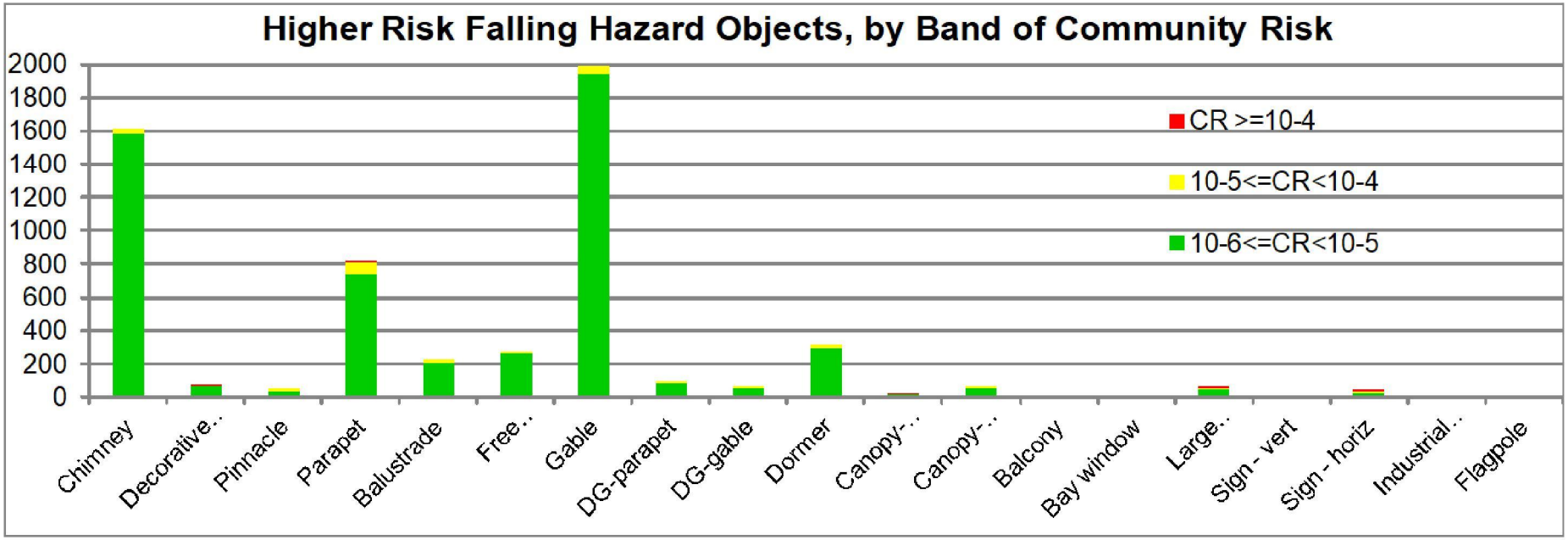
Most objects are NOT "High Risk". In subsequent charts, "higher risk" objects are selected based on threshold of CR > 10^{-6} and OIA > 10^{-6} to characterize the highest few 1000's of risk objects. There is no implication that these objects will all require upgrade.

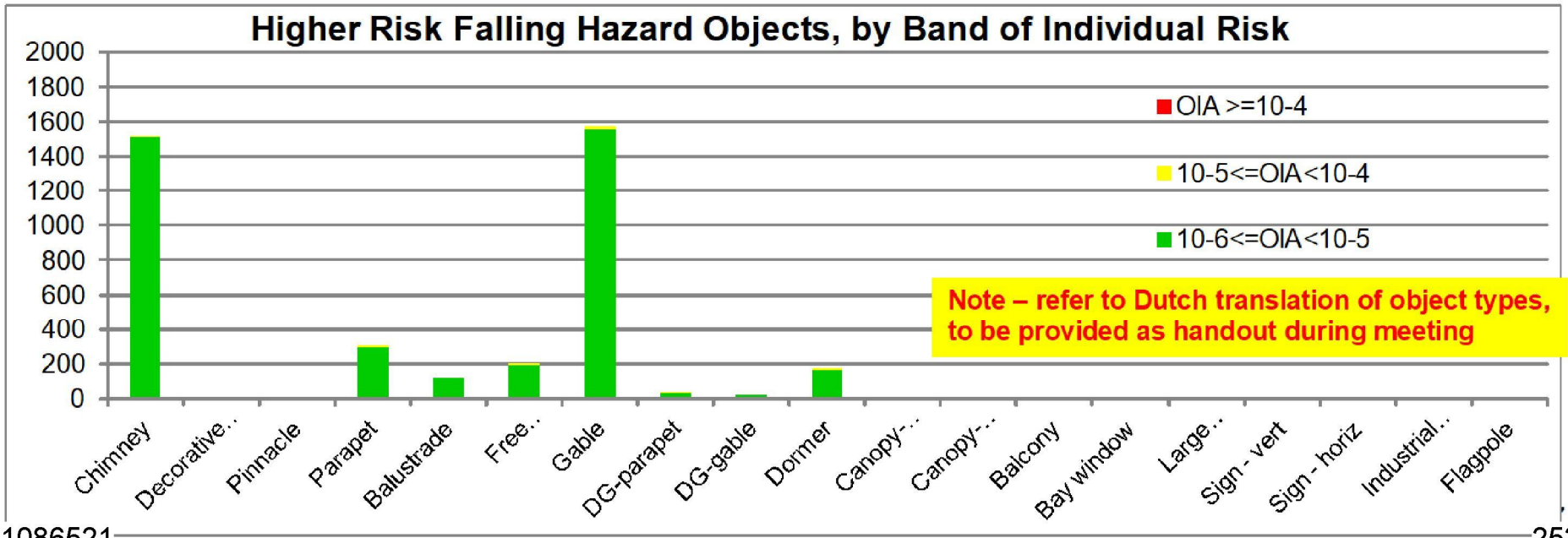
Higher Risk Objects – How many are there?



DG = Dutch Gable (Nederlands Kopgevel)

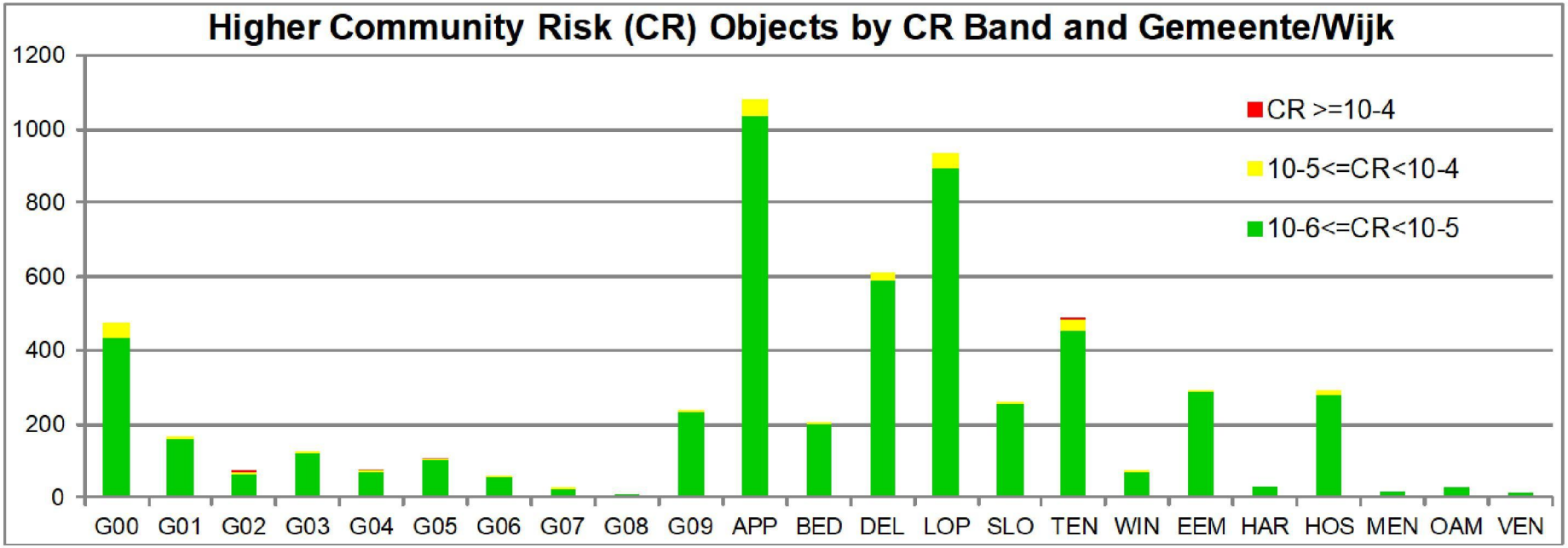
Higher Risk Objects: What sorts of Objects?

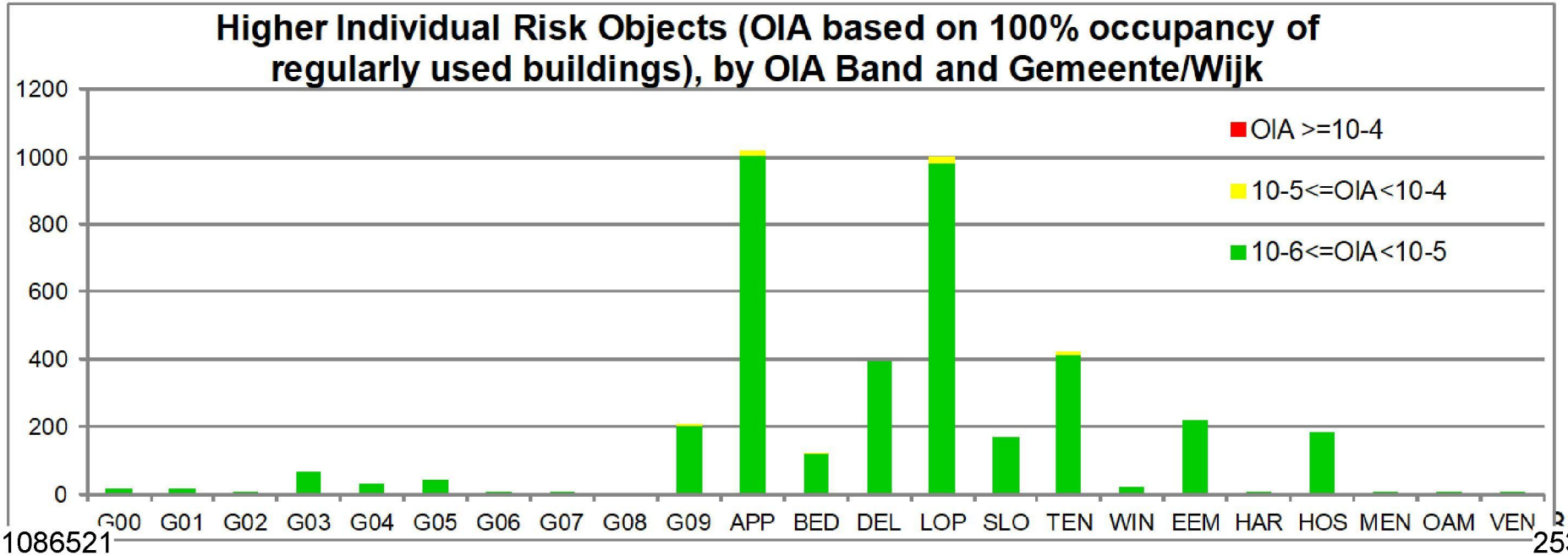




Note – refer to Dutch translation of object types, to be provided as handout during meeting

Higher Risk Objects: Where are They?





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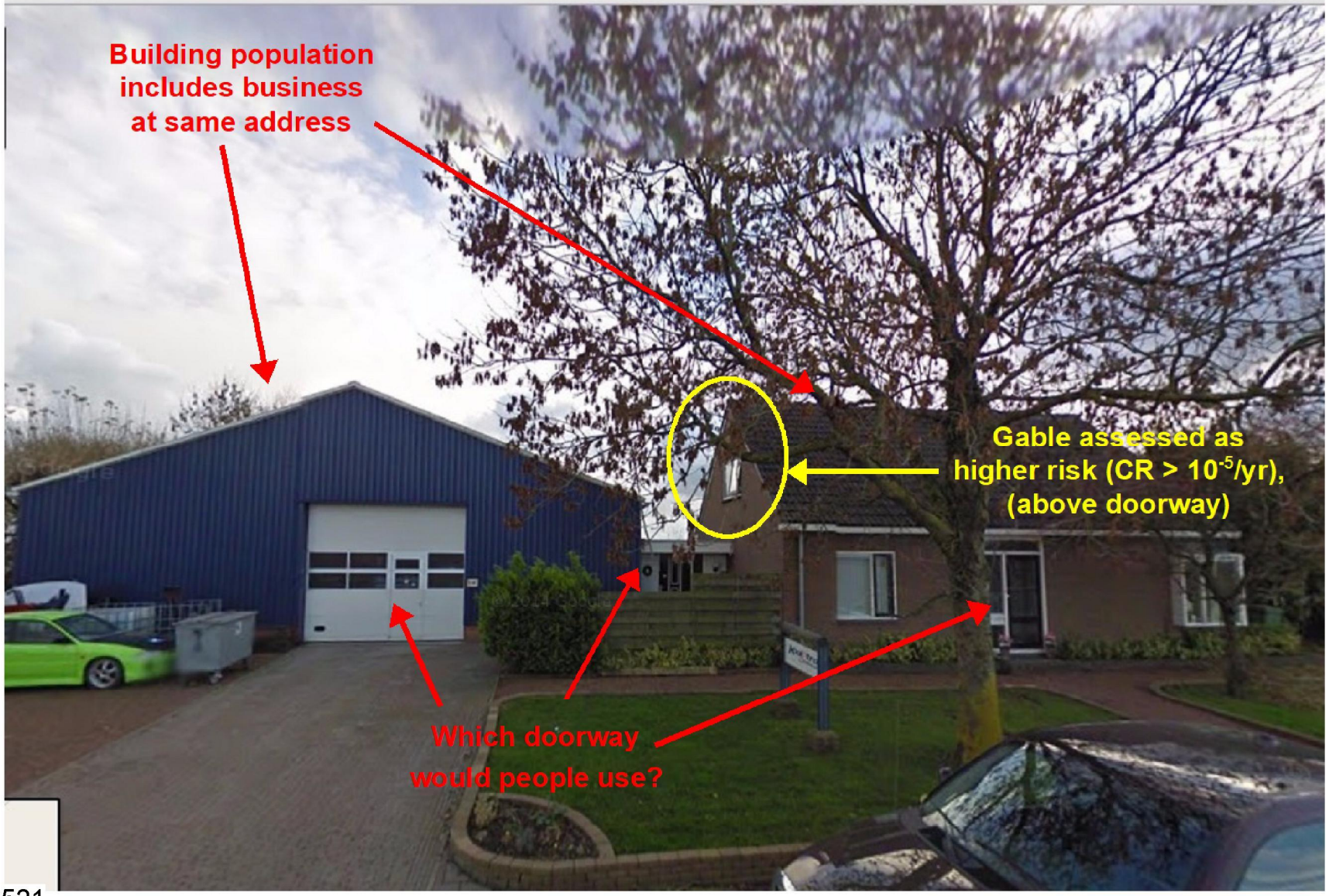
This is a simple, approximate model to help prioritize resources
(but local knowledge is important for final upgrading decision – example 1)



This is a simple, approximate model that can help prioritize resources
(but local knowledge is important for final upgrading decision – example 2)

Gables assessed as higher risk
(a) above roof
(b) above doorway

How "occupied" is the space where this gable would fall?

Who would use this doorway?

What about people sitting outside?

Falling Hazards Risk: Conclusions

- First version of falling objects risk assessment complete:
  - Covers 160,000 buildings/120,000 objects in potentially hazardous situations
  - Fit for purpose for prioritization and understanding risk drivers; final decision on upgrading objects requires inspection first (and local knowledge is also important)
- Level of risk assessed using both individual (OIA) and aggregate (Community Risk) metrics
- Objects that are relatively high in both Community Risk and OIA are concentrated in Loppersum and the surrounding Gemeenten
- Many objects were surveyed but only a small % are "higher risk" – prioritization strategy is thus important

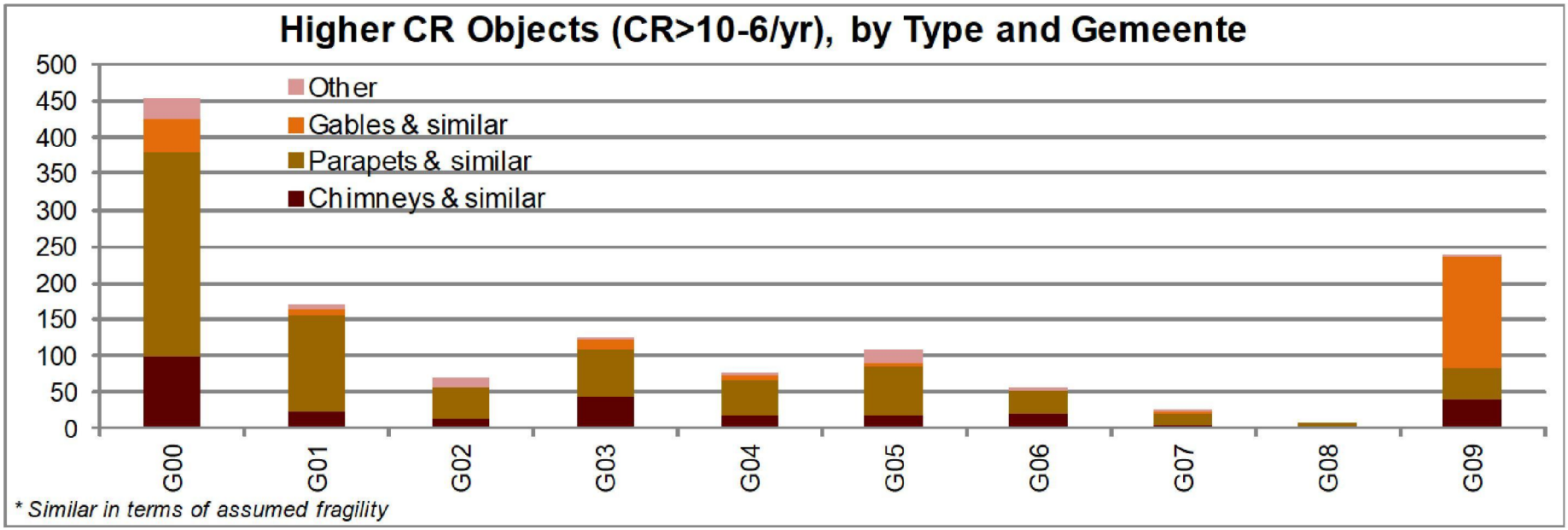
Recommendations

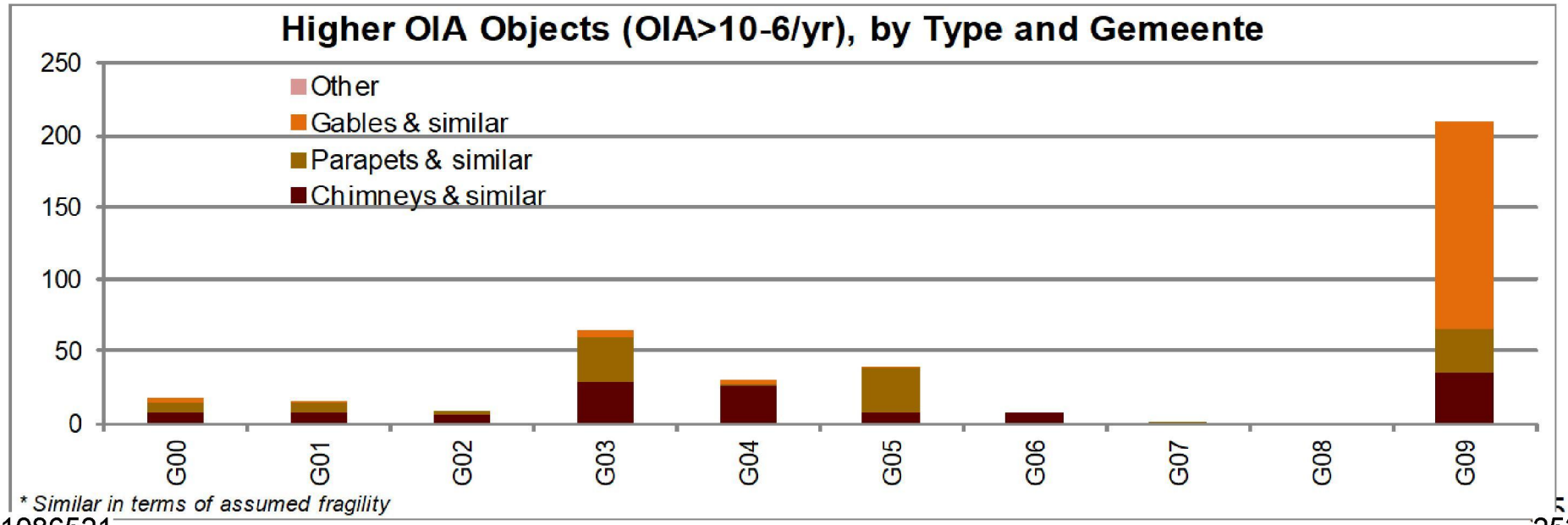
- Adopt strategy to prioritize areas with highest OIA and highest Community Risk objects first (for inspection)
  - Considers both individual and aggregate risk
  - Reduces risk to community as fast as possible
  - Minimizes chance of regrets
- Update inspection and decision protocol to reflect new insights from falling objects risk assessment

THE END

Backup slides: - breakdown of higher risk objects in Groningen City by object type and exposure pathway

Higher Risk Objects – Groningen City





Groningen City Higher Risk Objects – by exposure pathway