A Dürüm Döner View of Seismic Risk Assessment

Culinary adventures under high hazards

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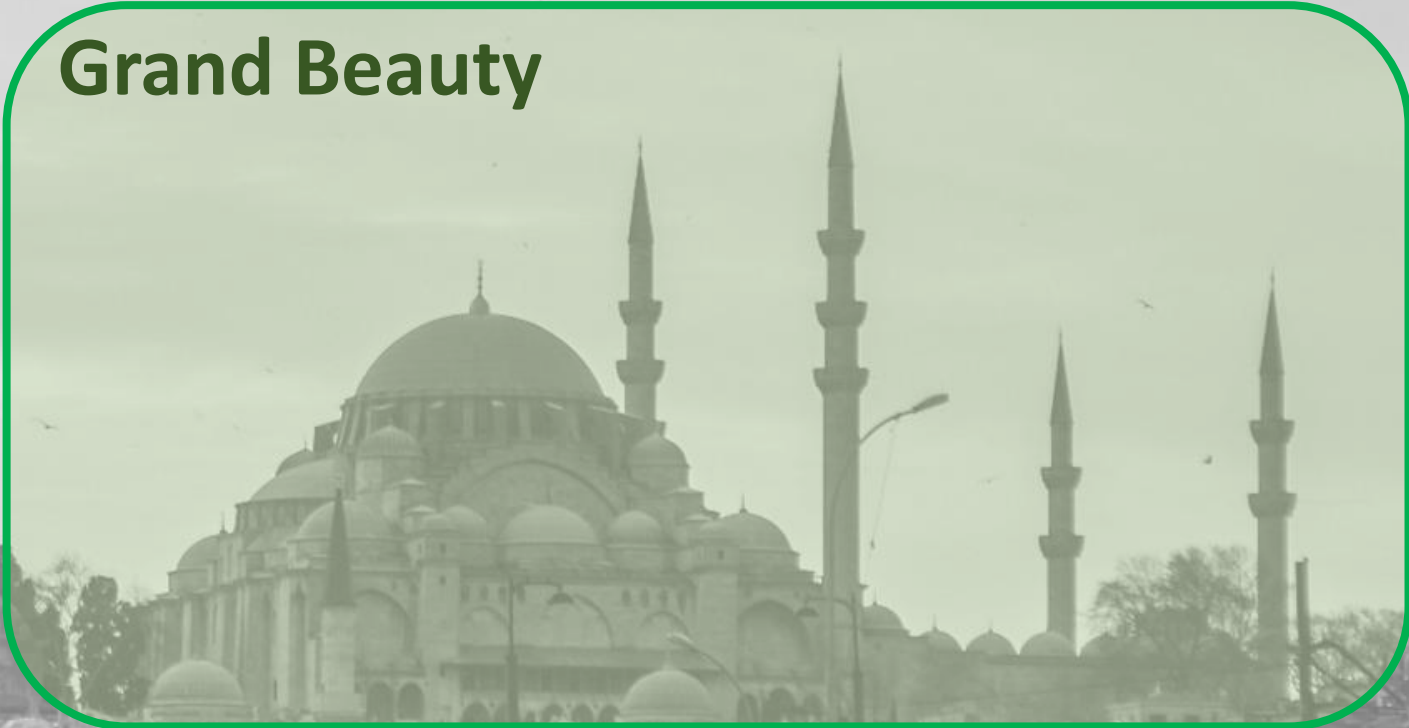**9th Turkish Conference on Earthquake Engineering, 3 June 2021**

Grand Beauty

Hidden Peril

Dramatis Personae #1

➢ **Dürüm Döner:**
  Super tasty
  Highly Addictive!

Hazardous event

➢ **Dürüm Döner Vendors:**
  Masters of DD
  Excellent quality
  Highly variable DDs

Hazard source

➢ **Dr. V:**
Researcher of risk
DD afficionado
Cuddly round figure
Considering sabbatical year in
Turkey

Exposure
Asset-at-risk

➢ **Mrs. V:**
Wife of Dr. V
Tough girl!
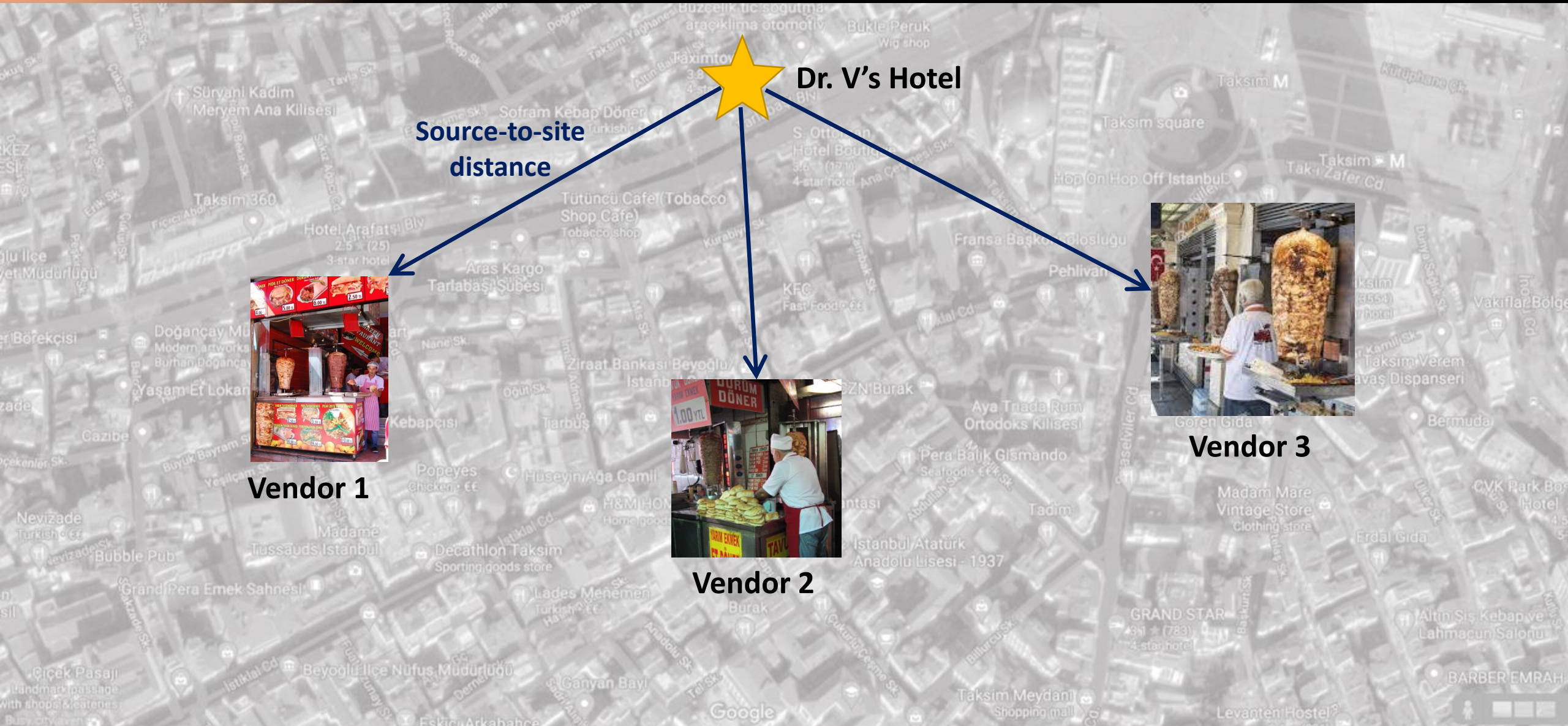Wants Dr. V healthy & handsome

Stakeholder
Decision maker

➢ **PhD student:**
Works with Dr. V.
…but reports to Mrs. V
Must quantify risk without bias!

Risk Analyst

Dr. V's Hotel

Source-to-site distance

Vendor 1

Vendor 2

Vendor 3

- 365 days of sabbatical

- 365 days of hazard

- 1 DD per day **on average**
  - Mean Daily Rate = 1 DD / day
  - Mean Annual Rate = 365 DD / yr

- Some days one, others two or none…

- DD events are independent

- Memoryless!

- **Poisson** process

- Dr. V must maintain excellent figure!

- Constrain calories from DDs

- Mean Daily Rate ≤ 1000 Kcal/day

- This is the **performance objective**

- If PhD overestimates, sabbatical is canceled → Dr. V angry

- If PhD underestimates, Dr. V ruins figure → Mrs. V angry

- Student never graduates…

It is all about assessing the probability of a complex event from its constituents:

1st tool: Use of simple logic operators (AND / OR / XOR)
e.g. a case of a chain

F ⟵ ⬭⬭⬭⬭⬭ ⟶ F

P(chain fails) = P(any link fails) = P (link 1 fails OR link 2 fails, OR ….) = …

Equivalent to a **statically determinate** problem: EASY ❤️

… but can only tackle easy problems!

2nd tool: Total Probability Theorem:
=> Finite element method for **statically indeterminate** problems ❤️❤️❤️

If E_i is a **Mutually Exclusive Collectively Exhaustive** partitioning of a sample space then, the probability of any event A in this space is estimated as:

$$P(event\ A) = \sum_i P(A \mid E_i) \cdot P(E_i)$$

We can go one level down:

$$P(event\ A) = \sum_i P(A \mid E_i) \cdot \left[\underbrace{\sum_j P(E_i \mid E_{ij}) \cdot P(E_{ij})}_{P(E_i)} \right]$$

Conditional

Or go directly to the smaller events

$$P(event\ A) = \sum_{i,j} P(A \mid E_{ij}) \cdot P(E_{ij})$$

Non-Conditional

Employ **Conditional** or **Non-Conditional** approach?

Non-Conditional Approach

Follow what nature does:

Every day 1 Dürüm Döner   →   **Productivity** of 1 event/day

Over 100 days sample 1 DD from each shop   →   Total = 300 samples

Run a lab experiment to determine kcals

Estimate probability of individual events:

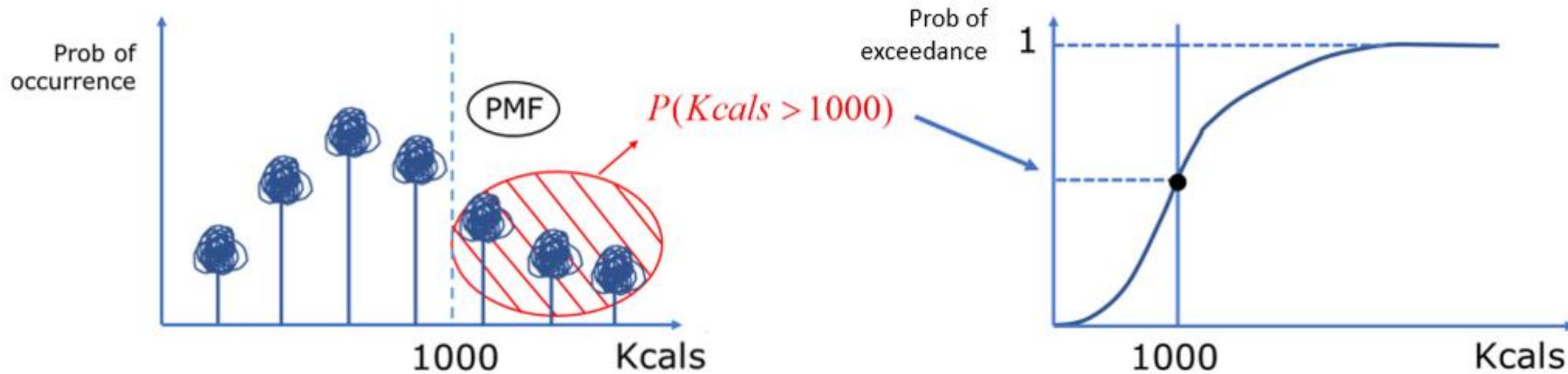$$\left.\begin{array}{l} i = 1...3 \, (shop) \\ j = 1...100 \, (day) \end{array}\right\} \rightarrow P(E_{ij}) = \frac{1}{300}$$

Easy but impractical….

We need $P(A \mid E_{ij})$ $\longrightarrow$ Create histogram of kcals in each of 300 samples

Conceptually easy, practically horrible:
- Dr V. has to wait 100 days!
- These lab tests are quite pricey: $ 1000 each! (minimum)
    300 x $1000 = $300,000 ☹

Conditional Approach

Most important choice: How to condition/split the DD assessment

Need **interface variable** to represent the DD in terms of kcals

1. Employ coordinates x/y/z to cut DD
   - 3-element vector
   - Useless: 200 small pieces of DD with mixed ingredients

2. Partition ingredients (5-element vector): meat/bread/onion/tomato/mayo
   - 5-element vector
   - Use tables of Kcal/gr for each ingredient
   - Useful! But is it practical?
   - I need to weigh each ingredient before wrapping…
   - DD vendor will probably throw me out after the 3rd try…

Let's look now for some **scalar** options

1. Diameter of the DD:
   – Easy to measure
   – Low information
   – Very vendor-dependent.
     site

2. Length of the DD: Same pros/cons as height

3. Weight:
   – Easy to measure, directly relates to Kcals
   – Cannot distinguish doner vs tomato weight.
   – Mildly vendor-dependent

Final approach: Get 4 representative DDs per vendor
                      Assess weight of individual ingredients   **3x2 vs 100 days**
                      Convert into Kcals (e.g. via lab experiment)   **3x4 vs 300 tests**
                      Sit 2 days observing weight of DDs produced per vendor

Properties of Optimal Interface Variables

Three important qualities of a good interface variable

① **"NO" BIAS**:   IV should not introduce bias when assessing DDs that are different from
i.e. <u>low</u>   those I happened to observe (only 12!)

② **"NO" VARIABILITY:** No variability is impractical, you end up with the non-conditional
i.e. low   approach. Settle for as low a variability as possible.

Say we have   (i) DD of height 7cm: [700, 1200] Kcals (high variability)
                     (ii) DD of weight 300gr: [900, 1100] Kcals (low varability)

③ **PRACTICABILITY:**   Complex IV = difficult to estimate it
no compromise!   Think 5 ingredient weights vs 1 total weight.
                     But simpler IVs tend to increase bias and variability.

DD Selection to the rescue!

There is no perfect IV (perfect IV = Non-Conditional approach)

How to remove bias of imperfect, practical IVs?

Employ "DD Selection"
   Given that to satisfy ③ I have to compromise on ① and ②
      I should be sampling DDs in a way similar to how Dr. V is eating them!

   Vendor 1 is putting **more meat** and Vendor 2 **more tomato** than Vendor 3
   Dr. V is eating **twice as often** from Vendor 2 than 1 or 3
      Sample 4 DDs from each (3x4=12) → **biased** weight-to-Kcal relationship!

   Must sample:
      3 DDs from Vendor 1
      6 DDs from Vendor 2   **12 samples unbiased!**
      3 DDs from Vendor 3

What if DDs where Earthquakes?

DD calorie risk assessment perfectly translates to Seismic Risk Assessment!

Dürüm Döner		**Earthquakes**
• Dr. V	→	building, dam, bridge, portfolio etc.
• Kcals	→	damage, loss
• DDs	→	seismic event, ground motion → cannot control it!
• Weight	→	intensity measure
• DD selection	→	ground motion selection
• DD vendor	→	faults
• DD Lab test	→	nonlinear timehistory analysis

End Game

- Going Conditional is **complex** but the only practicable approach **today**
- This can never be the final word in risk assessment
  - Computers grow more **powerful**
  - GM catalogues become more **populated**
  - Physics-based ground motion simulation will be **easier** (see wind risk!)
- Then, something **closer** to Non-Conditional may make sense

- Just do not forget:
  If something applies to the dürüm döner, it probably also applies to earthquakes

- Make your choices wisely!

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  - www.panoptis.eu   www.hyperion-project.eu

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