

Optimised Protection Strategy in Nuclear and Radiological Emergencies – the German Example

**Florian Gering
Federal Office for Radiation Protection – BfS
Germany**



Development of optimised protection strategy

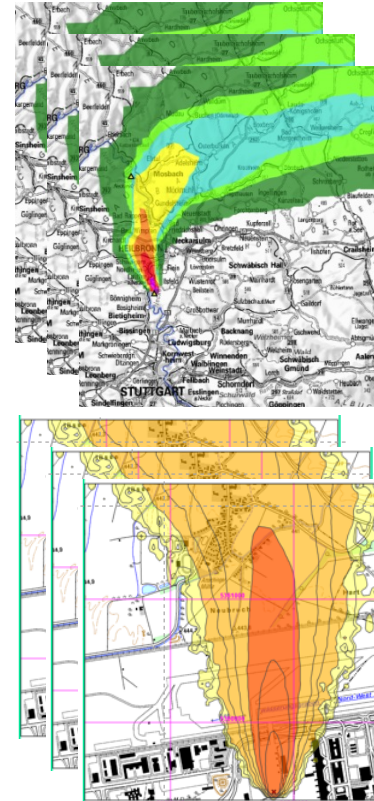
Scenario list

0. Unclear situation
1. NPP accident in Germany
2. NPP accident in neighbouring countries
3. NPP accident within Europe
4. NPP accident outside Europe
5. Accident in a nuclear facility
6. Terroristic attack
7. Transport accident
8. Radiological emergency situations
9. Satellite crash

Source terms (for planning)



Hazard assessment



Emergency response plans

Optimised strategy

Optimised strategy

...

...



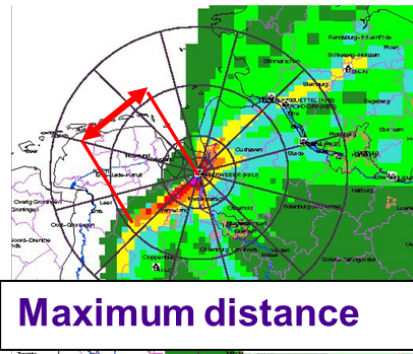
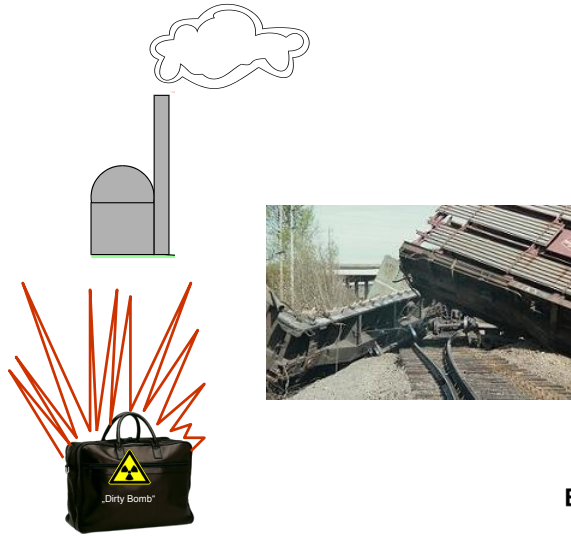
Main elements of the protection strategy

1. Hazard assessment
2. Accident phases
3. Protective actions
4. Criteria
5. Assessment & prognosis
6. Decision making
7. Evaluation & adjustment
8. Protection of emergency workers

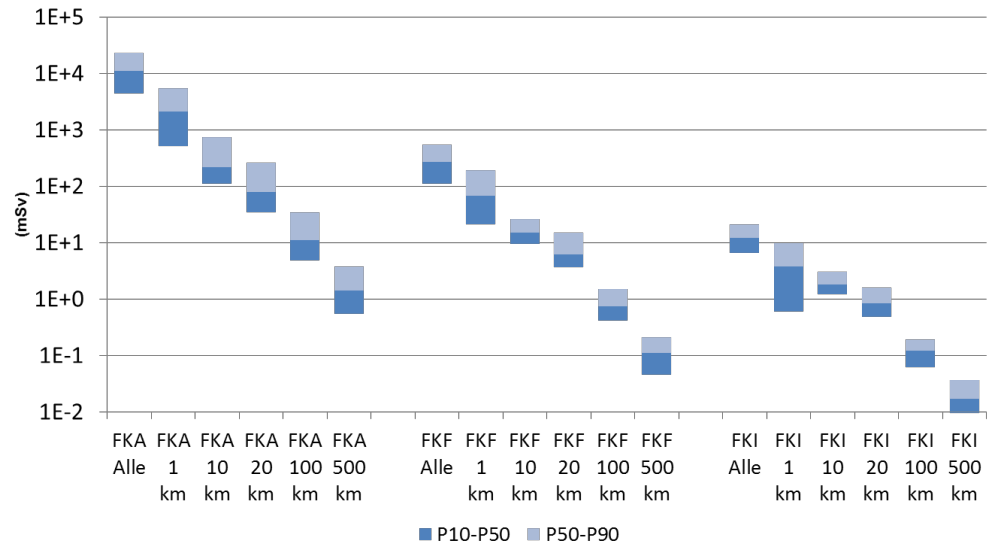


Hazard assessment

1. Hazard assessment
2. Accident phases
3. Protective actions
4. Criteria
5. Assessment & prognosis
6. Decision making
7. Evaluation & adjustment
8. Emergency workers



Eff. dose, infant, inhalation + external exposure over 7 days
NPP Grohnde - FKA, FKF, FKI



Protective actions and other actions

- 1. Hazard assessment
- 2. Accident phases
- 3. **Protective actions**
- 4. Criteria
- 5. Assessment & prognosis
- 6. Decision making
- 7. Evaluation & adjustment
- 8. Emergency workers

No	Action category	Number	Phase			
			A	B	C	D/E
1	Alarm	3	X	X	X	
2	Assessment & prognosis (monitoring)	6	X	X	X	X
3	Urgent protective actions	15	X	X	X	X
4	Actions for public communication	3	X	X	X	X
5	International notification	2	X	X	X	X
6	Mitigating actions	9		X	X	X
7	Recommendations for the public	8	X	X	X	X
8	Recommendations for agricultural production	10		X	X	X
9	Actions for drinking water supply	1		X	X	X
10	Actions for feed- and foodstuffs	11				X
11	Actions for other products	1				X
12	Actions for pharmaceutical products	1				X
13	Actions for transport of goods	1				X
14	Actions for international transport	5				X
15	Actions for contaminated areas	5				X
16	Actions for waste disposal	5				X
17	Actions for compensation	1				X
18	Personal actions (e.g. personal monitoring, decontamination)	16			X	X
	Sum	103				

Protection strategy – decision making criteria

1. Hazard assessment
2. Accident phases
3. Protective actions
4. **Criteria**
5. Assessment & prognosis
6. Decision making
7. Evaluation & adjustment
8. Emergency workers

Aim: Avoid major deterministic effects and reduce and limit the risk of stochastic effects



Reference level of the residual dose (in the first year):
100 mSv

2014



Generic intervention criteria
for protective actions

2014



Operational intervention levels
(German catalogue of countermeasures)

2010



Generic intervention criteria

Measure	Intervention reference levels		
	Organ dose (thyroid gland)	Effective dose	Integration times and exposure pathways
Sheltering		10 mSv	External exposure and committed effective dose due to inhaled radionuclides as a result of permanently staying outdoors for a period of 7 days
Iodine thyroid blocking	50 mSv Children and young people up to the age of 18 and pregnant women 250 mSv People aged 18 to 45		Committed equivalent dose due to inhaled radioactive iodine as a result of permanently staying outdoors for a period of 7 days
Evacuation		100 mSv	External exposure and committed effective dose due to inhaled radionuclides as a result of permanently staying outdoors for a period of 7 days

Consistency of reference level for residual dose with generic intervention criteria

- Assessment of residual dose over 1 year with consideration of:
 - Normal behaviour of representative persons
 - Effect of protective actions
(taken according to generic intervention criteria)
 - Additional effect of 3 relocation options
- Comparison of the maximum residual dose against reference level of 100 mSv
- Evaluation based on about 100 typical weather scenarios + new reference source term for nuclear emergency planning (FKA)
- Consistency was proven!

Assessment & Prognosis

1. Hazard assessment

2. Accident phases

3. Protective actions

4. Criteria

5. **Assessment & prognosis**

6. Decision making

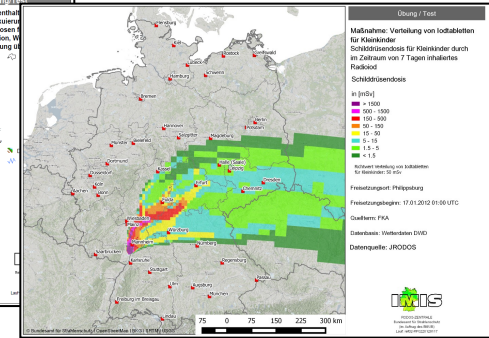
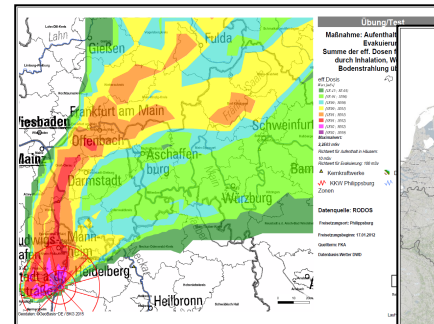
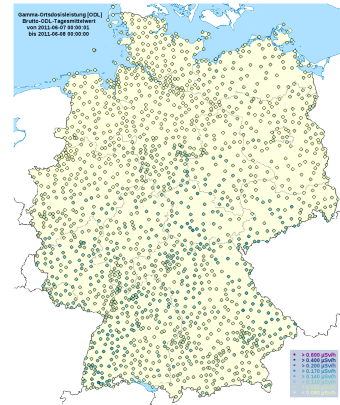
7. Evaluation & adjustment

8. Emergency workers

- Monitoring systems, mobile monitoring, radionuclides, monitoring strategy

- Decision support systems

- Radiological situation report



BfS-Notfallzentrale (24h), SW 2,2 Telefon (05316-333-2800), Telefax (05316-333-2805), Email: info@bfs.de
1. Lagerdarstellung vom 03.04.2017 um 09:25 Uhr (gesetzt, Zeit), Bearbeiter: F. Gering

4. Messdaten

76651 Philippburg

76297 Stotensee Of Friedhofst.

Nachrichtensätze für Aktivitätskonzentration in Luft relativ zu Cs-137	DWD	RODOS	Messungen	Quellterm
Cs-137	1	1		
I-131	4	2		
Ru-103	1	1		
Tc-99	10	10		

Die Bundesmessnetze wurden in den Intensivbetrieb versetzt. Die anlagenbezogenen ODL-Daten des Landes sind verfügbar.
Das Aufstellen mobiler ODL-Sonden (Land / BfS) wird derzeit vorbereitet.
Die ODL-Daten zeigen bisher keine erhöhten Werte (oder zeigen derzeit erhöhte Werte, die durch ein Regenereignis mit Ablagerung von Radionuclidprodukten zu erklären ist / oder zeigen an einer Messstelle erhöhte Werte, die vermutlich durch einen technischen Störung verursacht wird).

Auf dem Gebiet der BfS wurden bisher keine erhöhte Radioaktivität oder ODL-Messwerte zur Überschreitung des abg. Richtwertes von 100 µSv/h Maßnahmen Aufenthalt. Oder Die ODL-Messwerte zeigen Überschreitung des abg. Richtwertes von 100 µSv/h Maßnahmen Aufenthalt in folgenden Gebieten: - Landkreis ... - Landkreis ... - Landkreis ...

BfS-Notfallzentrale (24h), SW 2,2 Telefon (05316-333-2800), Telefax (05316-333-2805), Email: info@bfs.de

Kapitel 8: Maßnahmenempfehlung

Katastrophenschutz-Maßnahmen:

Maßnahmen	Landkreis	Wirkungsdauer (angegeben)	Zeit / Kennzeichnungs-Info (Einheit)	415
Verbot des Ausbleibens an Kinder (Kaufhaus)	03.04.2017 09:00			307
Verbot des Ausbleibens an Kinder (Kaufhaus)	03.04.2017 11:00			307
Verbot des Ausbleibens an Kinder (Kaufhaus)	03.04.2017 13:00			227

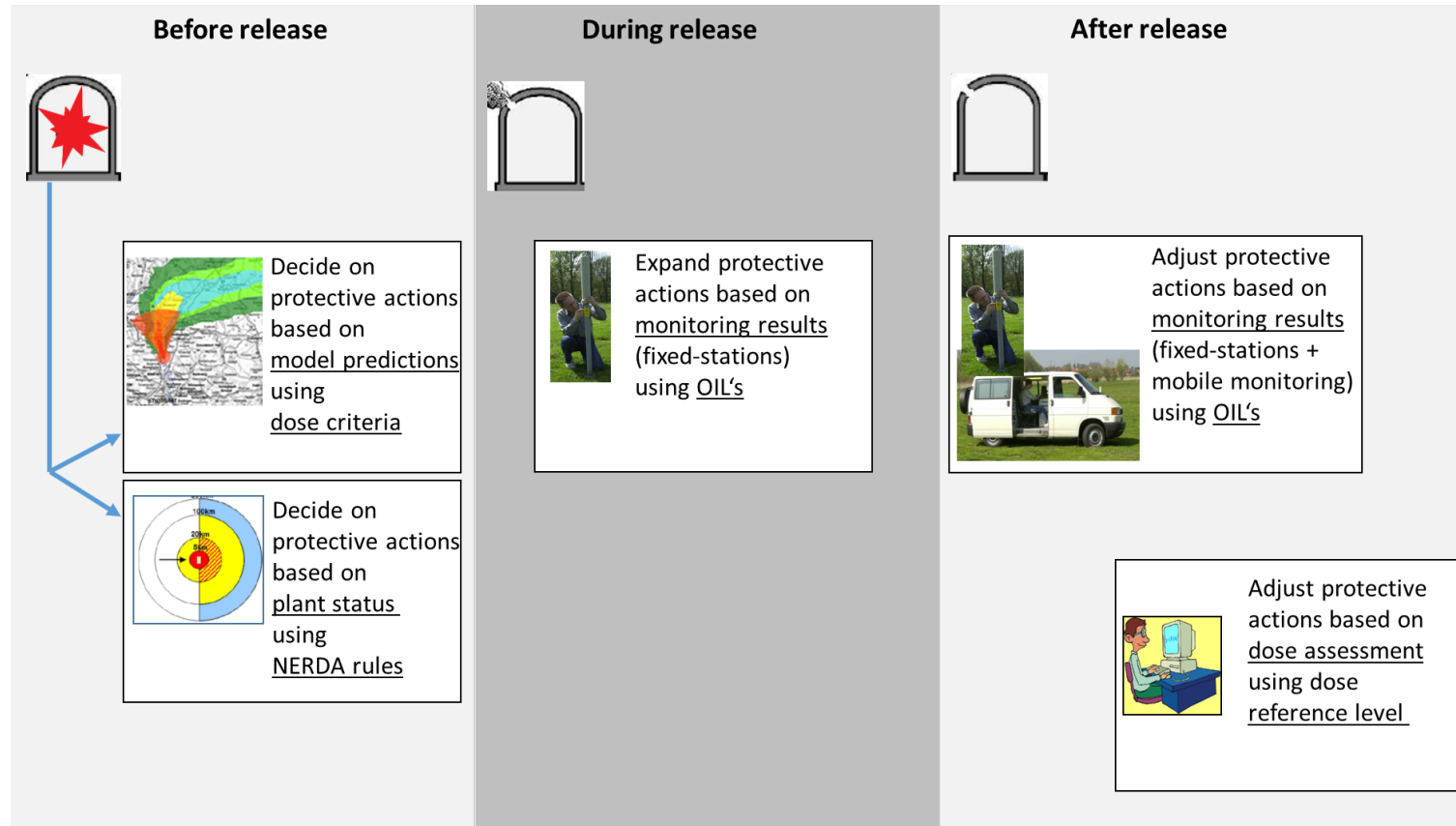
Die BfS empfiehlt zusätzlich der Bevölkerung in den folgenden Gebieten vorsorglich die folgenden Maßnahmen zu ergreifen:
- Süd-Osten von Baden-Württemberg (Landkreise ...)

Empfehlungen für die Bevölkerung:
- Gebiete aufsuchen, Aufenthalt im Freien vermeiden
- Fenster und Türen geschlossen halten, Lüftungen/Klimaanlagen ausschalten
- Wenn Aufenthalt im Freien, dann Regenprodukt und Gummistiefel tragen und nach Aufenthalt im Freien Überkleider und Schuhe wechseln, unbedeckte Körperpartien/Haare waschen
- Verzehr von frisch geernteten Nahrungsmitteln vermeiden
- Nutzung von Oberflächenwasser bis auf weiteres vermeiden
- Vieh nicht mit frisch geernteten Futtermitteln versorgen

Die oben genannten Maßnahmen sollten bis zur Ankunft der radioaktiven Wolke, d.h. vor 19 Uhr, abgeschlossen sein bzw. dann beendet werden.
Aktuelle Darstellungen der radiologischen Lage finden Sie auf der Internetseite des Bundesamtes für Strahlenschutz unter www.bfs.de.

Process for decision-making

1. Hazard assessment
2. Accident phases
3. Protective actions
4. Criteria
5. Assessment & prognosis
6. **Decision making**
7. Evaluation & adjustment
8. Emergency workers



Process for decision-making

Before release



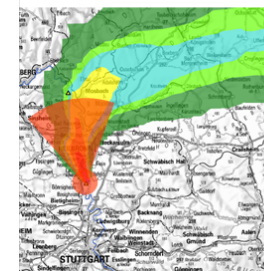
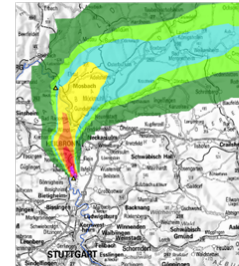
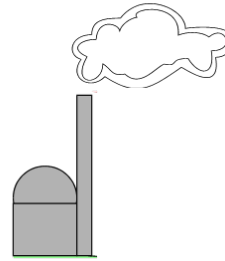
Decide on protective actions based on model predictions using dose criteria

Decide on protective actions based on plant status using NERDA rules

Source term assessment

Dispersion modelling

Comparison with intervention criteria



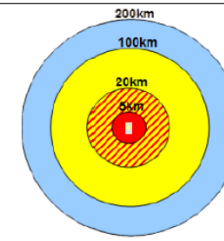
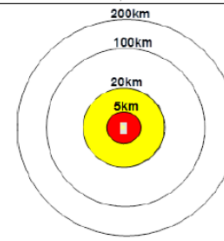
Expected release category

I / II

III

Wind direction not known or unstable

tionen

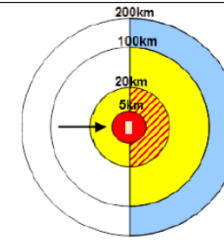
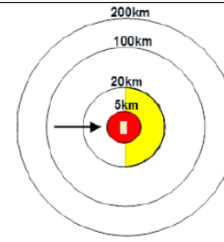


211/221

231

Wind direction known and stable

und



212/222

232

- ITB children
- Sheltering
- Evacuate immediately
- Shelter first, evacuate asap



Evaluation and adjustment of the protection strategy

1. Hazard assessment
2. Accident phases
3. Protective actions
4. Criteria
5. Assessment & prognosis
6. Decision making
7. Evaluation & adjustment
8. Emergency workers

During release



Expand protective actions based on monitoring results (fixed-stations) using OIL's

After release



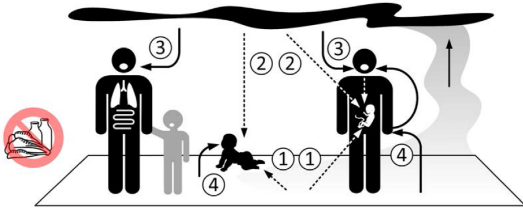
Adjust protective actions based on monitoring results (fixed-stations + mobile monitoring) using OIL's



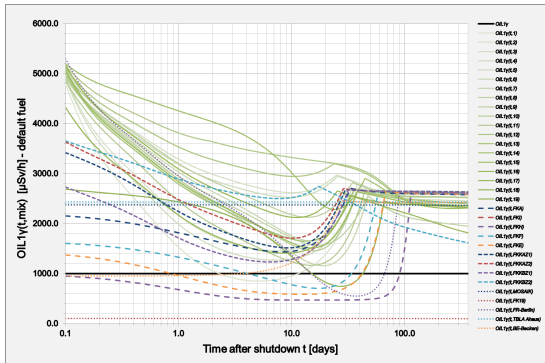
Adjust protective actions based on dose assessment using dose reference level



Evaluation and adjustment of the protection strategy



IAEA approach



During release



Expand protective actions based on monitoring results (fixed-stations) using OIL's

After release



Adjust protective actions based on monitoring results (fixed-stations + mobile monitoring) using OIL's

OIL's during the release

Action	Evacuation	Sheltering + ITB
OIL	1000 $\mu\text{Sv/h}$	100 $\mu\text{Sv/h}$

OIL's after the release

Action	Evacuation
OIL	1000 $\mu\text{Sv/h}$

Adjust protective actions based on dose assessment using dose reference level



Evaluation and adjustment of the protection strategy

Persönliche Daten
 Name Hans Muster evtl. ID
 Altersgruppe
 Geschlecht schwanger
 Fötus
 (Vorname, Name, Adresse, Familie, geb)

Messungen
 Messwert Ganzkörper:
 Messwert Schilddrüse
 Messwert Hautkontamination

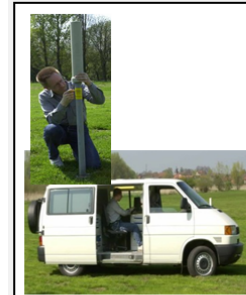
Ergebnisse Dosis

Organ	Dosis in mSv
Effektiv	2
Schilddrüse	
Rotes Knochenmark	
Foetus Stadium 1	

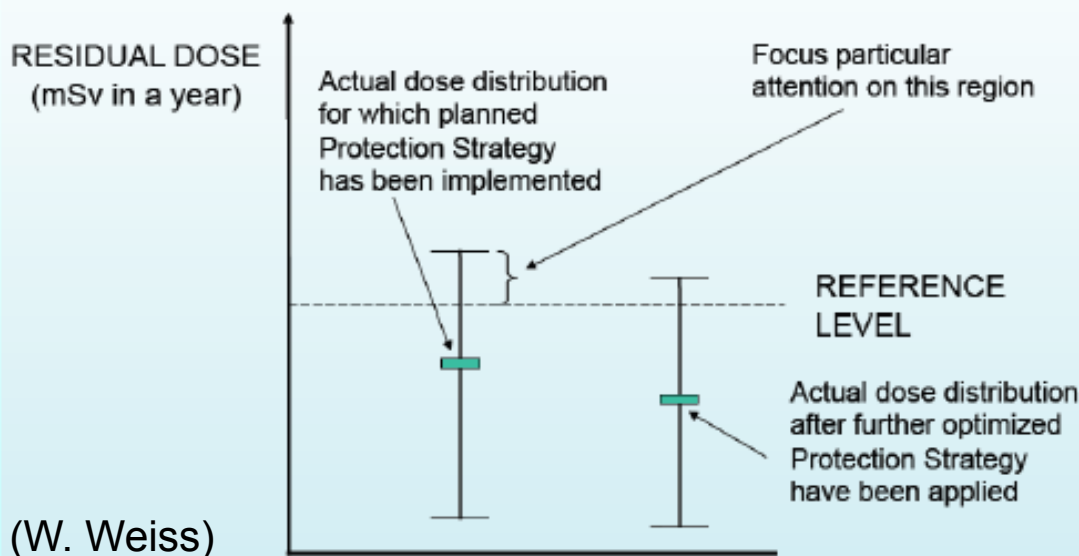
Messdaten bis incl. 26. Februar 2015 16:10

Start	Latitude	Longitude	Beginn	Ende	Aufenthaltsort	Massnahme
Schule			1.1.2015 8:00	1.1.2015 12:00	Im Haus	Einnahme Jodtabletten
Flughafen			12:00	12:12	im Freien/Auto	
Haltestelle			12:12	13:00	Im Freien/Auto	
kindergarten			13:00	14:00	Im Freien/Auto	

After release



Adjust protective actions based on monitoring results (fixed-stations + mobile monitoring) using OIL's



Adjust protective actions based on dose assessment using dose reference level



Protection of emergency workers

1. Hazard assessment
2. Accident phases
3. Protective actions
4. Criteria
5. Assessment & prognosis
6. Decision making
7. Evaluation & adjustment
8. **Emergency workers**

Worker Task	Reference level / guidance level
Life-saving actions, prevention of deterministic effects, disaster prevention	250 / 500 mSv
Protecting life or health	100 mSv
Other tasks	e.g. 20 mSv (occupational dose limits)

- Planning, Information
- Personal protective equipment
- Monitoring, decontamination



Transposition of Directive 2013/59/Euratom in Germany

- The new ***Act on Protection against the Dangers arising from Exposure to Ionising Radiation*** has passed both chambers of the parliament **last week!**
- The legislative procedure for the **Radiation Protection Ordinance(s)** should be finalized by **February 2018**.

End





Bundesamt für Strahlenschutz

Background

COUNCIL DIRECTIVE 2013/59/EURATOM of 5 December 2013

laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation

Emergency exposure situations *Article 69 - Emergency response*

4. In the event of an emergency on or outside its territory, the Member State shall require:

(a) the organisation of **appropriate protective measures**, taking account of the **real characteristics** of the emergency and **in accordance with the optimised protection strategy** as part of the **emergency response plan**, whereby the elements to be included in an emergency response plan are indicated in Section B of Annex XI;

(30) "emergency response plan" means arrangements to plan for adequate response in the event of an emergency exposure situation on the basis of postulated events and related scenarios;



Assessment of hazards

Scenario list

0. Unclear situation
1. NPP accident in Germany
2. NPP accident in neighbouring countries
3. NPP accident within Europe
4. NPP accident outside Europe
5. Accident in a nuclear facility
6. Terroristic attack
7. Transport accident
8. Radiological emergency situations
9. Satellite crash



Assessment of hazards, potential consequences and impacts of an emergency

Scenario list

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Source terms (for planning)

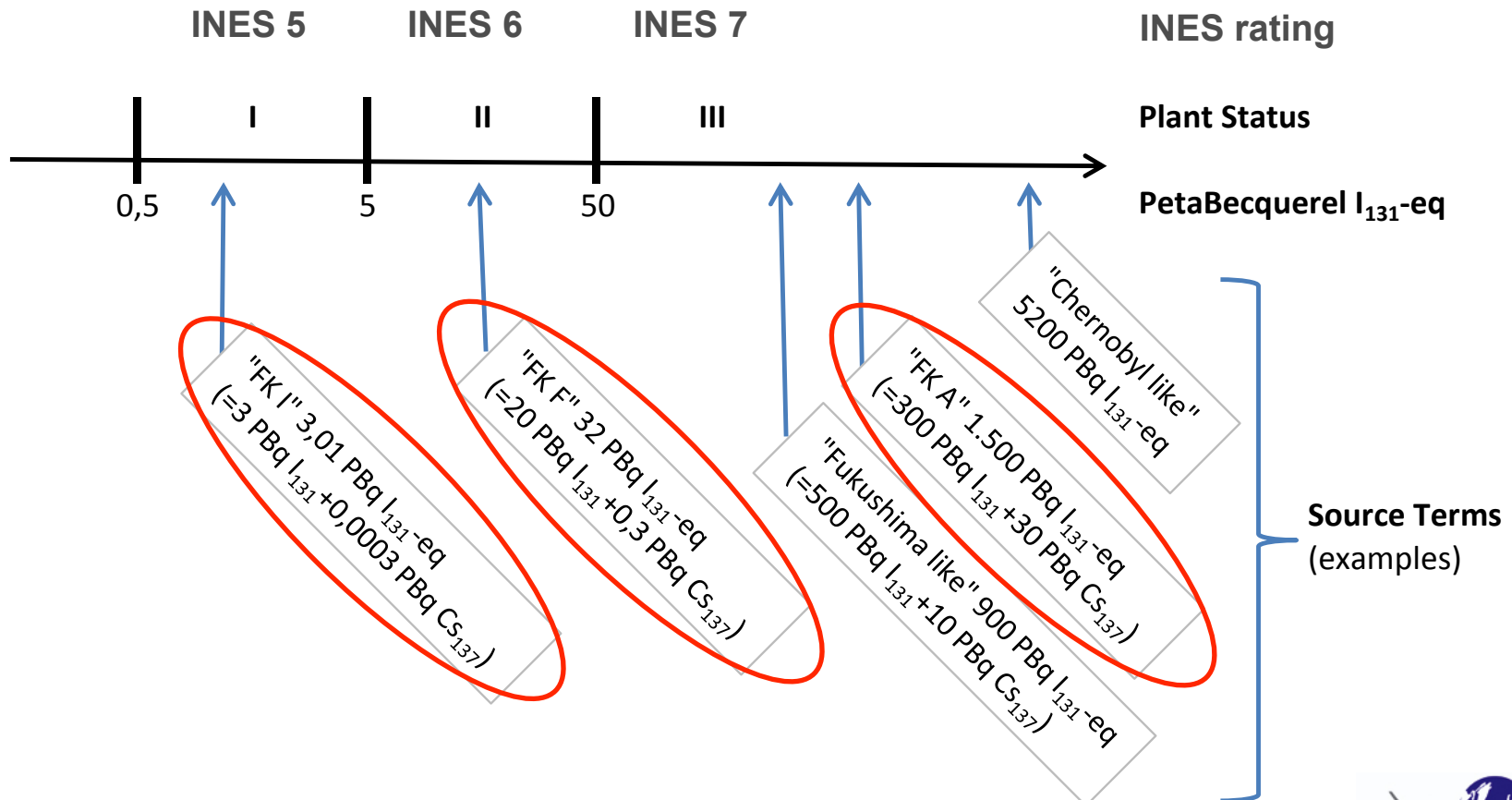


Source terms used for consequence assessment – Severe NPP accident

„could lead to core melt, no indication of loss of contain.“

„could lead to core melt, loss of containment“

AtHLET description



Source Terms
(examples)

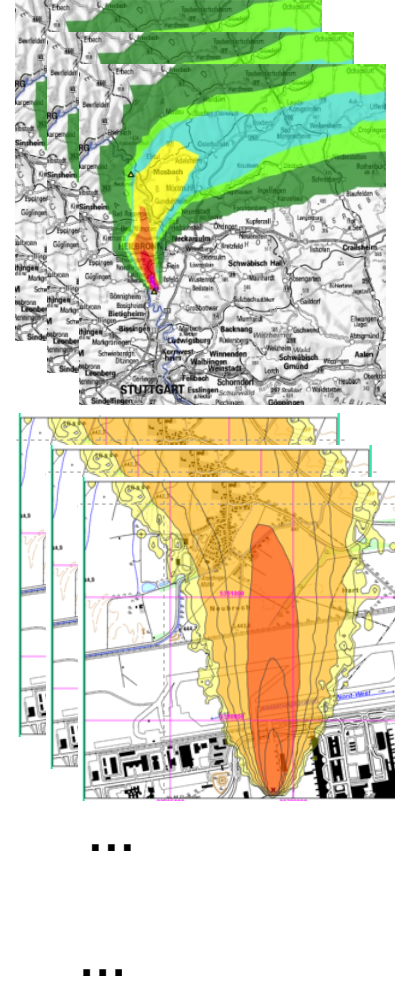
Assessment of hazards, potential consequences and impacts of an emergency

Scenario list

Source terms (for planning)

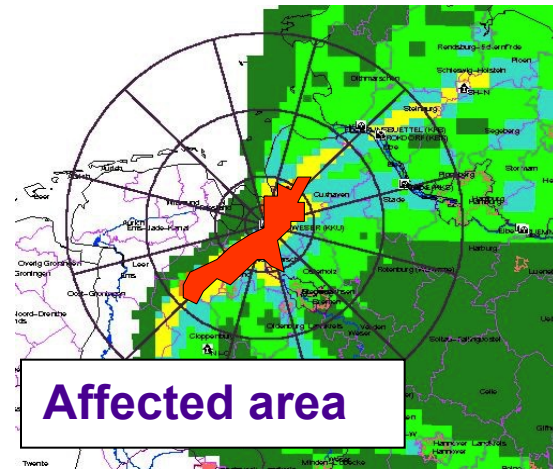
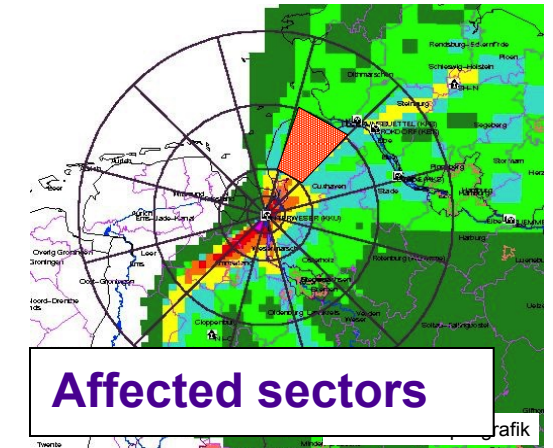
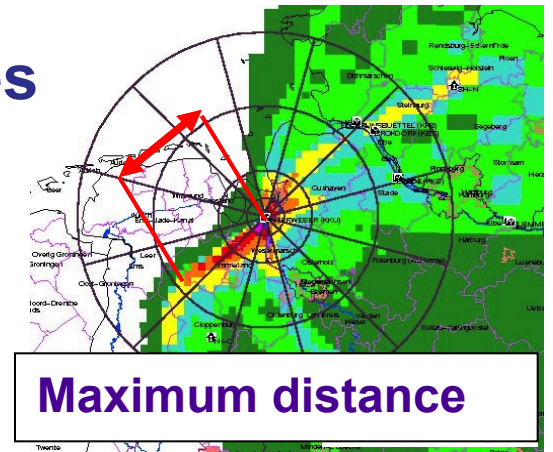
Radiological consequences

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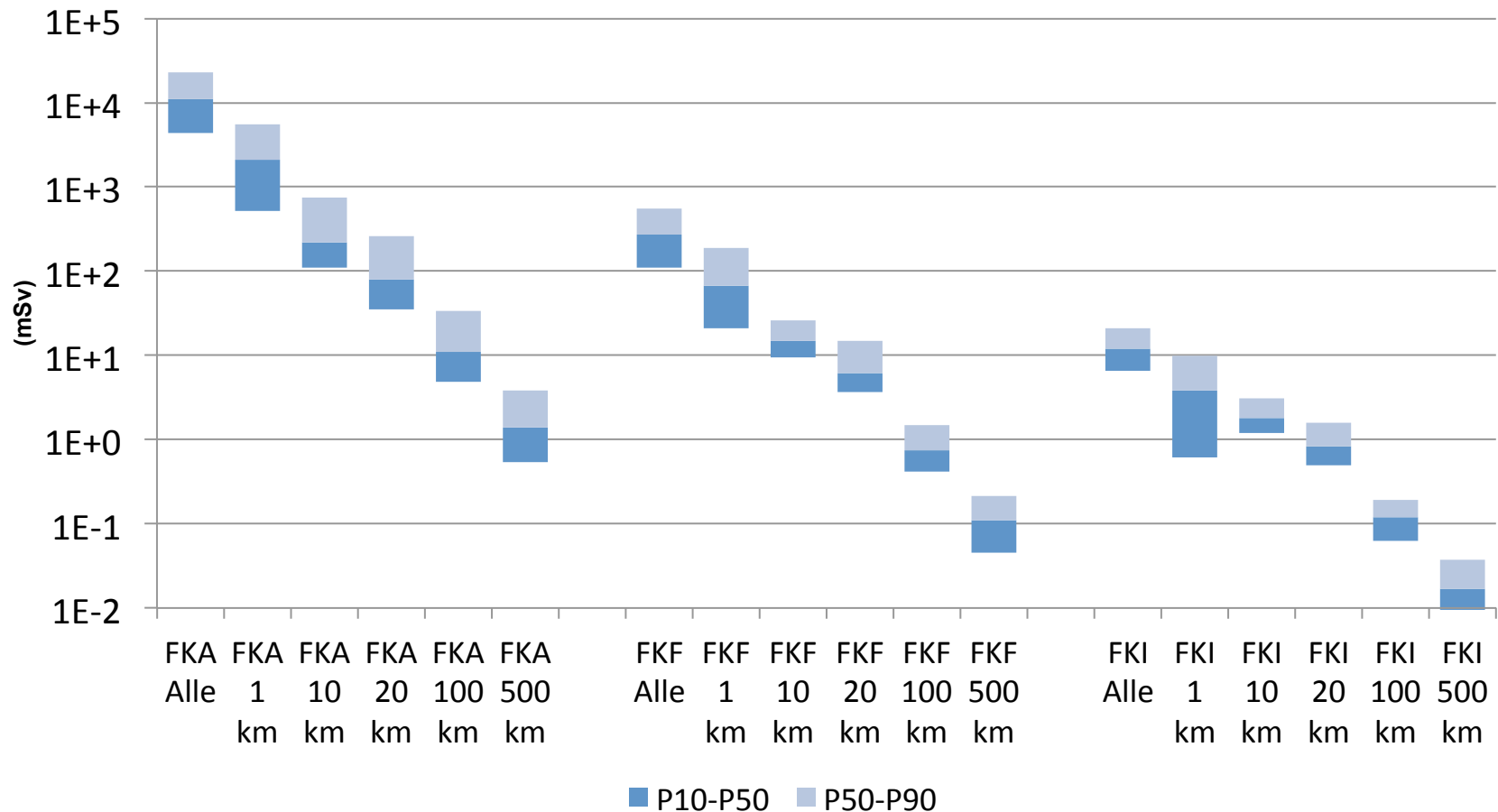
Assessment of potential consequences

- Selection of „reference source terms“ for each accident/release category
- Selection of representative NPP sites (Unterweser, Grohnde, Philippsburg)
- Simulations performed with RODOS based on numerical weather prediction data (Nov. 2011 - Oct. 2012; releases for each day)
- More than 5000 separate simulations
- Statistical analysis of results



Results of hazard assessment: exposure of the public

Eff. dose, infant, inhalation + external exposure over 7 days
NPP Grohnde - FKA, FKF, FKI



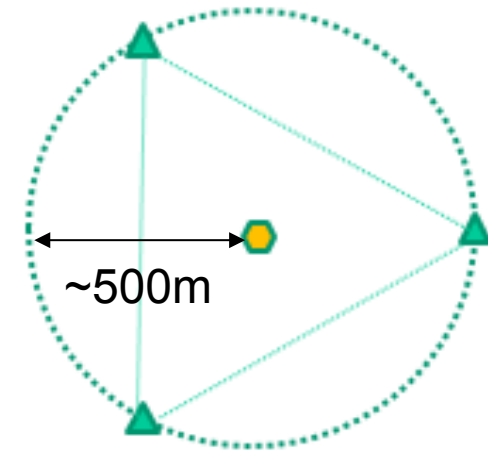
Results of hazard assessment: monitoring data

Scenario	# GDR-stations with signal	Max. distance GDR-station	Max. GDR ($\mu\text{Sv/h}$)	Time to 1. GDR-Signal	Time to 1. DWD-measurement
NPP-FKA	472	414 km	843	1 h (1-9h)	8 h (1-42h)
NPP-FKF	411	414 km	184	1 h (1-5h)	8 h (1-36h)
NPP-FKI	375	414 km	137	1 h (1-7h)	9 h (1-37h)
Research reactor	12	177 km	29	1 h (1-8h)	6 h (1-66h)
Transport accident	0 (43/ 365)	84 km	0.02	- (0-64h)	-



Results of hazard assessment: monitoring data

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Transport accident	0 (43/ 365)	84 km	0.02	- (0-64h)	-



3 detectors in the vicinity of NPP to get spectrometric information asap



Results of hazard assessment: protective actions

Maximum distance for evacuation, source term FKA

Adult	Maximum distance (km) in which intervention level for evacuation is exceeded		
	50%- Percentile	80%- Percentile	90%- Percentile
North (Unterweser)	9	15	22
Central (Grohnde)	11	20	26
South (Philippsburg)	18	25	31
Central (Grohnde) - FKF	0	0	0
Central (Grohnde) - FKI	0	0	0



Results of hazard assessment

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RODOS-based simulation of potential accident scenarios for emergency response management in the vicinity of nuclear power plants

Schriften

H. Walter

F. Gering

K. Arnold

B. Gerich

G. Heinrich

U. Welte*

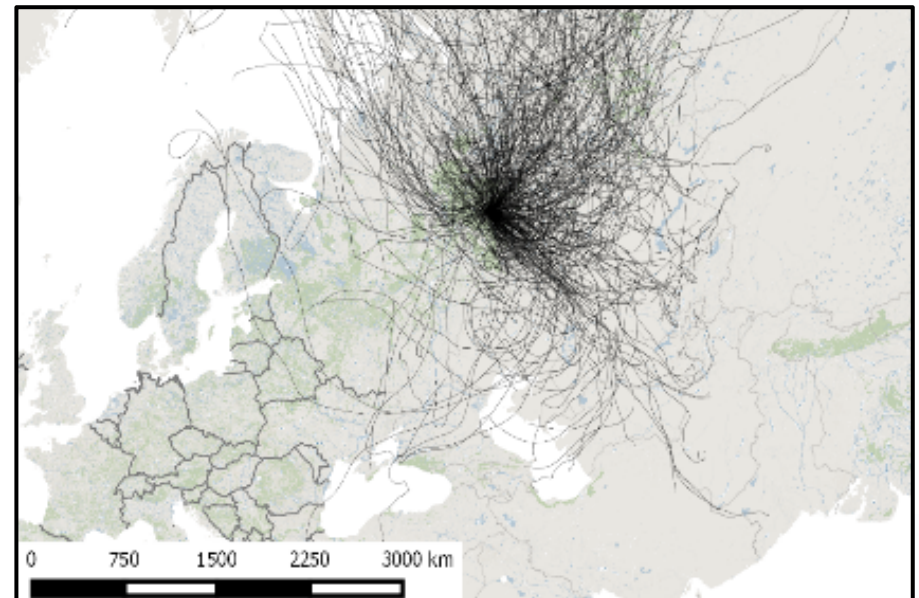
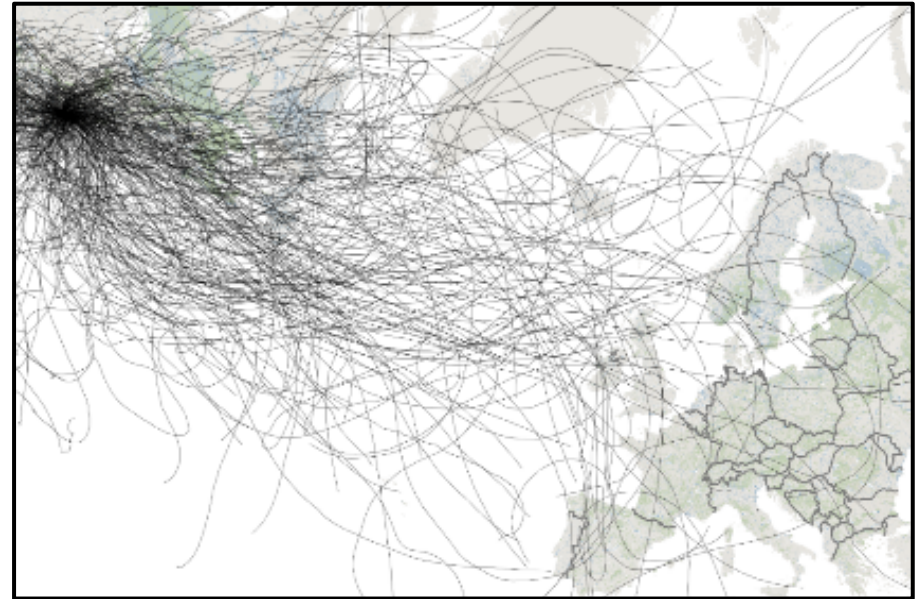
(* SSK, Vorsitzende des SSK-Ausschusses Notfallschutz)



Results of hazard assessment

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Trajectories for accidents at NPP Surry and NPP Belojarsk



Operational intervention levels („German catalogue of countermeasures“)

GDR	Protective action	Time period	Generic dose criteria
30 – 300 $\mu\text{Sv/h}$	Sheltering	0 – 7 days	10 mSv over 7 days (external exposure from radionuclides deposited on the ground)
300 – 3000 $\mu\text{Sv/h}$	Evacuation	0 – 7 days	100 mSv over 7 days (external exposure from radionuclides deposited on the ground)
18 – 120 $\mu\text{Sv/h}$	Temporary relocation	0 – 30 days	30 mSv over 30 days (external exposure from radionuclides deposited on the ground)
8 – 120 $\mu\text{Sv/h}$	Permanent relocation	0 – 365 days	100 mSv over 1 year (external exposure from radionuclides deposited on the ground)

...



Development of optimised protection strategies

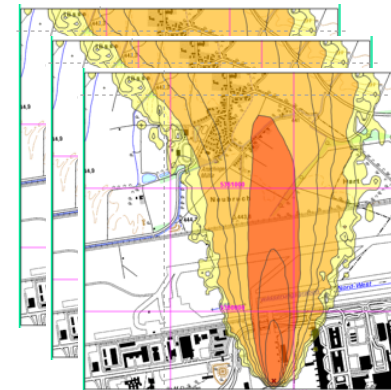
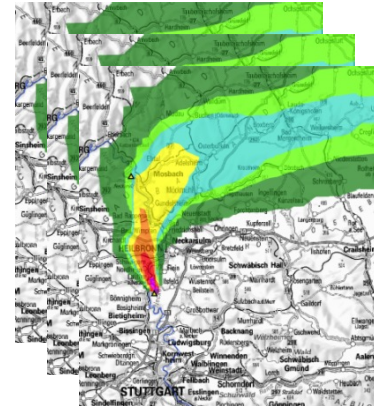
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Source terms (for planning)



Radiological consequences



...
...

Emergency response plans

Optimised strategy

Optimised strategy

...
...



Implementation of the protection strategy

Implementing appropriate **protective actions**

- in accordance with the optimised protection strategy
- within the framework of the emergency response plan
- under consideration of the prevailing situation
- with immediate coordination within all responsible authorities and organisations

Common **assessment and evaluation** of the radiological situation

-> New national emergency response centre BMUB-BfS-GRS

Decision about protective actions:

-> disaster response authorities and other specialized authorities



Transposition of Directive 2013/59/Euratom in Germany

Emergency Response Plans

- **Already exist** at Federal and Länder level and for specific facilities
- Optimised protection strategies for different scenarios will be postulated in a **general emergency response plan of the Federation**
- **Legal bases and responsibilities** of legislators and authorities at EU- and Euratom-, Federal and regional (Länder) level should be clearly described to avoid any discussions in the event of an emergency.

Responsibilities in nuclear and radiological emergencies

Current situation

0. Unclear situation
1. **NPP accident in Germany**
2. **NPP accident in neighbouring countries**
3. NPP accident within Europe
4. NPP accident outside Europe
5. **Accident in a nuclear facility**
6. **Terroristic attack**
7. **Transport accident**
8. **Radiological emergency situations**
9. Satellite crash



Future

0. Unclear situation
1. NPP accident in Germany
2. NPP accident in neighbouring countries
3. NPP accident within Europe
4. NPP accident outside Europe
5. Accident in a nuclear facility
6. Terroristic attack
7. **Transport accident**
8. **Radiological emergency situations**
9. Satellite crash

Responsibility of federal states

Challenges of developing a protection strategy

- **Source terms used as planning basis**
- **Categorization of scenarios / threats (level of detail, ...)**
- **Introduction of EAL's in Germany (not yet existing!)**
- **Concept of triggering urgent protective actions based on plant status (IAEA)**
- **Involvement of stakeholders**
- **Transition from an emergency exposure situation to an existing exposure situation**
- **Assessing the effectiveness of strategies and implemented actions and adjusting them as appropriate to the prevailing situation;**
- **Comparing the doses against the applicable reference level, focusing on those groups whose doses exceed the reference level**
- **...**



NPP accident scenarios in Germany, Europe and outside Europe



Decision about protective actions (urgent phase)

Decision on protective actions based on model predictions and generic dose criteria:

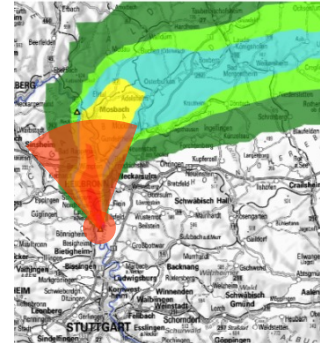
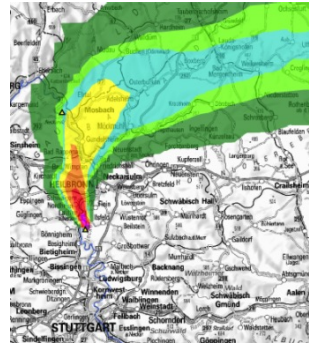
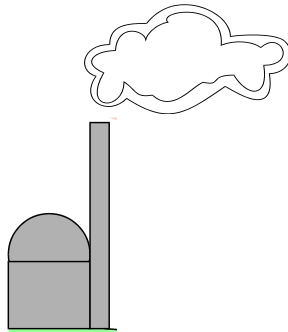
Source term assessment



Dispersion modelling




Comparison with intervention criteria

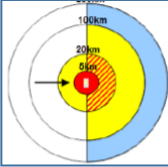


Process for decision-making (including adjusting)

Before release



Decide on protective actions based on model predictions using dose criteria



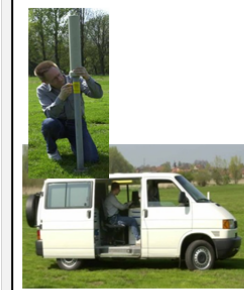
Decide on protective actions based on plant status using NERDA rules

During release

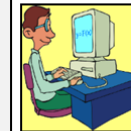


Expand protective actions based on monitoring results (fixed-stations) using OIL's

After release



Adjust protective actions based on monitoring results (fixed-stations + mobile monitoring) using OIL's



Adjust protective actions based on dose assessment using dose reference level



Decision about protective actions (urgent phase)

Alternative: Decision on protective actions based on plant status:

„Conditions“			
Time until release:	Several hours		Immediately before
Expected release:	I = „filtered venting“	II = „unfiltered venting“	III = „containment failure“
Weather information:	No information or wind direction unstable		Wind direction stable

Protective actions ... depend on the time remaining before the

... several hours	... immediately before
-------------------	------------------------

-  Prepare ITB children
-  Prepare sheltering
-  Evacuate immediately
-  Shelter first, evacuate asap

-  ITB children
-  Sheltering
-  Evacuate immediately
-  Shelter first, evacuate asap

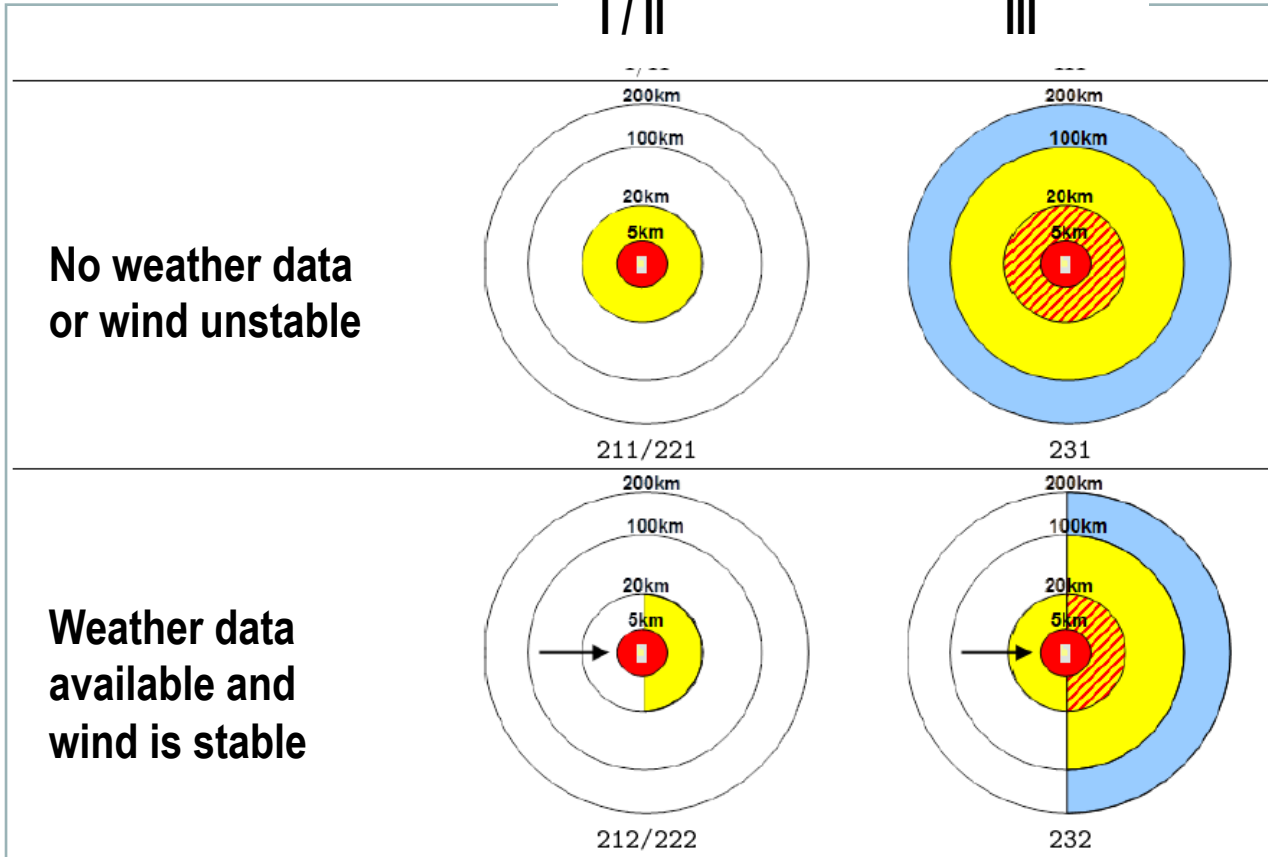
Decision about protective actions (urgent phase)

Alternative: Decision on protective actions based on plant status:

Expected release category

I / II

III



-  ITB children
-  Sheltering
-  Evacuate immediately
-  Shelter first, evacuate asap

Sheltering: ITB is included

Decision about protective actions (urgent phase)

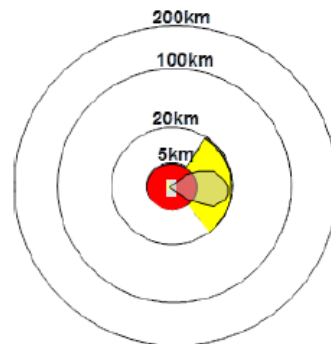
Alternative: Decision on protective actions based on plant status:

Dispersion results
Available and reliable

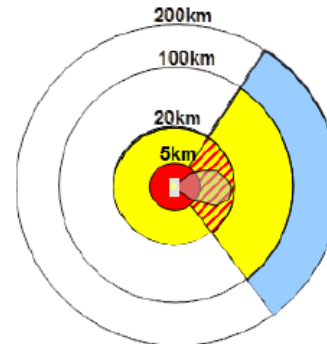
Expected release category

I / II

III



213/223



233

-  ITB children
-  Sheltering
-  Evacuate immediately
-  Shelter first, evacuate asap



„HERCA WENRA Approach“



HERCA-WENRA Approach
for a better cross-border
coordination of protective actions
during the early phase of a nuclear
accident

Stockholm, 22 October 2014

Non-radiological criteria in decision making



Revised OILs (under discussion)

OIL's during the release

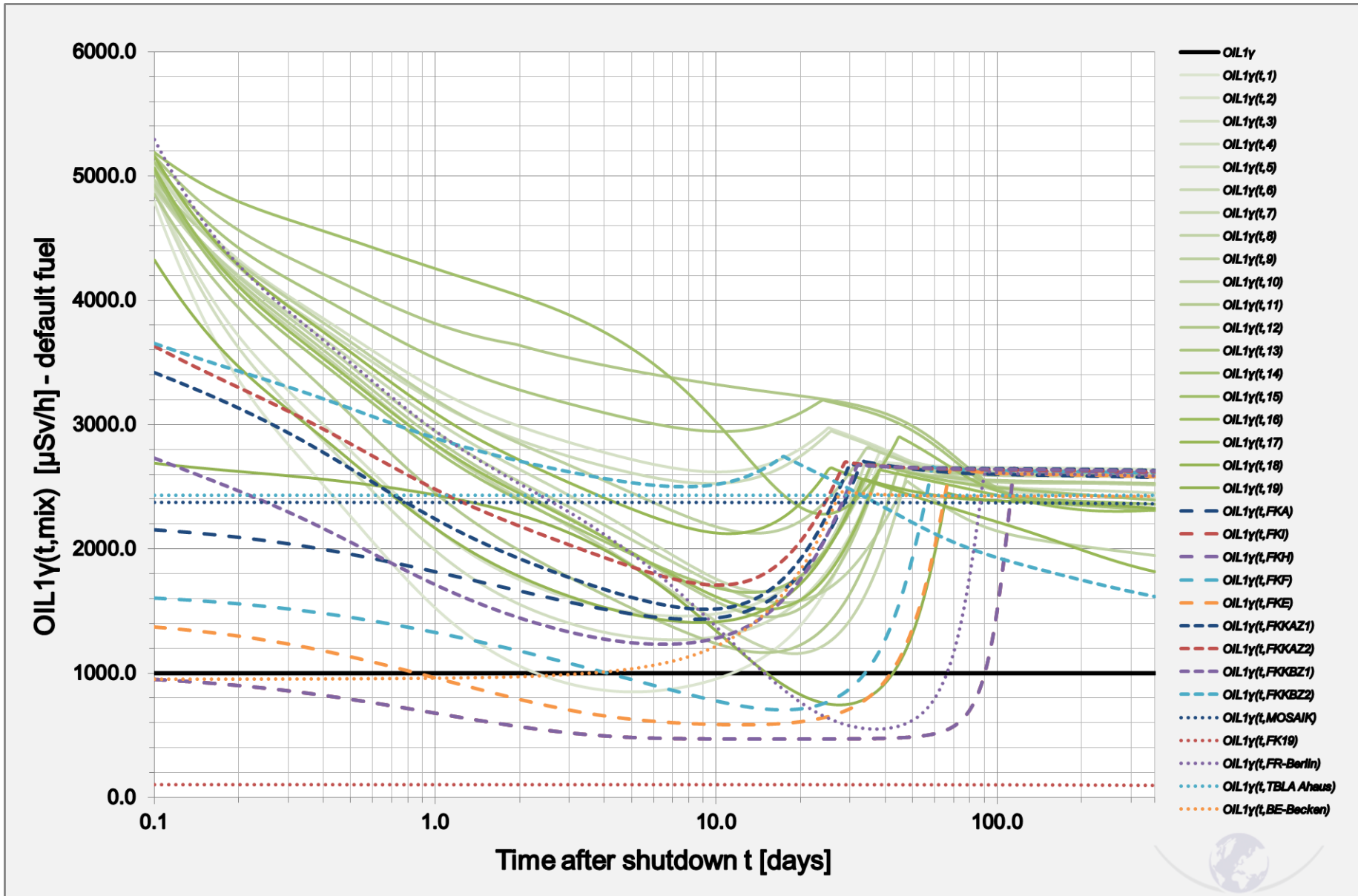
Action	Evacuation	Sheltering + ITB
OIL	1000 $\mu\text{Sv/h}$	100 $\mu\text{Sv/h}$

OIL's after the release

Action	Evacuation
OIL	1000 $\mu\text{Sv/h}$




Revised OILs (under discussion)

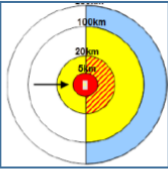


Process for decision-making (including adjusting)

Before release




Decide on protective actions based on model predictions using dose criteria




Decide on protective actions based on plant status using NERDA rules

During release




Expand protective actions based on monitoring results (fixed-stations) using OIL's

After release



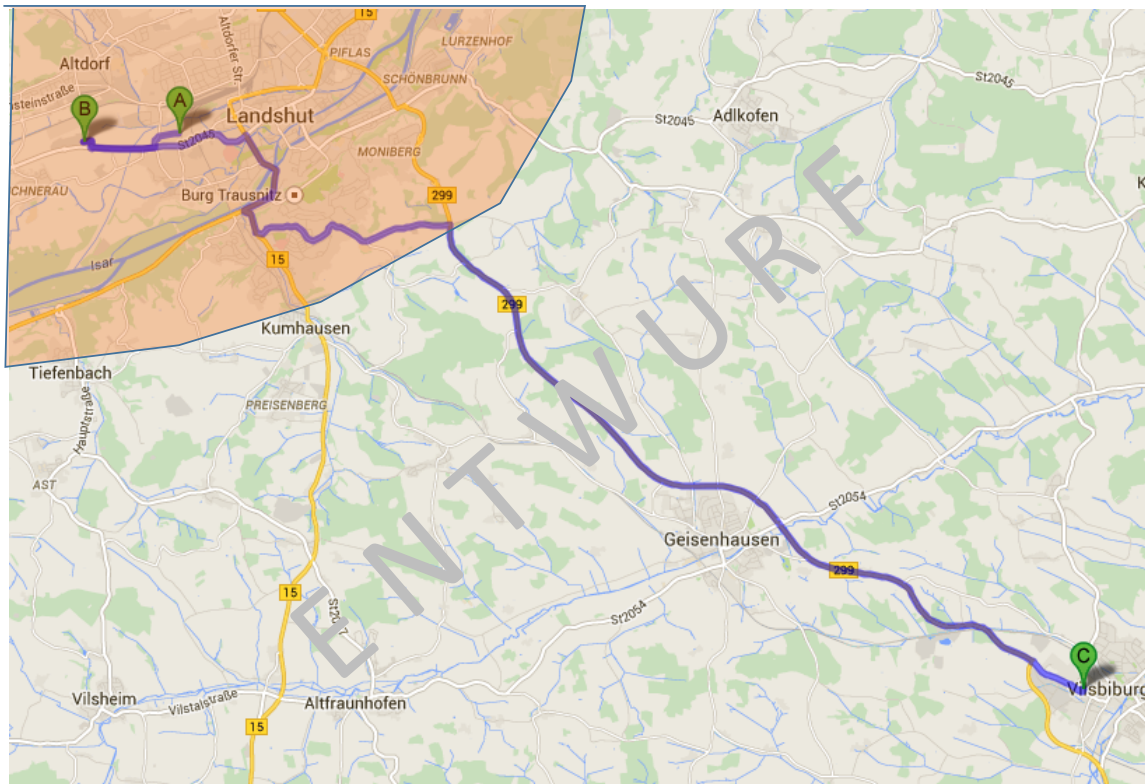
Adjust protective actions based on monitoring results (fixed-stations + mobile monitoring) using OIL's



Adjust protective actions based on dose assessment using dose reference level



Dose reconstruction (for individuals)



Persönliche Daten

Name Hans Muster evtl. ID

Altersgruppe

Geschlecht schwanger

Fötus

(Vorname, Name, Adresse, Familie, geb)

Messungen

Messwert Ganzkörper:

Messwert Schilddrüse

Messwert Hautkontamination

Ergebnisse Dosis

Organ	Dosis in mSv
Effektiv	2
Schilddrüse	
Rotes Knochenmark	
Foetus Stadium 1	

Messdaten bis incl. 26. Februar 2015 16:10

Start	Latitude	Longitude	Beginn	Ende	Aufenthaltsort	Massnahme
Schule			1.1.2015 8:00	1.1.2015 12:00	Im Haus	Einnahme Jodtabletten
Flughafen			12:00	12:12	imFreien/Auto	
Haltestelle			12:12	13:00	Im Freien/Auto	
kindergarten			13:00	14:00	Im Freien/Auto	



Implementation - Emergency response plans

