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# AN HOLISTIC EVALUATION OF THE STATE OF THE ART AND FUTURE DEVELOPMENTS ON NON-LETHAL MICROWAVE SYSTEMS

F. Valente; J. Neutz; H. Urban; A. Roland-Price; P. Paulissen



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# PRESENTATION OUTLINE

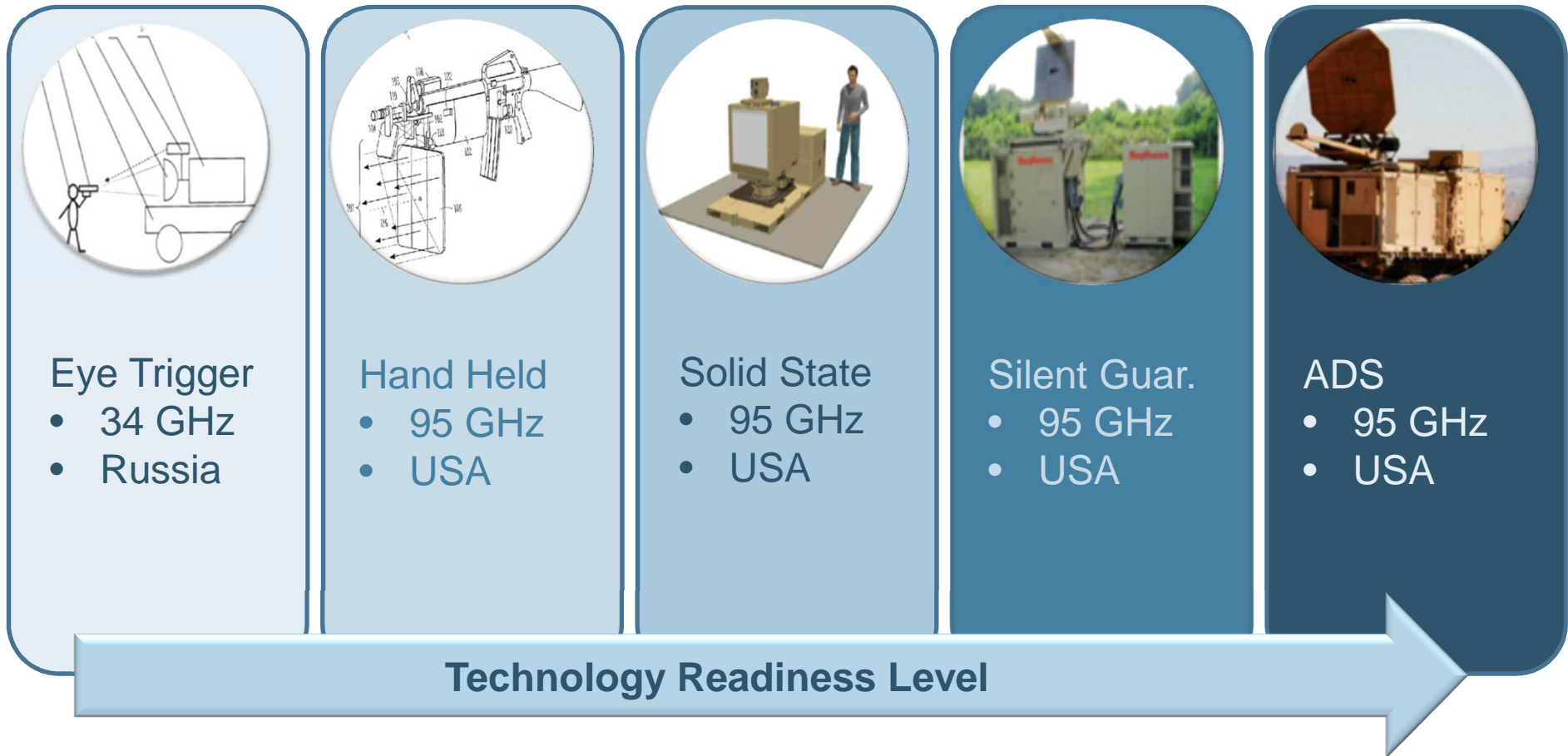
- › Scope of the study
- › State of the Art
- › Medical aspects
- › Evaluation of performance in military scenarios
- › Technological foresight
- › Conclusions

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# SCOPE OF THE STUDY

- › The scope of the study is to establish **the technological State of the Art on counter personnel microwave systems** and consequently evaluate the military operational merits and risks associate with the use of these systems as a non-lethal capability.
- › The study covered three major areas of interest:
  - technology,
  - medical and health related issues and
  - applicability in selected military scenarios.

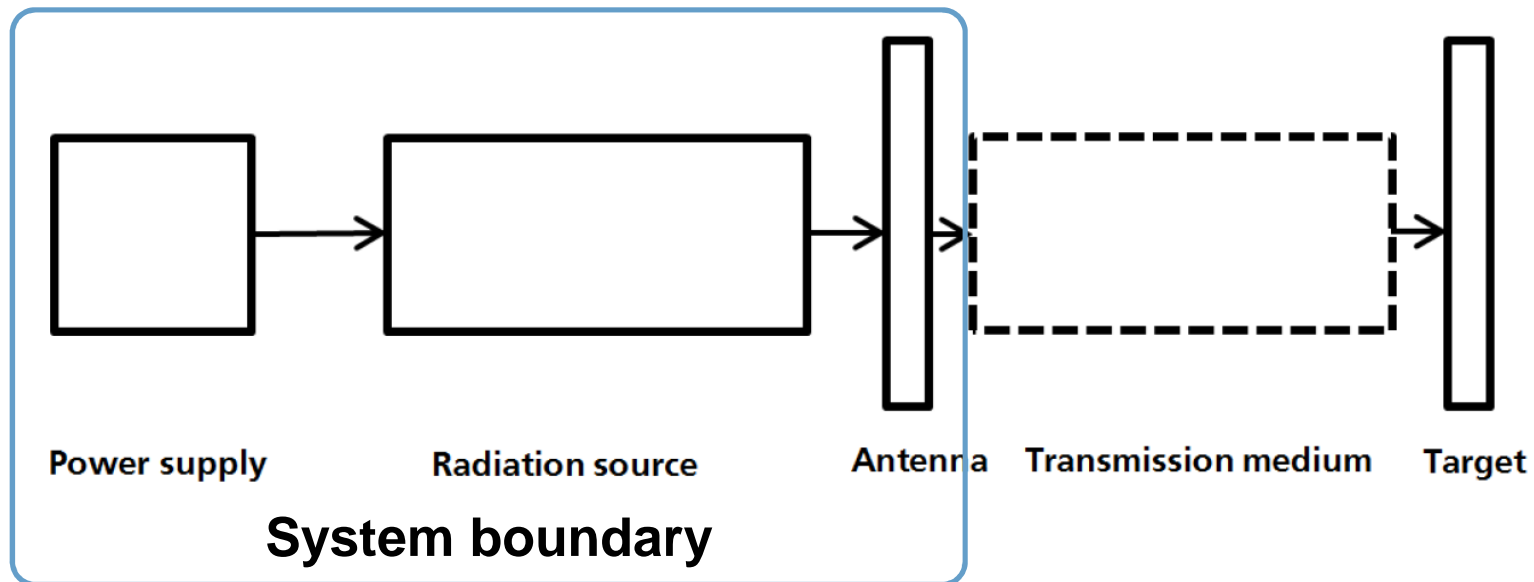
# STATE OF THE ART



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# SYSTEM ANALYSIS

Relevant components of the overall functional chain of an electromagnetic antipersonnel system



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# MEDICAL ASPECTS

- › Two types of effects were identified, a (short term) **thermal effect** and a (potentially long term) **non-thermal effect**.
- › In line with the vast majority of the scientific community: any biological effect occurring from 95 and 34 GHz mmw initiates within the skin or the cornea

## Thermal

Localised rise in temperature

Well documented, well understood

Balancing via conductive mechanism

$$\frac{dT}{dt}_{95\text{GHz}} > \frac{dT}{dt}_{35\text{GHz}}$$

## Non-thermal

Biological effects other than heating  
(hypothesis)

Very few studies at 95 or 34 GHz

No final consensus yet between  
investigators

# HEALTH ASSESSMENT

- › The health assessment (thermal effect) is performed by scoring different potentially occurring injuries on their chances of occurrence and on their associated severity.

Nominal opponent												
Conditions of exposure	Short exposure times				Medium exposure times				Long exposure times			
	95 GHz Systems		34 GHz Concept		95 GHz Systems		34 GHz Concept		95 GHz Systems		34 GHz Concept	
mmw system / concept	Chance	Severity	Chance	Severity	Chance	Severity	Chance	Severity	Chance	Severity	Chance	Severity
Injury potential	++	Skin	-	Skin / eye	O	Skin	+	Eye	-	Skin	++	Eye
	+	Skin	O	Eye	-	Skin	O	Eye	--	Skin	-	Eye
	O	Skin	+	Eye	--	Skin	-	Eye	N.A.	N.A.	--	Eye

Vulnerable opponent												
Conditions of exposure	Short exposure times				Medium exposure times				Long exposure times			
	95 GHz Systems		34 GHz Concept		95 GHz Systems		34 GHz Concept		95 GHz Systems		34 GHz Concept	
mmw system / concept	Chance	Severity	Chance	Severity	Chance	Severity	Chance	Severity	Chance	Severity	Chance	Severity
Injury potential	N.A.	N.A.	-	Skin / eye	+	Skin	+	Eye	O	Skin	++	Eye
	++	Skin	O	Eye	O	Skin	O	Eye	-	Skin	-	Eye
	+	Skin	+	Eye	-	Skin	-	Eye	--	Skin	--	Eye

## Assessment performed on:

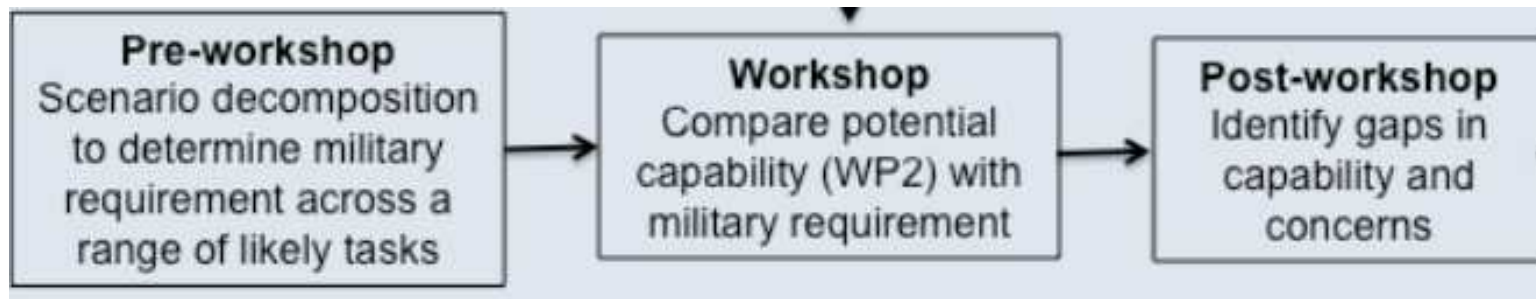
- › Two systems
- › Two opponent types
- › Three exposure conditions

The (short term) thermal effect can be managed for both systems at 95 and 34 GHz by limiting the exposure conditions within certain boundaries and therefore insuring a safe and effective use of the systems.

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# EVALUATION OF PERFORMANCE IN MILITARY SCENARIOS

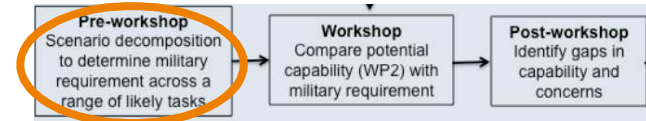
## Approach





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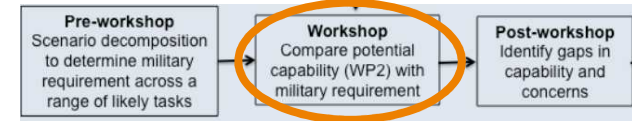
# EVALUATION OF PERFORMANCE IN MILITARY SCENARIOS



- › Selected 2 scenarios of potential interest to EU members:
  - › **Suriname** – instability and natural disaster
  - › **Djibouti** – political unrest and port of geostrategic importance
- › Used EU Generic Military Task List & NATO Tactical Task List
- › Vignettes for technology assessment were:
  - › Suriname
    - Crowd control
    - Vehicle Control Point
    - Establish a secure perimeter
    - Convoy security
  - › Djibouti
    - Visit, board, search and seize
    - Port security

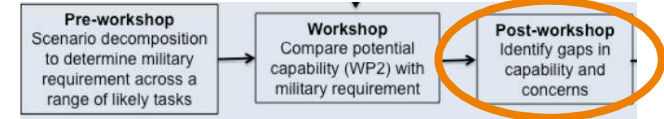
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# EVALUATION OF PERFORMANCE IN MILITARY SCENARIOS



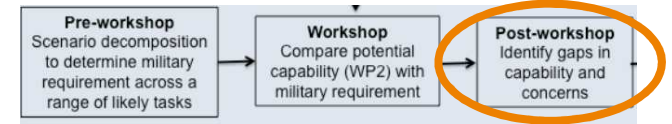
- › Graded metrics using traffic-light approach with support from JNLWD (for ADS & SG) and military / technology experts in a workshop (held at EDA on 24 Jun 14)
- › For each task, defined environment and military requirement
- › Assessed each system to meet military requirement, using following metrics:
  - › Range / environmental (rain / day or night / poor visibility)
  - › Effect on target / user and target safety
  - › Directivity and control
  - › Social acceptance
  - › Transportability and usability

# EVALUATION OF PERFORMANCE IN MILITARY SCENARIOS



Task		μWave Technology				
		ADS	SG	SS-ADT	Hand-held Systems	34 GHz Systems
Task 1	Move an individual within a crowd (in the open). Range 25-100m		✓	✓	✓	
Task 2	Move a group in the open. Range 25-45m		✓	✓	✓	
Task 3	Stop a vehicle. Range 150m		✓	✓		
Task 4	Deny access to vehicles. Range variable depending on 'stand-off'	✓	✓	✓		
Task 5	Provide warning to a crowd to disperse. Range 10-150m		✓	✓	✓	
Task 6	Disable weapons and comms equipment. Range 10-150m					
Task 7	Deny access to individuals in open. Range variable depends on 'stand-off'	✓	✓	✓	✓	
Task 8	Tag / mark individuals. Range 20-100m					
Task 9	Disable / stop a vessel. Range variable depending on 'stand-off'					
Task 10	Stop / incapacitate an individual on a vessel. Range 20m				✓	
Task 11	Deny access to individual in or underwater. Range depends on 'stand-off'					
Task 12	Move group from confined area. Range <50m				✓	

# EVALUATION OF PERFORMANCE IN MILITARY SCENARIOS



System	Range	Effect	Directivity	Social acceptance	Utility
ADS/SG	✓	✓	✓	—	—
SS ADT	—	✓	✓	—	—
Hand Held	—	—	—	✓	✓
Eye trigger	—	⊘	—	⊘	—

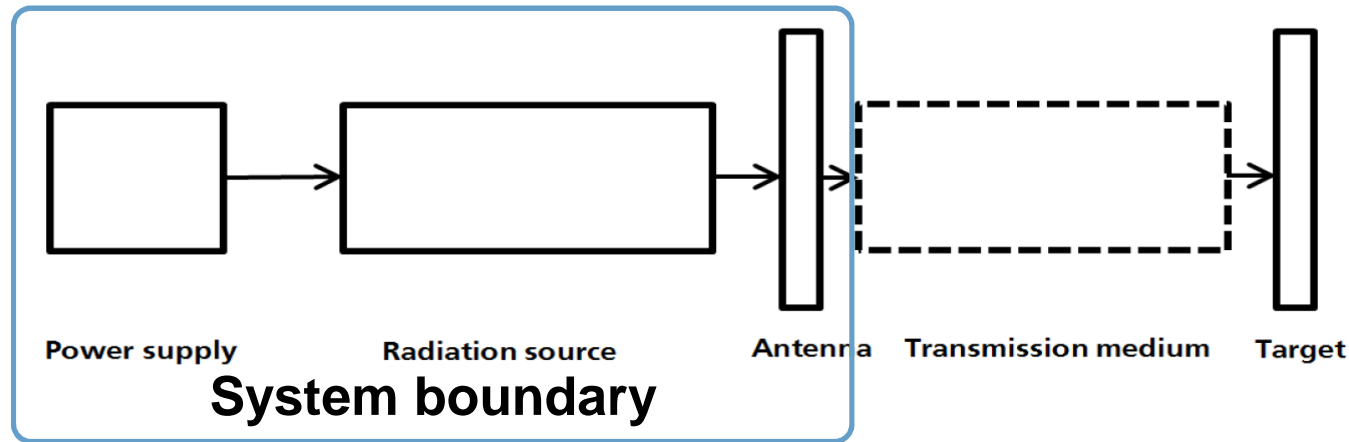
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# EVALUATION OF PERFORMANCE IN MILITARY SCENARIOS

- › No technology met the military requirement in full but 95 GHz systems were deemed effective in most CP tasks.
- › Hand-held systems seem to bring highest operational benefits.
- › Experts expressed concern regarding acceptability.
- › Availability of mounted versus dismounted systems.
  
- › Identified area for improvement:
  - Short range versus long range
  - Flexibility in deployment
  - Ease of transport/handling

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# TECHNOLOGY FORESIGHT



- › The following three technologies would provide on the long term the most benefits for the systems (based on identified gaps and requirements):
- Lithium based power supplies
  - Gallium Nitride based RF sources (Solid State technology)
  - Array design of antennas

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# TECHNOLOGY FORESIGHT

**Technological maturity prediction of 95 GHz components in the next five years**

Technological development	General current TRL	$\mu$ W relevant current TRL	$\mu$ W relevant desired TRL	Investment demand	Future military potential
<b>Power supply</b>	8-9	8	8-9	Moderate (0)	Large (+)
<b>RF source (GaN)</b>	6-7	5-6 (US) not recognized (EU)	7-8 (US) 3-4 (EU)	Substantial (++)	Large (+)
<b>Antenna</b>	8-9	5-6 (US) not recognized (EU)	7-8 (US) 5-7 (EU)	Moderate (o)	Moderate (o)

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# CONCLUSIONS AND RECOMMENDATIONS

- › The study assessed the current state of the art in counter personnel millimetre wave systems on technical, operational and medical aspects.
- › The assessment shows that the microwave systems operating at 95 GHz have a very high potential for counter personnel applications specifically in the smaller, lighter and more flexible (in deployment) version.
- › General recommendations for CP microwave systems :
  - › Develop guidelines on concepts of use and TTPs
  - › Decisive Information Operations campaign in theatre
  - › Research on long term effects of microwave radiations (at relevant frequencies)

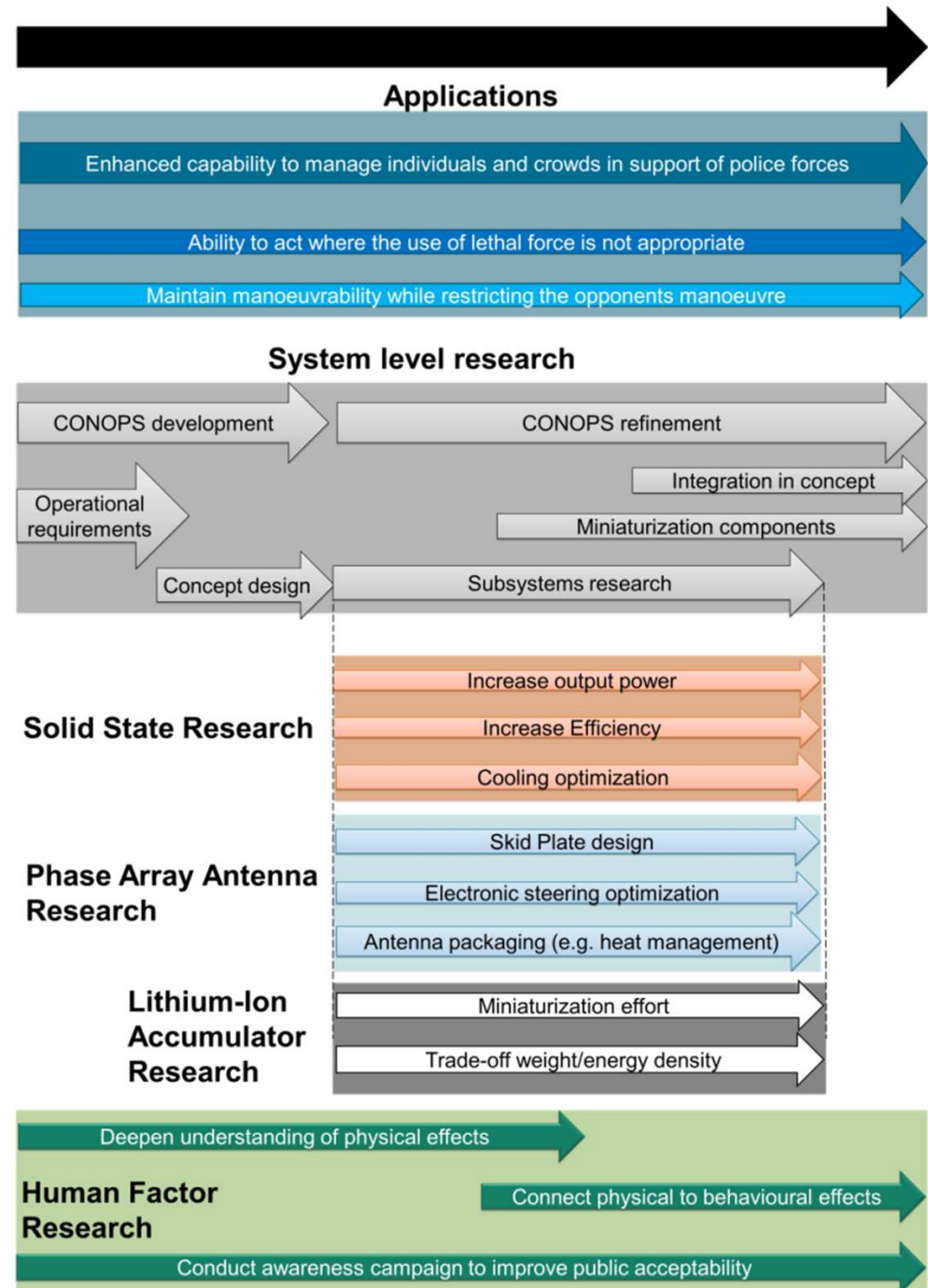


# ROADMAP TOWARD EU DEVELOPMENTS

- › The roadmap is intended as blueprint to develop a compact millimeter wave system.
- › The recommendations (including technological) from the study were used as guidelines to develop it.

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