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***Agent-Based Models in  
a Changing Environment***

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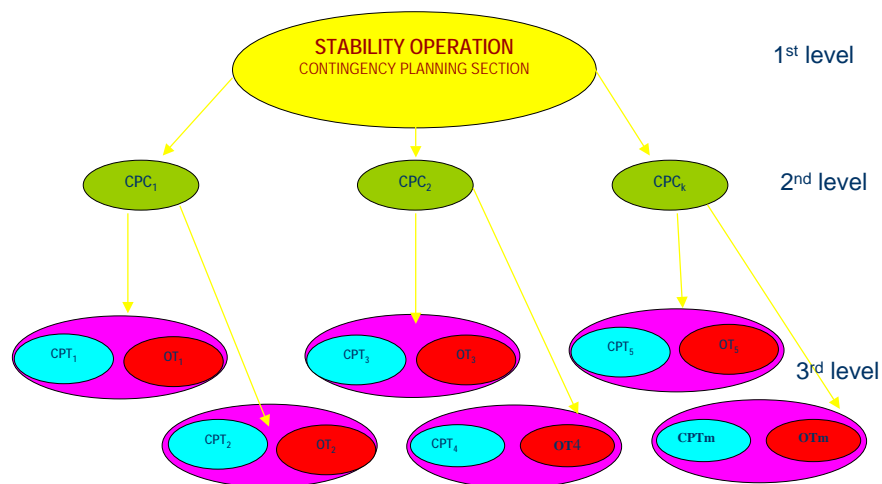


## AGENT-BASED MODELS IN A CHANGING ENVIRONMENT

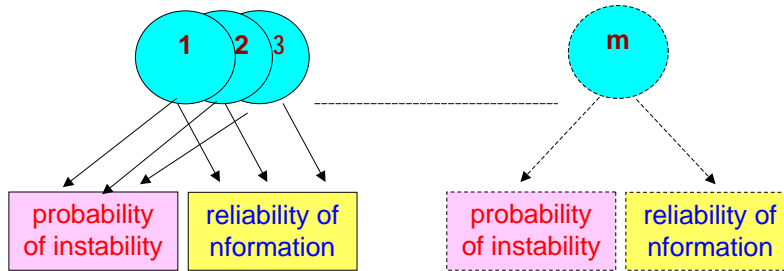
### Proposed Methodology:

- 3 Level Structure of Adaptive Agent-Based Model at Tactical Level,
- Agents of Contingency Planning Team on the spot,
- A Conversion of Information on Stability Threats to Subjective Probability as part of D-P-N,
- A Selection of Threat (Risks) to Stability.

### Proposed Formal Structure at a SO



## Agents of CPT of Proposed Model



## Formula for Criterion of CPT Agent Information

Agents of CPT:

- $M = \{a_1, a_2, \dots, a_m\}$  – set of sources of information,
- $N = \{b_1, b_2, \dots, b_n\}$  – a set of possible threats (risks),
- $R = \{c_1, c_2, \dots, c_r\}$  – a set of possible stability measures (stages).

As criterion of reasons of instability we can choose probability of its creation based on possible threat identified by agents.

We can mark such criterion by the formula:

$$f_j(p_{i,j}) = p_{i,j} \cdot z_i, \quad \text{for } j = 1, \dots, N$$

- where,  $p_{i,j}$  – probability of creation of instability identified by an agent and as a consequence of its reason  $j$ ,
- $z_i$  - reliability (weight) of source of information  $i$ .

## Conversion of verbal expressions to numerical values

Verbal (qualitative) expressions	Probability
excluded	0
almost excluded	0,1
little possibility	0,2
less probable	0,3
nearly probable	0,4
uncertainly	0,5
probably	0,6
enough probably	0,7
more probably	0,8
almost certainly	0,9
certainly	1,0

## Matrix of Subjective Probability

$M \setminus N$	$b_1$	$b_2$	...	$b_{n-1}$	$b_n$
$a_1$	$p_{11}$	$p_{12}$		$p_{1n-1}$	$p_{1n}$
$a_2$	$p_{21}$	$p_{22}$		$p_{2n-1}$	$p_{2n}$
...	...	...		...	...
$a_{m-1}$	$p_{m-11}$	$p_{m-12}$		$p_{m-1n-1}$	$p_{m-1n}$
$a_m$	$p_{m1}$	$p_{m2}$		$p_{mn-1}$	$p_{mn}$

$$f_j(p_{i;j}) = p_{i;j} \cdot z_i, \quad \text{for } j = 1, \dots, N$$

## Criterion of Possible Threats

Suppose that risks are of different significance (weight).

After that,

a value of criterion is determined by the formula:

$$F_j = f_j \cdot v_j$$

$$\sum_{j=1}^n v_j = 1$$

## The Probability of Stability

- To judge a stability of a stage or system we can use an aspiration level method,
- To determine a certain level of acceptable risk - aspire level,
- If some of values  $F_j$  overstep the level, stability of the system is threatened, necessary to take measures to fix the stage.

## **CONCLUSION**

**It is the one of possible approaches.**

**It based on a conversion of verbal (qualitative) expressions to quantitative ones. It is expected it will improve realism of simulation systems.**

**Added value of the article is proposed the multi-agent model of CPT which processes information on threat in stability operation.**