

BowTie Metodologija procijene sigurnosnog rizika



Marino Tudor
marino@galiot.net
MER Systems d.o.o.

Zajednički ciljevi i principi svih upravljačkih sustava sigurnosti

1. Ciljevi

- (i) Sustav temeljen na performansama
- (ii) Proaktivno model upravljanja

2. Principi

- (i) “Plan, Do, Check, Act”
- (ii) Upravljanje temeljeno na procjeni rizika

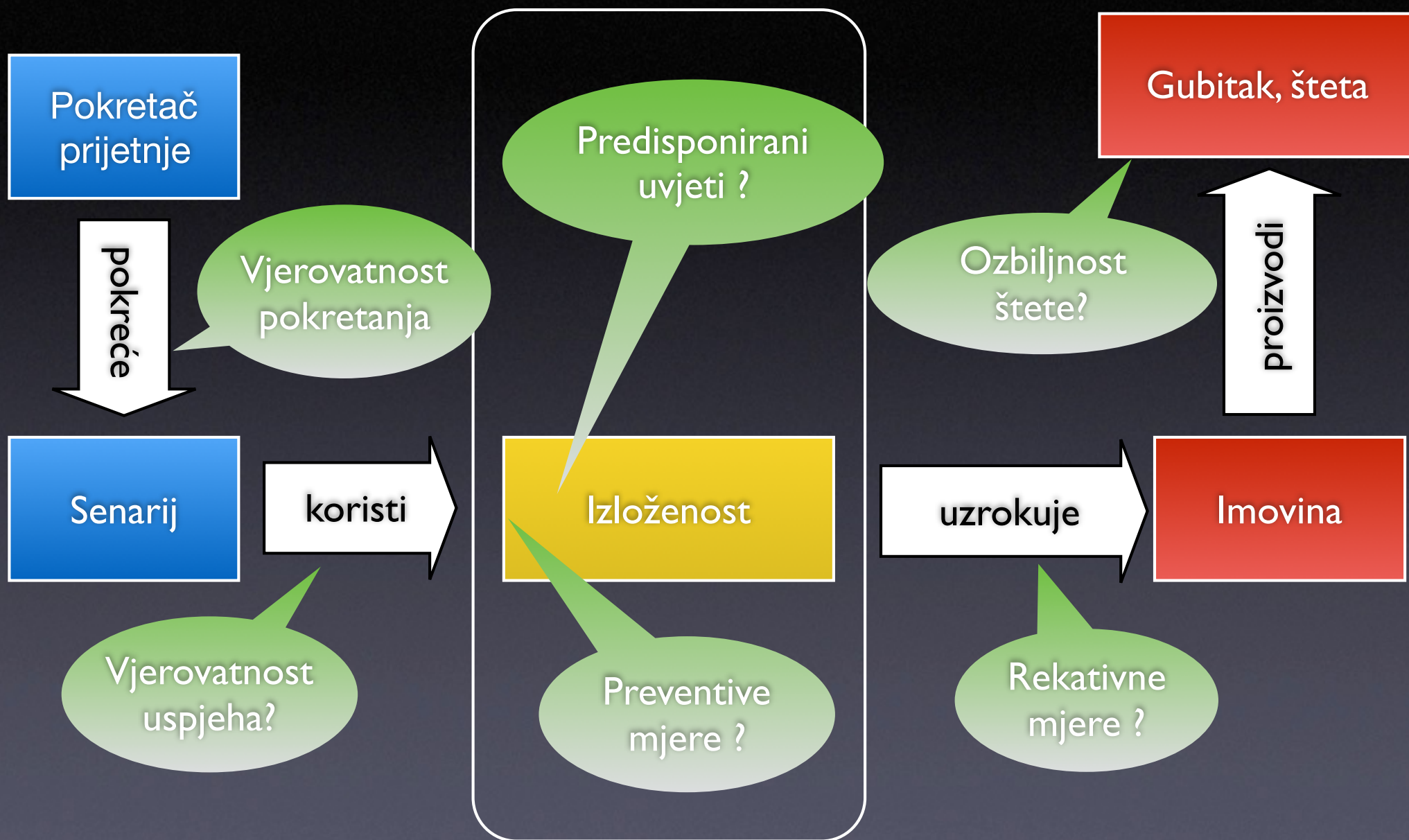
Osnovna funkcija procijene rizika -> Matrica Rizika

$$\text{Rizik} = f(\text{Vjerojatnost, Ozbiljnost Štete})$$

Risk Assessment Matrix

	E - (1) Negligible Little consequences	D - (2) Minor Nuisance / Operating limitations / Use of emergency procedures / Minor incident	C - (3) Major A significant reduction in safety margins, a reduction in the ability of the operators to cope with adverse operating conditions as a result of increase in workload, or as a result of conditions impairing their efficiency / Serious incident / Injury to persons	B - (4) Hazardous A large reduction in safety margins, physical distress or a workload such that the operators cannot be relied upon to perform their tasks accurately or completely / Serious injury / Major equipment damage	A - (5) Catastrophic Equipment destroyed / Multiple deaths
5 - Frequent	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input checked="" type="radio"/> Tolerable <input type="radio"/> Unacceptable 5E 1 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input checked="" type="radio"/> Tolerable <input type="radio"/> Unacceptable 5D 11 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input type="radio"/> Tolerable <input checked="" type="radio"/> Unacceptable 5C 12 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input type="radio"/> Tolerable <input checked="" type="radio"/> Unacceptable 5B 13 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input type="radio"/> Tolerable <input checked="" type="radio"/> Unacceptable 5A 14 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval
4 - Occasional	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input checked="" type="radio"/> Tolerable <input type="radio"/> Unacceptable 4E 2 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input checked="" type="radio"/> Tolerable <input type="radio"/> Unacceptable 4D 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input type="radio"/> Tolerable <input checked="" type="radio"/> Unacceptable 4C 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input type="radio"/> Tolerable <input checked="" type="radio"/> Unacceptable 4B 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input type="radio"/> Tolerable <input checked="" type="radio"/> Unacceptable 4A 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval
3 - Remote	<ul style="list-style-type: none"> <input checked="" type="radio"/> Acceptable <input type="radio"/> Tolerable <input type="radio"/> Unacceptable 3E 3 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input checked="" type="radio"/> Tolerable <input type="radio"/> Unacceptable 3D 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input checked="" type="radio"/> Tolerable <input type="radio"/> Unacceptable 3C 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input type="radio"/> Tolerable <input checked="" type="radio"/> Unacceptable 3B 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input type="radio"/> Tolerable <input checked="" type="radio"/> Unacceptable 3A 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval
2 - Improbable	<ul style="list-style-type: none"> <input checked="" type="radio"/> Acceptable <input type="radio"/> Tolerable <input type="radio"/> Unacceptable 2E 4 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input checked="" type="radio"/> Acceptable <input type="radio"/> Tolerable <input type="radio"/> Unacceptable 2D 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input checked="" type="radio"/> Tolerable <input type="radio"/> Unacceptable 2C 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input checked="" type="radio"/> Tolerable <input type="radio"/> Unacceptable 2B 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input type="radio"/> Acceptable <input type="radio"/> Tolerable <input checked="" type="radio"/> Unacceptable 2A 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval
1 - Extremely improbable	<ul style="list-style-type: none"> <input checked="" type="radio"/> Acceptable <input type="radio"/> Tolerable <input type="radio"/> Unacceptable 1E 5 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input checked="" type="radio"/> Acceptable <input type="radio"/> Tolerable <input type="radio"/> Unacceptable 1D 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input checked="" type="radio"/> Acceptable <input type="radio"/> Tolerable <input type="radio"/> Unacceptable 1C 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input checked="" type="radio"/> Acceptable <input type="radio"/> Tolerable <input type="radio"/> Unacceptable 1B 0 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval 	<ul style="list-style-type: none"> <input checked="" type="radio"/> Acceptable <input type="radio"/> Tolerable <input type="radio"/> Unacceptable 1A 54 Reassessment (Months) <ul style="list-style-type: none"> <input type="radio"/> No approval <input type="radio"/> Hazard Owner approval <input checked="" type="radio"/> Acc.Manager approval

Tijek sigurnosnog događaja



Napredna funkcija procijen rizika:

- > Višestruke matrice rizika
- > BowTie

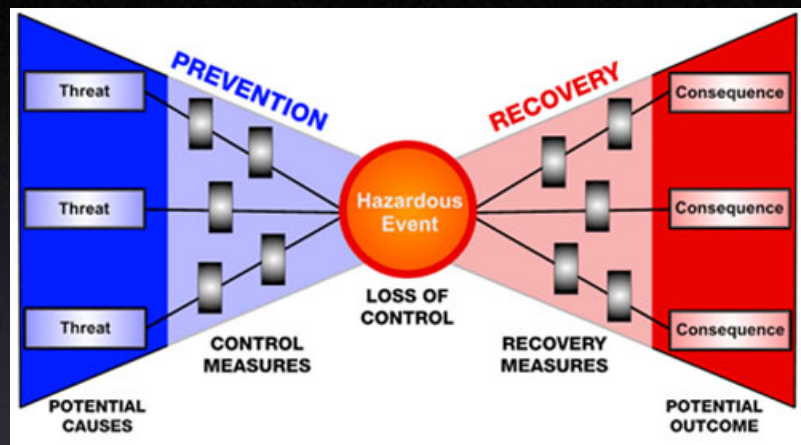
$$\text{Rizik} = f(\text{Vjerovatnost pokretanja}, \text{Nivo Izloženosti}, \text{Ozbiljnost Štete})$$


$$\text{Rizik} = f(\text{Vjerovatnost}, \text{Ozbiljnost Štete})$$

Višestruke Matrice Rizika

		Vulnerability (Vuln)					
Threat Capabi (TCap)	Threat Event Frequency (TEF)	VH	VH	VH	H	M	
		H	VH	VH	H	L	
		Loss Event Frequency (LEF)					
Threat Capabi (TCap)	Threat Event Frequency (TEF)	VH	M	H	VH	VH	VH
		H	L	M	H	H	H
		Risk					
Probable Loss Magnitude (PLM)	Severe	H	H	C	C	C	
	High	M	H	H	C	C	
	Significant	M	M	H	H	C	
	Moderate	L	M	M	H	H	
	Low	L	L	M	M	M	
	Very Low	L	L	M	M	M	
		VL	L	M	H	VH	
		Loss Event Frequency (LEF)					

BowTie Metoda

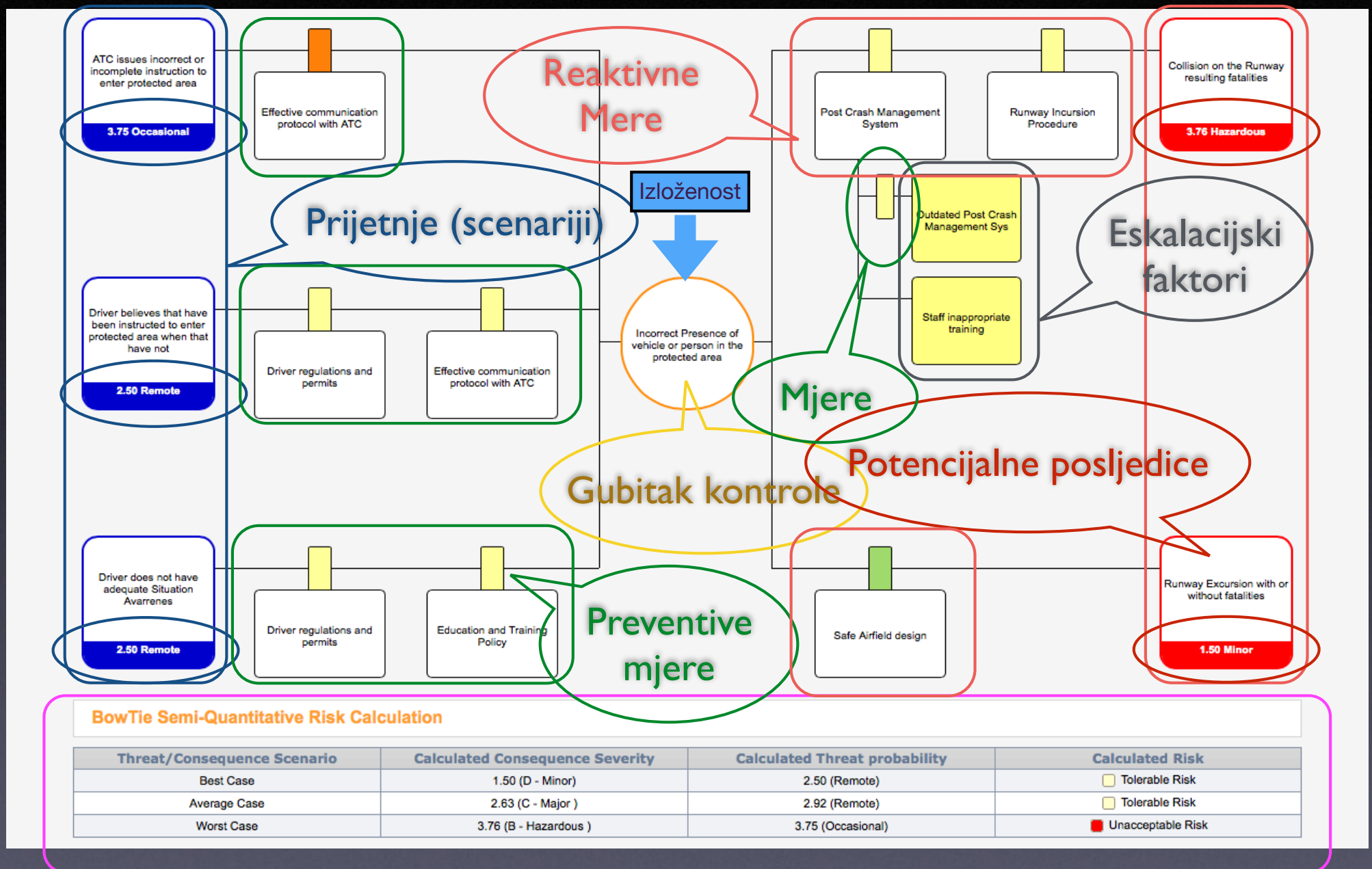


Izvori i povijest:

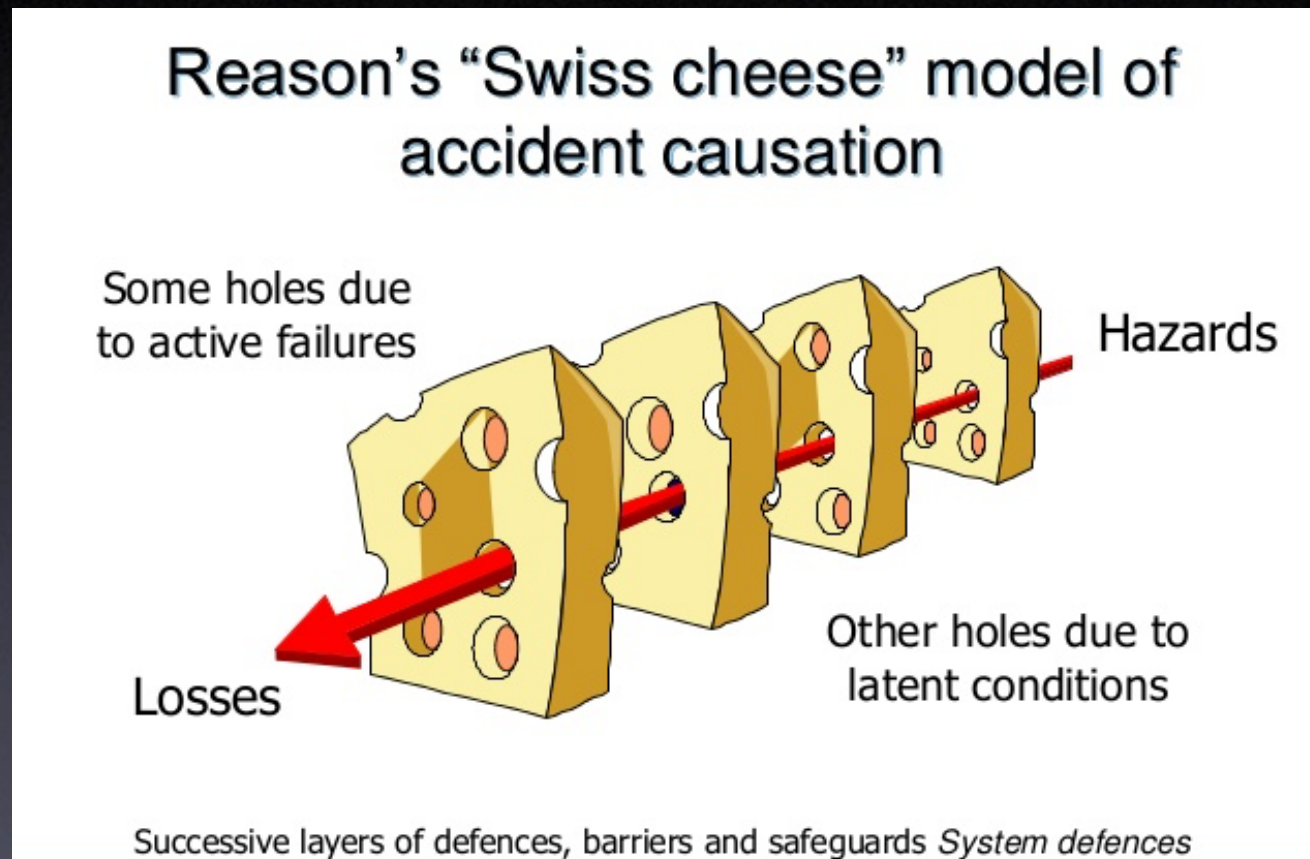
- Naslanja se na "Fault" i "Event Tree" metode
- 1979, University of Queensland, prvo akademsko pojavljivanje
- 1988, Nesreća Piper Alpha platforme, prvo korištenja
- 1992, Royal Dutch/Shell Group, standardna, širaka upotreba

....

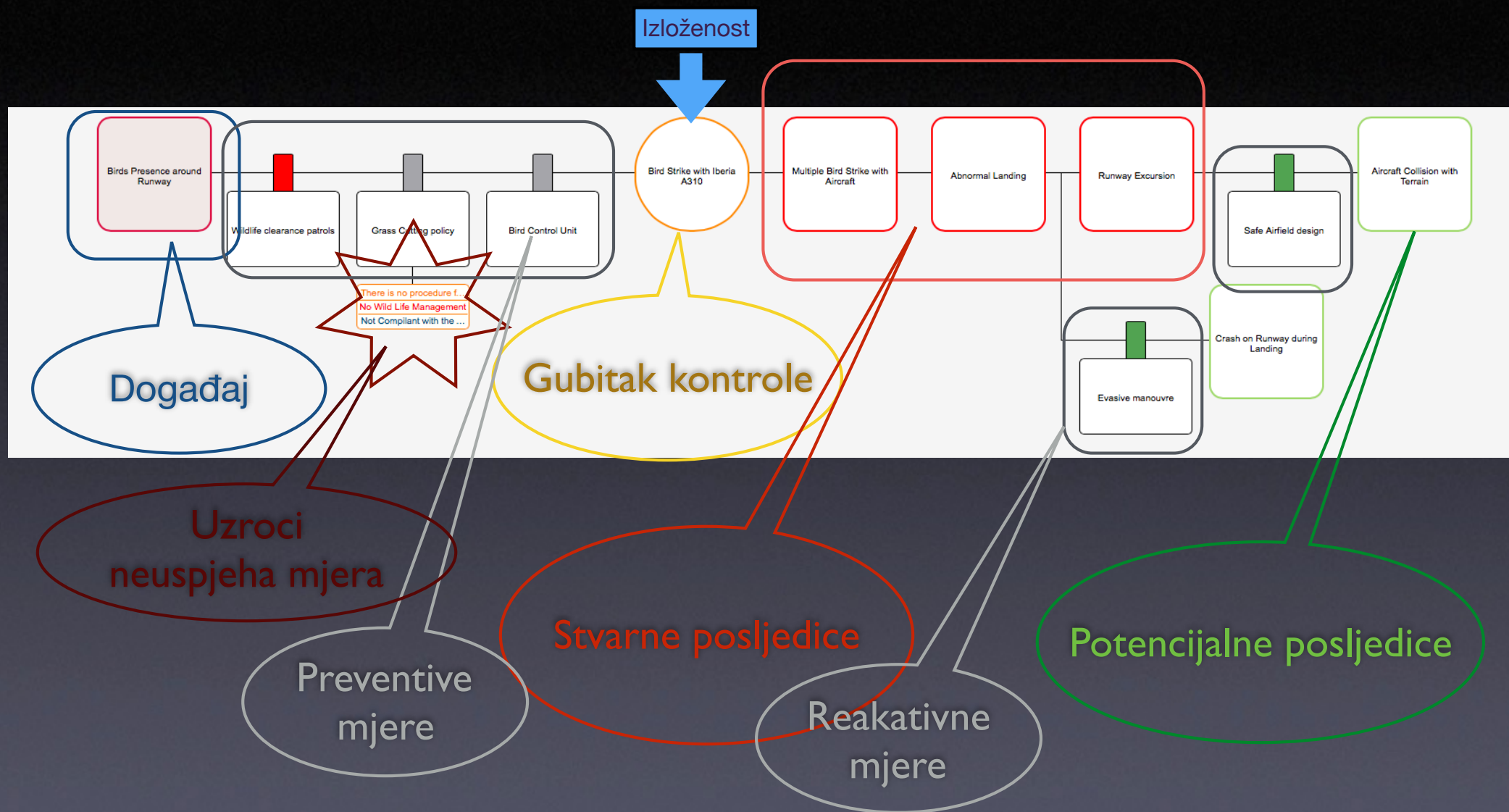
BowTie Metoda - osnovni elementi



Uzroci nezgode - “Swiss Cheese” Model



BSCAT - Metoda analize stvarne nezgode



Mjerenje efikasnosti sigurnosnih kontrola

Safety Barrier	Occurrence	Total ERC	Contribution %
MM-0006-2015 Effective communication protocol with ATC	2	512	35.50
MM-0001-2015 Wildlife clearance patrols	2	204	14.14
MM-0005-2015 Grass Cutting policy	2	204	14.14
MM-0024-2015 Bird Control Unit	2	204	14.14

MM-0018-
MM-0019-
MM-0020-
MM-0017-
MM-0008-

Safety Barrier List sort by Efficiency

No	Safety Barrier	Occurrence	Missing	Failed	Unreliable	Effective	Average Efficiency	Average Efficiency
1	MM-0017-2015 Traffic collision alerting and avoidance system	1	1	0	0	0	-	
2	MM-0005-2015 Grass Cutting policy	3	3	0	0	0	-	
3	MM-0006-2015 Effective communication protocol with ATC	3	1	2	0	0	0.66 %	
4	MM-0008-2015 Airfield lighting	1	0	1	0	0	1.0 %	
5	MM-0024-2015 Bird Control Unit	3	1	1	1	0	17.0 %	
6	MM-0001-2015 Wildlife clearance patrols	3	0	2	1	0	17.33 %	
7	MM-0019-2015 Post Crash Management System	2	0	1	1	0	25.5 %	
8	MM-0018-2015 Established Manoeuvre to avoid	2	0	1	1	0	25.5 %	
9	MM-0022-2015 Safe Airfield design	2	1	0	0	1	50.0 %	
10	MM-0020-2015 Crew Escape							
11	MM-0002-2014 Evasive manoeuvre							
12	MM-0010-2015 Appropriate							

MM-0017-2015 Tra...
MM-0008-2015 Airf...
0

Barrier Performance by Efficiency



Usporedba procjene uzroka nezgoda

Glavni uzroci potencijalnih nezgoda na temelju BowTie procijene rizika

No	Root Causes from Risk Assessment	Count
1	Hardware --> Hardware	78
2	Physical environment --> Other human-environment interface	40
3	Physical environment --> Weather/visibility conditions	30
4	Personal workload management --> Personal prioritization/task scheduling	26
5	Psychological limitations --> Psychological-attention, perception and monitoring	11
6	Human interface-procedures --> Human interface-air traffic control procedures	11
7	Psychological limitations --> Personality and attitude factors	9
8	Operational task demands --> Miscellaneous operational task demands	9
9	Human interface-procedures --> Human interface-Standard Operating Procedures	8
10	Human and hardware interface --> Workplace equipment/workplace design liveware - hardware interface	7
11	Software --> Software	7
12	Personal workload management --> Other workload management	6

Glavni uzroci nesukladnosti na temelju nalaza internih audita

Audit Finding Root Cause	Occurrence	Contribution %
Personal workload management --> Personal prioritization/task scheduling	11	34.37
Personal workload management --> Task allocation	6	18.75
Environment --> Environment	5	15.62
Software --> Software	4	12.5
Personal workload management --> High workload task shedding	2	6.25
Company, management, manning or regulatory issues --> Management's personnel policies	2	6.25
Company, management, manning or regulatory issues --> Pressure to achieve	1	3.12
The interface between humans in relation to interactions/team skills crew/team resource management training --> The interface between humans in relation to formal coordination	1	3.12

Glavni uzroci nezgoda na temelju BSCAT analize stvarnih događaja

Occurrence Root Cause	Occurrence	Total ERC	Contribution %
Hardware --> Hardware	77	525	25.57
Personal workload management --> Personal prioritization/task scheduling	26	187	9.10
Physical environment --> Other human-environment interface	40	160	7.79
Experience, knowledge and recency --> Inadequate or inaccurate knowledge	4	134	6.52
Physical environment --> Weather/visibility conditions	30	112	5.45
Physical environment --> Physical workspace environment	3	108	5.26
The interface between humans in relation to interactions/team skills crew/team resource management training --> The interface between humans in relation to formal coordination	1	102	4.96
Human software/firmware interface --> Human firmware interface	4	72	3.50
Human interface-procedures --> Human interface-air traffic control procedures	11	65	3.16

BowTie - Sažetak

- ✓ BowTie je zrela i široko korištena metoda procijene rizika
- ✓ Matrica Rizika je još uvijek standard
- ✓ BowTie je efikasna za vizualizaciju rizika za sve potencijalne scenarije
- ✓ BowTie je jednostavna za objasniti i komunicirati unutar tvrtke
- ✓ BowTie jasno razlikuje proaktivni i reaktivni dio u procjeni rizika
- ✓ BowTie je temeljena na mjerama/kontrolama i njihovoj efikasnosti
- ✓ BowTie se lako integrira sa sustavom održavanja (kvarovi)
- ✓ BowTie se lako integrira sa “scenario-based internal audits”
- ✓ BowTie jasno prezentira/identificira slabosti sustava
 (“Escalation Factor” = “Defeating Factor” = “Holes in Swiss Cheese Model”)
- ✓ BowTie je jedina metoda procijene koja se može povezati i ponovo upotrijebiti kod analize stvarne nezgode (BSCAT)
- ✓ BowTie je izvrsna platforma za razvoj i primjenu “semi-quantitative risk assessment” modela

ICAO Doc 8793 preporuka:

“Enterprise Risk Management for Total Risk Landscape”:

- Upravljanje sigurnosnim rizicima (Galiot SMS - Safety)
- Upravljanje rizicima zaštite (Galiot SeMS - Security)
- Upravljanje poslovnim rizicima (Galiot SQM - Quality)
(operacijski, finansijski, pravni, reputacijski, ... rizici)