Assumptions

Assumption 4: A 'Vulnerability Scale' may be defined, based on the assessment of the system state in the (U, V)-space. Obviously, such a definition is not univocal. One possibility, hereby adopted, is:

Measure the **Vulnerability Index by the Euclidian distance of the state (U,V) to the cusp line** in the U>=0, V>=0 region of the (U, V)-plane.
b) **Normalize the index such that**, **everywhere on the cusp line**, including its V --> 0 portion, the **Vulnerability Index** be equal to 100,
that is - reach its assumed maximum.

Thus, if D is the said the Euclidian distance to the cusp line, then the 'Vulnerability Index', Vscale, on the 0 – 100 - *'Vulnerability Scale'* - is:

Vscale = 100(1-D/15), where the (U, V) field has been conventionally limited to 0 <= U <= 15, 0 <= V <= 15.

Analytical Approach to QVA

$$\frac{-e^{\frac{u\zeta+v}{\theta}}+e^{-\frac{u\zeta+v}{\theta}}+}{\left(\frac{1}{2}-\zeta\right)e^{\frac{u\zeta+v}{\theta}}-\left(\frac{1}{2}+\zeta\right)e^{-\frac{u\zeta+v}{\theta}}}+\frac{u}{\theta}=2M$$

$$\frac{\frac{1}{2}\left(e^{\frac{u\zeta+v}{\theta}}-e^{-\frac{u\zeta+v}{\theta}}\right)-\zeta\left(e^{\frac{u\zeta+v}{\theta}}+e^{-\frac{u\zeta+v}{\theta}}\right)}{e^{\frac{u\zeta+v}{\theta}}-e^{-\frac{u\zeta+v}{\theta}}}=\frac{1}{\frac{u}{\theta}-2M}$$

$$\frac{1}{2}-\zeta\coth\left(\frac{u\zeta+v}{\theta}\right)=\frac{1}{\frac{u}{\theta}-2M}$$

$$\coth\left(\frac{u\zeta+v}{\theta}\right)=\left(\frac{1}{2}-\frac{1}{\frac{u}{\theta}-2M}\right)\frac{1}{\zeta}\approx\frac{1}{2\zeta}$$

Equation of State

$$\tanh\left(\frac{u\zeta+v}{\theta}\right)=2\zeta$$

The Vulnerability Equation of State

$$\tanh\left(\frac{u\zeta + v}{\theta}\right) = 2\zeta$$

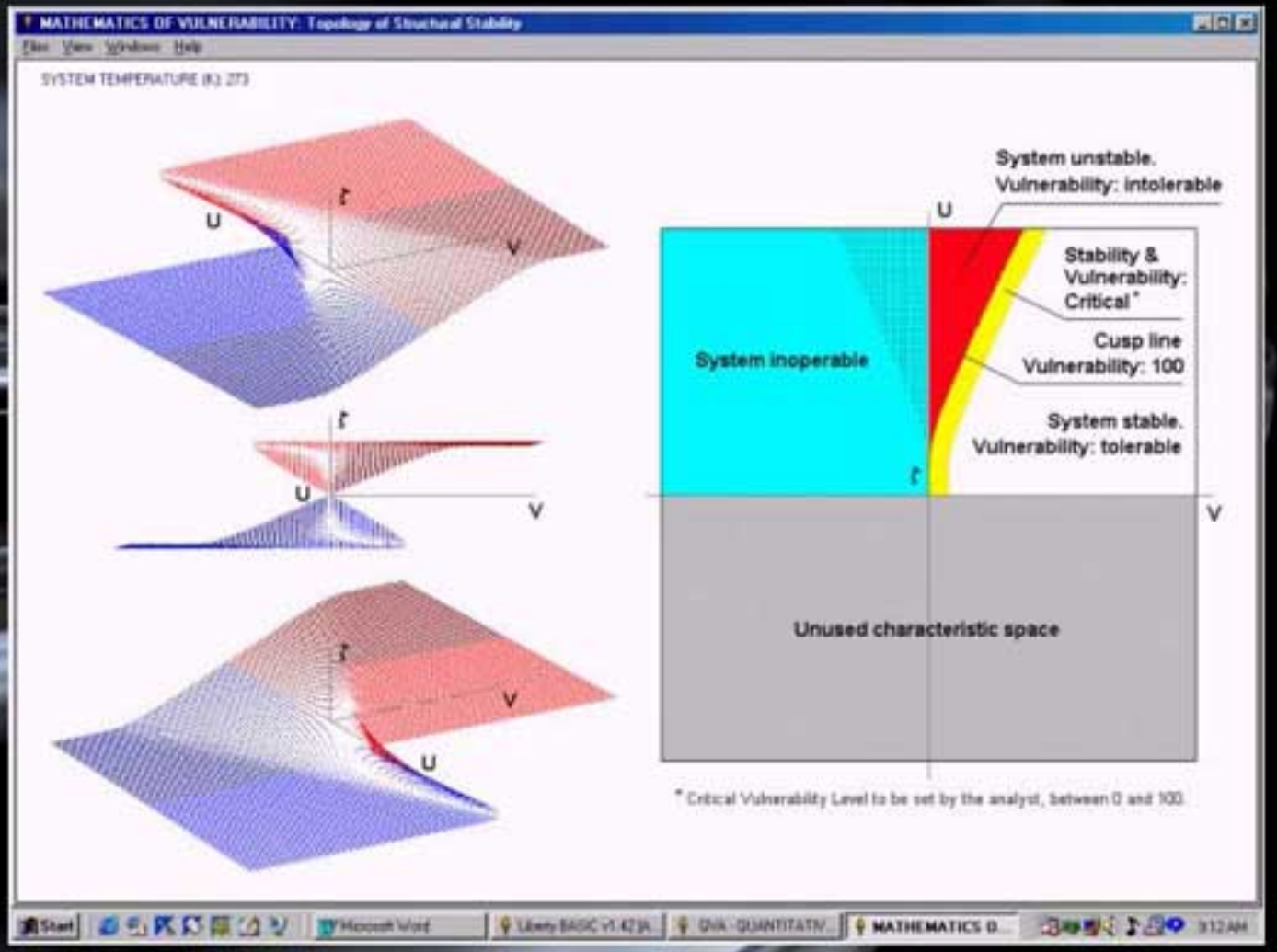
Where u : Internal-type Indicators

v : External-type Indicators

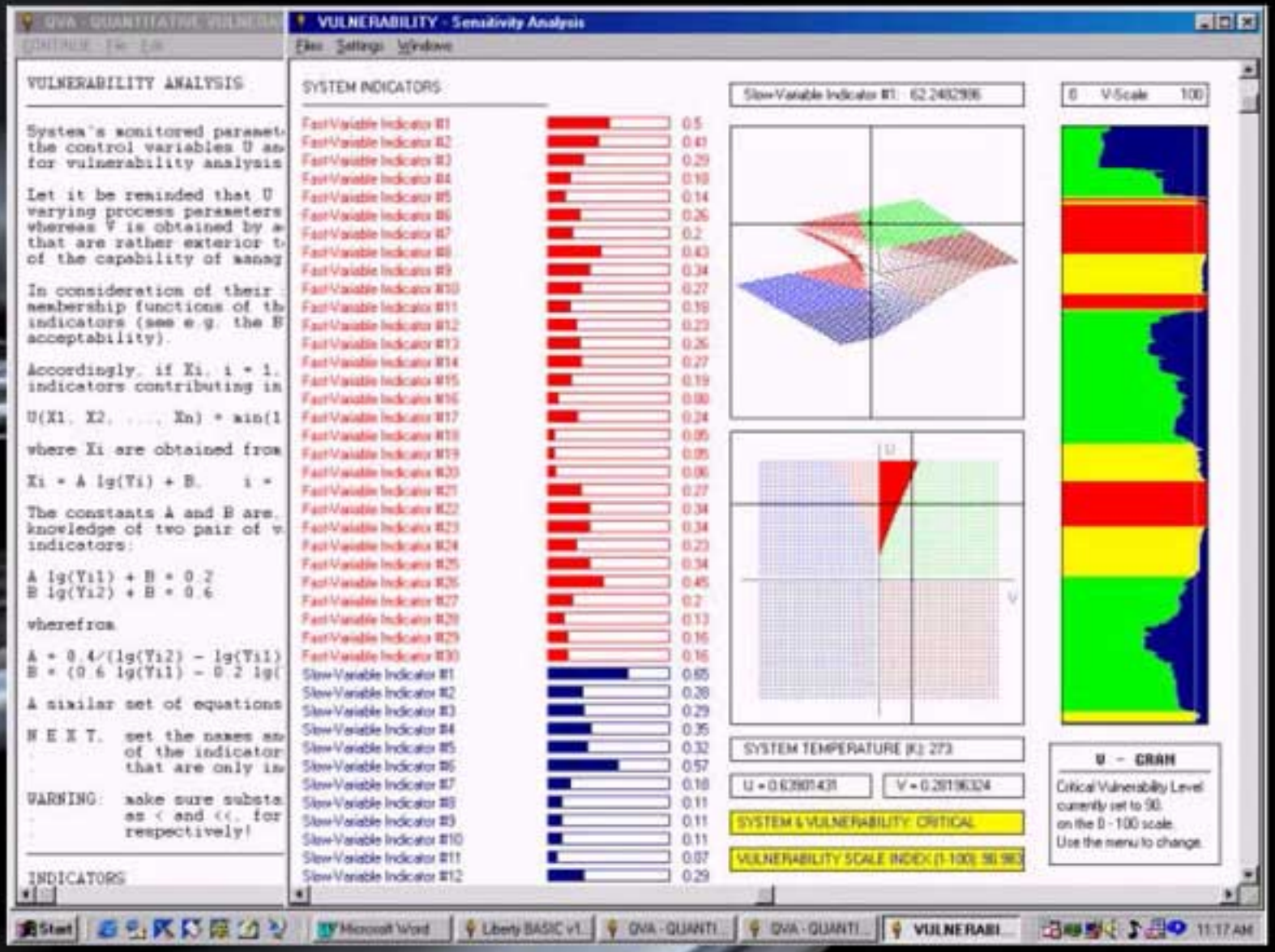
θ : Degree of Induced Stress into The System

ζ : Vulnerable State Space Indicator

Towards a Theory of Indicators Aggregation…



V-Scale


VULNERABILITY - Sensitivity Analysis
Files Settings Windows
VULNERABILITY ANALYSIS
SYSTEM INDICATORS
Slow-Variable Indicator #1: 62.2462986
0 V-Scale 100
SYSTEM TEMPERATURE (K): 273
U = 0.6360143
V = 0.28196324
SYSTEM & VULNERABILITY: CRITICAL
U - CRAN
Critical Vulnerability Level currently set to 90, on the 0 - 100 scale.
Use the menu to change.
INDICATORS

Vulnerability Assessment Petrochemical and Refineries as Critical Infrastructures: Modeling, and Decision Support System Design

VULPET VARIABLES AND RELATED ISSUES

The Vulnerability Index

The *Vulnerability Index* is a measure of the distance of the point-state of the system in its (U,V) space, to the cusp line - the limit for the 'Intolerable Vulnerability', or 'red', basin. While more analytical details may be obtained from Section 10.5, that also explains the notion of '*Residual Vulnerability*', the following are noteworthy at this time:

The meaning of the grades for Vulnerability Index is as follows:

Grade	Definition
Low	Vulnerability Index is low, and thereby system stability is considered high.
Medium	Vulnerability Index takes a median position in the 0-100 range, and thereby system stability is considered tolerable.
High	Vulnerability Index is high, and thereby system stability is considered low.

The grades are based on comparisons against peers within a defined industry segment. Guidelines specific to those industry segments are being used in the assessments.

The Vulnerability Matrix

The Vulnerability Matrix field of values is spanned by two aggregated indices, generated from plant indicators and relating to the Vulnerability Index (see 10.1) - and thereby to the U and V variables. These are:

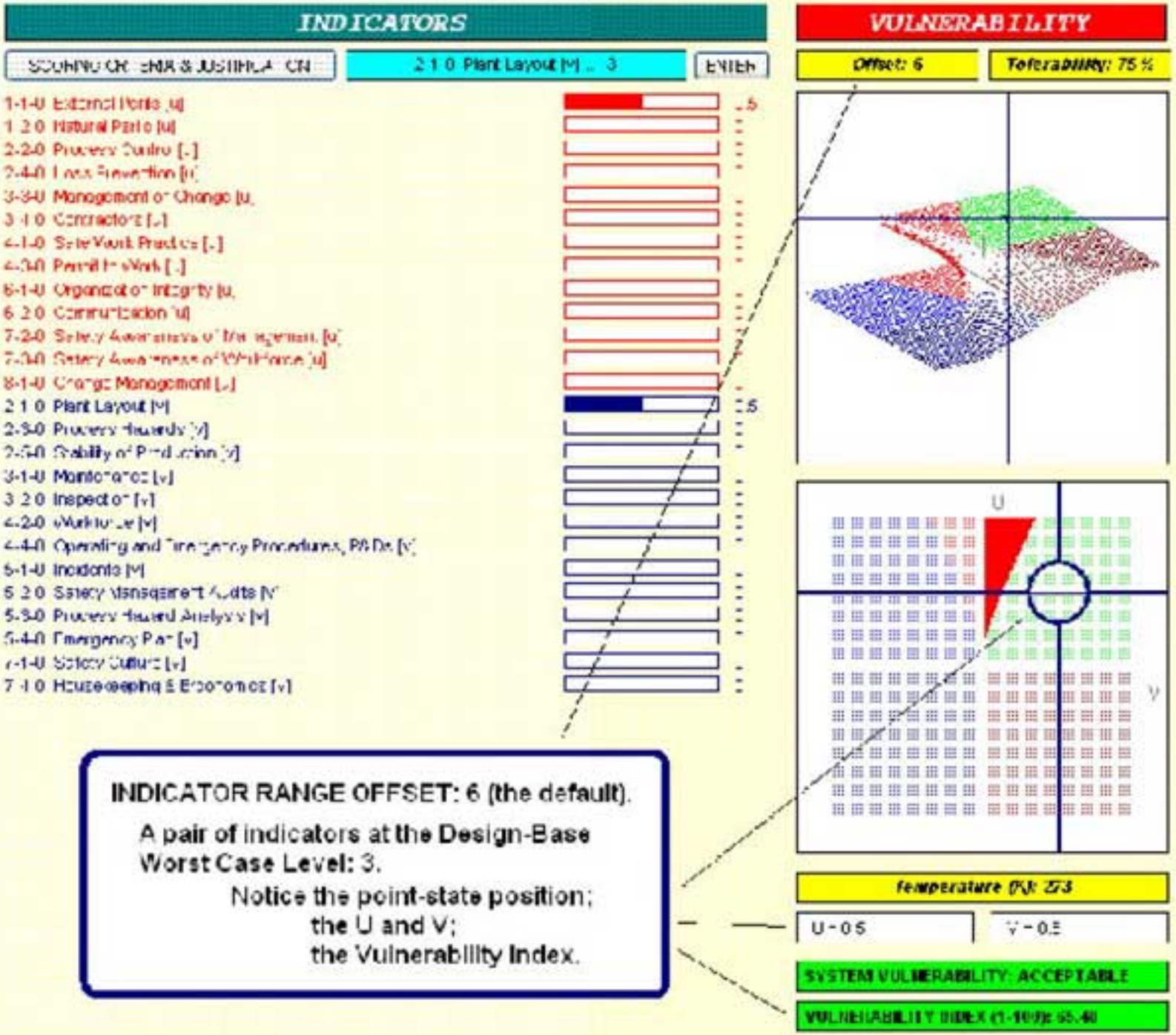
(i) the *System Deficiency Index* (U), and
(ii) the *Management Deficiency Index* (1-V).

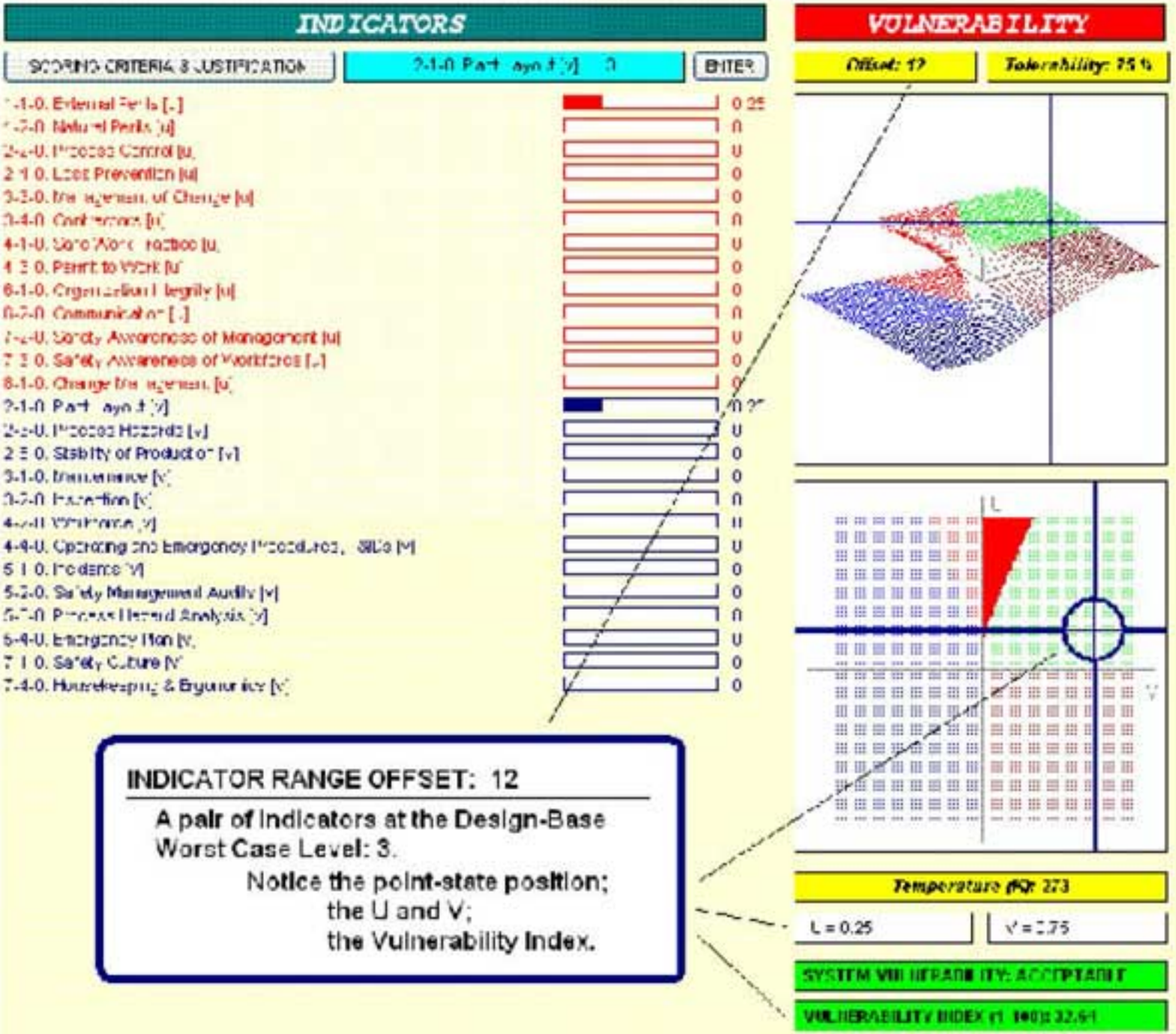
A pair of such indices features, at any time, *the vulnerability state (condition) of the plant* and corresponds to a 'point-state' in the field of the matrix.

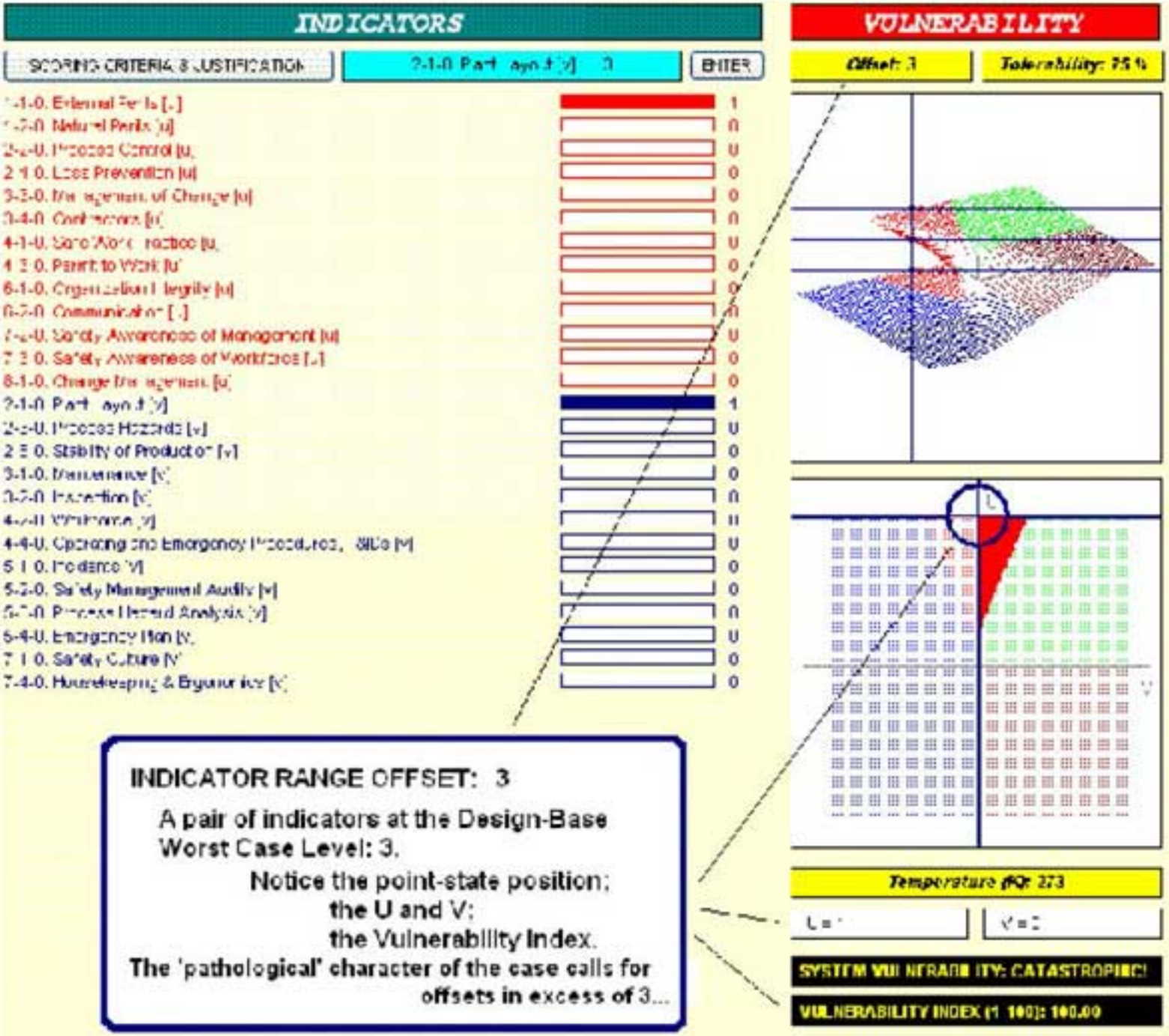
The analytical manner of building *indexes* U and V from hosts of *indicators* of [u], and [v] types, respectively is derived from the Fuzzy Set theory of impact indicators, and is explained at some length in the chief reference paper, readable at code's runtime from the *Vulnerability Assessment Machine' module* - the 'Help' menu.

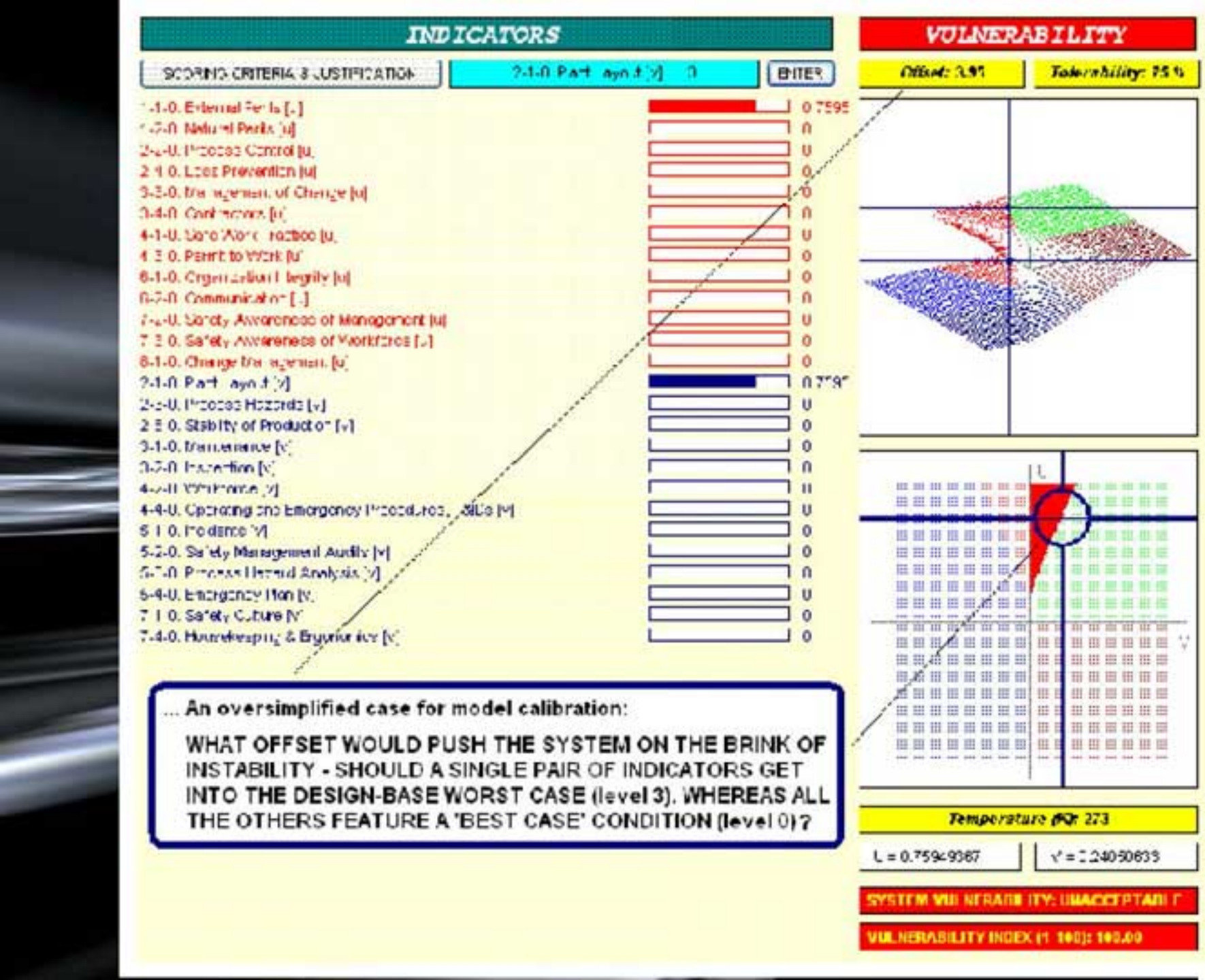
The appraisal of the vulnerability grades that result from such an analysis is based on comparisons against industry standards within a defined industry segment. Guidelines specific to those industry segments are being used in the assessments.

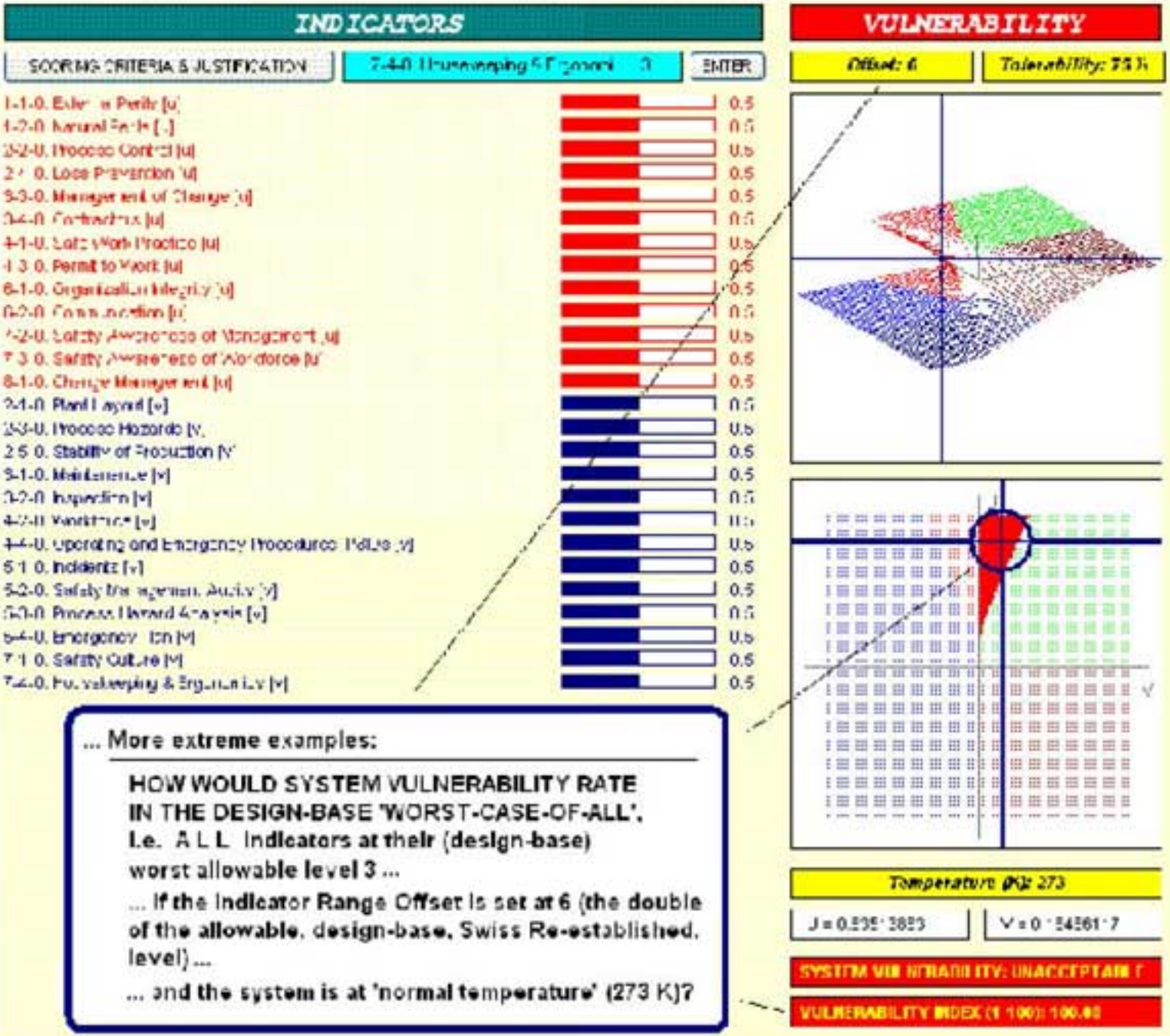
Grade	Definition
	• Expectation exceeded. • Minor or insignificant deficiency (-ies) may exist. • Strive for perfection or proactive behavior exceeds compliance. • Best in class, or exemplifying some of the best practices in the industry. **Equivalent words: Good, Above standard.** • Most expectations met. • Noteworthy deficiencies (-y) exist(s). • Compliance secured. • Acceptable standards evidenced, yet with room for improvement. **Equivalent words: Adequate, Standard.**
	• Expectations partially met. • Significant deficiencies (-y) exist(s). • Reactive behavior, leaning towards doing the minimum • Some areas are below the standard of current day practice, with considerable potential for improvement. **Equivalent words: Fair, Below Standard, Improvement needed.**
	• Expectations not met. • Critical deficiencies (-y) exist(s). • Defensive behavior, culture of 'cutting corners'. • Embodies few or none of the standards expected, of current day practice, with major

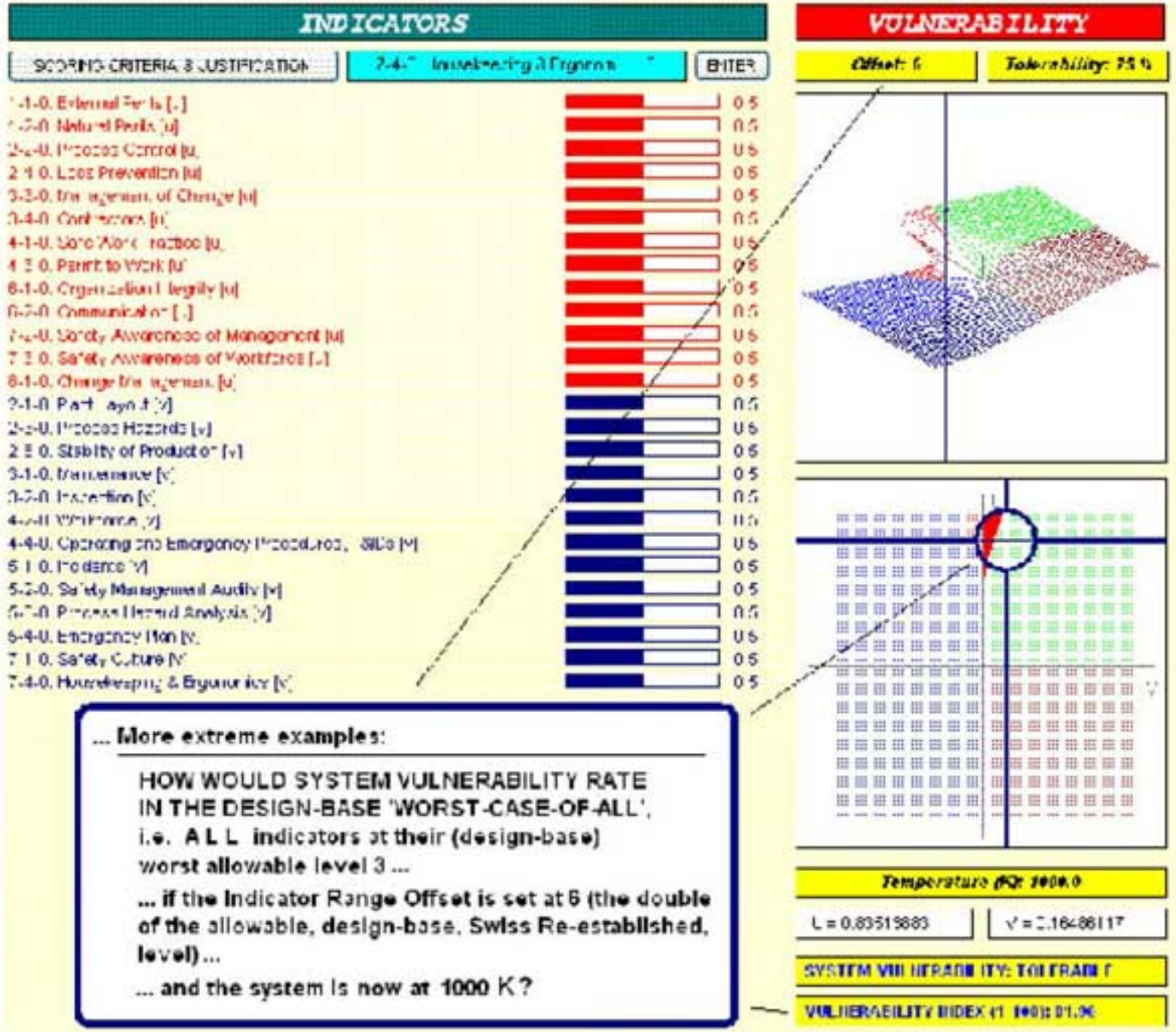

INDICATORS
2 1 0 Plant Layout [M] .. 3
1-1-0 External Forces [u]
1 2 0 Natural Perils [u]
2-2-0 Process Quality [..]
2-4-0 Loss Prevention [v]
3-3-0 Management of Change [u]
3 1 0 Connectors [..]
4-1-0 Safe Work Practices [..]
4-3-0 Permit to Work [..]
5-1-0 Organization Integrity [u]
6 2 0 Communication [u]
7-2-0 Safety Awareness of Management [u]
7-3-0 Safety Awareness of Workforce [u]
8-1-0 Change Management [..]
2 1 0 Plant Layout [M]
2-3-0 Process Hazards [v]
2-5-0 Stability of Production [v]
3-1-0 Maintenance [v]
3 2 0 Inspection [v]
4-2-0 Work Force [v]
4-4-0 Operating and Emergency Procedures, P&Ds [v]
5-1-0 Incidents [M]
5 2 0 Safety Management Audits [v]
5-3-0 Process Hazard Analysis [v]
5-4-0 Emergency Plan [v]
7-1-0 Safety Culture [v]
7 1 0 Housekeeping & Ergonomics [v]
.5
.5
VULNERABILITY
Offset: 6
Tolerability: 75 %
U
V
Temperature (K): 273
U - 0.5
V - 0.5
SYSTEM VULNERABILITY: ACCEPTABLE
INDICATOR RANGE OFFSET: 6 (the default).
A pair of indicators at the Design-Base Worst Case Level: 3.
Notice the point-state position;
the U and V;
the Vulnerability Index.


INDICATORS
SCORING CRITERIA & JUSTIFICATION
ENTER
VULNERABILITY
Offset: 12
Tolerability: 75 %
Temperature (K): 273
L = 0.25
V = 2.75
SYSTEM VULNERABILITY: ACCEPTABLE
INDICATOR RANGE OFFSET: 12
A pair of Indicators at the Design-Base Worst Case Level: 3.
Notice the point-state position;
the U and V;
the Vulnerability Index.


INDICATORS
VULNERABILITY
SCORING CRITERIA & JUSTIFICATION
ENTER
Offset: 3
Tolerability: 75 %
1-1-0. External Perils [..] 1
1-2-0. Natural Perils [u] 0
2-1-U. Protected Control [u] U
2-1-0. Loss Prevention [u] 0
3-3-0. Management of Change [u] 0
3-4-0. Conformance [u] 0
4-1-U. Safe Work Practice [u] U
4-3-0. Permit to Work [u] 0
6-1-0. Organizational Integrity [u] 0
6-2-0. Communication [..] 0
7-1-U. Safety Awareness of Management [u] U
7-3-0. Safety Awareness of Workforce [..] 0
8-1-0. Change Management [u] 0
2-1-0 Part ayout [y] 1
2-1-U. Protected Hazards [v] U
2-3-0. Stability of Production [v] 0
3-1-0. Maintenance [v] 0
3-2-0. Inspection [v] 0
4-2-U. Maintenance [y] U
4-4-U. Operating and Emergency Procedures, Skills [v] U
5-1-0. Prudence [v] 0
5-3-0. Safety Management Audits [v] 0
5-5-0. Process Hazard Analysis [y] 0
6-4-U. Emergency Plan [v] U
7-1-0. Safety Culture [v] 0
7-4-0. Housekeeping & Ergonomics [v] 0
INDICATOR RANGE OFFSET: 3
A pair of indicators at the Design-Base Worst Case Level: 3.
Notice the point-state position:
the U and V;
the Vulnerability Index.
The 'pathological' character of the case calls for offsets in excess of 3...
Temperature (K): 273
U = 1
V = 1
SYSTEM VULNERABILITY: CATASTROPHIC!
VULNERABILITY INDEX (1-100): 100.00


INDICATORS
VULNERABILITY
ENTER
0.7595
0.7787
... An oversimplified case for model calibration:
WHAT OFFSET WOULD PUSH THE SYSTEM ON THE BRINK OF INSTABILITY - SHOULD A SINGLE PAIR OF INDICATORS GET INTO THE DESIGN-BASE WORST CASE (level 3), WHEREAS ALL THE OTHERS FEATURE A 'BEST CASE' CONDITION (level 0)?


INDICATORS
VULNERABILITY
SCORING CRITERIA & JUSTIFICATION
ENTER
Offset: 6
0.5
0.6
Temperature (K): 273
... More extreme examples:
HOW WOULD SYSTEM VULNERABILITY RATE IN THE DESIGN-BASE 'WORST-CASE-OF-ALL', I.e. A L L Indicators at their (design-base) worst allowable level 3 ...
... If the Indicator Range Offset is set at 6 (the double of the allowable, design-base, Swiss Re-established, level) ...
... and the system is at 'normal temperature' (273 K)?

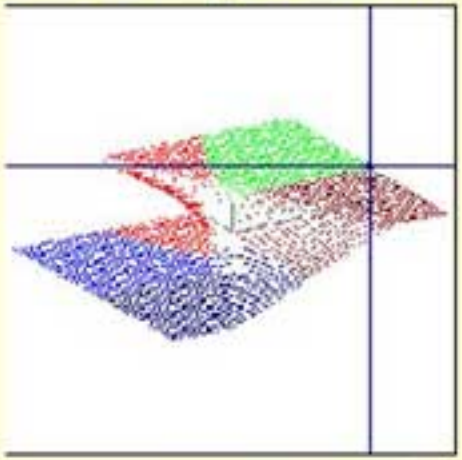

INDICATORS
VULNERABILITY
SCORING CRITERIA & JUSTIFICATION
ENTER
Offset: 6
Tolerability: 75 %
0.5
Temperature [K]: 1000.0
L = 0.83519883
V = 2.16486117
SYSTEM VULNERABILITY: TOLERABLE
... More extreme examples:
HOW WOULD SYSTEM VULNERABILITY RATE IN THE DESIGN-BASE 'WORST-CASE-OF-ALL', i.e. ALL indicators at their (design-base) worst allowable level 3 ...
... if the Indicator Range Offset is set at 6 (the double of the allowable, design-base, Swiss Re-established, level) ...
... and the system is now at 1000 K?

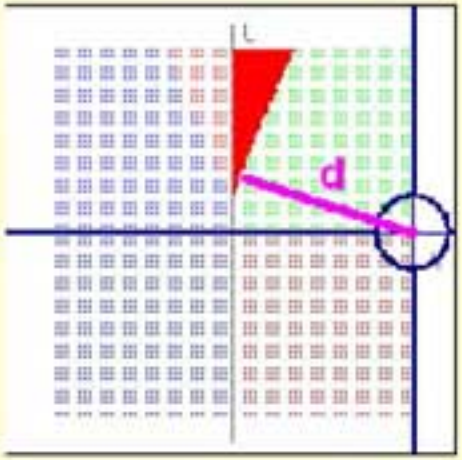
INDICATORS

SCORING CRITERIA & JUSTIFICATION	TRADEOFFS CHANGEABILITY	ENTER
1-1-0. External Perils [-]		0
1-2-0. Natural Perils [-]		0
2-1-U. Process Control [u]		U
2-1-0. Loss Prevention [u]		0
3-3-0. Management of Change [u]		0
3-4-0. Contractors [u]		0
4-1-U. Work Atmosphere [u]		U
4-2-0. Permit to Work [u]		0
6-1-0. Organizational Integrity [u]		0
6-2-0. Communication [-]		0
7-1-U. Safety Awareness of Management [u]		U
7-2-0. Safety Awareness of Workforce [-]		0
8-1-0. Change Management [u]		0
2-1-0. Plant Layout [v]		0
2-2-U. Process Hazards [v]		U
2-5-0. Stability of Production [v]		0
3-1-0. Maintenance [v]		0
3-2-0. Inspection [v]		0
4-2-U. Work Permit [v]		U
4-4-U. Operating and Emergency Procedures, SIOs [v]		U
5-1-0. Procedure [v]		0
5-2-0. Safety Management Audits [v]		0
5-3-0. Process Hazard Analysis [v]		0
6-4-U. Emergency Plan [v]		U
7-1-0. Safety Culture [v]		0
7-4-0. Housekeeping & Equipment [v]		0

VULNERABILITY

Offset: 6 | Tolerability: 75 %





Temperature (K): 273

L = 0 | V = 1

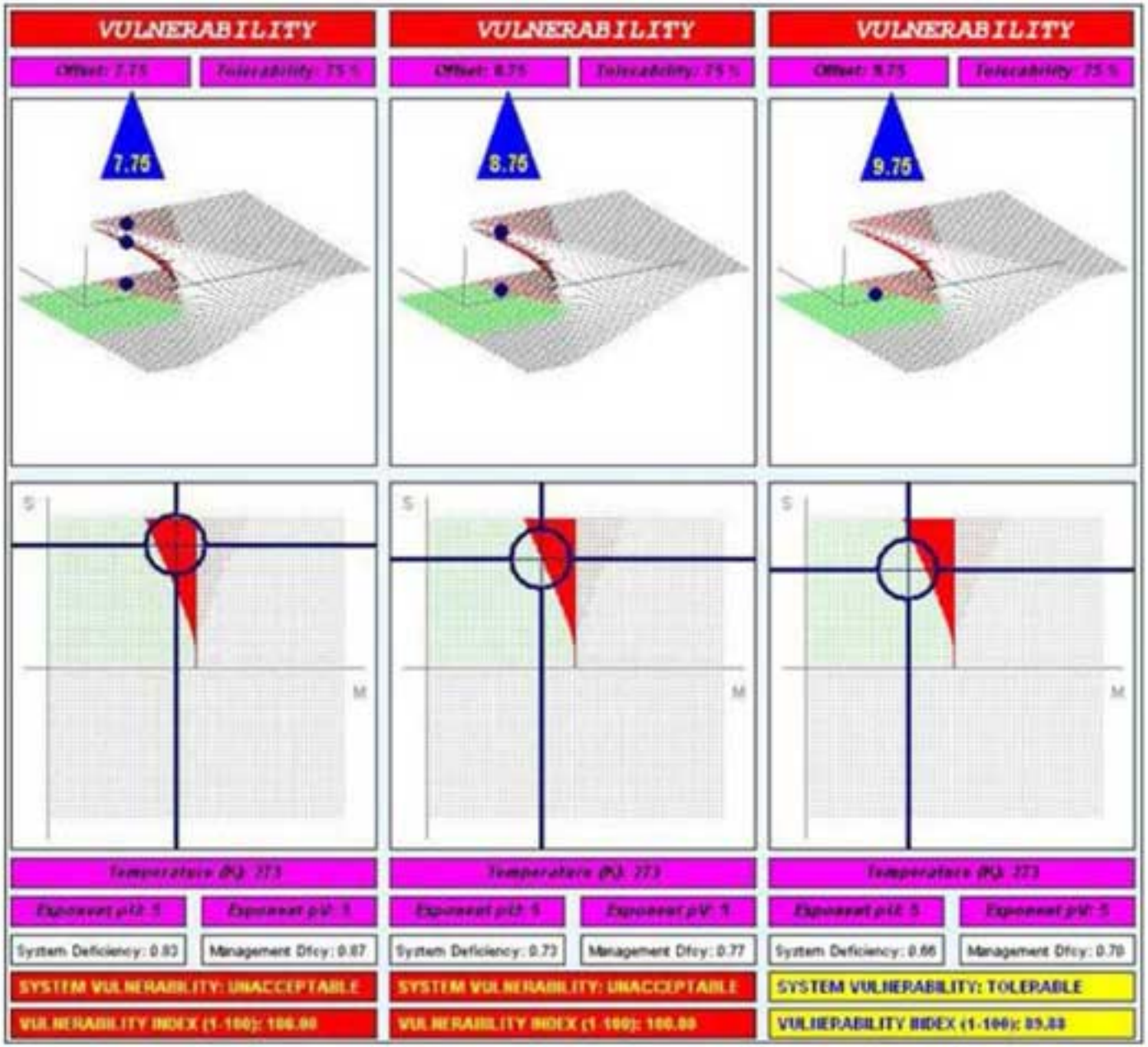
SYSTEM VULNERABILITY: ACCEPTABLE

VULNERABILITY INDEX (1-100): 0.26

VULNERABILITY INDEX and RESIDUAL VULNERABILITY.

Defining the Vulnerability Index, Vindex, as
Vindex = 100(1-d/15),
with d the distance of the system's point-state to the cusp and 15 - a graphics scale factor, has as a result, inter alia, the fact that even when the system is at its best (all indicators at zero), the relative position of the point-state to the cusp is such that Vindex may not reach its zero-value - this depending on 'temperature'.

At 273 K, the Residual Vulnerability is 0.26.



Effect of different Indicator Range Offsets: 7.75 (default), 8.75, and 9.75.
Observe relative position of extreme point state (the state system *cannot go beyond*, even if all scores are at their worst, i.e. 3) and instability area.

The 'Residual Vulnerability'.

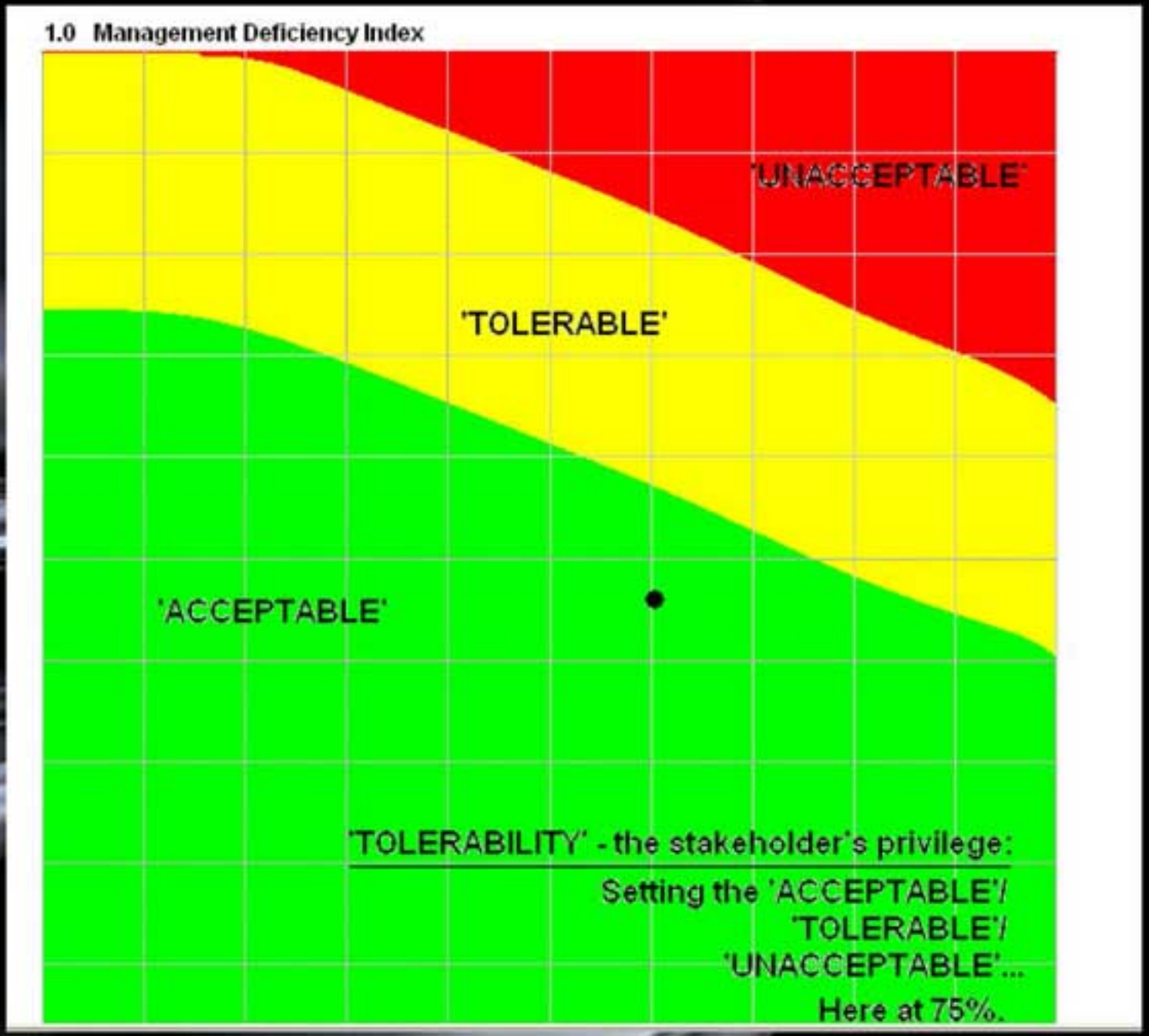
The figures that follow provide a straightforward and indeed 'graphical' explanation on why, when ALL indicators are at their best, that is - at the 0 (zero) level prescribed by the Swiss Re wisdom on the matter of plant condition, the Vulnerability Index may happen to *not* be reaching its zero value. Please read carefully the insets.

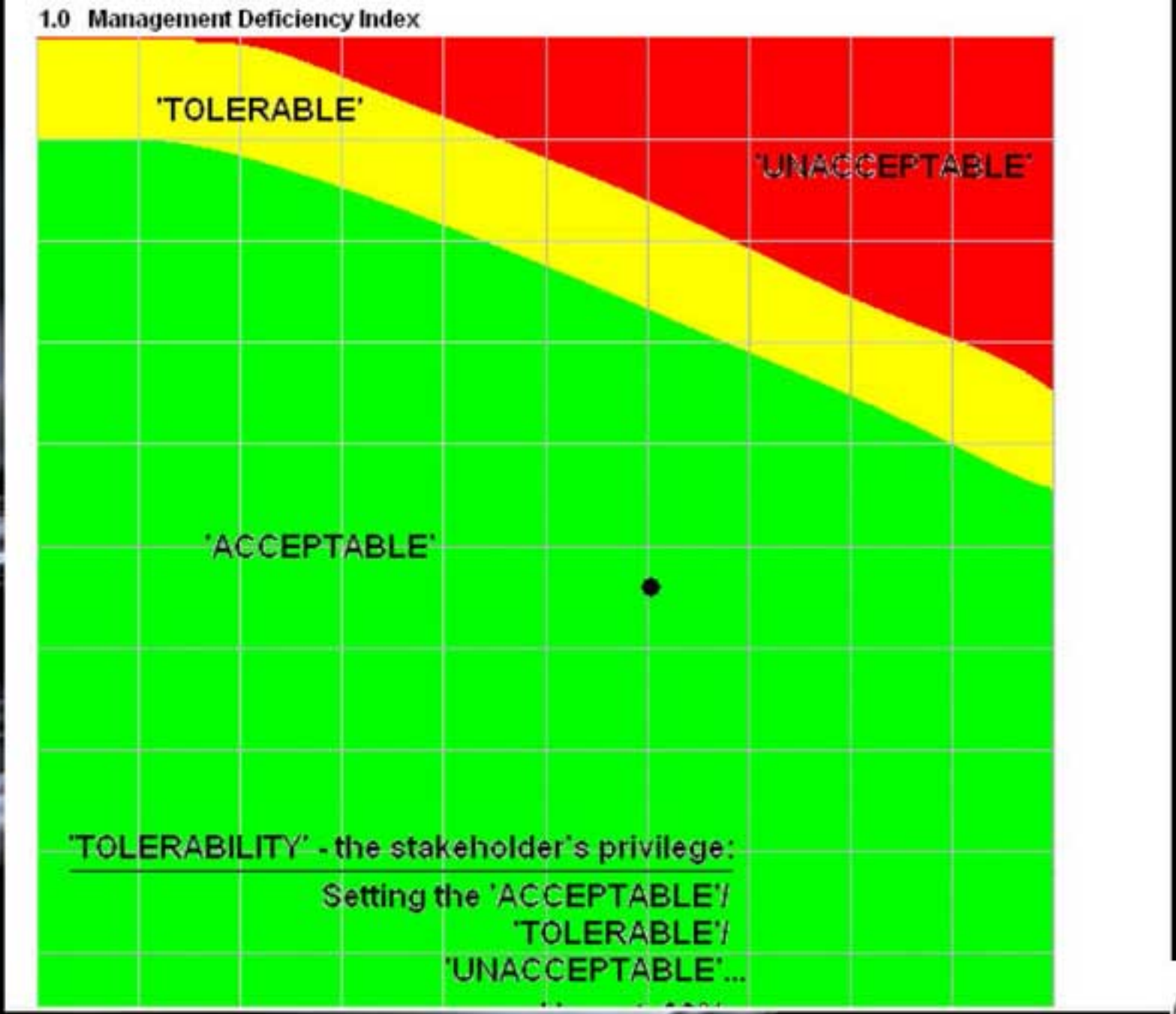
As a general remark, the lower the 'temperature', the higher the vulnerability - even the residual one - which is consistent with the physical analogy on which the model rests, implying that at lower temperatures *the cooperative effects* (that play a leading part in the onset of system's instability) are stronger.

The 'Tolerability' - a Stakeholder's Privilege.

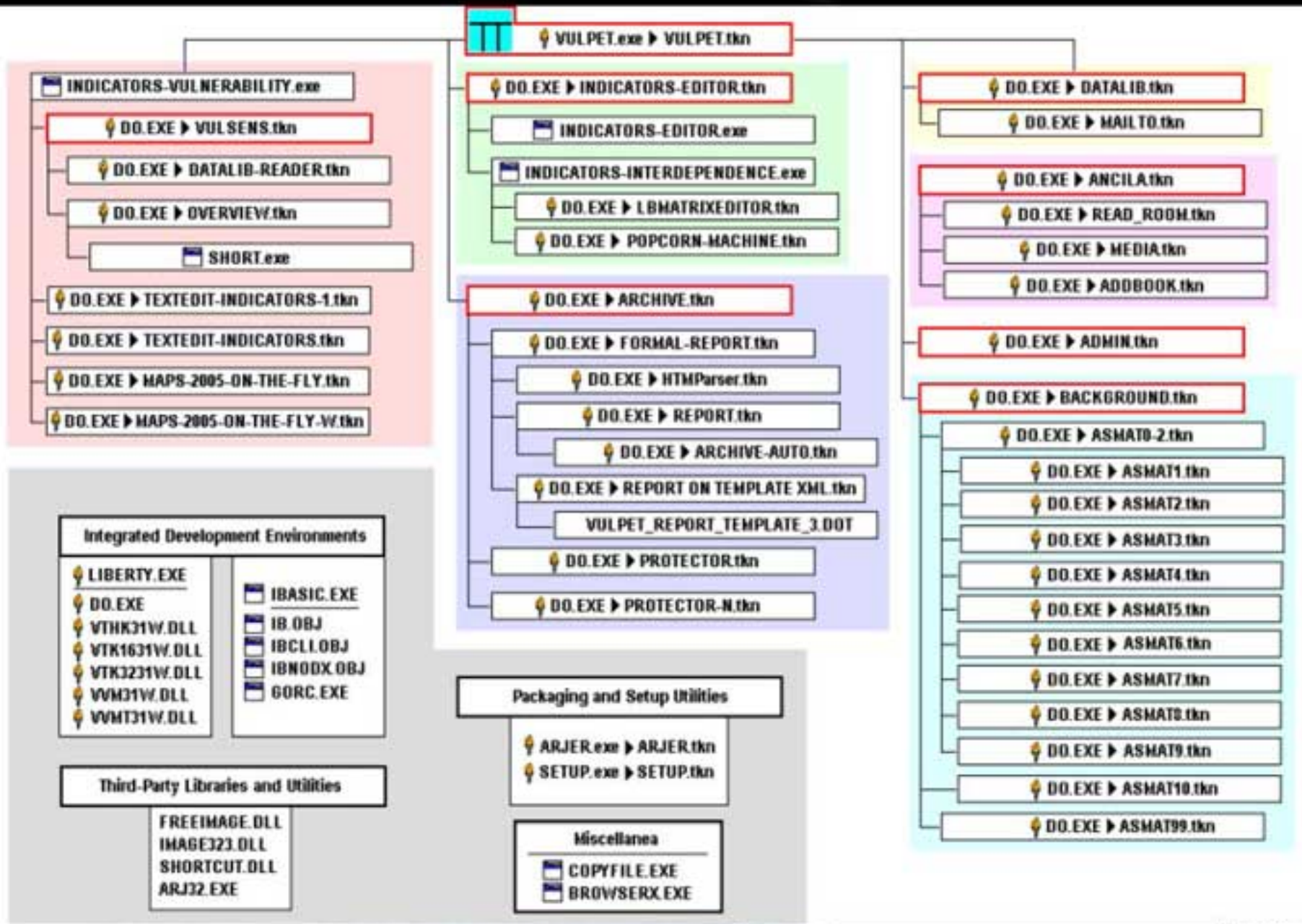
In a similar manner, the figures in the sequel explain 'Tolerability' - a variable which, while not exactly a 'model control parameter', controls however *the relationship between model and user*, in the sense that it allows the user to determine *the borderlines between the 'acceptable' - or 'green', the 'tolerable' - or 'yellow' and the 'unacceptable' - or 'red', basins in system's space (U,V), in terms of Vulnerability Index*. Please read the insets.

Vulnerability Acceptance Matrix

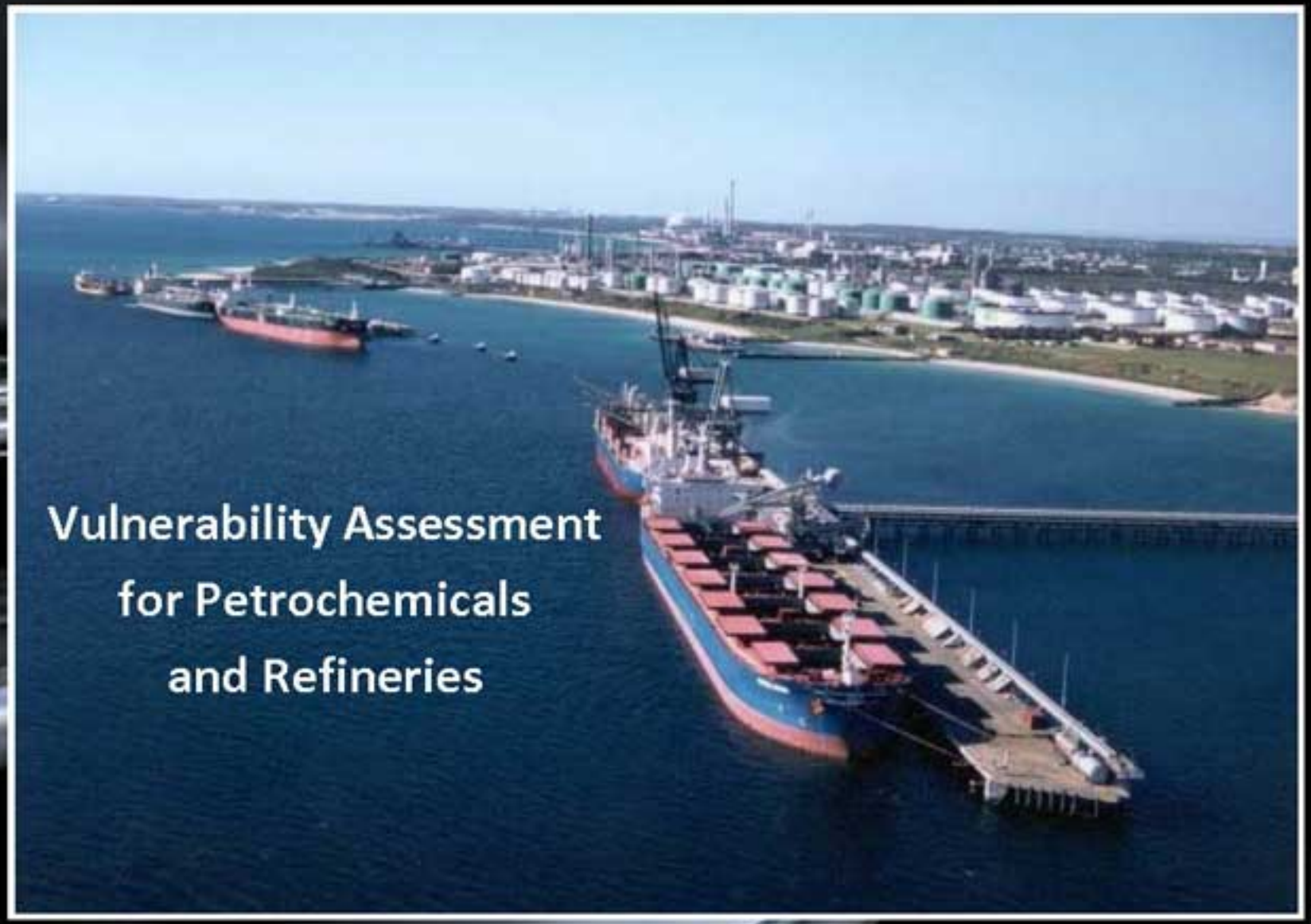

1.0 Management Deficiency Index
'UNACCEPTABLE'
'TOLERABLE'
'ACCEPTABLE'
'TOLERABILITY' - the stakeholder's privilege:
Setting the 'ACCEPTABLE'/
'TOLERABLE'/
'UNACCEPTABLE'...
Here at 75%.


1.0 Management Deficiency Index
'TOLERABLE'
'UNACCEPTABLE'
'ACCEPTABLE'
'TOLERABILITY' - the stakeholder's privilege:
Setting the 'ACCEPTABLE'/
'TOLERABLE'/
'UNACCEPTABLE'...

Decision Support System Architecture

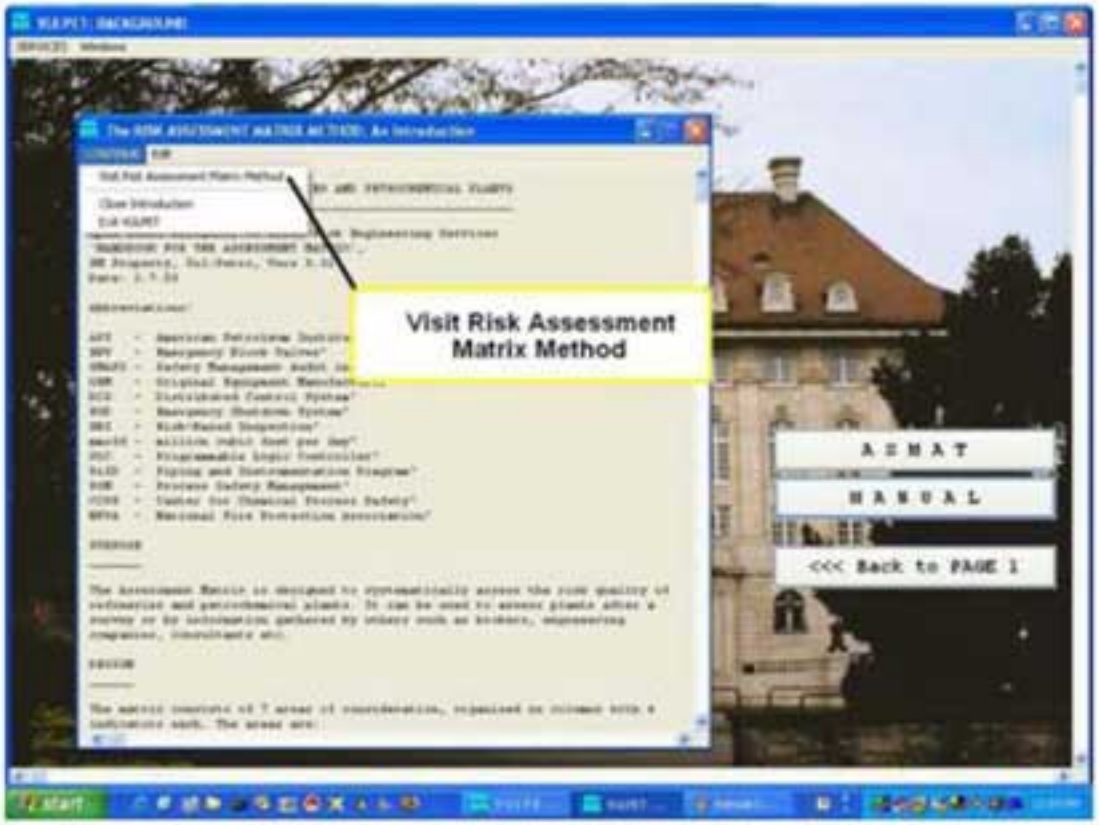

VULPET.exe ▶ VULPET.tkn
INDICATORS-VULNERABILITY.exe
DO.EXE ▶ VULSENS.tkn
DO.EXE ▶ DATALIB-READER.tkn
DO.EXE ▶ OVERVIEW.tkn
SHORT.exe
DO.EXE ▶ TEXTEDIT-INDICATORS-1.tkn
DO.EXE ▶ TEXTEDIT-INDICATORS.tkn
DO.EXE ▶ MAPS-2005-ON-THE-FLY.tkn
DO.EXE ▶ MAPS-2005-ON-THE-FLY-W.tkn
DO.EXE ▶ INDICATORS-EDITOR.tkn
INDICATORS-EDITOR.exe
INDICATORS-INTERDEPENDENCE.exe
DO.EXE ▶ LBMATRIXEDITOR.tkn
DO.EXE ▶ POPCORN-MACHINE.tkn
DO.EXE ▶ ARCHIVE.tkn
DO.EXE ▶ FORMAL-REPORT.tkn
DO.EXE ▶ HTMParser.tkn
DO.EXE ▶ REPORT.tkn
DO.EXE ▶ ARCHIVE-AUTO.tkn
DO.EXE ▶ REPORT ON TEMPLATE XML.tkn
VULPET_REPORT_TEMPLATE_3.DOT
DO.EXE ▶ PROTECTOR.tkn
DO.EXE ▶ PROTECTOR-N.tkn
DO.EXE ▶ DATALIB.tkn
DO.EXE ▶ MAILTO.tkn
DO.EXE ▶ ANCILA.tkn
DO.EXE ▶ READ_ROOM.tkn
DO.EXE ▶ MEDIA.tkn
DO.EXE ▶ ADDBOOK.tkn
DO.EXE ▶ ADMIN.tkn
DO.EXE ▶ BACKGROUND.tkn
DO.EXE ▶ ASMAT0-2.tkn
DO.EXE ▶ ASMAT1.tkn
DO.EXE ▶ ASMAT2.tkn
DO.EXE ▶ ASMAT3.tkn
DO.EXE ▶ ASMAT4.tkn
DO.EXE ▶ ASMAT5.tkn
DO.EXE ▶ ASMAT6.tkn
DO.EXE ▶ ASMAT7.tkn
DO.EXE ▶ ASMAT8.tkn
DO.EXE ▶ ASMAT9.tkn
DO.EXE ▶ ASMAT10.tkn
DO.EXE ▶ ASMAT99.tkn
Integrated Development Environments
LIBERTY.EXE
DO.EXE
VTHK31W.DLL
VTK1631W.DLL
VTK3231W.DLL
VVM31W.DLL
VVMT31W.DLL
IBASIC.EXE
IB.OBJ
IBCLI.OBJ
IBNODX.OBJ
GORC.EXE
Third-Party Libraries and Utilities
FREEIMAGE.DLL
IMAGE323.DLL
SHORTCUT.DLL
ARJ32.EXE
Packaging and Setup Utilities
ARJER.exe ▶ ARJER.tkn
SETUP.exe ▶ SETUP.tkn
Miscellanea
COPYFILE.EXE
BROWSERX.EXE

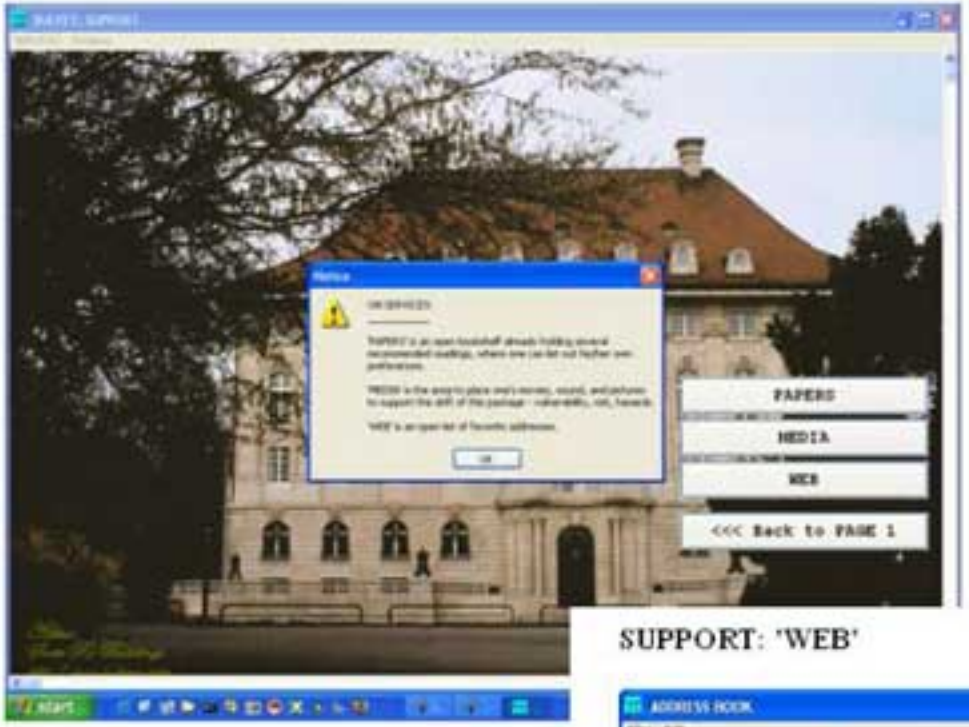
VULPET


Vulnerability Assessment
for Petrochemicals
and Refineries


TO ASMAT, Step 1
Click 'BACKGROUND'


TO ASMAT, Step 2:
Click 'ASMAT'


Visit Risk Assessment
Matrix Method
ASMAT
MANUAL
<<< Back to PAGE 1


PAPERS
MEDIA
WEB
<<< Back to PAGE 1

SUPPORT: 'WEB'


ADDRESS BOOK
Swiss Re Public Web Site
About Us
Corp. responsibility
Water initiatives
Swiss Re Reference Award
Winners of the Re/Source Award 2004
Helvetic Seas for Haiti
International Water Management Course
Interactive information

The VULPET Implementation of the QVA Model.

The generic concept of the quantitative vulnerability assessment (QVA) employed with VULPET is described in section 4.1. The adaptation of the generic QVA model to the analysis of vulnerabilities in petrochemical plants, and in a manner relevant to the reinsurance business, has required – in the QVA terminology:

a) The definition of appropriate variables underlying the (U,V,ζ) space of most probable states of the system (the cuspidal foil), and the Vulnerability Matrix, respectively. VULPET has adopted:
   - A *System Deficiency Index*, named S, relating to model variable U, and spanning the y-cartesian axis;
   - A *Management Deficiency Index*, named M, relating to model variable V, and spanning the x-cartesian axis.

b) A proper choice of the origin ($S = 0$, $M = 0$) in the model's (U,V) plane, guided by the principle that, *whenever either S of M are incremented, the system vulnerability should increase* – a principle of common sense, consistent with the notion that S and M are *deficiency*-relating indexes (the higher a deficiency, the higher the vulnerability). The choice $S = U$, $M = V + 1$ was found to satisfy the terms above, which places the said origin, S=0, M=0, at model's U=0, V= -1, respectively. Consistently, the two extreme cases of vulnerability allowed by the VULPET implementation of the QVA method are as rendered in *Figure 4.2.1*.

c) The definition of appropriate sets of indicators featuring the internal (system) variables contributing in the construction of the S variable (the '[u]-type indicators'), and the external (influence) variables contributing in the construction of the M variable (the [v]-type indicators). VULPET comes with two sets of indicators, each in two versions:
   - *A 'short' set*, of 26 indicators, without and with indicator interdependence, respectively; and
   - *A 'long' set*, of 105 indicators, without and with indicator interdependence, respectively.

The VULPET code takes the ***long*** *set* ***with*** *interdependence* as the default.

THE DEFAULT SET, REDUCED, interdependence considered

1-0. Environmental Perils

1-1-0. External Perils [u]
1-2-0. Natural Perils [u]

2-0. Infrastructure Integrity

2-1-0. Plant Layout [v]
2-2-0. Process Control [u]
2-3-0. Process Hazards [v]
2-4-0. Loss Prevention [u]
2-5-0. Stability of Production [v]

3-0. Process & Equipment Integrity

3-1-0. Maintenance [v]
3-2-0. Inspection [v]
3-3-0. Management of Change [u]
3-4-0. Contractors [u]

4-0. Operation

4-1-0. Safe Work Practice [u]
4-2-0. Workforce [v]
4-3-0. Permit to Work [u]
4-4-0. Operating and Emergency Procedures, P&IDs [v]

5-0. Risk Management

5-1-0. Incidents [v]
5-2-0. Safety Management Audits [v]
5-3-0. Process Hazard Analysis [v]
5-4-0. Emergency Plan [v]

6-0. Organization

6-1-0. Organization Integrity [u]
6-2-0. Communication [u]

7-0. Commitment to Safety

7-1-0. Safety Culture [v]
7-2-0. Safety Awareness of Management [u]
7-3-0. Safety Awareness of Workforce [u]
7-4-0. Housekeeping & Ergonomics [v]

8-0. Organisational Changes

8-1-0. Change Management [u]

THE DEFAULT SET, COMPLETE, interdependence considered

1-0. Environmental Perils

1-1. External Perils

1-1-1. Security and IT threats [u]
1-1-2. Chemical plants/refineries [u]

1-2. Natural Perils

1-2-1. Extreme weather conditions [u]
1-2-2. Windstorm/Hurricane/Tornado [u]
1-2-3. Flooding/Tsunami [u]
1-2-4. Avalanches/Landslides/Volcanic activity [u]

2-0. Infrastructure Integrity

2-1. Plant Layout

2-1-1. Between unit spacing [v]
2-1-2. Within unit layout [v]
2-1-3. Fireproofing [u]
2-1-4. Drainage/Spill control [u]
2-1-5. Flood protection [v]
2-1-6. Earthquake design [v]
2-1-7. Metallurgy for purpose (Hg, sour crude) [u]

2-2. Process control

2-2-1. Control room [u]

3-0. Process & Equipment Integrity

3-1. Maintenance

3-1-1. MTBR / MTBF Analysis [v]
3-1-2. Backlog of WO [v]
3-1-3. Clamp list [v]
3-1-4. Per cent of breakdown maintenance [v]
3-1-5. Number of leaks, spills (trend) [v]
3-1-6. Maintenance of process equipment [u]
3-1-7. Trend of budget [v]

3-2. Inspection

3-2-1. Backlog of inspections of PSV, vessels, elbows [u]
3-2-2. Resources [v]
3-2-3. Inspection program [v]
3-2-4. Trending of data [v]
3-2-5. Trend of budget [v]

3-3. Management of Change

3-3-1. MOC (permanent, temporary, variance) [u]

3-4. Contractor, Third Party Services

3-4-1. Area and extent of subcontraction [v]
3-4-2. Selection [u]
3-4-3. Training [u]

4-0. Operation

4-1. Safe Work Practice

4-1-1. LOTO [u]
4-1-2. Hot tap [u]
4-1-3. Shift changes [u]
4-1-4. Blinding [u]

Calibrating Models for Vulnerability Assessment

The interplay of the model control parameteres explained in section 4.2 favors one essential operation in making VULPET a meaningful tool of petrochemical plants vulnerability assessment: the *calibration*.

> ***Calibrating means to set (i) the Temperature; (ii) the Indicator Range Offset; and (iii) the U/V-Constructor Function Exponents pU and pV so that, for known vulnerability conditions of reference plants and the respective indicator scores, the point-state of the system fall in an appropriate place in the Vulnerability Matrix Field spanned by the System Deficiency Index, S, and the Management Deficiency Index, M.***

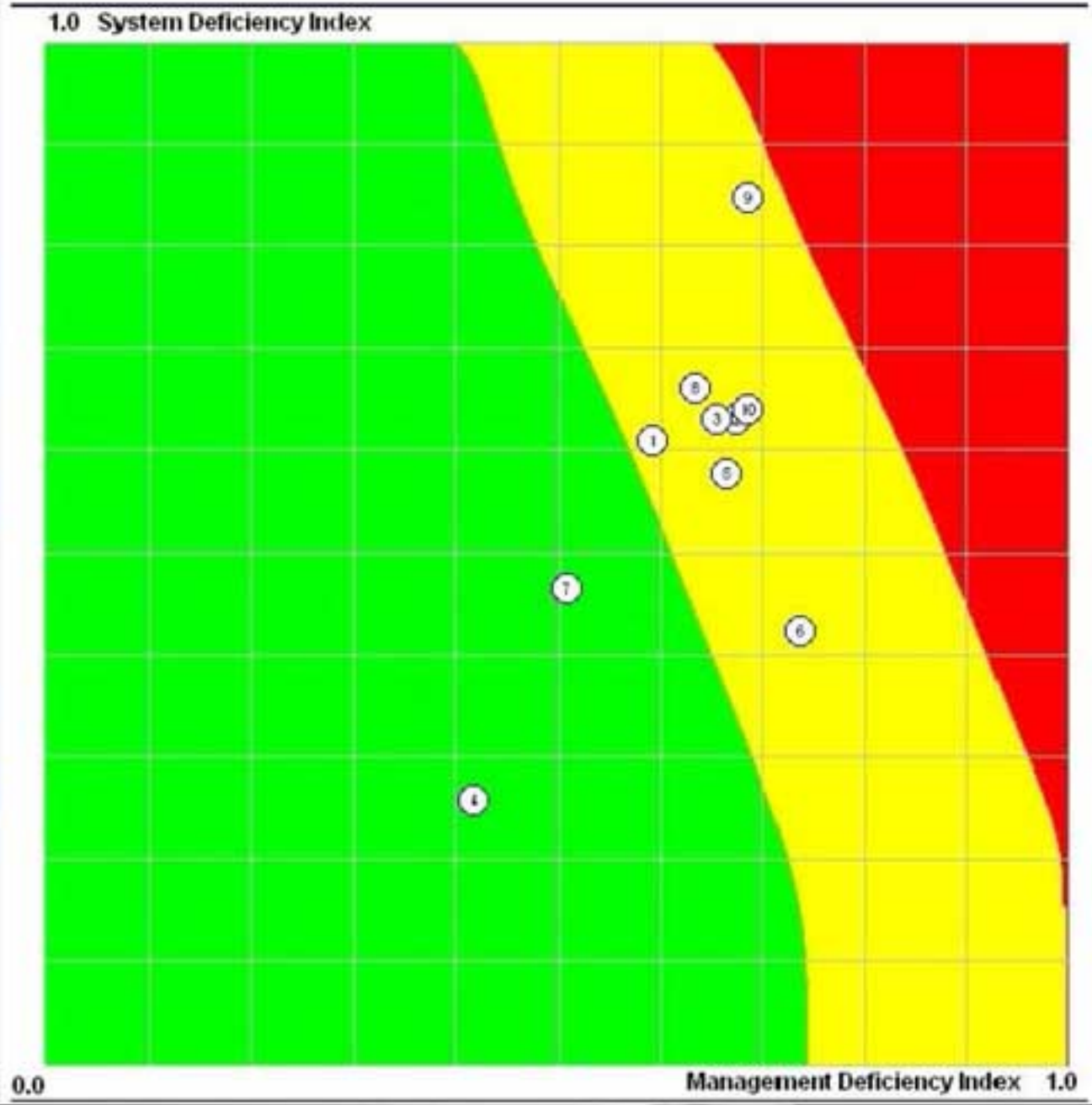
The assumption underlying the model calibration is – as usual in the modeling and measuring trade – that,

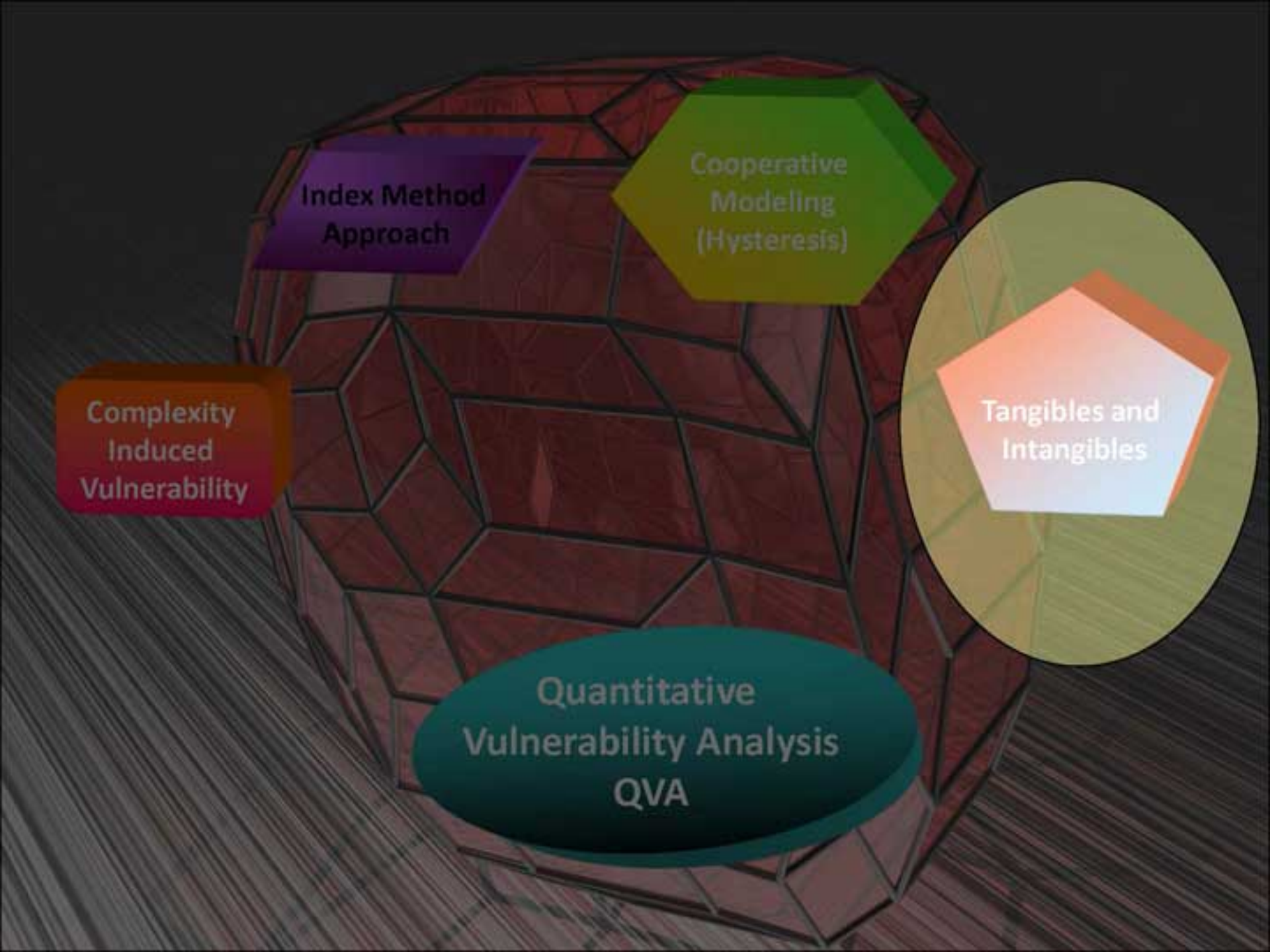
> ***Once a sufficient number of cases are well represented, in average, by an established set of model control parameters like the temperature, the offset, and pU and pV, one may assume with an acceptable degree of confidence that the model is able to determine with a sufficient accuracy the Vulnerability Index, and condition (acceptable, tolarable, unacceptable), of any enterprise that came under assessors' scrutiny and has been properly scored.***

Numerical experiments conducted with VULPET on a series of cases on record with Swiss Re has resulted in the following *terms of calibration*:


ENTERPRISES
SELECT ENTERPRISE
PLANT BUSINESS NAME: Plant #.#.
DIVISION BUSINESS NAME: Divisi
CORPORATION BUSINESS NAME: CORI
PLANT REGISTERED IN: U.S.A, Va
INDUSTRY SEGMENT: Oil and othe
LOCATION DESCRIPTION: geograph
demograp
risk/vuls
etc.
BUSINESS HISTORY: profile evol
notable deve
success/fail
etc.
PLANT BUSINESS ADDRESSES: Addr
Addr
PLANT TOP MANAGEMENT: John Doe,
Name Ta
Name Ta
Name Ta
Name Ta
ASSESSOR
Assessor 1
DATE OF ASSESSMENT
2006/03/02_10:32:11
JOB No.
01
INDICATORS
1-1-1 Security and IT threats list
LIST
EXECUTE
SCORING CRITERIA
JUSTIFICATION / RECOMMENDATIONS
2-5-3. Process flow configuration [v] 1.7534
2-5-4. Critical equipment [v] 2.5616
2-5-5. History of unplanned shutdowns [v] 2.782
2-5-6. Onstream factors [v] 1.533
3-1-1. MTBR / MTBF Analysis [v] 0.9704
3-1-2. Backlog of WO [v] 1.3497
3-1-3. Clamp list [v] 1.8808
3-1-4. Per cent of breakdown maintenance [v] 1.2739
3-1-5. Number of leaks, spills (trend) [v] 1.6532
3-1-6. Maintenance of process equipment [u] 1.5774
3-1-7. Trend of budget [v] 3
3-2-1. Backlog of inspections of PSV, vessels, elbows [u] 1.1816
3-2-2. Resources [v] 1.2572
3-2-3. Inspection program [v] 1.0303
3-2-4. Trending of data [v] 2.3162
3-2-5. Trend of budget [v] 1.5596
3-3-1. MOC (permanent, temporary, variance) [u] 3
3-4-1. Area and extent of subcontraction [v] 1.5007
3-4-2. Selection [u] 1.7206
3-4-3. Training [u] 1.6526
4-1-1. LOTO [u] 3
4-1-2. Hot tap [u] 2.4143
4-1-3. Shift changes [u] 0.9712
4-1-4. Blinding [u] 1.5029
4-1-5. Safety meetings, committees [v] 2.1105
4-1-6. Safety manuals [v] 1.4269
4-1-7. Bypass procedure [u] 1.0472
4-1-8. Impairment of safety system [u] 1.1991
4-2-1. Manning level [v] 2.7701
4-2-2. Training [v] 1.396
4-2-3. Education [v] 2.2357
4-2-4. Experience [u] 1.7014
4-2-5. Hiring practice (recruiting standards) [v] 2.0067
4-2-6. Know-how on site [u] 0.938
4-3-1. Work permit system [u] 1.6373
4-3-2. Coordination of work permit system LOTO [u] 2.0944
4-4-1. Operation, emergency, P & ID, & upgrades [v] 1.0934
4-4-2. (Equipment) Shutdown / restart procedures, & PSSR [u] 1.5473
5-1-1. Tracking & Trending [v] 1.1283
5-1-2. Investigation & Reporting culture & follow up on reco... 1.2047
5-1-3. Number & trend of near misses & reporting culture [v] 1.7396
VULNERABILITY
Offset: 7.75
Vulnerability: 75 %
Temperature (R): 373
Exponent p/d: 5
Exponent p/d: 5
System Deficiency: 0.81
Management Dfcy: 0.59
SYSTEM VULNERABILITY: TOLERABLE
VULNERABILITY INDEX (1-100): 78.32

Comparison of Vulnerability Index of Accounts' Plants

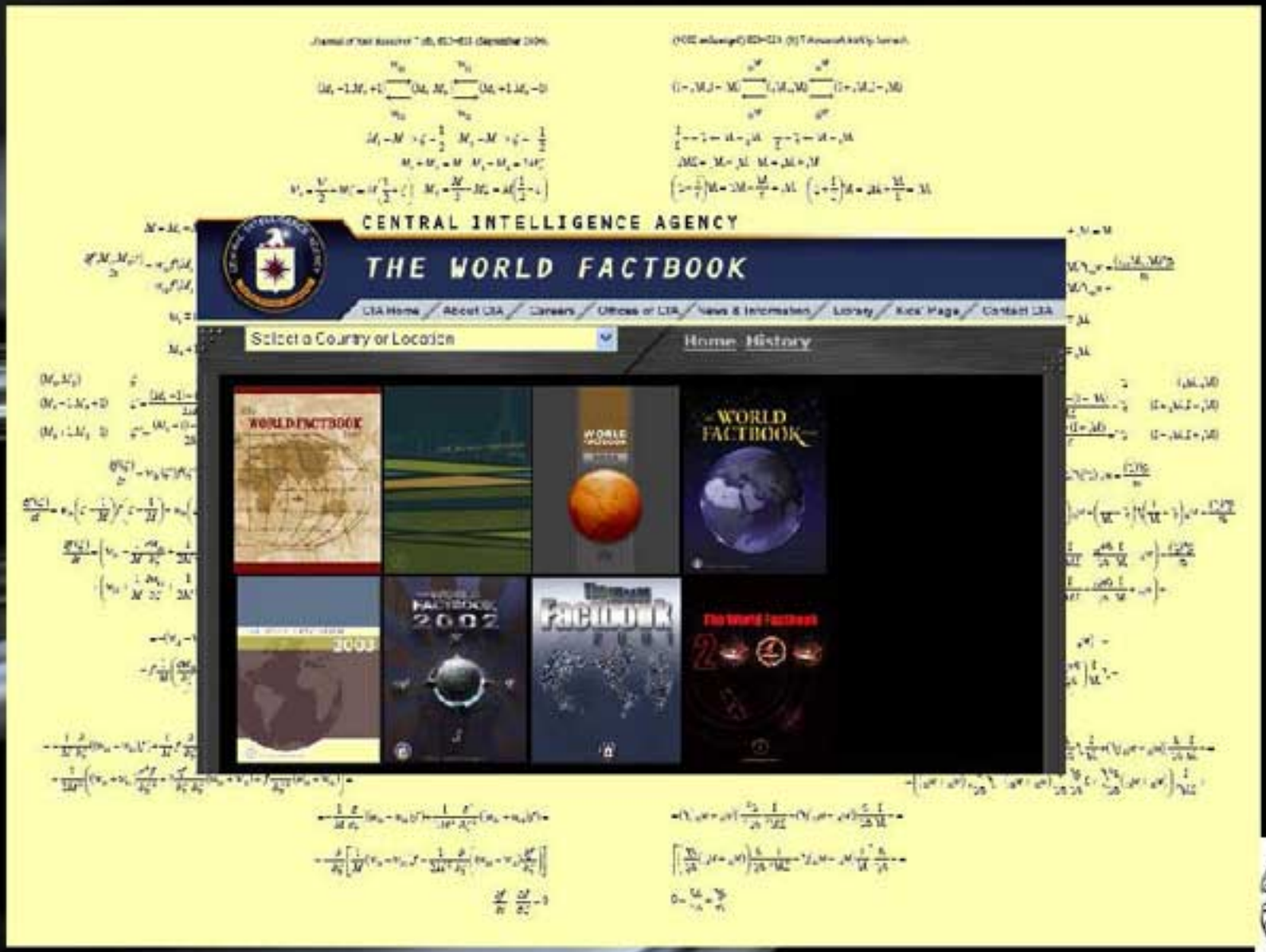



Index Method Approach
Cooperative Modeling (Hysteresis)
Complexity Induced Vulnerability
Tangibles and Intangibles
Quantitative Vulnerability Analysis QVA

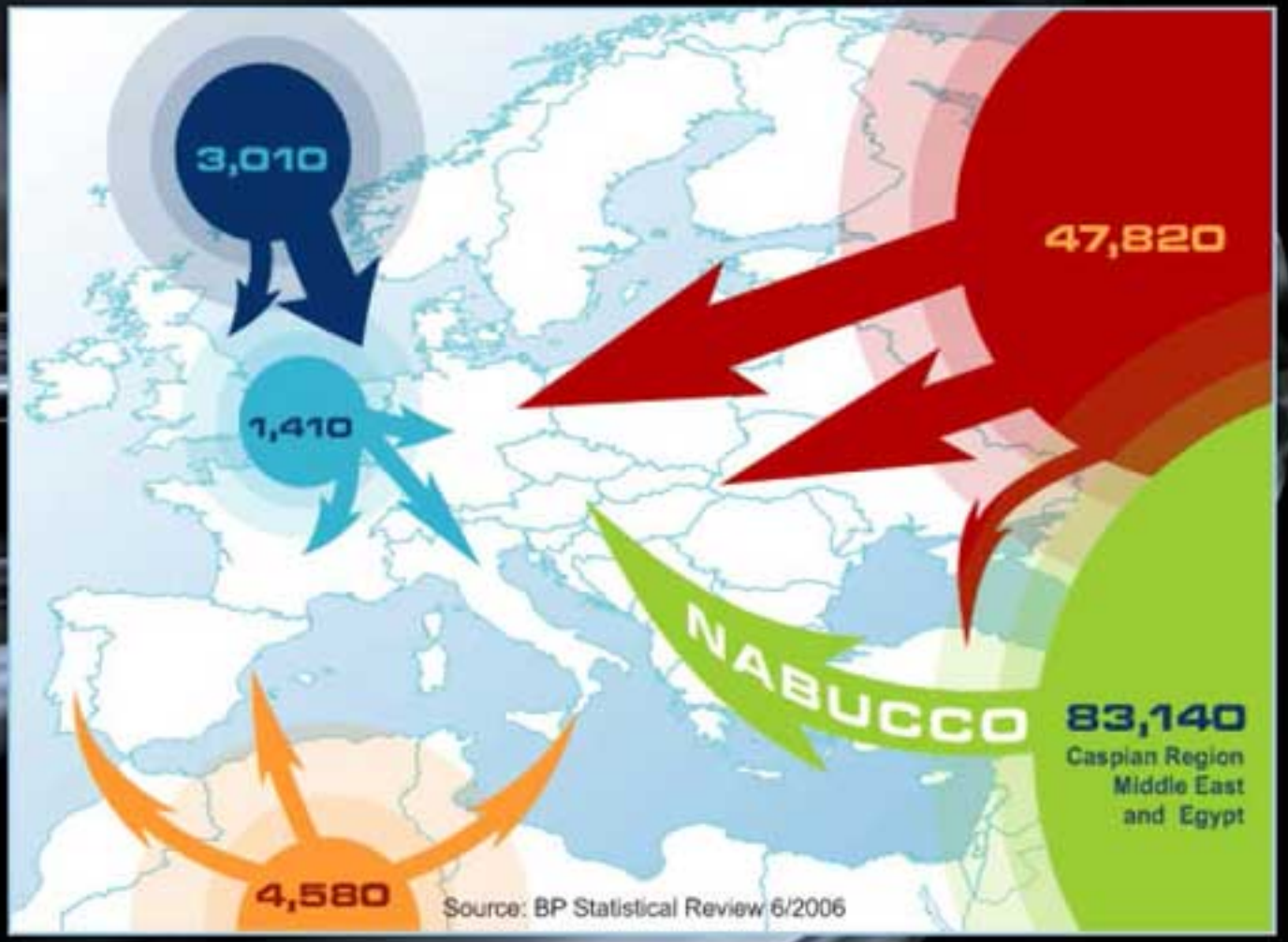
Tangibles and Intangibles

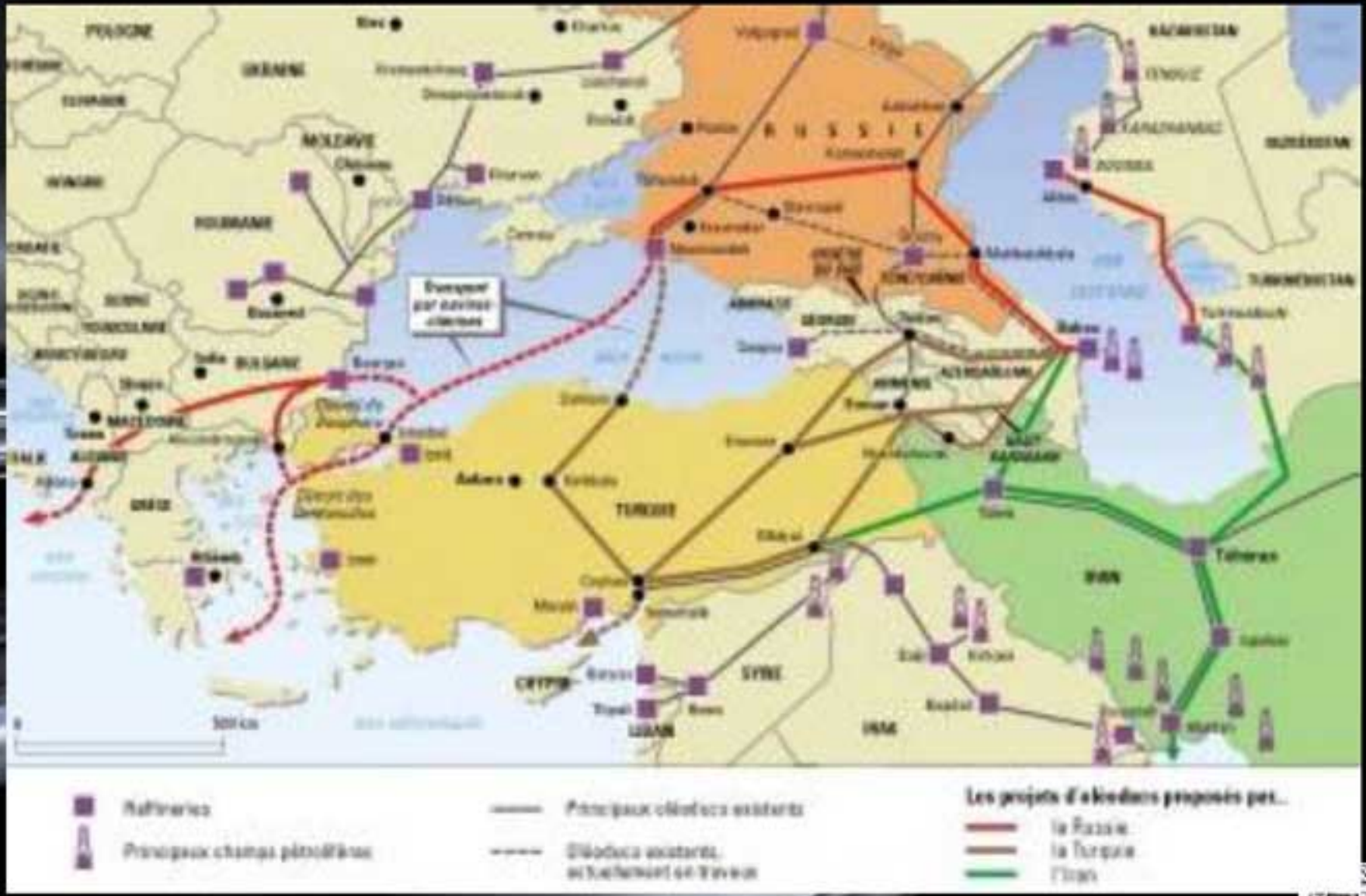
Cooperative Modeling Approach

A Meta Database - CIA Facts

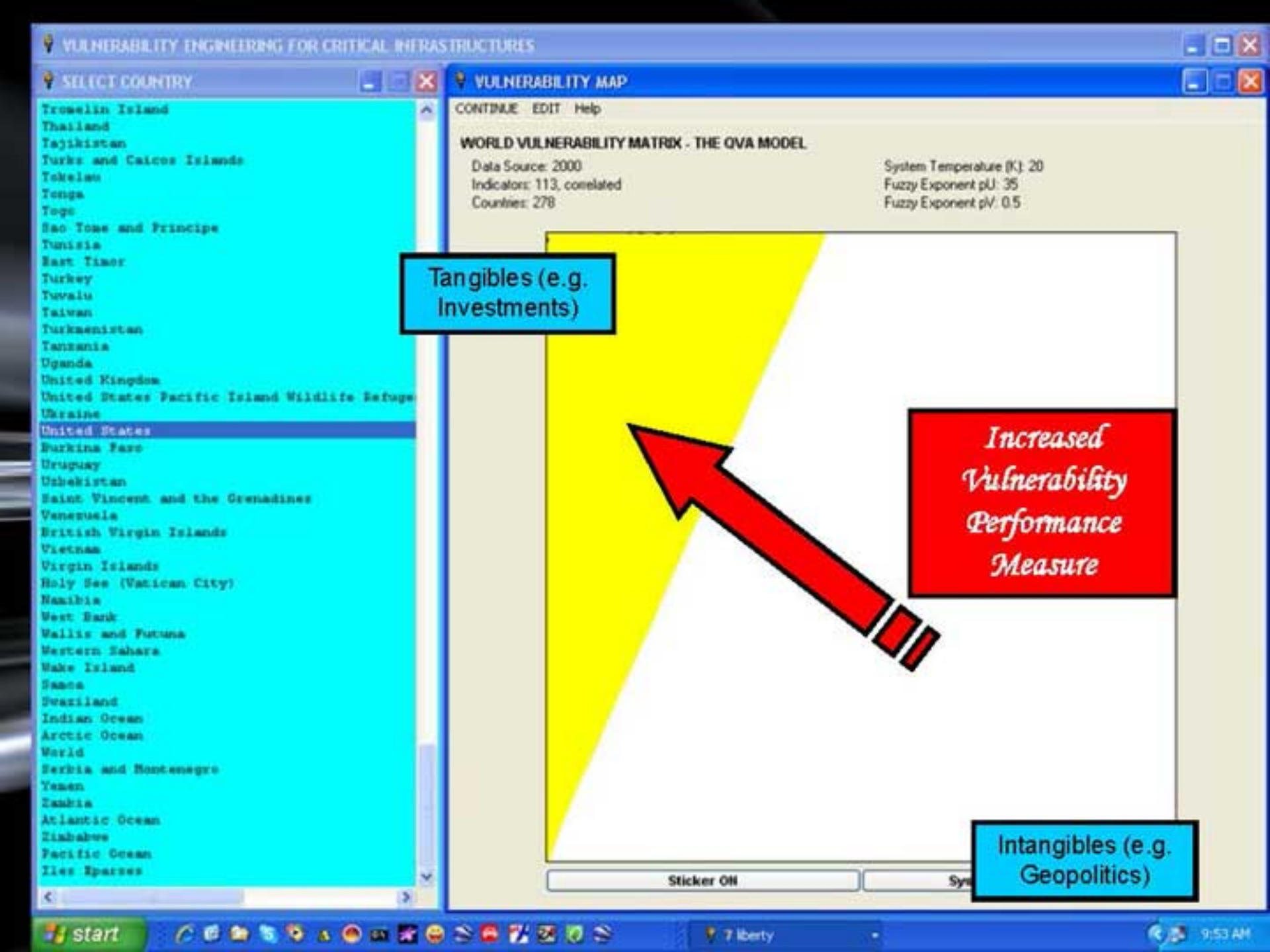


Europe's Pipeline War




POLOGNE
UKRAINE
MOLDAVIE
ROUMANIE
BULGARIE
GRECE
TURQUIE
GEORGIE
ARMENIE
AZERBAIDJAN
KAZAKHSTAN
TURKMENISTAN
IRAN
SYRIE
CHYPRE
LIBAN
IRAK
Europe par navires citernes
Raffineries
Principaux champs pétrolifères
Principaux oléoducs existants
Oléoducs existants actuellement en travaux
Les projets d'oléoducs proposés par...
la Russie
la Turquie
l'Iran


(Kiev) Kyiv
Kharkov
Ukraine
Volgograd
Slovakia
Dnepropetrovsk
Donetsk
Budapest
Hungary
Moldova
(Rostov-on-Don)
Rostov-na-Donu
Chisinau
Romania
Sea of Azov
Belgrade
Beograd
Sarajevo
(Bucharest)
Bucuresti
Centralna Srbija
Pristina
Sofiya
Bulgaria
Black Sea
Skopje
Georgia
Tbilisi
Macedonia (FYROM)
Albania
Istanbul
(Istanbul)
Yerevan
Armenia
Sea of Marmara
Bursa
Ankara
Aegean Sea
Tabriz
(Athens)
Athina
Izmir
(Izmit)
Turkey
© 2008 Basarsoft
© 2008 Tele Atlas
© 2008 Basarsoft
© 2008 Europa Technologies
Gaziantep
Google
Pointer lat 43.015098° lon -37.133576°
Streaming 100%
Eye alt 2019.85 km


VULNERABILITY ENGINEERING FOR CRITICAL INFRASTRUCTURES
SELECT COUNTRY
Tromelin Island
Thailand
Tajikistan
Turks and Caicos Islands
Tokelau
Tonga
Togo
Sao Tome and Principe
Tunisia
East Timor
Turkey
Tuvalu
Taiwan
Turkmenistan
Tanzania
Uganda
United Kingdom
United States Pacific Island Wildlife Refuge
Ukraine
United States
Burkina Faso
Uruguay
Uzbekistan
Saint Vincent and the Grenadines
Venezuela
British Virgin Islands
Vietnam
Virgin Islands
Holy See (Vatican City)
Namibia
West Bank
Wallis and Futuna
Western Sahara
Wake Island
Samoa
Swaziland
Indian Ocean
Arctic Ocean
World
Serbia and Montenegro
Yemen
Zambia
Atlantic Ocean
Zimbabwe
Pacific Ocean
Iles Eparses
VULNERABILITY MAP
CONTINUE EDIT Help
WORLD VULNERABILITY MATRIX - THE QVA MODEL
Data Source: 2000
Indicators: 113, correlated
Countries: 278
System Temperature (K): 20
Fuzzy Exponent pU: 35
Fuzzy Exponent pV: 0.5
Tangibles (e.g. Investments)
Increased Vulnerability Performance Measure
Intangibles (e.g. Geopolitics)
Sticker ON
start
7 liberty
9:53 AM

VULNERABILITY ENGINEERING FOR CRITICAL INFRASTRUCTURES

SELECT COUNTRY

Tromelin Island
Thailand
Tajikistan
Turks and Caicos Islands
Tokelau
Tonga
Togo
Sao Tome and Principe
Tunisia
East Timor
Turkey
Tuvalu
Taiwan
Turkmenistan
Tanzania
Uganda
United Kingdom
United States Pacific Island Wildlife Refuge
Ukraine
United States
Burkina Faso
Uruguay
Uzbekistan
Saint Vincent and the Grenadines
Venezuela
British Virgin Islands
Vietnam
Virgin Islands
Holy See (Vatican City)
Namibia
West Bank
Wallis and Futuna
Western Sahara
Wake Island
Samoa
Swaziland
Indian Ocean
Arctic Ocean
World
Serbia and Montenegro
Yemen
Zambia
Atlantic Ocean
Zimbabwe
Pacific Ocean
Iles Eparses

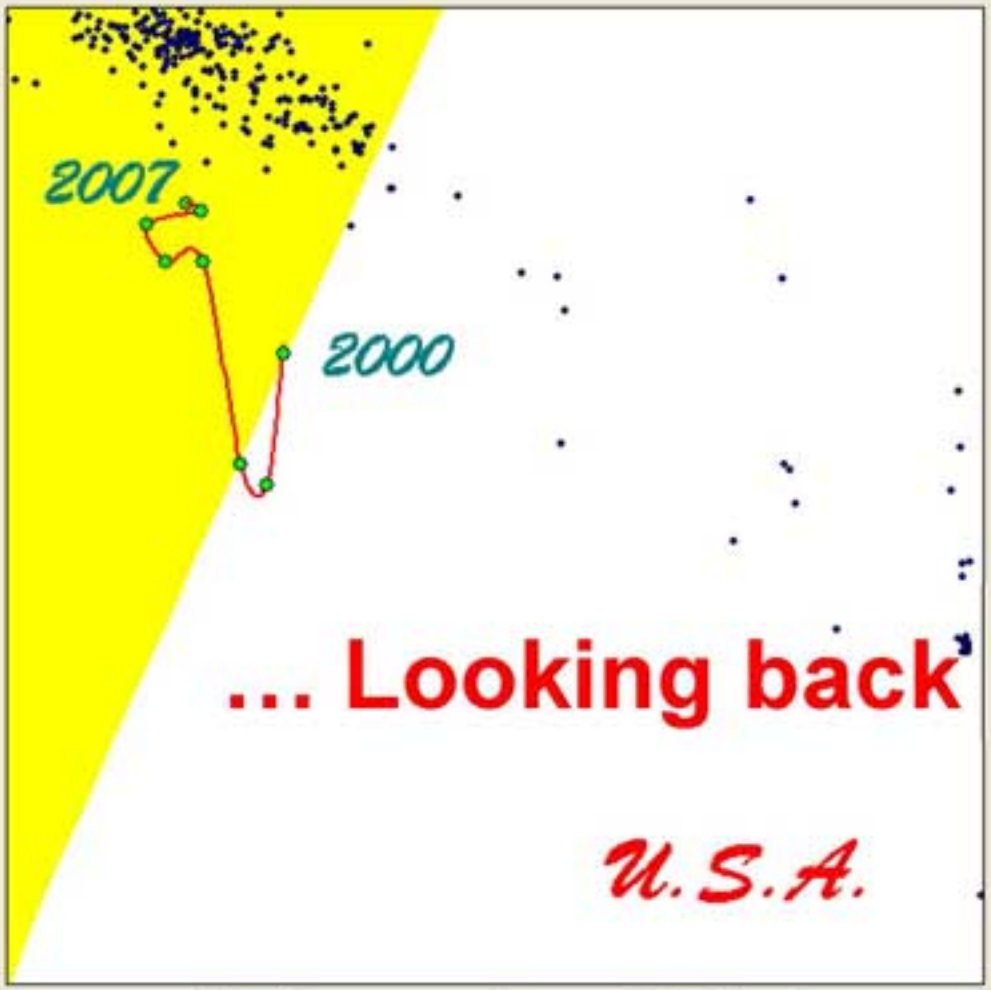
VULNERABILITY MAP

CONTINUE EDIT Help

WORLD VULNERABILITY MATRIX - THE OVA MODEL

Data Source: 2000
Indicators: 113, correlated
Countries: 278

System Temperature (K): 20
Fuzzy Exponent pU: 35
Fuzzy Exponent pV: 0.5



Sticker ON | System Phase Space

start

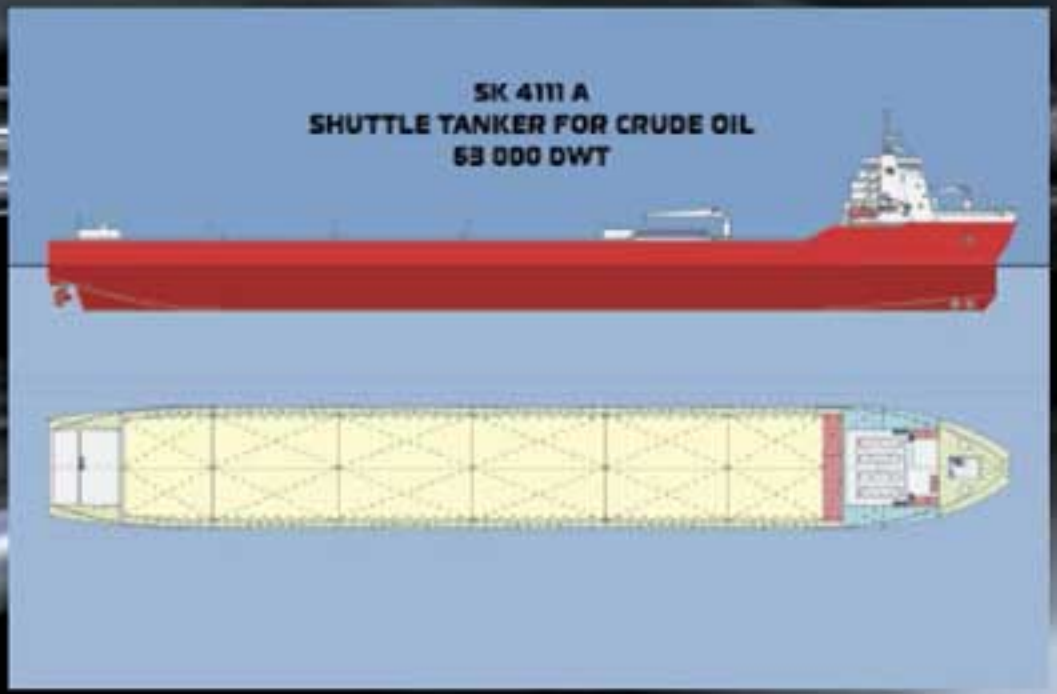
7 liberty

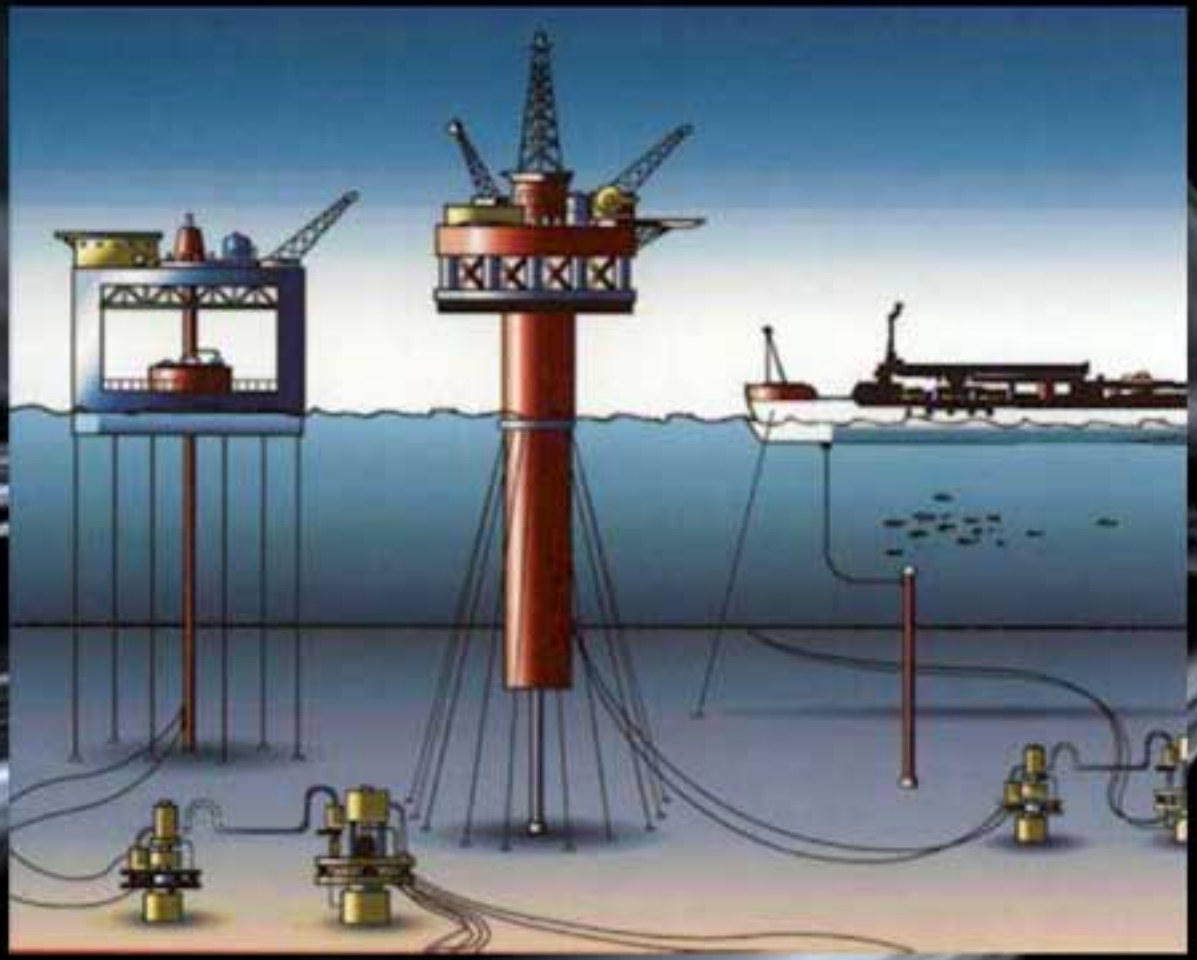
9:53 AM

Tangibles and Intangibles

Vectorial Approach

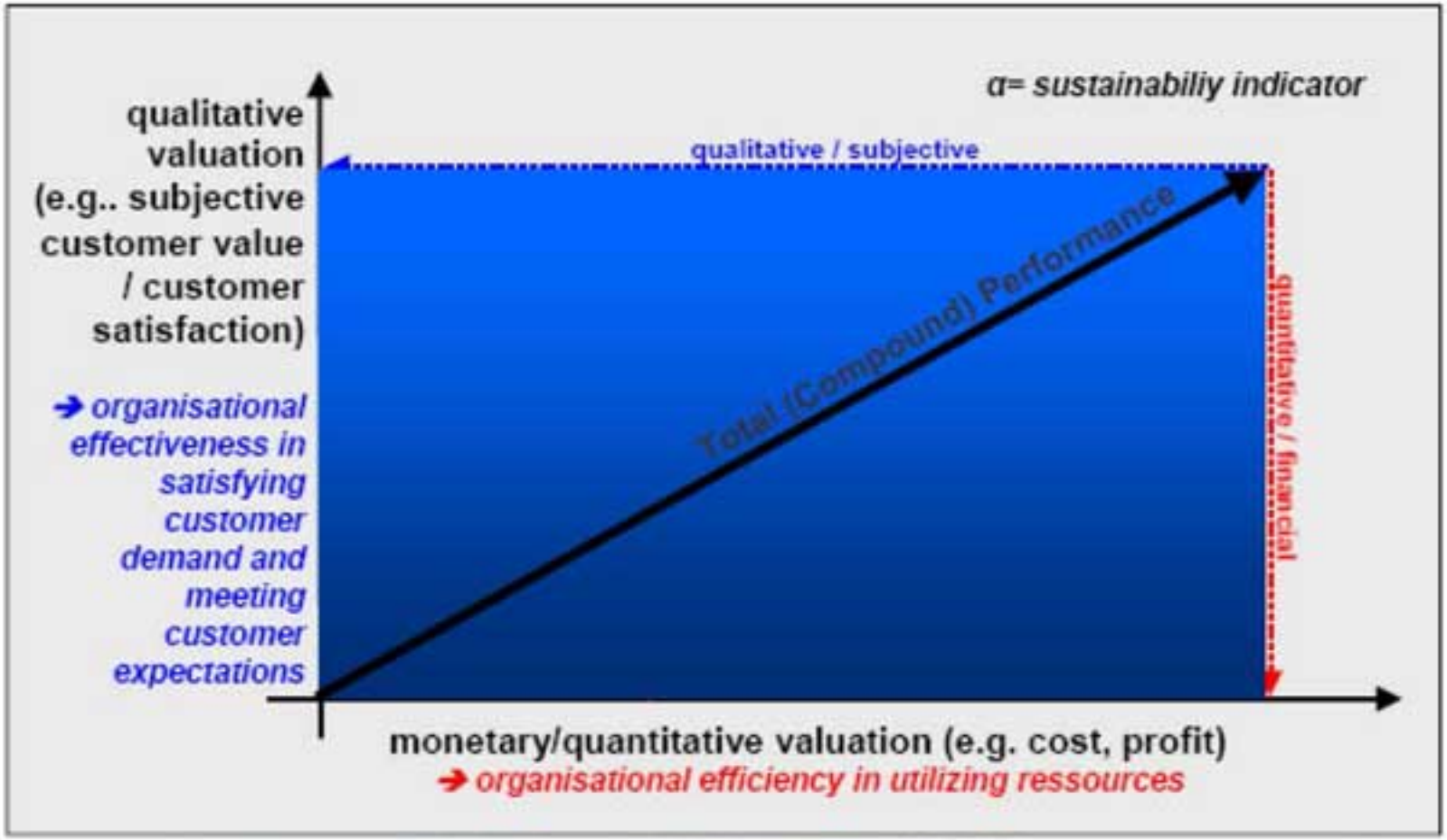
Tangibles





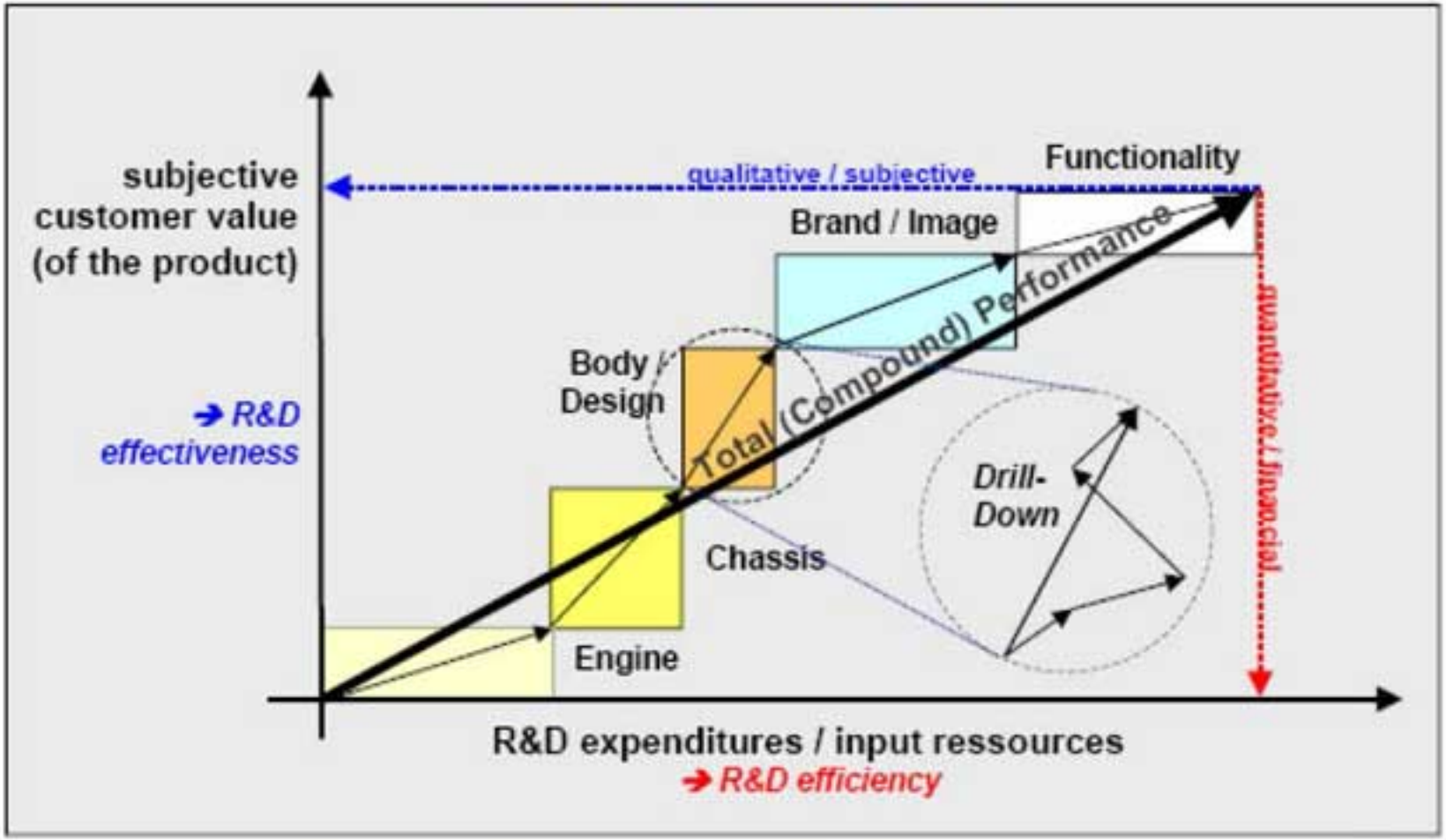
Intangibles:
URBAN REGENERATION IN TURKMENISTAN

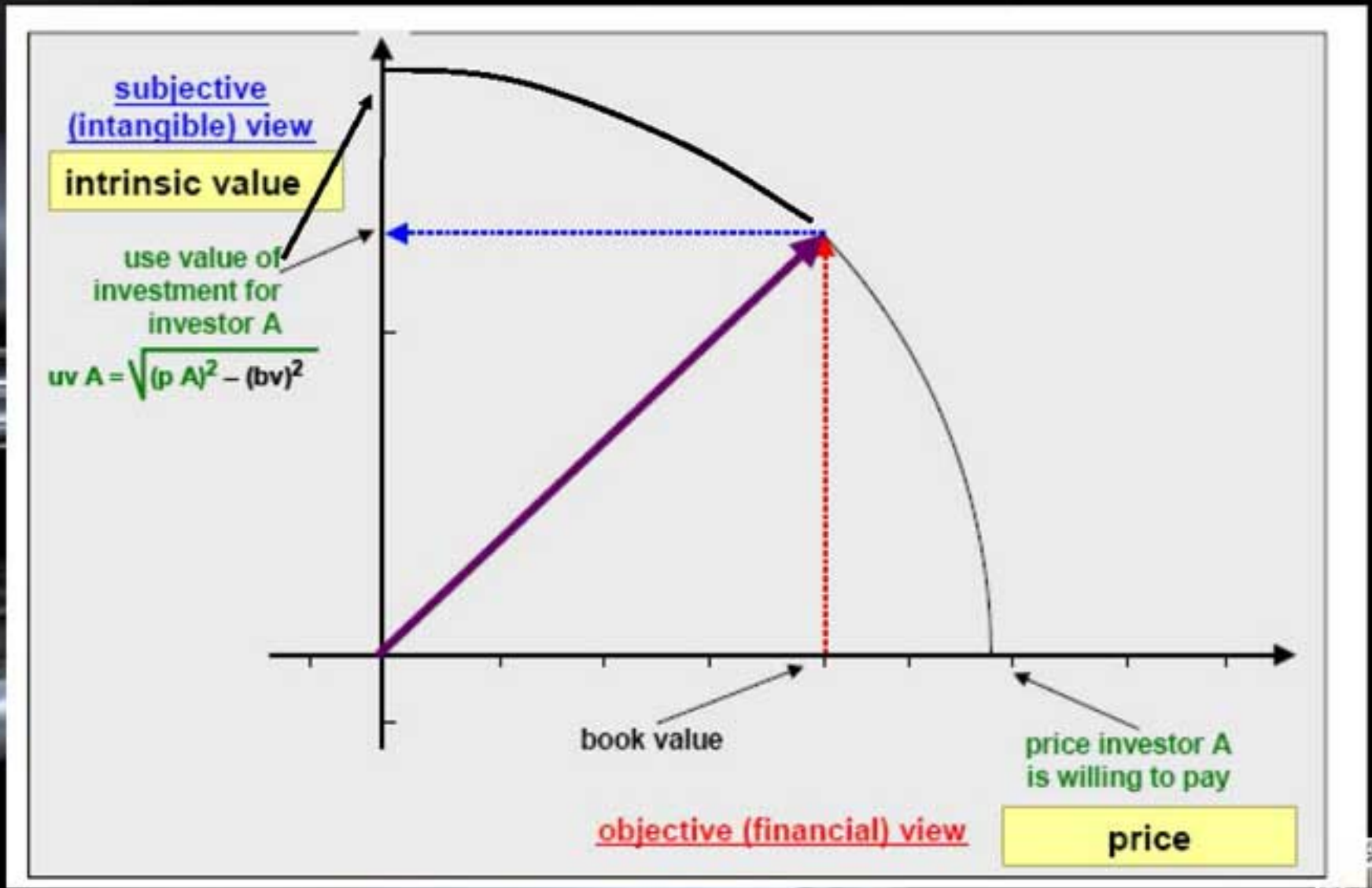
The Basics of the Concept



Vector Aggregation and Drilldown Analysis

(Example: Automotive R&D)




subjective
(intangible) view
intrinsic value
use value of
investment for
investor A
uv A = √((p A)² – (bv)²)
book value
price investor A
is willing to pay
objective (financial) view
price

ASSESSING THE INTANGIBLES - THE METHOD

ASSUMPTIONS/FOUNDATIONS

1) **ENERGY SECURITY** (of Project) = *VSUM* [**ENERGY SECURITY** (of Project Player)]
VSUM – vector sum over all Project Players

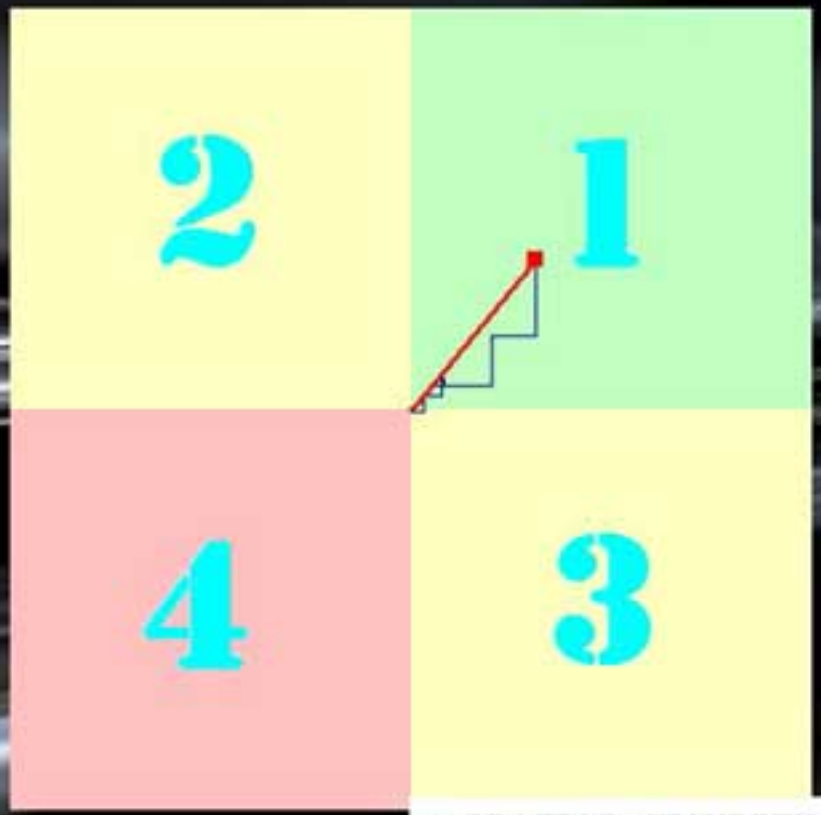
2) **ENERGY SECURITY** (of Project Player) = **PROFITABILITY** (secured by Player) *X* **OPERABILITY** (secured by Player)
X – cartezian product

3) **PROFITABILITY** (secured by Player) = *SUM* [**TANGIBLE (T) ASSET** SCORES]
SUM – algebraic sum over scores (-10 to 10) assigned to T-assets by brain tanks

4) **OPERABILITY** (secured by Player) = *SUM* [**INTANGIBLE (I) ASSET** SCORES]
SUM – algebraic sum over scores (-10 to 10) assigned to I-assets by brain tanks

5) **TANGIBLE ASSETS** – Factbook (e.g. CIA Factbook) *Numeric* Country Indicators (e.g. GDP/capita, pipeline lengths...)
INTANGIBLE ASSETS – Factbook (e.g. CIA Factbook) *Verbose* Country Indicators (e.g. governance, religions...)

Dealing with a Matrix for Tangibles / Intangibles



» PROJECT SECURITY ASSESSMENT, by PLAYERS

- Tier 1: Good Profitability and Good Operability. Security - GOOD.
- Tier 2: Poor Profitability and Good Operability. Security - MODERATE.
- Tier 3: Good Profitability and Poor Operability. Security - POOR.
- Tier 4: Poor Profitability and Poor Operability. Security - UNACCEPTABLE.

Exit
full screen mode

ODU-ONLINE
Assessing the Intangibles

version October 2008
by A.V. Gheorghe, Batten Chair, Norfolk
& D. Vamanu, Rs. Associate, Bucharest

OldDominionUNIVERSITY

Batten Chair of Systems of Systems Engineering

* PLAYERS
* ASSETS
* ASSESS COUNTRIES BY SYSTEMS
* ASSESS PROJECT BY COUNTRIES
* Close Program

ODU-ONLINE
Assessing the Intangibles
» The Assets

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* Back

Select Player

Aruba / aa txt | Open Player File

```
CIA - The World Factbook -- Romania

Background: The principalities of Wallachia and Moldavia - for centuries under the suzerainty of the Turkish Otto
Empire - secured their autonomy in 1856; they united in 1859 and a few years later adopted the new name of Romani
country gained recognition of its independence in 1878. It joined the Allied Powers in World War I and acquired s
territories - most notably Transylvania - following the conflict. In 1940, Romania allied with the Axis powers an
```

Assets Featuring Player

Notes: Retain only the assets that are relevant to the assessment.
To eliminate assets, or edit asset attributes, click asset and go as directed.
Types: n(umeric), v(erbose). Category: t(angible), i(ntangible).
Impact Rank: 0.0 to 1.0.

Save Retained Assets

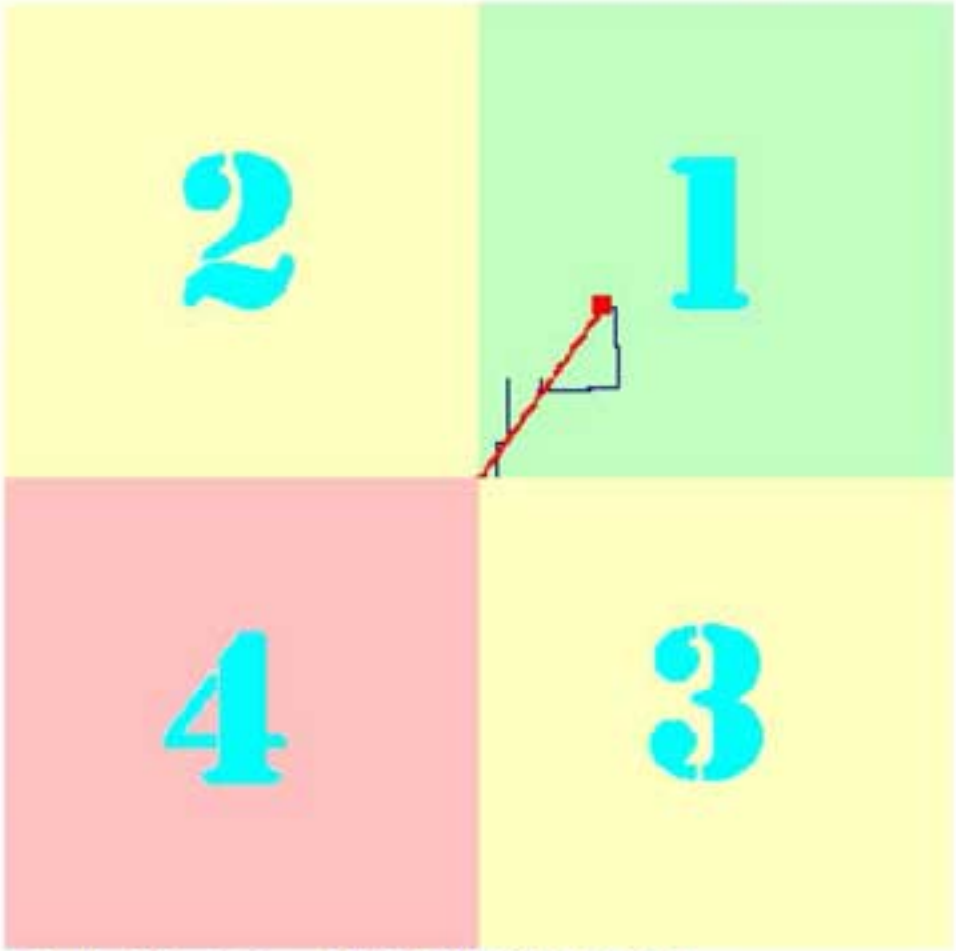
Asset	Value	System	Type	Category	Working Score
Background	The principalities of Wallachia and Moldavia - for centuries under the suzerainty of the Turkish Ottoman Empire - secured their autonomy in 1856; they united in 1859 and a few years later adopted the new name of Romania. The country gained recognition of its independence in 1878. It joined the Allied Powers in World War I and acquired new territories - most notably Transylvania - following the conflict. In 1940, Romania allied with the Axis powers and participated in the 1941 German invasion of the USSR. Three years later, overrun by the Soviets, Romania signed an armistice. The post-war Soviet occupation led to the formation of a Communist "people's republic" in 1947 and the abdication of the king. The decades-long rule of dictator Nicolae CEAUSESCU, who took power in 1965, and his Securitate police state became increasingly oppressive and draconian through the 1980s. CEAUSESCU was overthrown and executed in late 1989. Former Communists dominated the government until 1996 when they were swept from power. Romania joined NATO in 2004 and the EU in 2007.	HISTORY	v	i	1069
Location	Southeastern Europe, bordering the Black Sea, between Bulgaria and Ukraine	NATURE	v	i	75
Geographic coordinates	46 00 N, 25 00 E	NATURE	n	t	46
Map references	Europe	NATURE	v	i	7
Area total	237500 sq km	NATURE	n	t	237500
land	230340 sq km	NATURE	n	t	230340
water	7160 sq km	NATURE	n	t	7160
Area - comparstive	slightly smaller than Oregon	NATURE	v	i	29

adjective	Romanian	DEMOGRAPHY	v	i	9
Ethnic groups	Romanian 89.5%, Hungarian 6.6%, Roma 2.5%, Ukrainian 0.3%, German 0.3%, Russian 0.2%, Turkish 0.2%, other 0.4% (2002 census)	DEMOGRAPHY	v	i	125
Religions	Eastern Orthodox (including all sub-denominations) 86.8%, Protestant (various denominations including Reformate and Pentecostal) 7.5%, Roman Catholic 4.7%, other (mostly Muslim) and unspecifed 0.9%, none 0.1% (2002 census)	CULTURE	v	i	224
Languages	Romanian (official), Hungarian, German	CULTURE	v	i	33
Literacy definition	age 15 and over can read and write	CULTURE	v	i	35
total population	98.4%	CULTURE	n	t	98.4
male	99.1%	CULTURE	n	t	99.1
female	97.7% (2003 est.)	CULTURE	n	t	97.7
Country name conventional long form	none	ADMINISTRATION	v	i	8
conventional short form	Romania	ADMINISTRATION	v	i	8
local long form	none	ADMINISTRATION	v	i	8
local short form	Romania	ADMINISTRATION	v	i	8
Government type	republic	ADMINISTRATION	v	i	9
Capital name	Bucharest	ADMINISTRATION	v	i	10
geographic coordinates	44 26 N, 26 06 E	ADMINISTRATION	n	t	44
time difference	UTC+2 (7 hours ahead of Washington, DC during Standard Time)	ADMINISTRATION	v	i	61
daylight saving time	+1hr, begins last Sunday in March; ends last Sunday in October	ADMINISTRATION	v	i	63
Administrative divisions	41 counties (judete, singular - judet) and 1 municipality* (municipiu): Alba, Arad, Arges, Bacau, Bihor, Bistrita-Nasaud, Botosani, Braila, Brasov, Bucuresti (Bucharest)*, Buzau, Calarasi, Caras-Severin, Cluj, Constanta, Covasna, Dimbovita, Dolj, Galati, Gorj, Giurgiu, Harghita, Hunedoara, Ialomita, Iasi, Ilfov, Maramures, Mehedinti, Mures, Neamt, Olt, Prahova, Salaj, Satu Mare, Sibiu, Suceava, Teleorman, Timis, Tulcea, Vaslui, Vilcea, Vrancea	ADMINISTRATION	n	t	41

ports - partners	Italy 15.5%, Germany 14%, Russia 8.3%, France 6.8%, Turkey 4.9%, China 4.1% (2005)	ECONOMY	v	i	83	8.21
serves of foreign change and gold	27.88e9 (2006 est.)	ECONOMY	n	t	2.788e10	6.87
Debt - external	42.76e9 (2006 est.)	ECONOMY	n	t	4.276e10	8.27
rency (code) leu ROL) is being sed out in 2006. ' leu (RON) was oduced in 2005 ue to currency revaluation	10000 ROL = 1 RON	ECONOMY	n	t	10000	2.25
Currency code	ROL	ECONOMY	v	i	4	-4.59
xchange rates	lei per US dollar - 2.84 (2006), 3 (2005), 3 (2004), 3 (2003), 3 (2002)	ECONOMY	v	i	72	8.41
Fiscal year	calendar year	ECONOMY	v	i	14	-4.19
ephones - main lines in use	4.391e6 (2005)	INFRASTRUCTURE	n	t	4.391e6	2.37
phones - mobile cellular	13.3b4e6 (2005)	INFRASTRUCTURE	n	t	1.3354e7	9.20
ephone system eral assessment	rapidly improving domestic and international service, especially in wireless telephony	INFRASTRUCTURE	v	i	87	3.74
domestic	90% of telephone network is automatic; liberalization in 2003 is transforming telecommunications; there has been 20% growth in fixed lines with a penetration rate of 58% of households; nation-wide wireless service is growing even faster with four major providers and a penetration rate of 32%	INFRASTRUCTURE	n	t	90	7.09
international	country code - 40; satellite earth station - 10 (Intelsat 4); digital, international, direct-dial exchanges operate in Bucharest (2005)	INFRASTRUCTURE	v	i	136	0.80
adio broadcast stations	AM 40, FM 202, shortwave 3 (1998)	INFRASTRUCTURE	v	i	34	-3.83

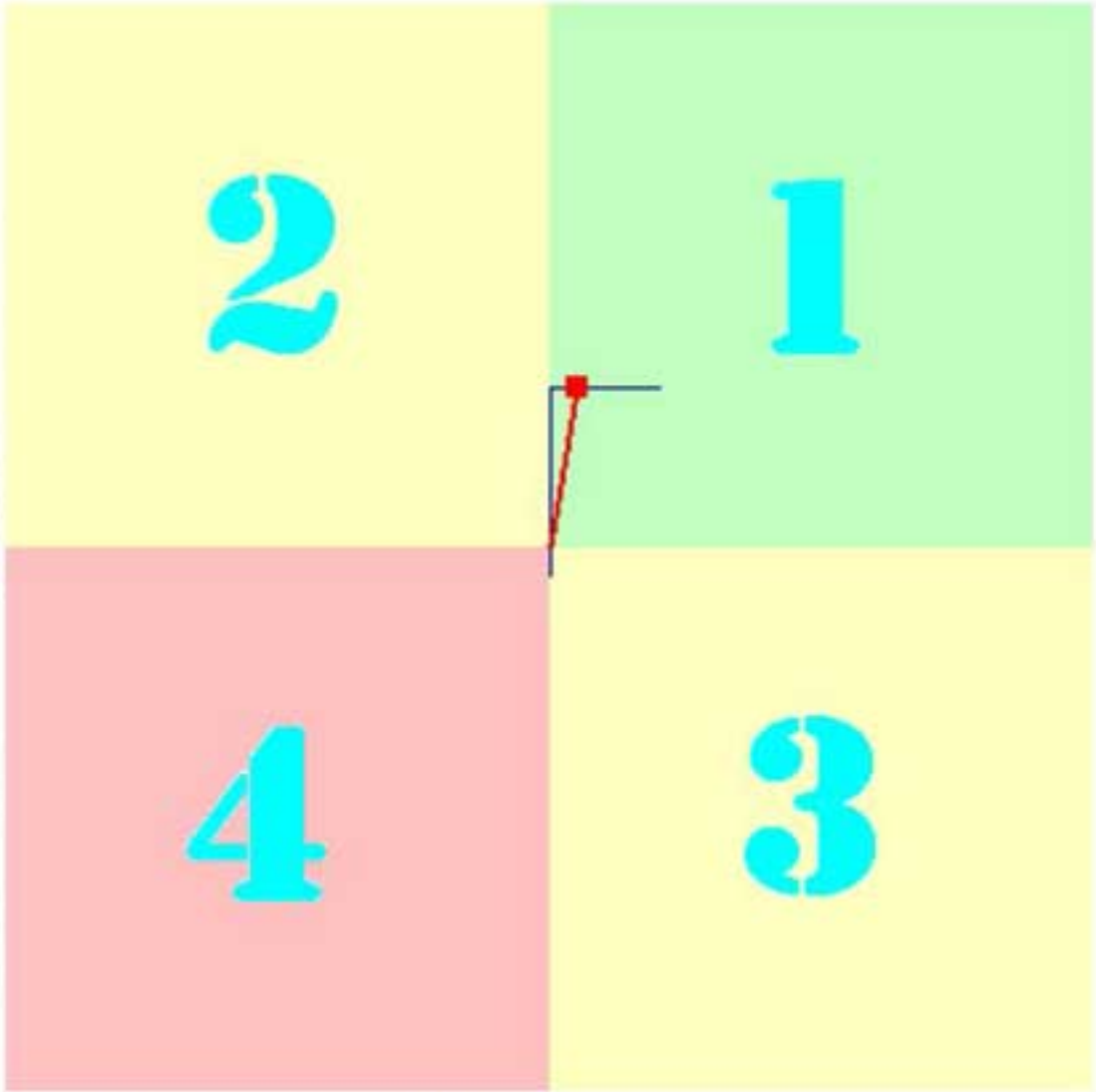
- Tier 1: Good Profitability and Good Operability. Security - GOOD.
- Tier 2: Poor Profitability and Good Operability. Security - MODERATE.
- Tier 3: Good Profitability and Poor Operability. Security - POOR.
- Tier 4: Poor Profitability and Poor Operability. Security - UNACCEPTABLE.

» Assessment by INFRASTRUCTURE SYSTEM - Romania



- Profitability Index of INFRASTRUCTURE: 0.26
- Operability Index of INFRASTRUCTURE: 0.36

» Assessment by CULTURE SYSTEM - Romania

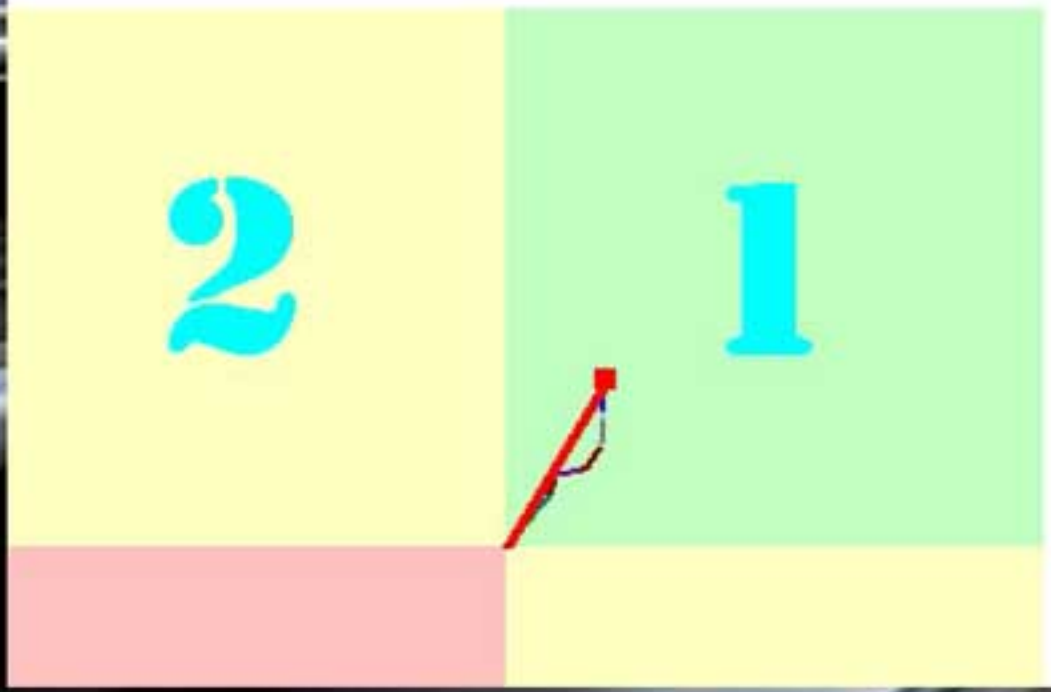


- Profitability Index of CULTURE: 0.05
- Operability Index of CULTURE: 0.30

ASSESSMENY BY COUNTRY as a SYSTEM OF SYSTEMS - Romania

Systems contributing (v. above):

- *Infrastructure;*
- *Economy;*
- *Nature;*
- *Demography;*
- *Administration;*
- *Politics;*
- *Defense;*
- *National Security;*
- *History;*
- *Culture.*

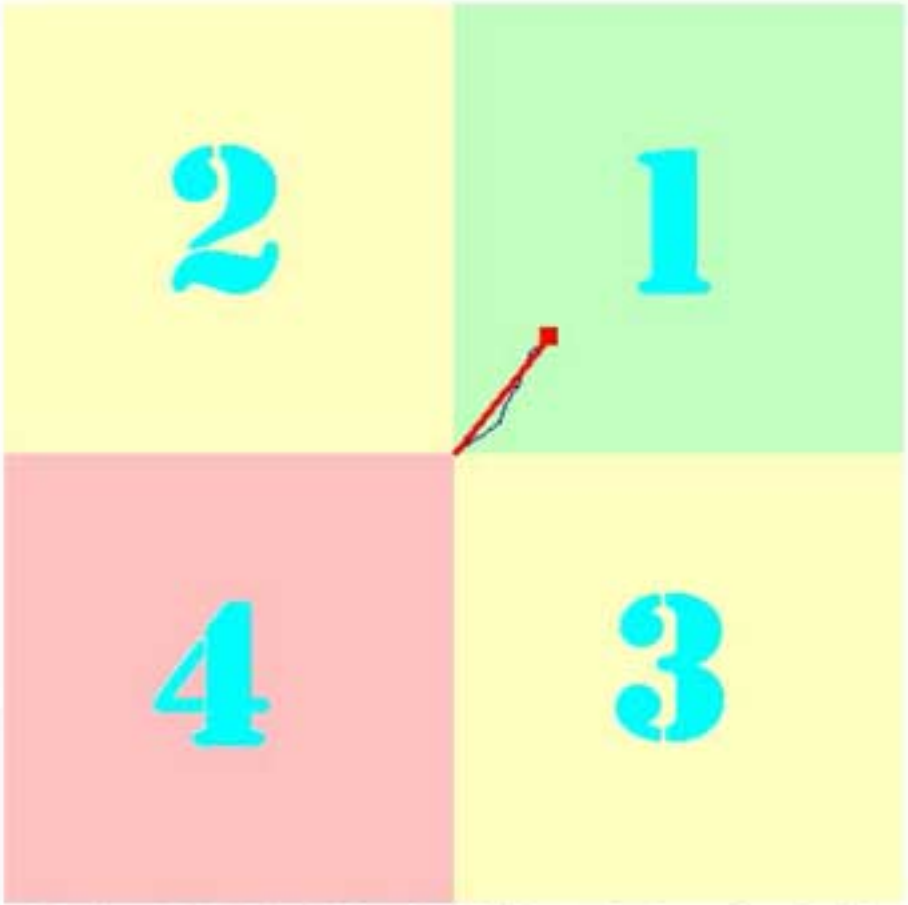


» **PROJECT SECURITY ASSESSMENT, by PLAYERS**

- *Tier 1: Good Profitability and Good Operability. Security - GOOD.*
- *Tier 2: Poor Profitability and Good Operability. Security - MODERATE.*
- *Tier 3: Good Profitability and Poor Operability. Security - POOR.*
- *Tier 4: Poor Profitability and Poor Operability. Security - UNACCEPTABLE.*

PROJECT PLAYERS are:

» Azerbaijan: 0.24 0.19
» Russia: 0.28 0.19
» Ukraine: 0.29 0.24
» Hungary: 0.09 0.30
» Austria: 0.23 0.30
» Germany: 0.11 0.26
» France: 0.13 0.35
» Italy: 0.32 0.26

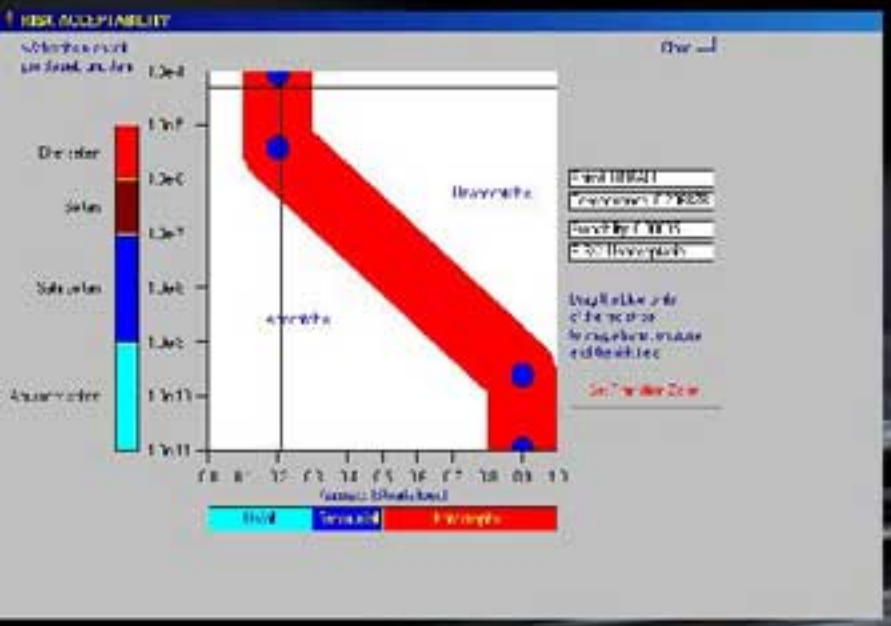


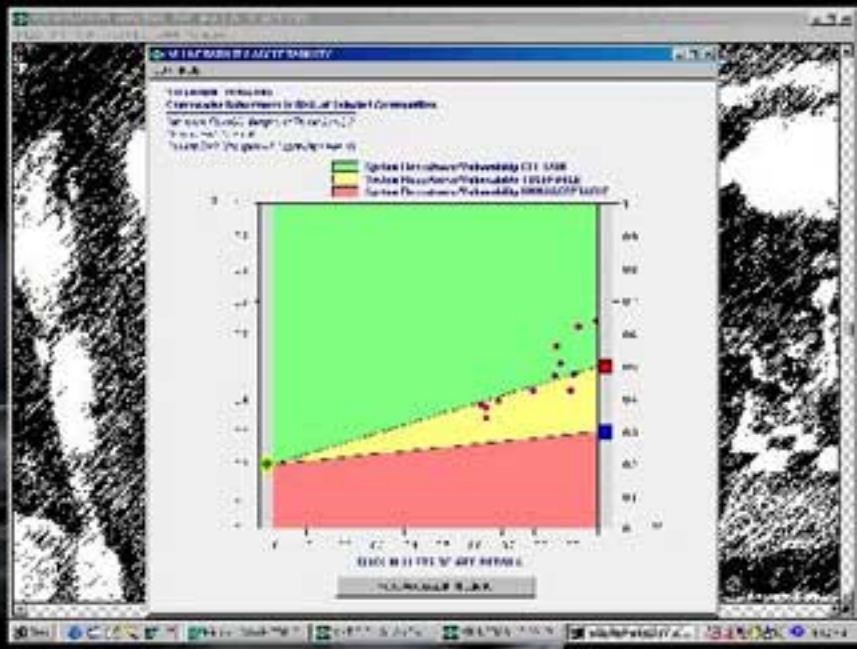
- Project Combined Profitability Index of : 0.21
- Project Combined Operability Index of : 0.26

The "Rolex Approach"

- Our borders can be guarded as well as a "*Perpetual Oyster*", however one needs a working *Rolex* mechanism inside in order to manage vulnerabilities.

Risk and Vulnerability Governance





ALARA – As Low As Reasonably Acceptable

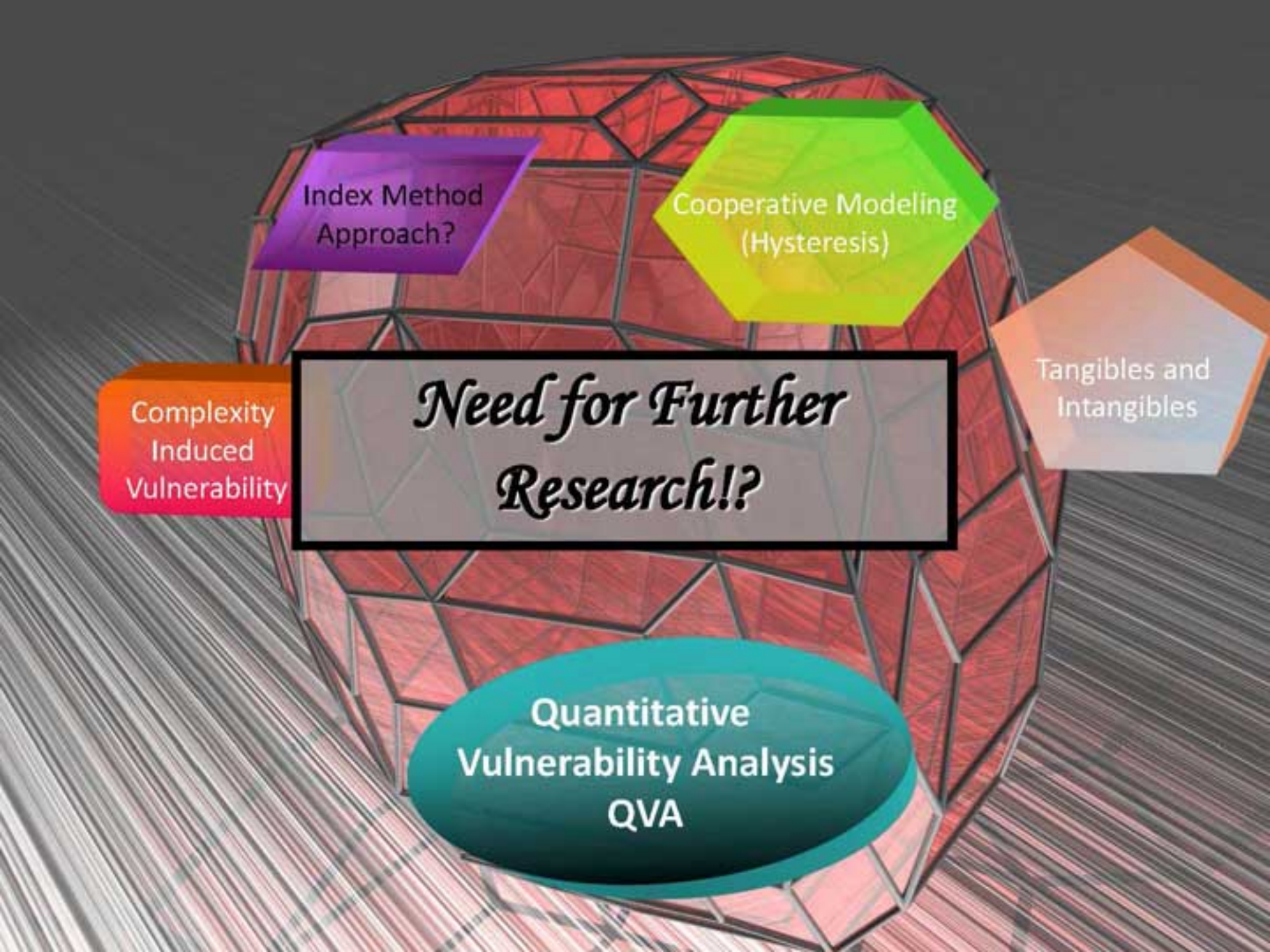
ARASP- As Resilient As Society Permits

Governance

Sustainability

Acceptability, Perception, Trust, Participation

Multicriteria Indicators and their Integration


Index Method Approach?
Cooperative Modeling (Hysteresis)
Tangibles and Intangibles
Complexity Induced Vulnerability
Need for Further Research!?
Quantitative Vulnerability Analysis QVA

Where Next?