

Carnegie Mellon University

From the Selected Works of Cécile Péraire

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A Step Forward in Software Engineering Education: Introducing the SEMAT Essence Framework

Cécile Péraire, *Carnegie Mellon University*



Available at: https://works.bepress.com/cecile_peraire/2/

A Step Forward in Software Engineering Education: Introducing the SEMAT Essence Framework

Dr. Cécile Péraire

Carnegie Mellon University - Silicon Valley Campus
Evidence-Based Software Engineering Group

With the Participation of
Dr. Carlos Zapata
Universidad Nacional
de Colombia



LACREST
REQUIREMENTS ENGINEERING & SOFTWARE TESTING
LATIN AMERICAN CONGRESS

Who am I?

- Assistant Professor at CMU SV
- Co-Lead SEMAT Education Area
- Areas of Interest
 - Agile, Lean & Disciplined Software Development
 - Requirements Engineering, Empirical Studies

Carnegie Mellon University
Silicon Valley



Previous Life:

- Ph.D. in C.S. (Software Testing) from EPFL
- Postdoc at SRI & HP
- Various experiences at Rational & IBM
 - Consultant, Project/Program Manager, Methodologist
 - Contributed to RUP and IBM's internal methods



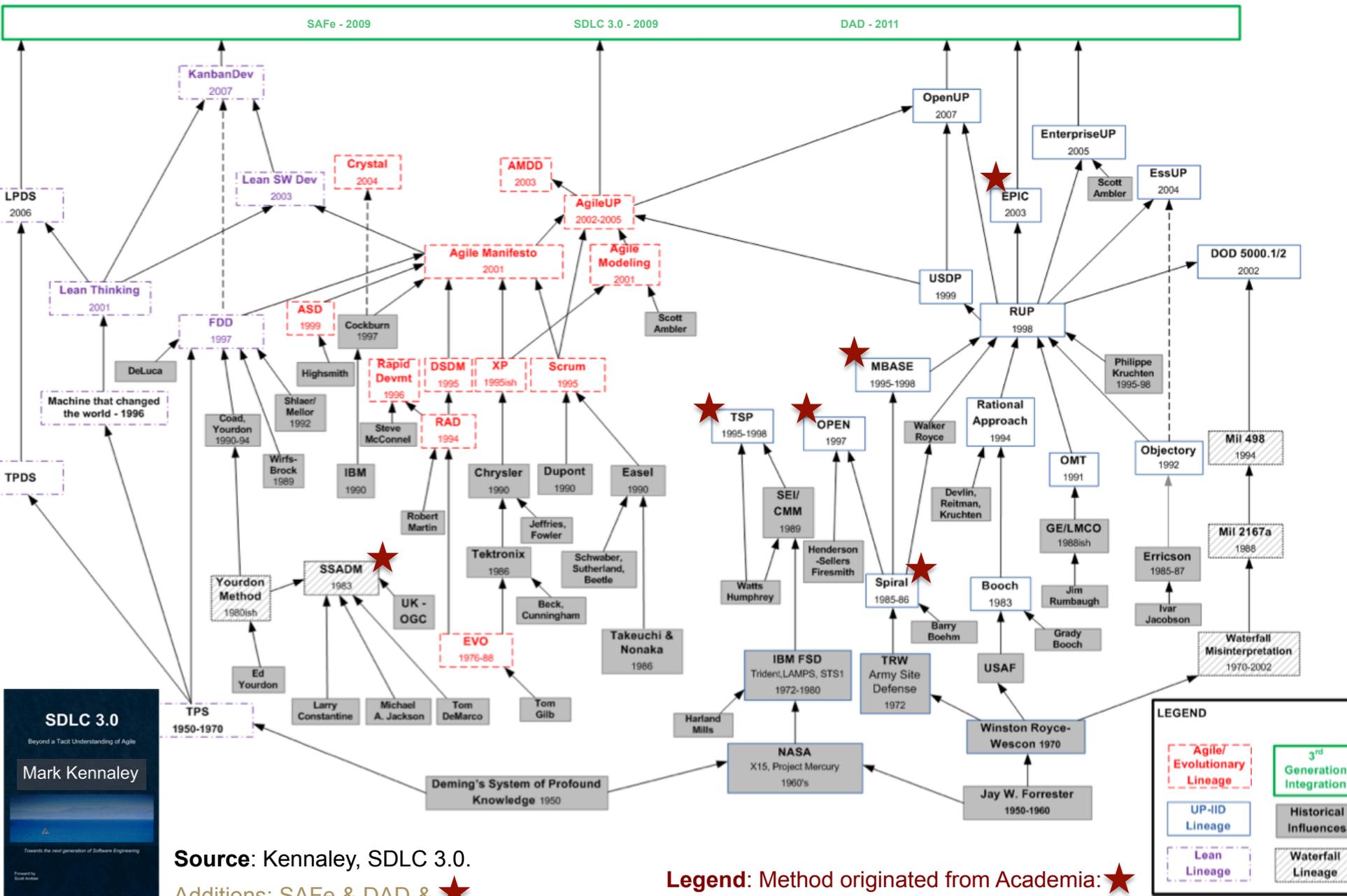
Agenda

- Challenges in SE Education
- What is SEMAT? What is Essence?
- How does the Essence Kernel Work?
- World Tour of SEMAT Educational Activities
 - Carnegie Mellon University
 - Universidad Nacional de Colombia
- SEMAT Vision for Education

Fact or Fiction?

The Industry is driving software engineering innovation with Academia lagging behind.

Evolution of Software Methods

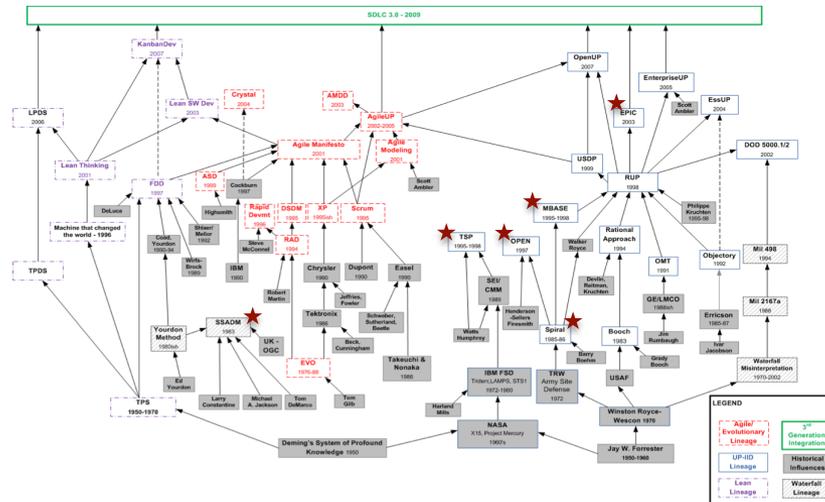


SDLC 3.0
 Beyond a Tacit Understanding of Agile
 Mark Kennaley
 Towards the next generation of Software Engineering
 Fourth Medium Press

Evolution of Software Methods

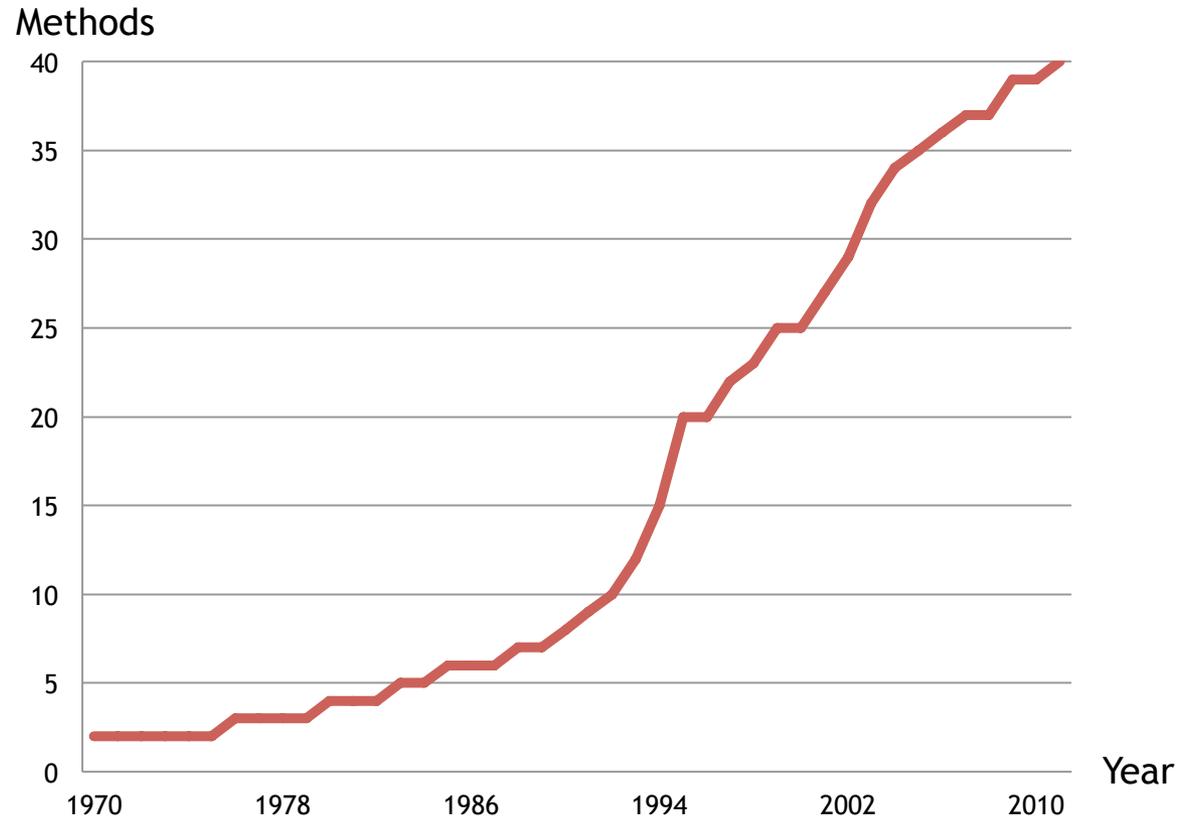
Out of the 40 methods which made it to the chart a minority (about 15%) originated from Academia or was significantly influenced by Academia.

Among this minority, none are from Agile or Lean lineage.



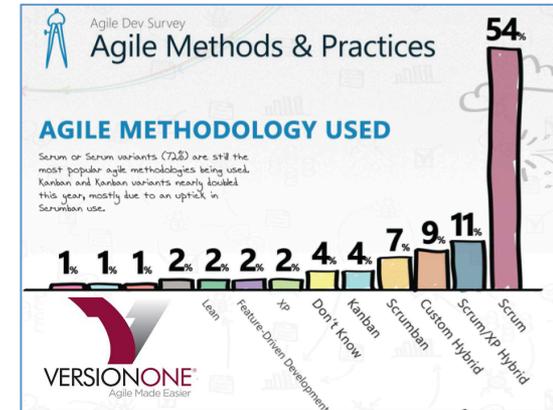
Evolution of Software Methods

32 methods emerged in the last 20 years
→ 1.6 new methods per year

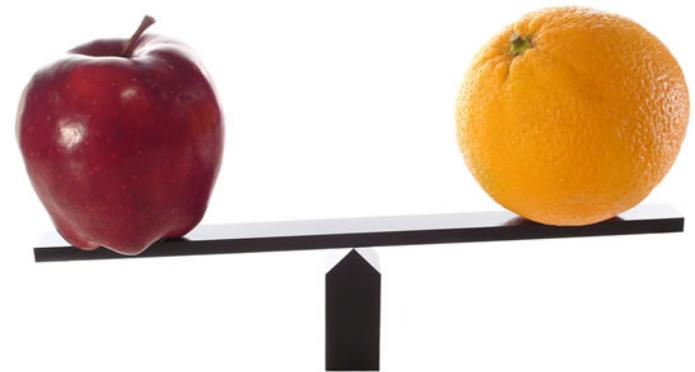


Challenges in SE Education

- Select Method(s) to Teach
 - Based on what criteria?
 - Adoption rate
 - Effectiveness
 - Coverage
 - Etc.



- Compare Methods



Challenges in SE Education

- Select Terminology



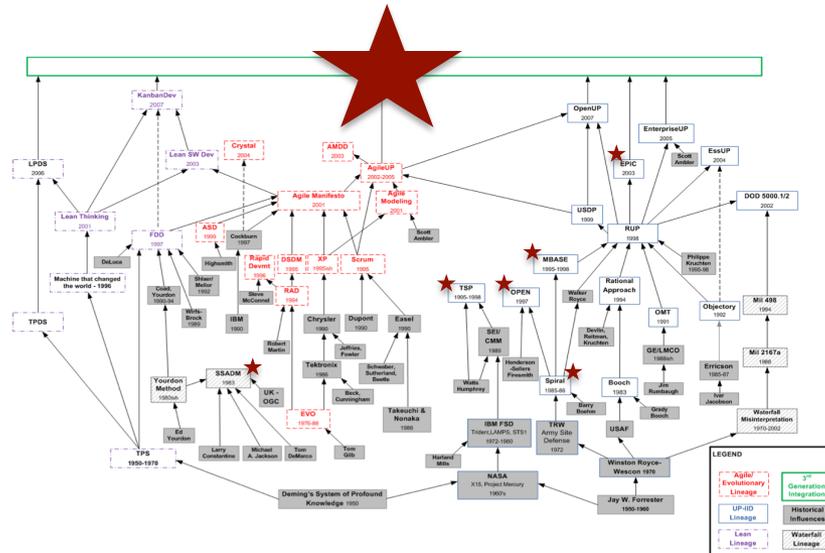
- Address Various Needs of Students

I want to
create
a startup

I want to join
an international
corporation

Challenges in SE Education

- Keep courses cutting edge with minimum waste/rework
- Conduct research adding value to our courses and to the industry



Some Ideas

Stop teaching methods;
Start teaching practices!

**Methods are composed out of a buffet
of generally accepted practices**

*“Teams are puzzling out the mix of methodologies
and combining them
to fit within their organizational realities,
blending Agile and non-Agile techniques and practices
to create a hybrid methodology”*

D. West, T. Grant, 2010

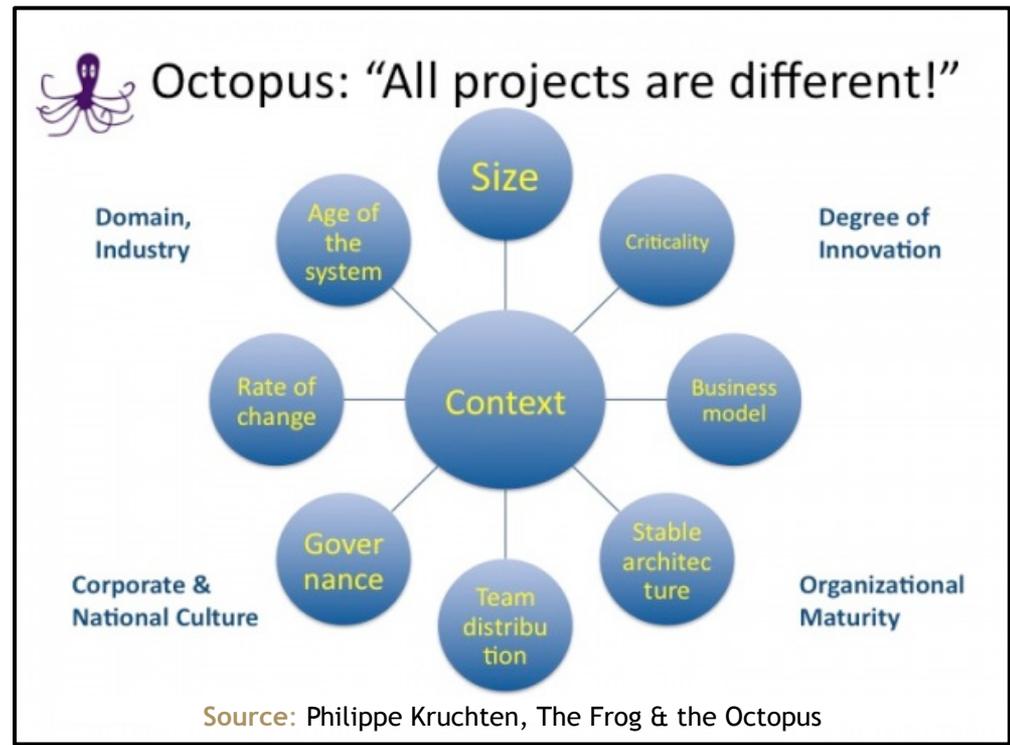
FORRESTER®



Some Ideas

Teach practices in context

Practices are only “GOOD” in context

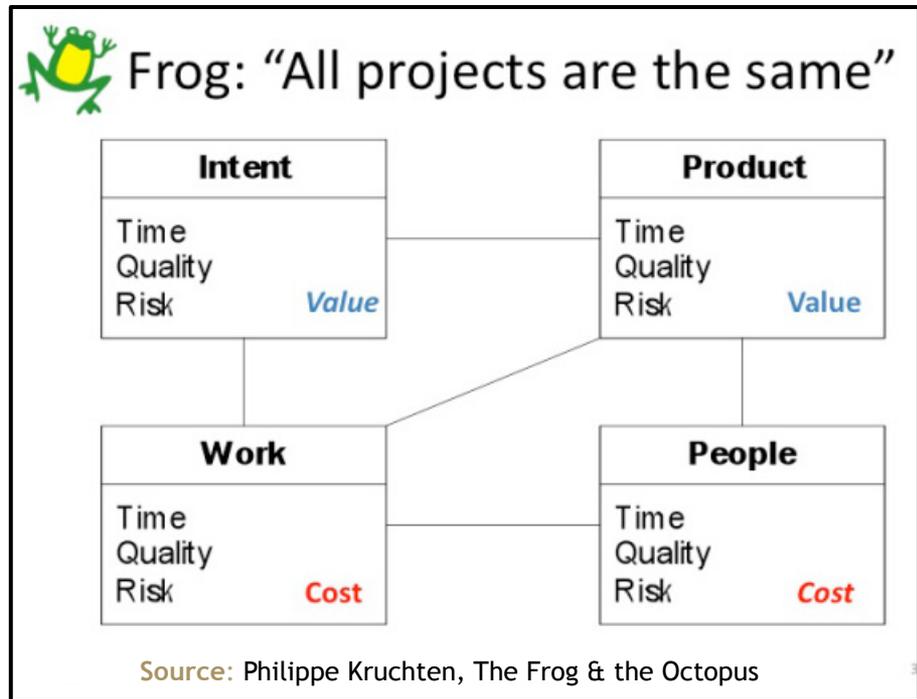
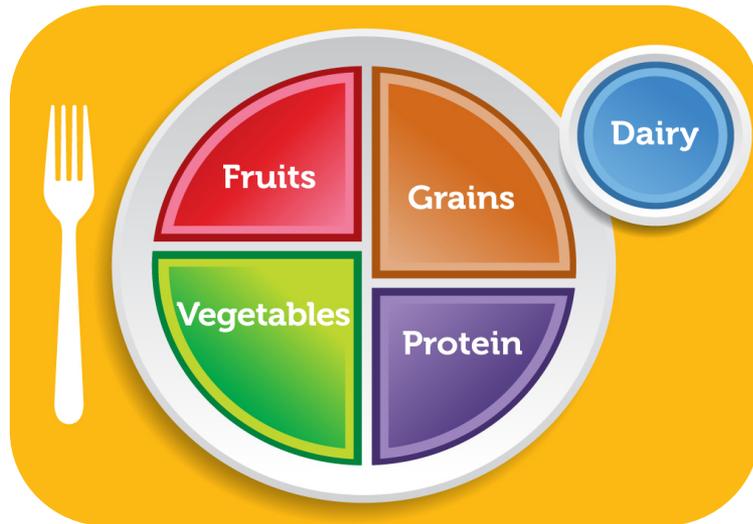
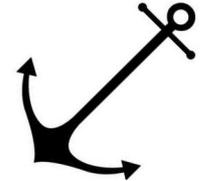


Other authors advocating about context: B. Boehm, A. Cockburn & S. Ambler

Some Ideas

Teach the essence of methods

Anchor SE courses in common grounds



Some Ideas

- Conduct research around:
 - The essence of methods / software engineering
 - Practices (definition & validation in context)



Agenda

- Challenges in SE Education
- **What is SEMAT? What is Essence?**
- How does the Essence Kernel Work?
- World Tour of SEMAT Education Activities
- SEMAT Vision for Education

What is SEMAT?

SEMAT: Software Engineering Method and Theory



SEMAT
COMMUNITY
www.semat.org

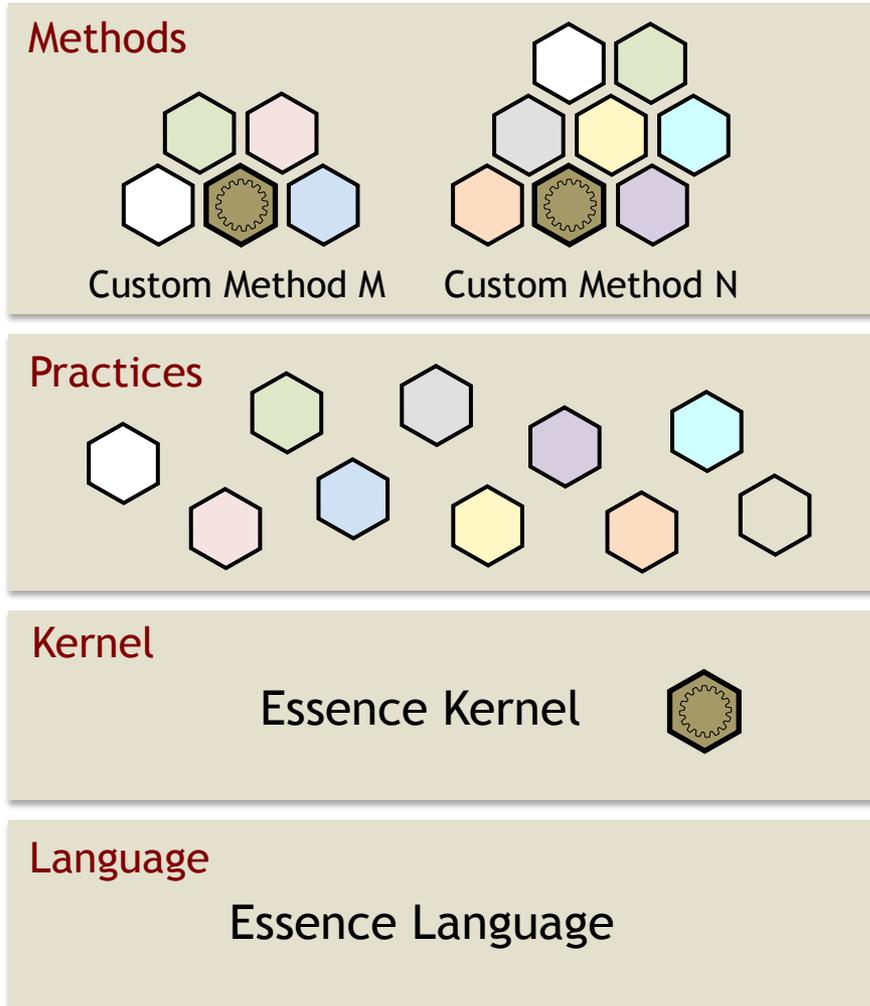
Creation:
2009

Founders: Ivar Jacobson, Bertrand Meyer, Richard Soley

Vision: Re-found software engineering as a rigorous discipline based on a general theory of software engineering and a unifying process framework

What is Essence?

Essence Method Architecture

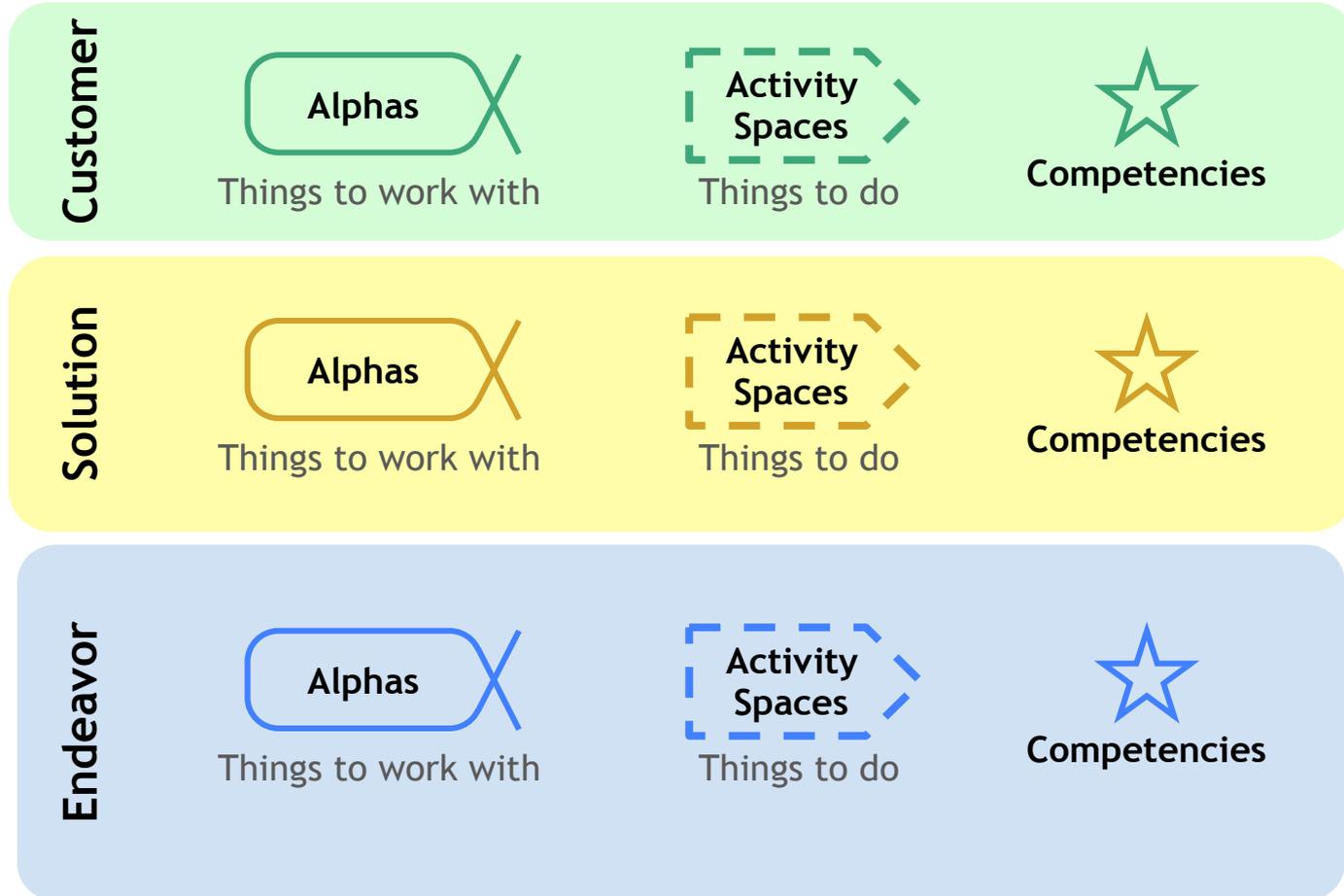


Essence Language & Kernel
became OMG beta standard
in 2013

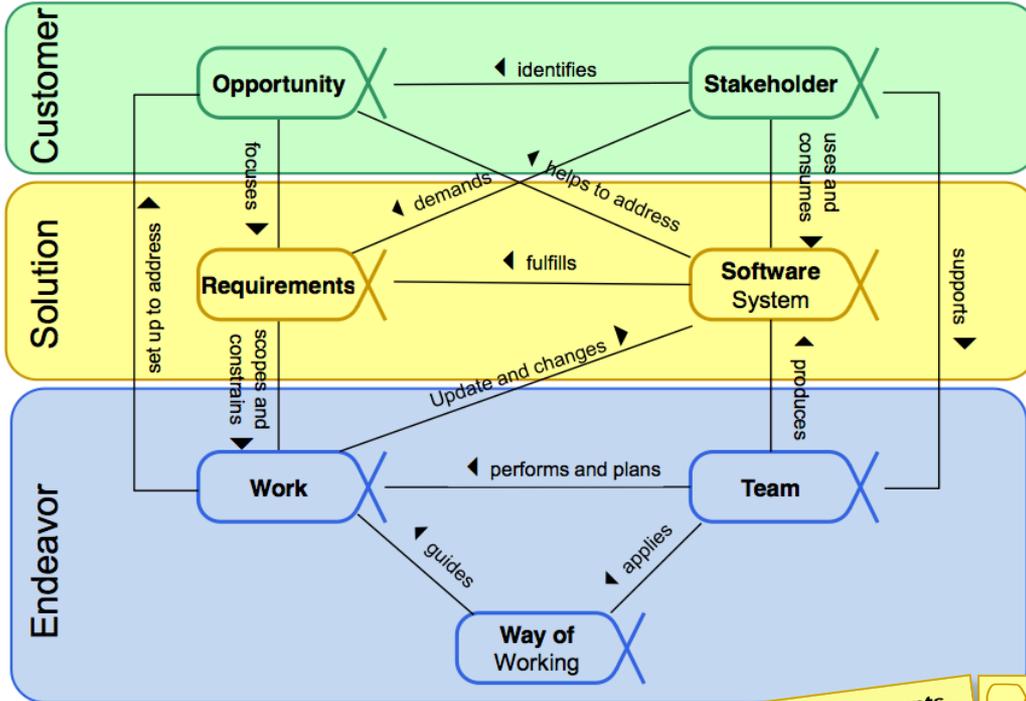
State-based Progress Monitoring
& Goal-driven Project Steering



Essence Kernel



Essence Kernel Alphas

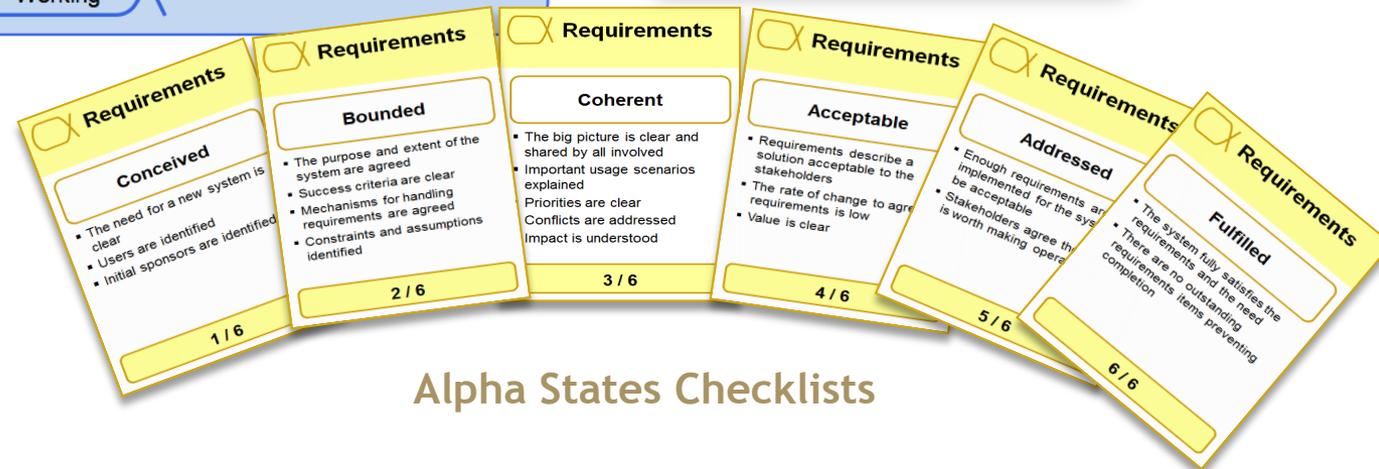


Kernel Alphas

Requirements

- Conceived
- Bounded
- Coherent
- Acceptable
- Addressed
- Fulfilled

Alpha States



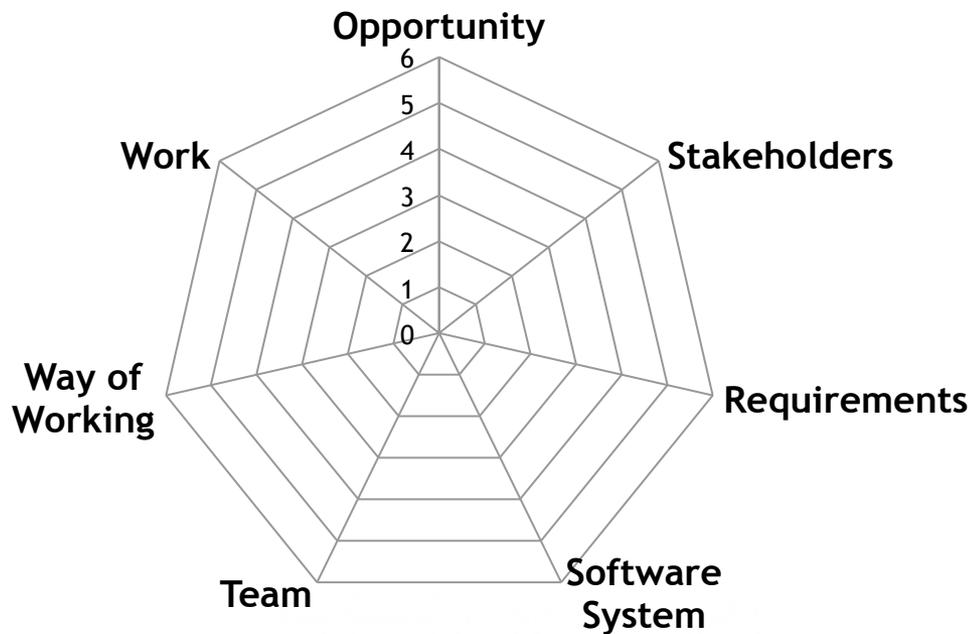
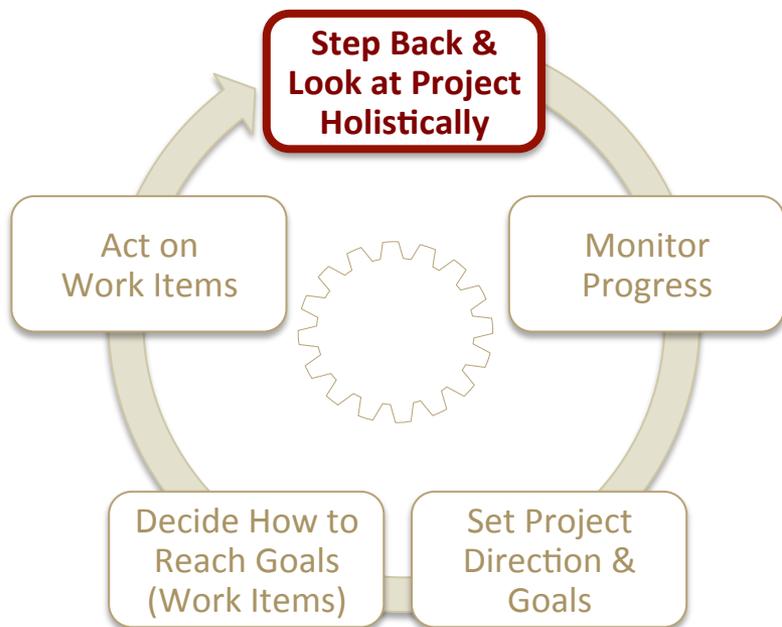
Alpha States Checklists

Agenda

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- **How does the Essence Kernel Work?**
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- SEMAT Vision for Education

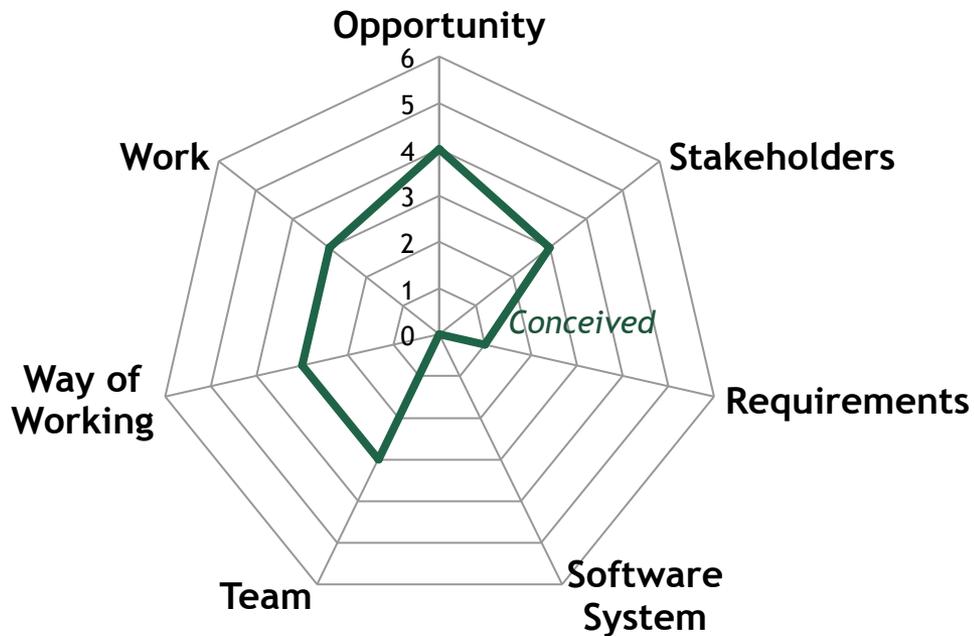
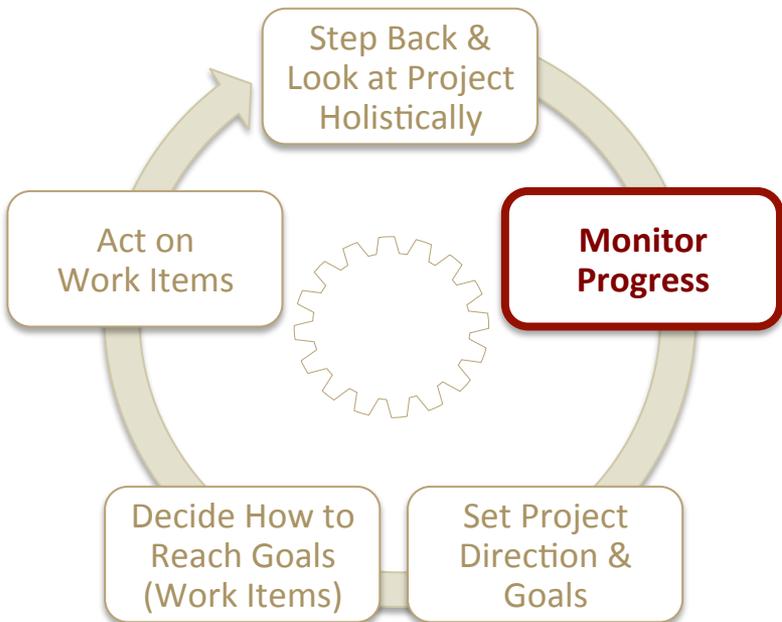


How does the Essence Kernel Work?

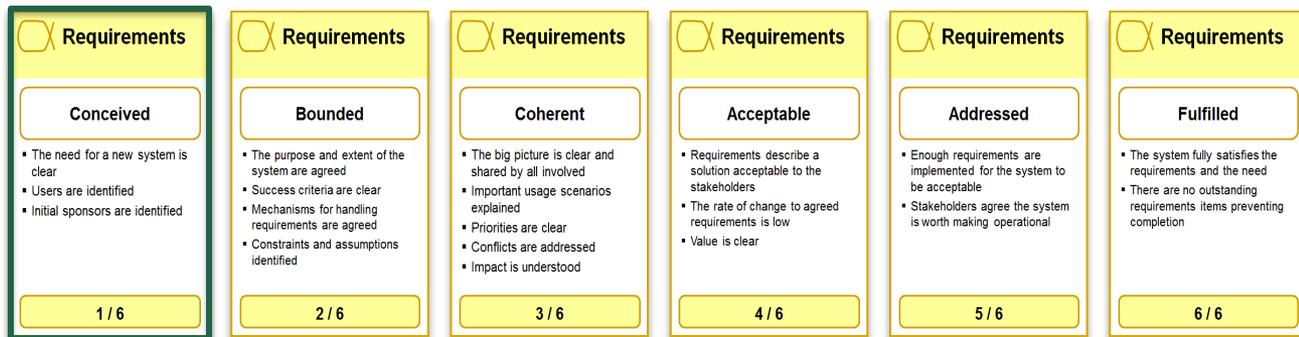




How does the Essence Kernel Work?

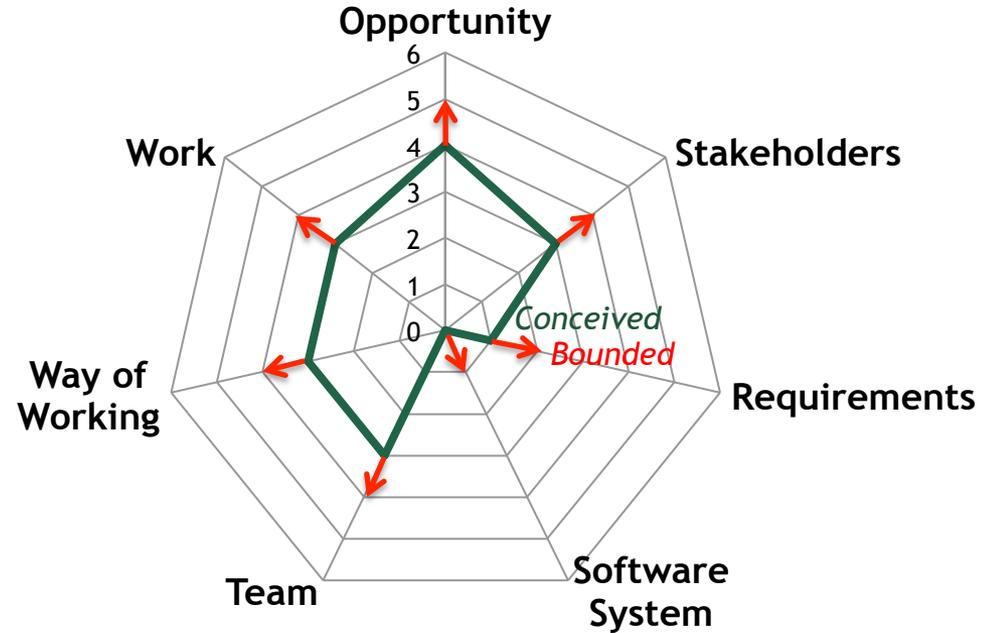
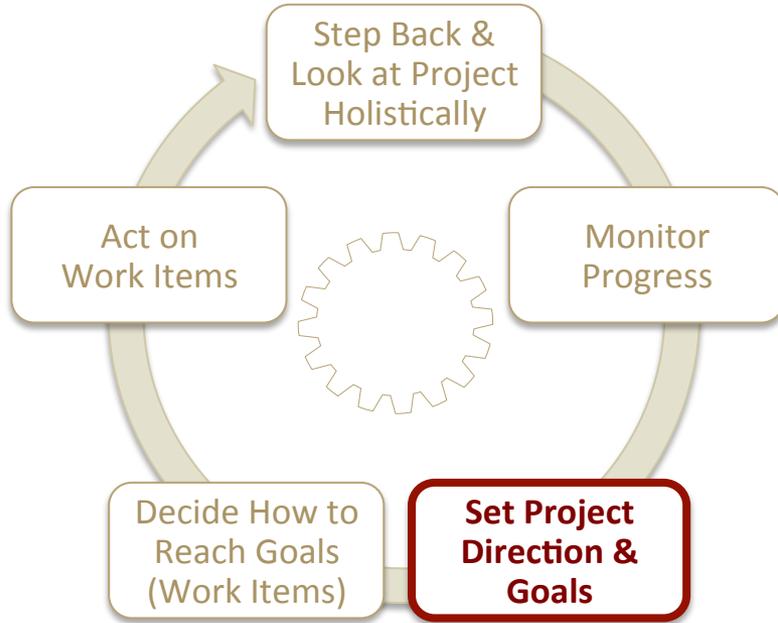


Current State





How does the Essence Kernel Work?



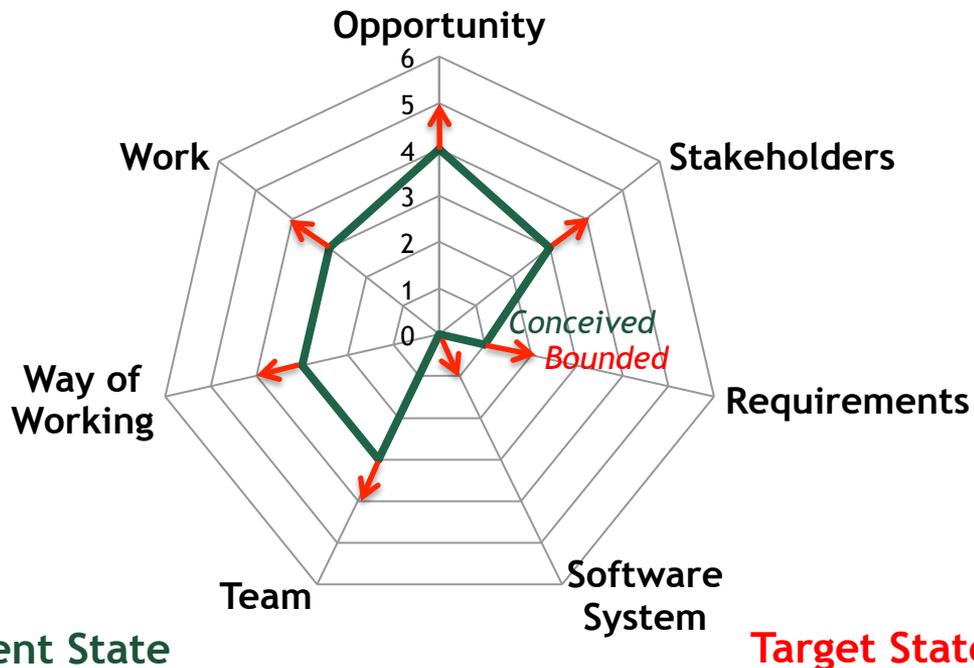
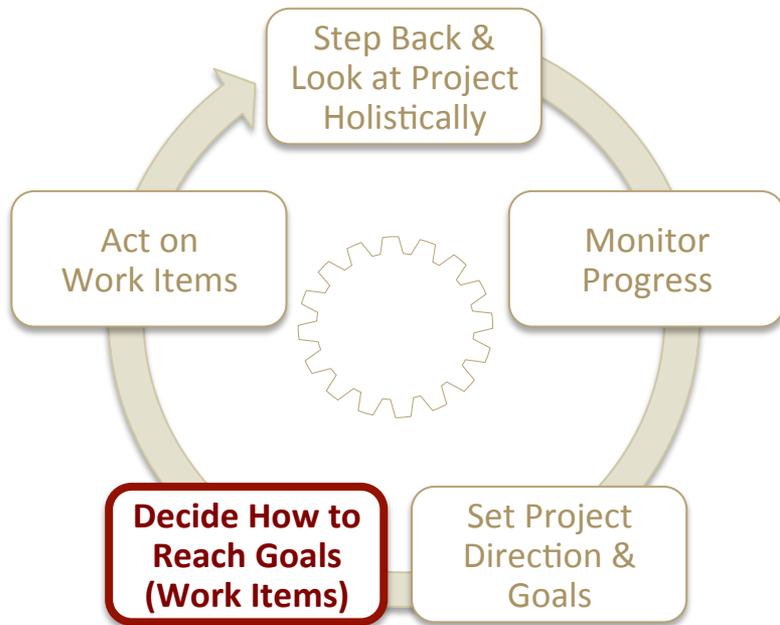
Current State

Target State

Requirements	Requirements	Requirements	Requirements	Requirements	Requirements
<input type="checkbox"/> Conceived <ul style="list-style-type: none"> The need for a new system is clear Users are identified Initial sponsors are identified 	<input type="checkbox"/> Bounded <ul style="list-style-type: none"> The purpose and extent of the system are agreed Success criteria are clear Mechanisms for handling requirements are agreed Constraints and assumptions identified 	<input type="checkbox"/> Coherent <ul style="list-style-type: none"> The big picture is clear and shared by all involved Important usage scenarios explained Priorities are clear Conflicts are addressed Impact is understood 	<input type="checkbox"/> Acceptable <ul style="list-style-type: none"> Requirements describe a solution acceptable to the stakeholders The rate of change to agreed requirements is low Value is clear 	<input type="checkbox"/> Addressed <ul style="list-style-type: none"> Enough requirements are implemented for the system to be acceptable Stakeholders agree the system is worth making operational 	<input type="checkbox"/> Fulfilled <ul style="list-style-type: none"> The system fully satisfies the requirements and the need There are no outstanding requirements items preventing completion
1 / 6	2 / 6	3 / 6	4 / 6	5 / 6	6 / 6



How does the Essence Kernel Work?



Current State

Requirements

Conceived

- The need for a new system is clear
- Users are identified
- Initial sponsors are identified

1 / 6

Work Items:

- Define Project Scope
- Clarify Success Criteria

Target State

Requirements

Bounded

- The purpose and extent of the system are agreed **Goals**
- Success criteria are clear
- Mechanisms for handling requirements are agreed
- Constraints and assumptions identified

2 / 6



How does the Essence Kernel Work?



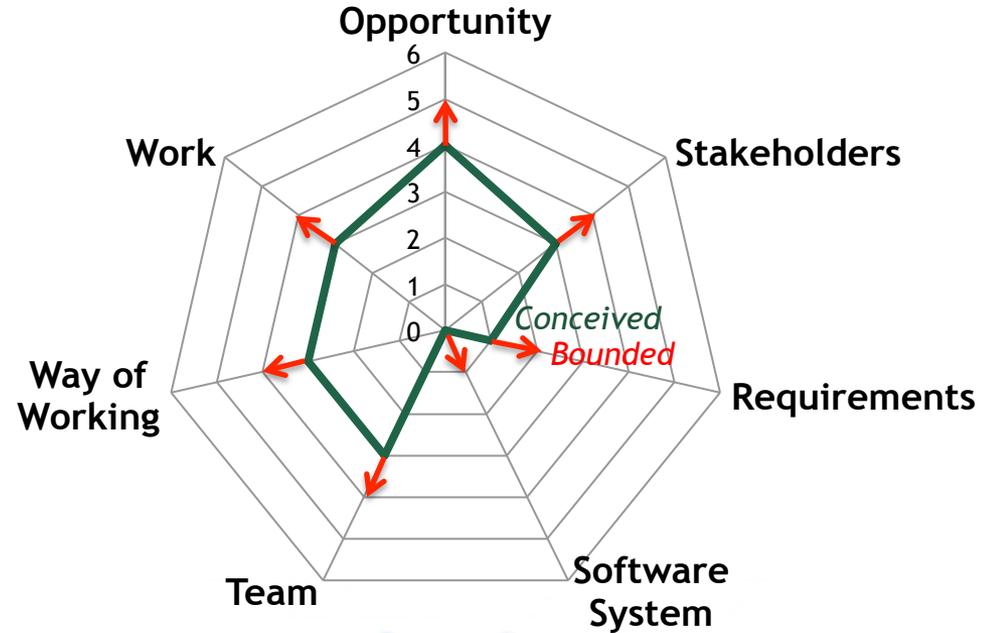
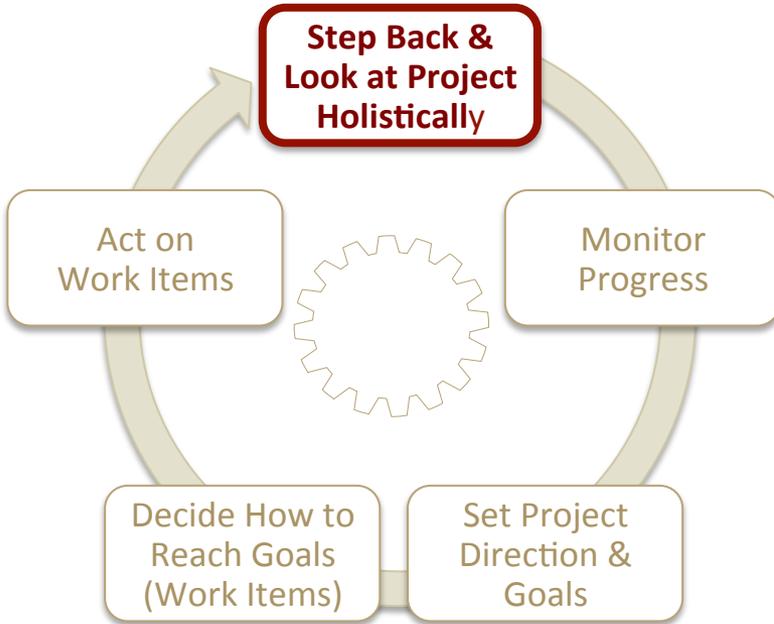
Work Items

- Define Project Scope
- Clarify Success Criteria
- ...
- ...
- ...
- ...





How does the Essence Kernel Work?



Time has passed...

Agenda

- Challenges in SE Education
- What is SEMAT? What is Essence?
- How does the Essence Kernel Work?
- **World Tour of SEMAT Educational Activities**
 - Carnegie Mellon University
 - Universidad Nacional de Colombia
- The SEMAT Vision for Education

World Tour of SEMAT Educational Activities



 Universities and institutes members of the SEMAT Education Area and leveraging Essence in software engineering education (2013)



Field Study of Essence Kernel at CMU



Cécile Péraire



Todd Sedano



Research Goal: Evaluate the effectiveness of Essence's monitoring and steering approach provided by the kernel alphas and their states in the context of practicum graduate courses



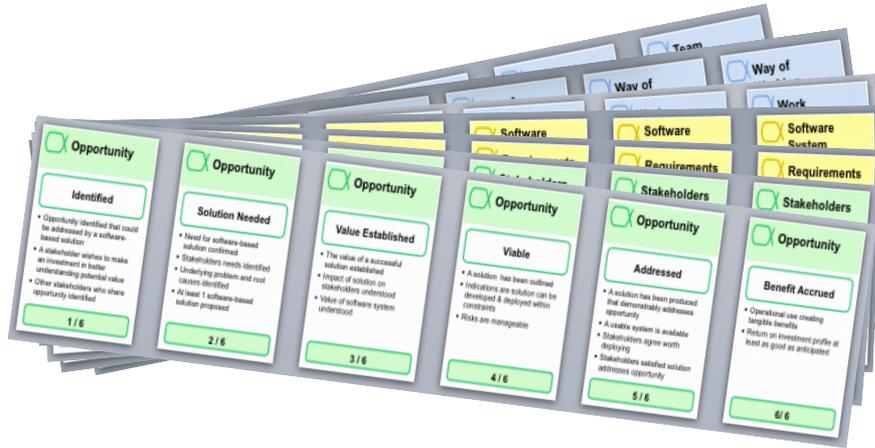
Field Study of Essence Kernel at CMU

Team Name	Industry Project Medium to high technical complexity	Team Size	Average Work Experience
15 week project - Each student works 20 hours per week			
Distributed-1	Audio streams rendering for accessibility	3	10 years
Distributed-2	Access/preservation of electronic journals	4	6 years
Distributed-3	Survivable social network	4	8 years
12 week project - Each student works 20 hours per week			
Co-located-1	Electric vehicle fleet management	2	3 years
Co-located-2	Sonification of financial trading	4	3 years
Co-located-3	Mobile performance testing	3	4 years
Co-located-4	Virtual sensors definition & management	5	5 years

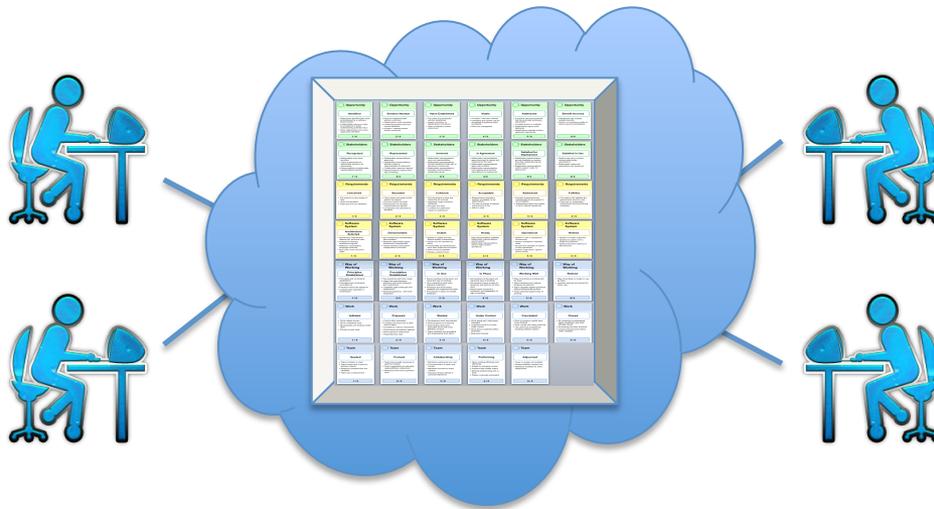
Teams are self-organizing - No constraints on development method - Iterative lifecycle



Field Study of Essence Kernel at CMU



Physical Strips
(versus Cards)
One Strip per Alpha



Digital Essence Board



Field Study of Essence Kernel at CMU

Date:

Iteration:

Week:

Alpha	Current State	Target State	Work Item / Notes
Stakeholders			
Opportunity			
Requirements			
Soft. System			
Team			
Way of Working			
Work			

Essence Log
Updated weekly
(1/2 hour session)

- What did you like the most about Essence?
- What did you like the least about Essence?
- Was following Essence worth your time?
(Please explain why or why not)
- Would you use Essence on your next project?
(Please explain why or why not)
- ...

Final Survey



Field Study of Essence Kernel at CMU

Research Questions

Does the approach provide value to the project team?

How does it provide value to the project team?

When in the project lifecycle does it add value?

What are the limits of the approach?





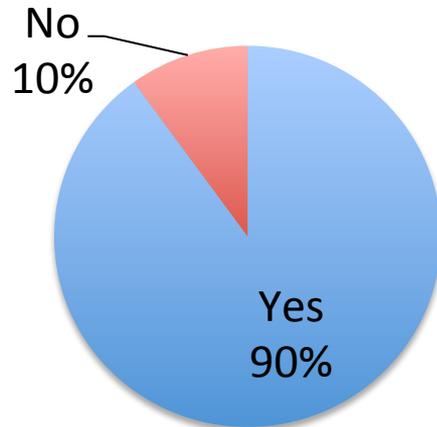
Field Study of Essence Kernel at CMU

Research Question:

Does the approach provide value to the project team?

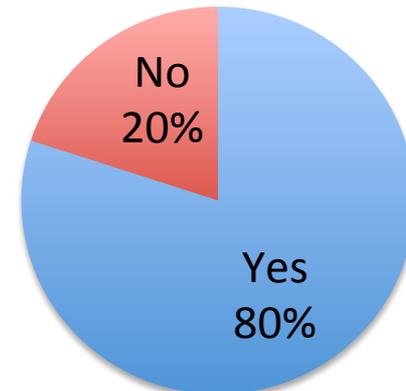
Survey Question:

Was following the Essence approach worth your time?



Survey Question:

Would you use Essence on your next project?

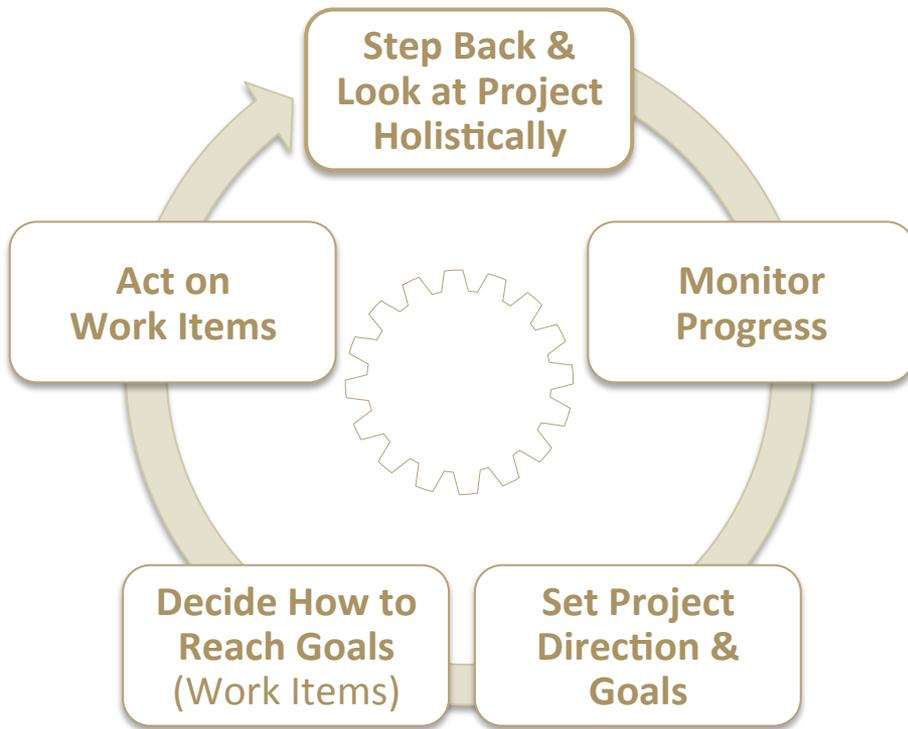




Field Study of Essence Kernel at CMU

Research Question:

How does the approach provide value to the project team?



Value comes primarily from team discussions

Let's take a closer look...



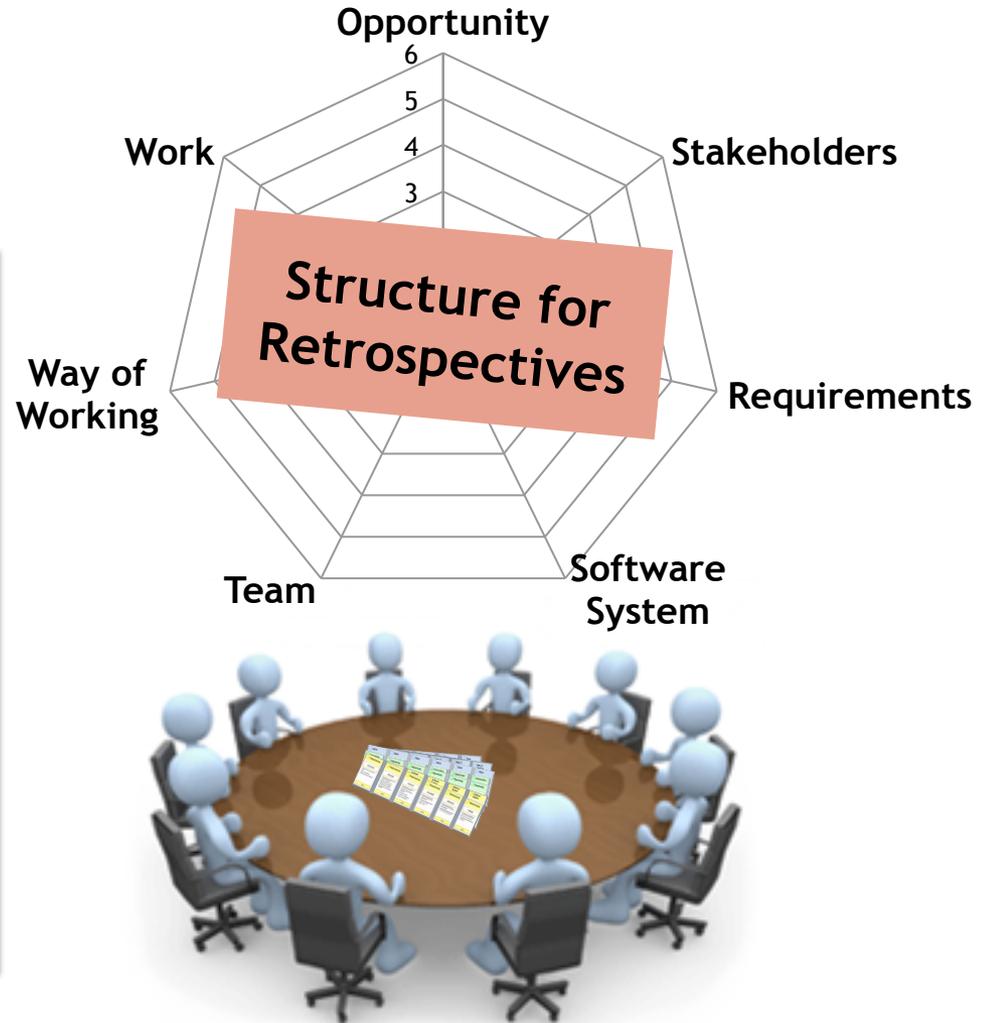
Field Study of Essence Kernel at CMU

Step Back &
Look at Project
Holistically

Quotes from CMU Students:

“Essence gives us a chance to back up and look at the project as a whole, from the birds point of view.”

“Essence provides a structured way of thinking about critical aspects of the project. Without Essence, our team could have overlooked some of these aspects.”





Field Study of Essence Kernel at CMU

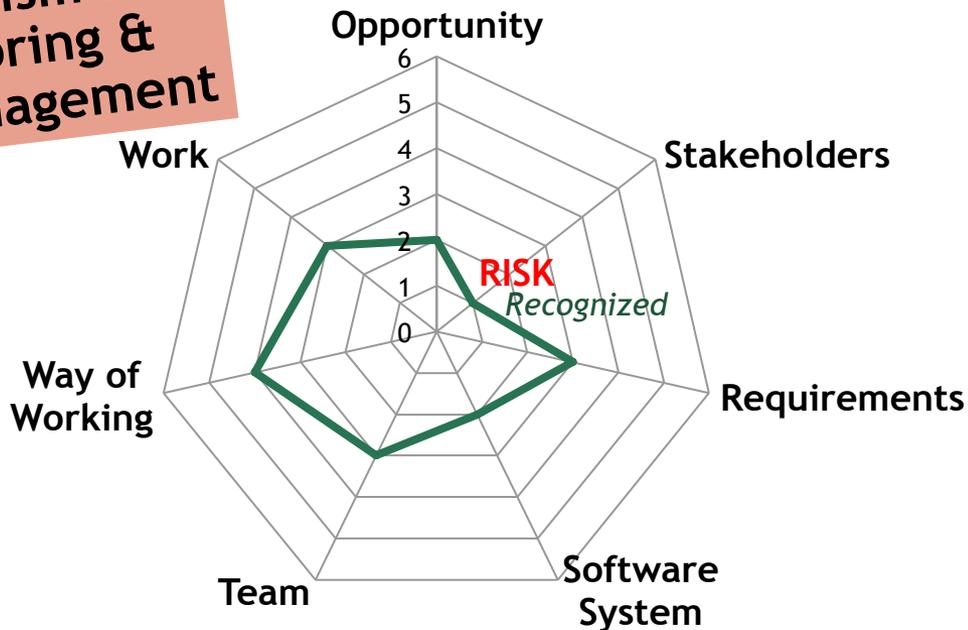
Monitor Progress

Mechanism for Monitoring & Risk Management

Quotes from CMU Students:

“The alphas seem to be exactly the right areas to monitor to promote project success.”

“Essence is great for team reflection & risk management.”



RISK: Opportunity & Requirements defined without proper stakeholders involvement

Current State

Stakeholders	Stakeholders	Stakeholders	Stakeholders	Stakeholders	Stakeholders
Recognized	Represented	Involved	In Agreement	Satisfied for Deployment	Satisfied in Use
<ul style="list-style-type: none"> Stakeholders have been identified There is agreement on stakeholder groups to be represented Responsibilities of stakeholder representatives defined 	<ul style="list-style-type: none"> Stakeholder representatives appointed Stakeholder representatives agreed to take on responsibilities & authorized Collaboration approach agreed Representatives respect team way of working 	<ul style="list-style-type: none"> Stakeholder representatives carry out responsibilities Stakeholder representatives provide feedback & take part in decisions in timely way Stakeholder representatives promptly communicate to stakeholder group 	<ul style="list-style-type: none"> Stakeholder representatives agree their input is valued and respected by the team Stakeholder representatives agree with how different priorities balance Stakeholder representatives have agreed upon minimal expectations for deployment 	<ul style="list-style-type: none"> Stakeholder representatives provide feedback on system from their stakeholder group perspective Stakeholder representatives confirm system ready for deployment 	<ul style="list-style-type: none"> System has met or exceed minimal stakeholder expectations Stakeholder needs and expectations are being met
1 / 6	2 / 6	3 / 6	4 / 6	5 / 6	6 / 6



Field Study of Essence Kernel at CMU

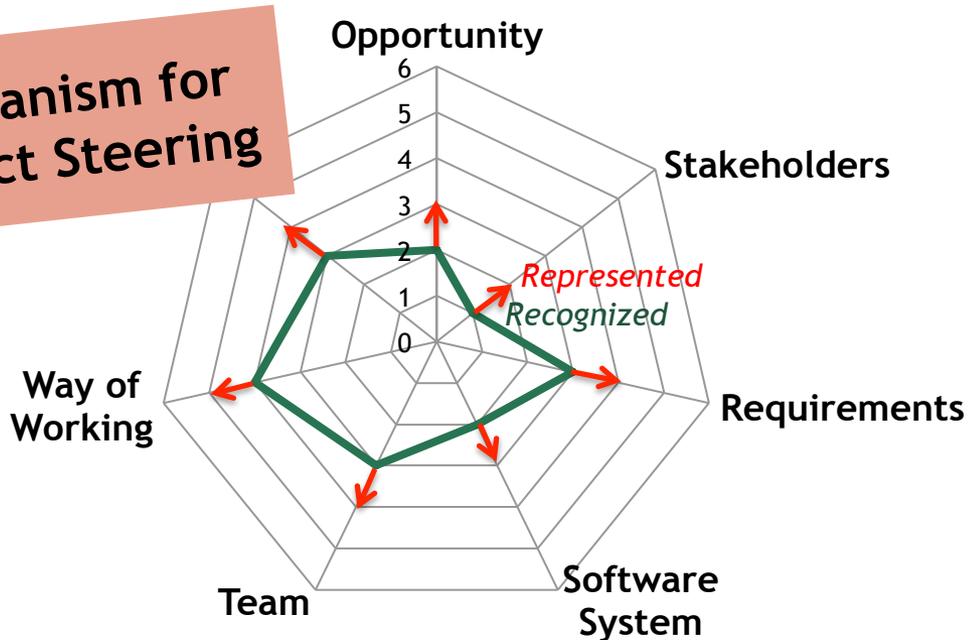
Set Project Direction & Goals

Mechanism for Project Steering

Quotes from CMU Students:

“Essence gives us structure and direction.”

“Essence is useful, as it gives you an agenda or checklist based on various dimensions.”



Current State

Target State

Current State	Target State	Current State	Current State	Current State	Current State
<p><input checked="" type="checkbox"/> Stakeholders</p> <p>Recognized</p> <ul style="list-style-type: none"> Stakeholders have been identified There is agreement on stakeholder groups to be represented Responsibilities of stakeholder representatives defined <p>1 / 6</p>	<p><input checked="" type="checkbox"/> Stakeholders</p> <p>Represented</p> <ul style="list-style-type: none"> Stakeholder representatives appointed Stakeholder representatives agreed to take on responsibilities & authorized Collaboration approach agreed Representatives respect team way of working <p>2 / 6 Goals</p>	<p><input checked="" type="checkbox"/> Stakeholders</p> <p>Involved</p> <ul style="list-style-type: none"> Stakeholder representatives carry out responsibilities Stakeholder representatives provide feedback & take part in decisions in timely way Stakeholder representatives promptly communicate to stakeholder group <p>3 / 6</p>	<p><input checked="" type="checkbox"/> Stakeholders</p> <p>In Agreement</p> <ul style="list-style-type: none"> Stakeholder representatives agree their input is valued and respected by the team Stakeholder representatives agree with how different priorities balance Stakeholder representatives have agreed upon minimal expectations for deployment <p>4 / 6</p>	<p><input checked="" type="checkbox"/> Stakeholders</p> <p>Satisfied for Deployment</p> <ul style="list-style-type: none"> Stakeholder representatives provide feedback on system from their stakeholder group perspective Stakeholder representatives confirm system ready for deployment <p>5 / 6</p>	<p><input checked="" type="checkbox"/> Stakeholders</p> <p>Satisfied in Use</p> <ul style="list-style-type: none"> System has met or exceed minimal stakeholder expectations Stakeholder needs and expectations are being met <p>6 / 6</p>

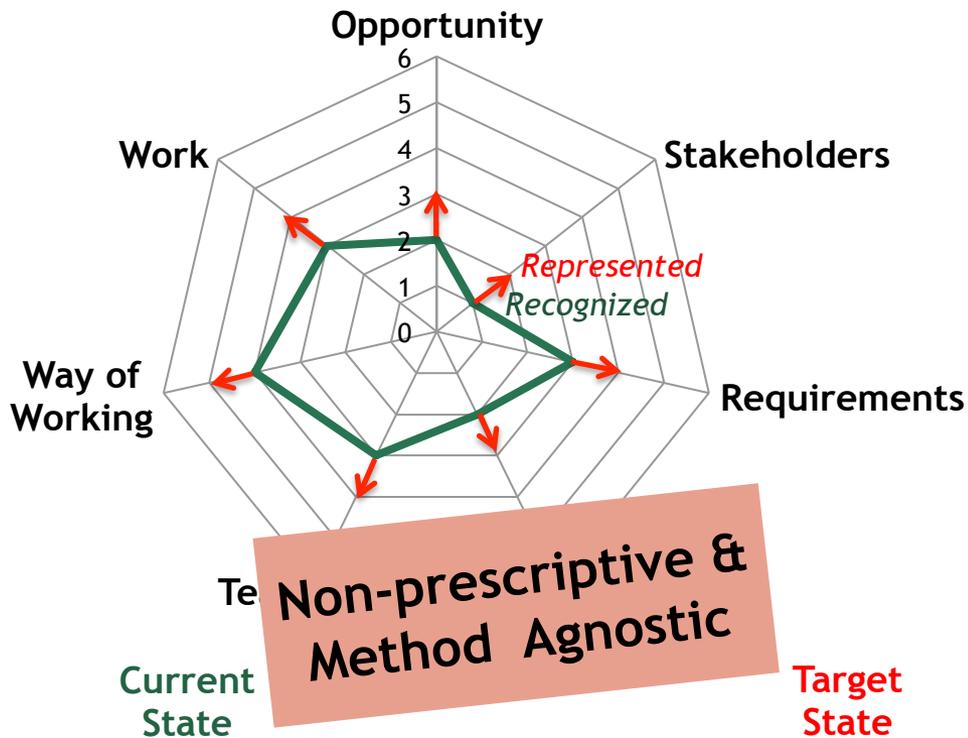


Field Study of Essence Kernel at CMU

Decide How to Reach Goals (Work Items)

Quote from CMU Student:

“I will use Essence on my next project, especially with a team that is not used to the same software engineering process. In that case Essence is a backdrop at the basis of the communication about all the considerations for the success of the project.”



Current State

Stakeholders

Recognized

- Stakeholders have been identified
- There is agreement on stakeholder groups to be represented
- Responsibilities of stakeholder representatives defined

1 / 6

Work Items:

- ...
- ...
- ...

Up to the team!

Target State

Stakeholders

Represented

- Stakeholder representatives appointed
- Stakeholder representatives agreed to take on responsibilities & authorized
- Collaboration approach agreed
- Representatives respect team way of working

2 / 6 **Goals**



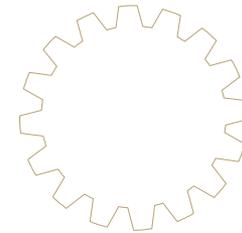
Field Study of Essence Kernel at CMU

Research Question:

How does the approach provide value to the project team?

**The Essence kernel provides
a structure and mechanism for:**

- **Progress monitoring**
- **Retrospectives**
- **Risk management**
- **Project steering**



**In a holistic, simple, lightweight,
non-prescriptive and method-agnostic fashion**

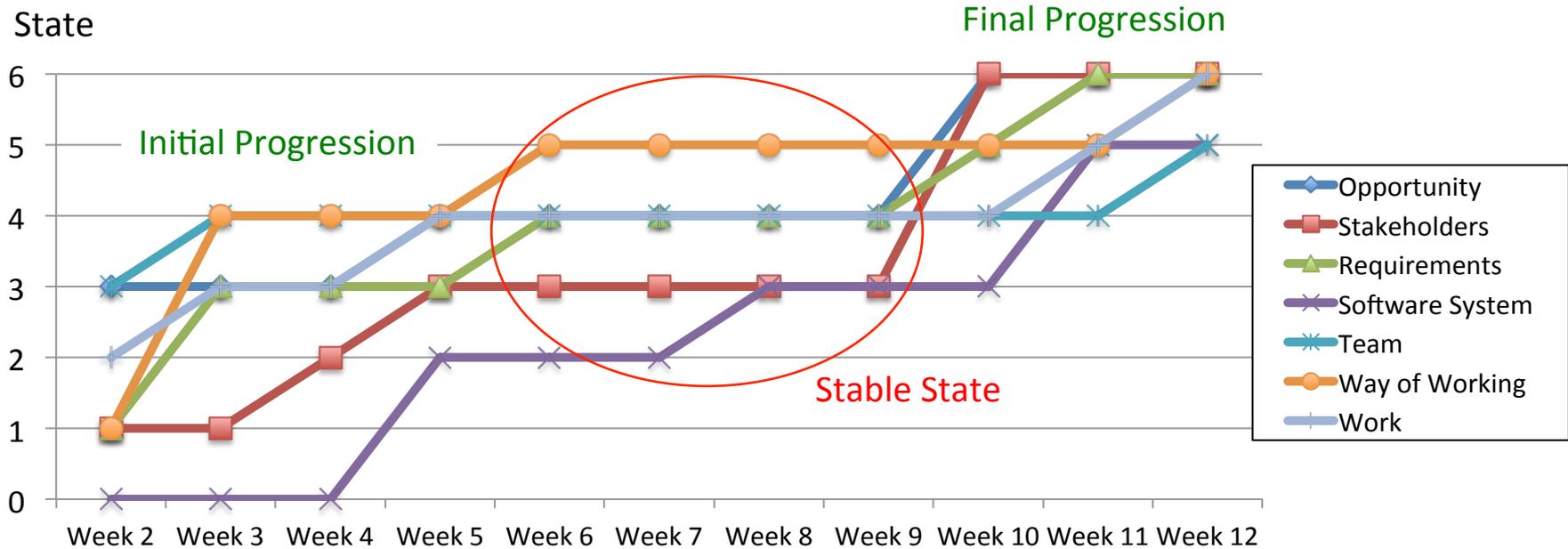


Field Study of Essence Kernel at CMU

Research Question:

When in the project lifecycle does the approach add value?

Alpha State Progression for Team Co-located-3



Initial state progression is driven by Essence-generated work items

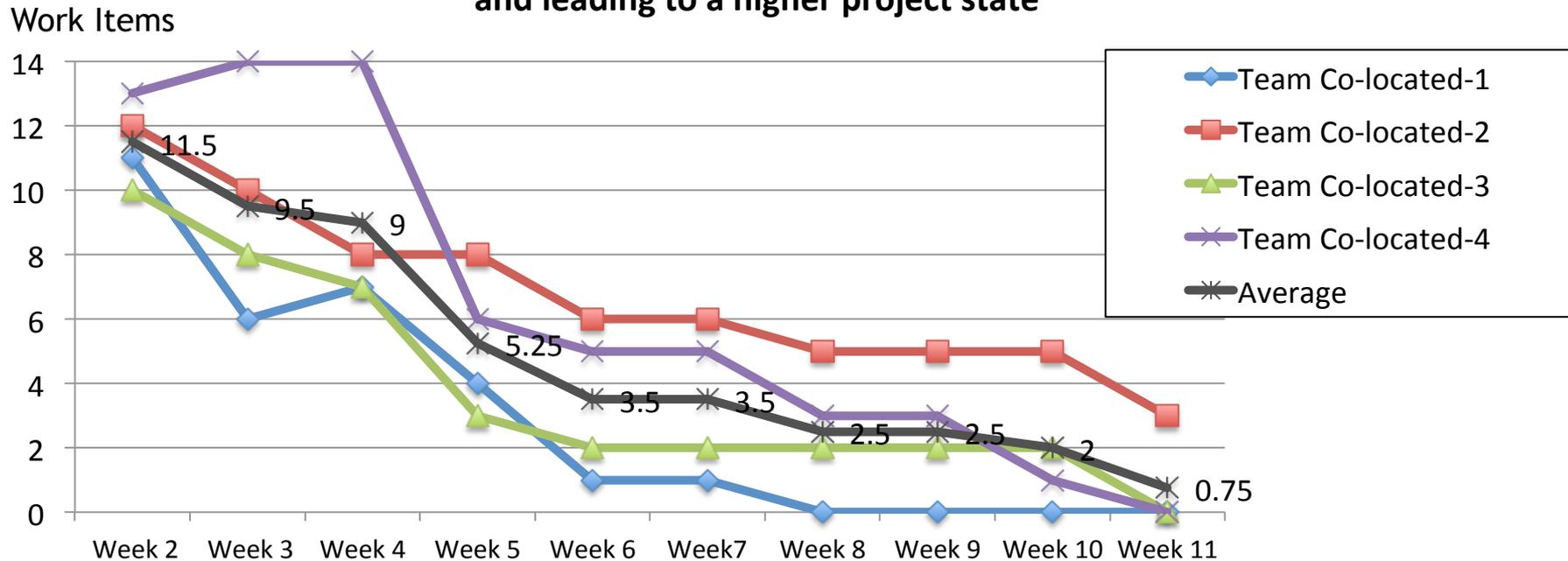


Field Study of Essence Kernel at CMU

Research Question:

When in the project lifecycle does the approach add value?

Number of work items generated per week and leading to a higher project state





Field Study of Essence Kernel at CMU

Research Question:

When in the project lifecycle does the approach add value?

Effectiveness is optimal during project initiation
& decreases over time

Quote from CMU Student:

“Essence [Kernel] lost value once the project settled because we dead ended on a set of cards.”

Quote from Practicum Course Faculty:

“Compared to previous years, I see a much better early project organization with lot less floundering. I hope that we keep using Essence in the future. We should definitely keep it at the beginning of the projects.”



Field Study of Essence Kernel at CMU

Research Question:

When in the project lifecycle does the approach add value?

Most teams continue to perceive value throughout the lifecycle out of the retrospectives

Quote from CMU Student:

“Even though we are not generating new tasks, the SEMAT meetings remain useful as they give us the opportunity to reflect upon our project.”



Field Study of Essence Kernel at CMU

Research Question:

What are the limits of the approach?

By design, the Kernel is universal:

- Lifecycle-independent
 - Iterative development requires additional support
- Generally expressed at a project/release level
 - Lower level work requires additional support
(like technical work done during an iteration)

Hence the work done during construction on iterative projects
requires additional support



Field Study of Essence Kernel at CMU

Research Question:

What are the limits of the approach?

Essence's monitoring and steering approach provided by the kernel alphas and their states is optimum during project initiation and for monitoring and steering the work done at the project or release level.

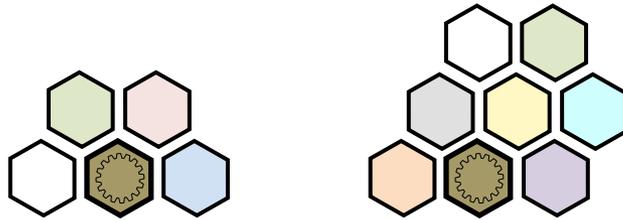
Beyond that, the approach's value decreases as the inherent limits of the universal kernel are reached.



Field Study of Essence Kernel at CMU

How could we push the limits?

- Leverage practices on top of the Kernel



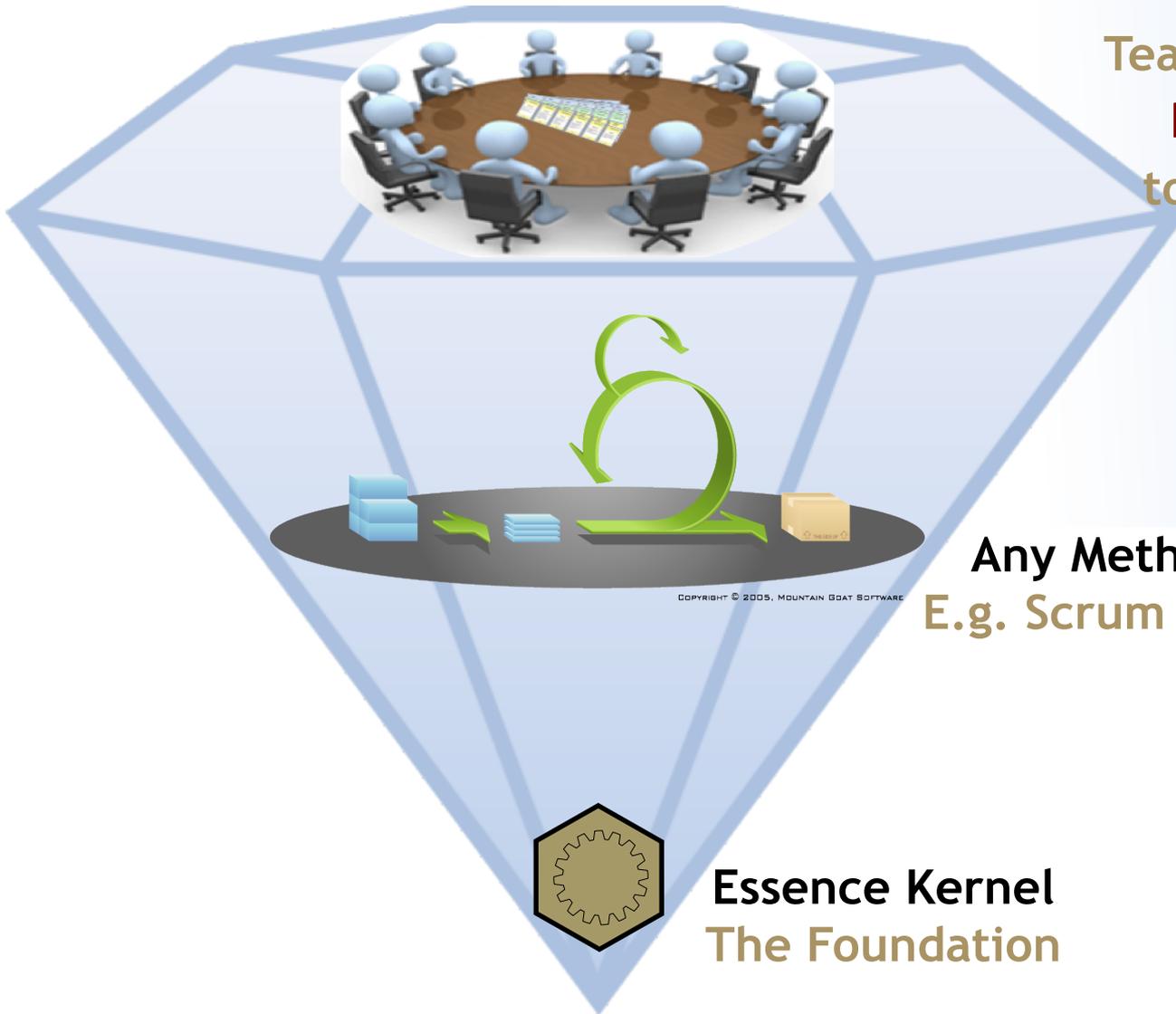
- Leverage other facets of the Kernel



- Extend or alter the Kernel definition
 - Is the Kernel truly universal?
 - Are there universal elements that are missing?



Field Study of Essence Kernel at CMU



Essence Value:

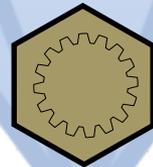
Team discussions based on **holistic project view** to achieve lightweight:

- Progress monitoring
- Retrospectives
- Risk management
- Project steering

Any Method

E.g. Scrum & XP

Essence Kernel
The Foundation





Carlos Zapata



UNIVERSIDAD
NACIONAL
DE COLOMBIA

- Main activities
 - Modifications to current courses
 - Proposal of a new course
 - Game design and playing
 - Tutorials in several events

- **Current courses**
 - Software project management
 - Requirements engineering
 - Software application design and construction
- **Modifications to existing courses**
 - Representation of the UNC-Method in the SEMAT kernel
 - Control of Endeavour health and progress with alpha cards
 - Risk control with the SEMAT kernel

- Proposal of a new course:
 - Name: **“Software Engineering Methods and Theory”**
 - Syllabus
 - **A. General Software Engineering Theory Introduction**
 - A.1. Motivation
 - A.2. General problems about Software Engineering
 - A.3. Why we need a Software Engineering Theory?
 - **B. Basic Elements of the Software Engineering Kernel**
 - B.1. Alphas
 - B.2. Activity spaces
 - B.3. Methods and practices
 - B.4. Competencies
 - B.5. Work products

– Syllabus

- **C. Advanced elements of the Software Engineering kernel**
 - C.1. Patterns
 - C.2. Resources
 - C.3. Detail levels
 - C.4. Competency levels
 - C.5. Card representation
 - C.6. Separation of concerns
 - C.7. Kernel work tools
- **D. Formal representation of the Software Engineering kernel**
 - D.1. Introduction
 - D.2. Kernel metamodel
 - D.3. Kernel textual specification
 - D.4. Object diagrams and executable pre-conceptual schemas

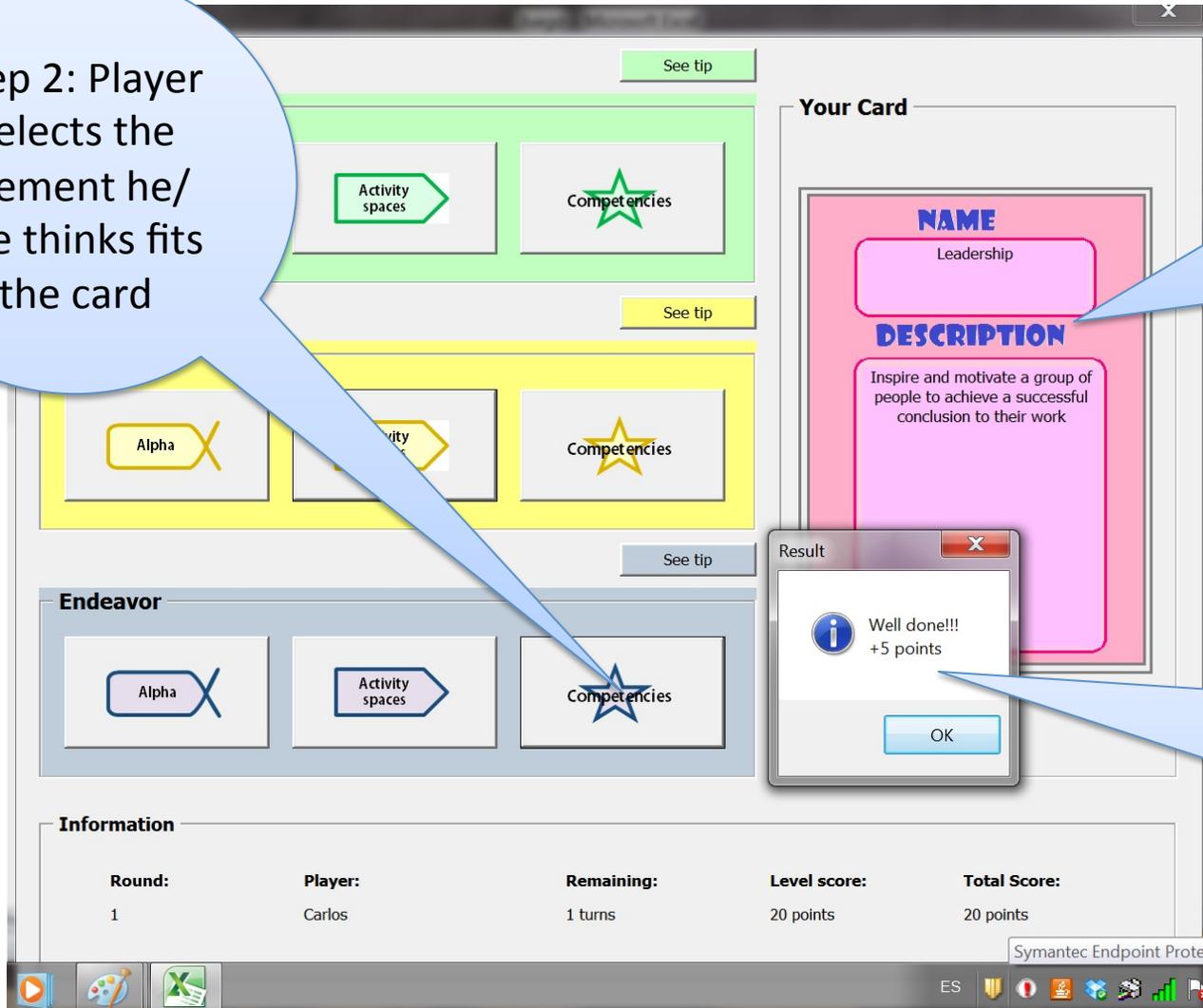
- Game design and playing:
 - SemCards
 - MetricC
 - The software system alpha
 - The requirements alpha
 - Etc.

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Step 2: Player selects the element he/she thinks fits the card

Step 1: A card with a description appears

Step 3: The system assigns points according to the answer



SemCards - Results of the game

Carlos	40
Ivar	35

Winner:

Carlos

Step 4: After some turns, the system notifies the winner

- **MetricC**

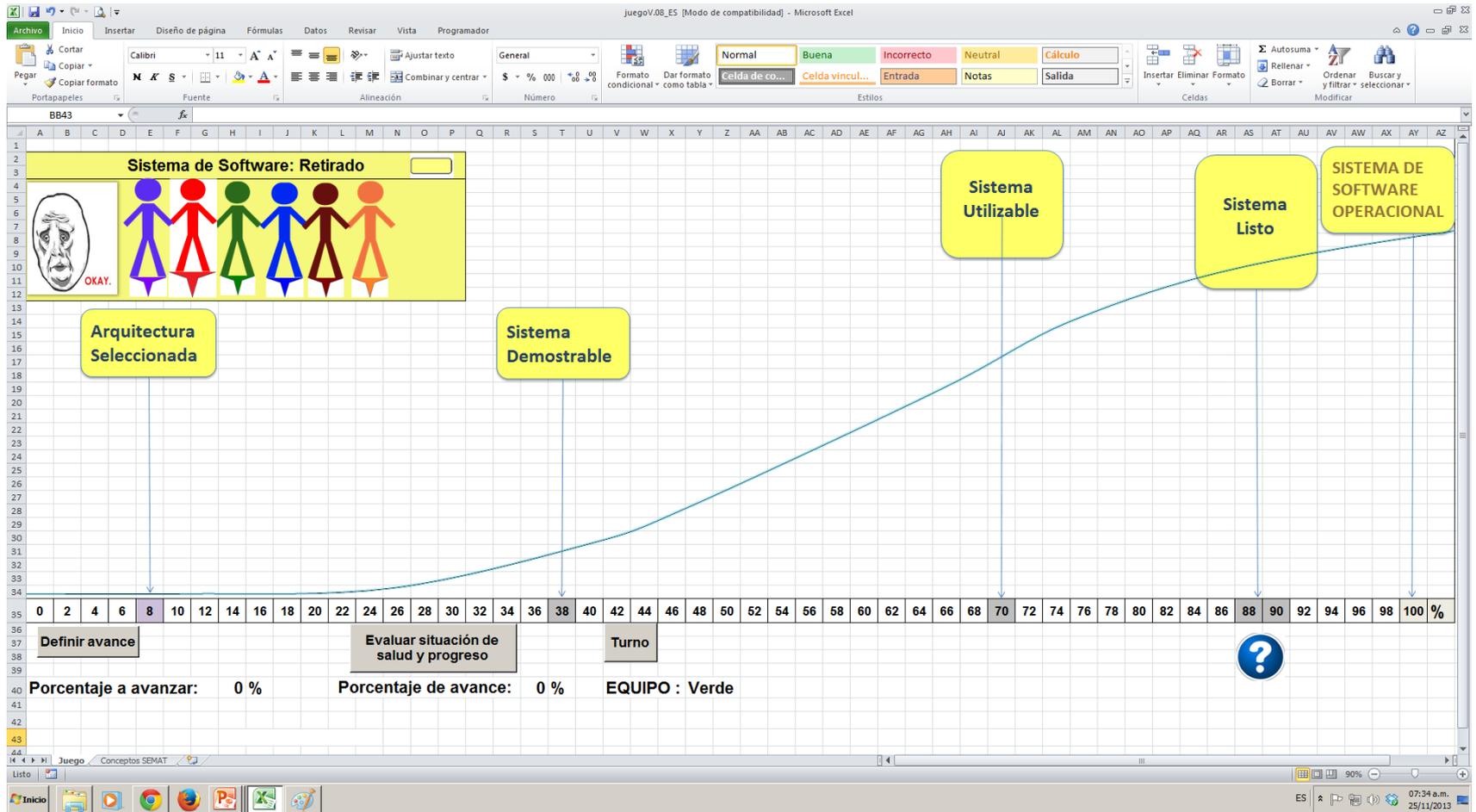
- The game is based on Hasbro™'s *Mille Bornes*
- It matches metrics and completion criteria with activity spaces
- Four kinds of cards:
attack, defense, metric, and completion criteria
- The goal of the game is achieving three completion criteria by adding values to metrics

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<p>Good practice</p>  <p>Activity Space: Understand the requirements</p>	<p>Discard a Metric</p> 	<p>Enable a Completion Criterion</p> 	<p>Completion Criterion</p>  <p>The initial set of stakeholders agrees that a system is to be produced</p>
<p>Limit Metric</p>  <p>Max Metric Value: 10</p>	<p>Completeness of description</p> <p>30</p> <p>Metric</p> <p>Related Completion Criterion: The initial set of stakeholders agrees that a system is to be produced</p>	<p>Bad practice</p>  <p>Activity Space: Understand the requirements</p>	<p>Full Metric</p> 

- The software system alpha
 - Only available in Spanish
 - Players are team members whom need to “travel” across the states of a software system
 - Some situations arise for giving the possibility of advancing the states
 - The situations are described in terms of the SEMAT kernel elements (alphas, activity spaces, competencies, etc.)
 - The “retired” state is always a possibility of the game

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- The requirements alpha
 - Only available in Spanish
 - Players are team members whom need to “travel” across the states of the requirements of a software system
 - “Guessing” the states belonging to certain alpha is one of the options for advancing the states
 - Some situations arise for giving the possibility of advancing the states
 - The situations are described in terms of the SEMAT kernel elements (alphas, activity spaces, competencies, etc.)

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Latin American
Software Engineering
Symposium 2011
Present and Future of Software Engineering in Latin America



CLEI 2013

Conferencia Latinoamericana
en Informática

7 al 11 de Octubre, 2013



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**Octavo Congreso Colombiano
de Computación**

Agosto 21 al 23 de 2013 Armenia - Colombia



Essence-Powered SE Education at UniBz



Pekka
Abrahamsson



Daniel
Graziotin



Xiaofeng
Wang



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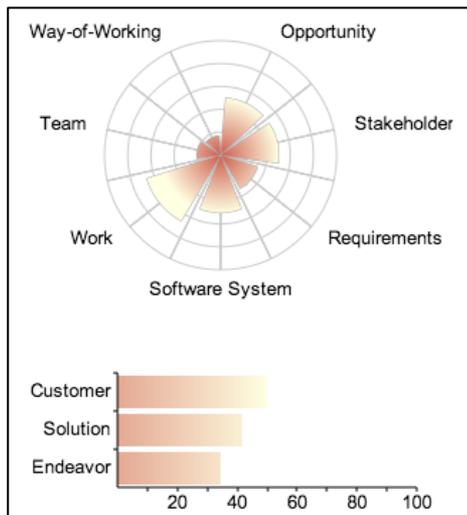
LIBERA UNIVERSITÀ DI BOLZANO

FREE UNIVERSITY OF BOZEN - BOLZANO

Italy

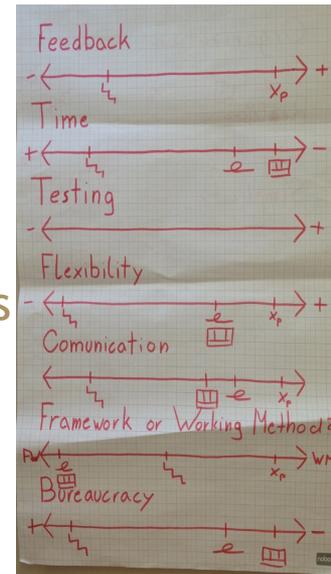
Open Source Web-based Tool for SEMAT Kernel

<http://sematacc.meteor.com>



Course: Introduction to Management Engineering

Research question:
How intrinsic are
SEMAT Essence Kernel elements
for inexperienced students?



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Essence-Powered SE Education at KTH



Mira Kajko-Mattson

Using the Essence Kernel at KTH
in the context of an
IT-Project course (2012-2013)

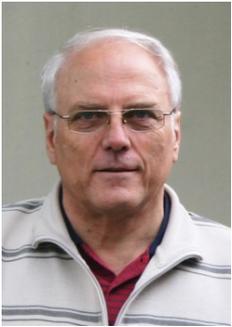


Royal Institute
of Technology
Sweden



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Essence-Powered SE Education at JCSE



Barry Myburgh

Educational Activities under auspices of
The Jo'burg Centre for Software Engineering (JCSE)
In the School of Electrical and Information Engineering
At the University of the Witwatersrand

www.jcse.org.za



JCSE Courses & Workshops Leveraging Essence:

- **ELEN 7044 - Software Engineering Principles and Methods**
Audience: Masters Students and/or Continuous Professional Development
- **ELEN 7012 - Selected Topics in Software Engineering**
Audience: Masters Students and/or Continuous Professional Development
- **Using SEMAT Essence for Project Health Check and Action Planning**
Workshop Audience: Practitioners in Industry

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Essence-Powered Education at MIPT



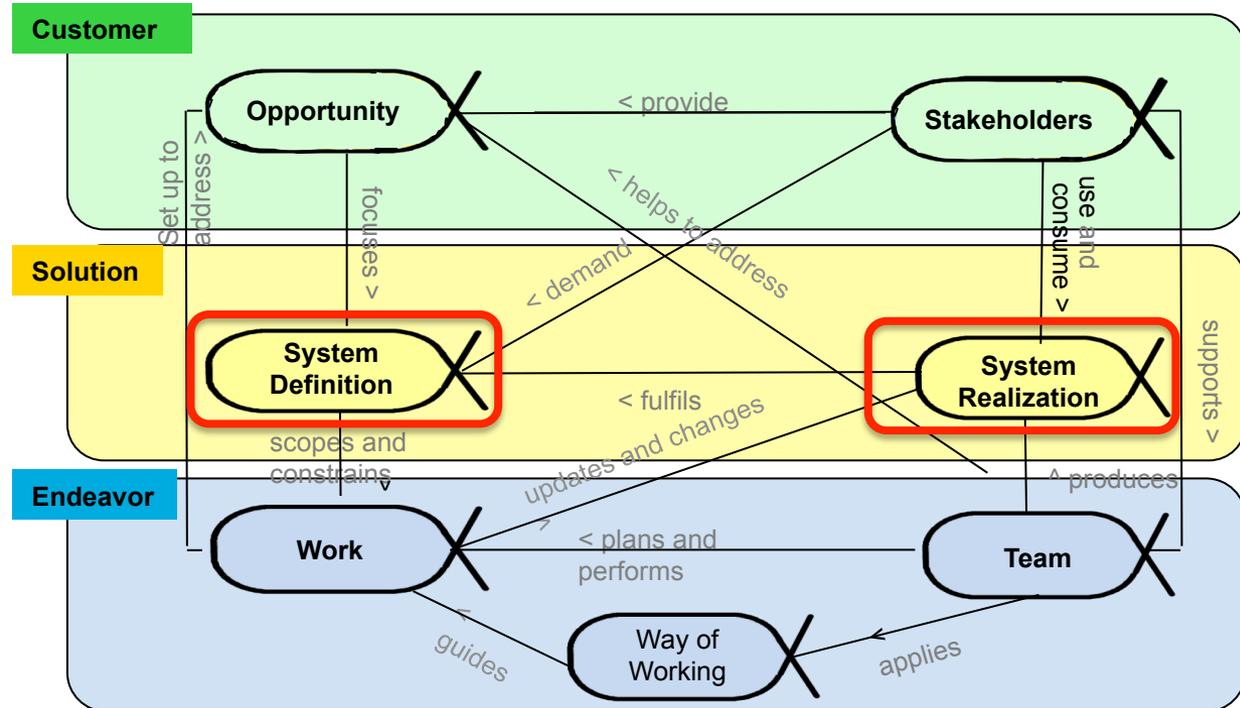
Anatoly Levenchuk



Russian Chapter



Essence for Systems Engineering



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MIPT Courses leveraging Essence:

- Foundation of Systems Engineering (2013)
- Systems Engineering Thinking in Lifecycle Management (2014)
- Practices of Model-based Systems Engineering (2014)

Essence Education Material from IJI



Pan-Wei Ng



Ian Spence



Progress Poker	Lifecycle Layout
Chase the State	Milestone Mapping
Objective Go	Health Monitoring
Checkpoint Construction	And more.....

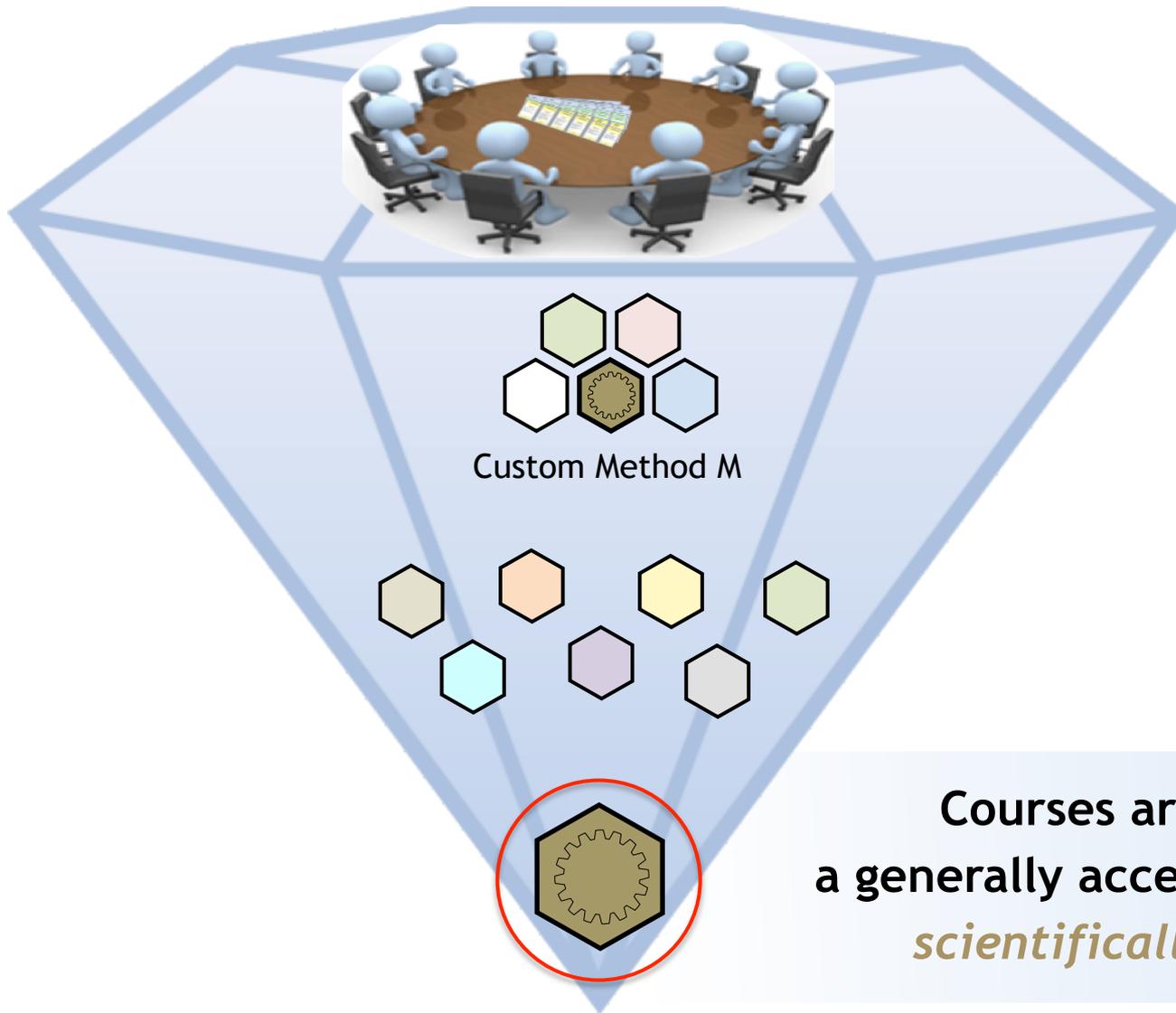
<http://www.ivarjacobson.com/alphastatecards/>

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Agenda

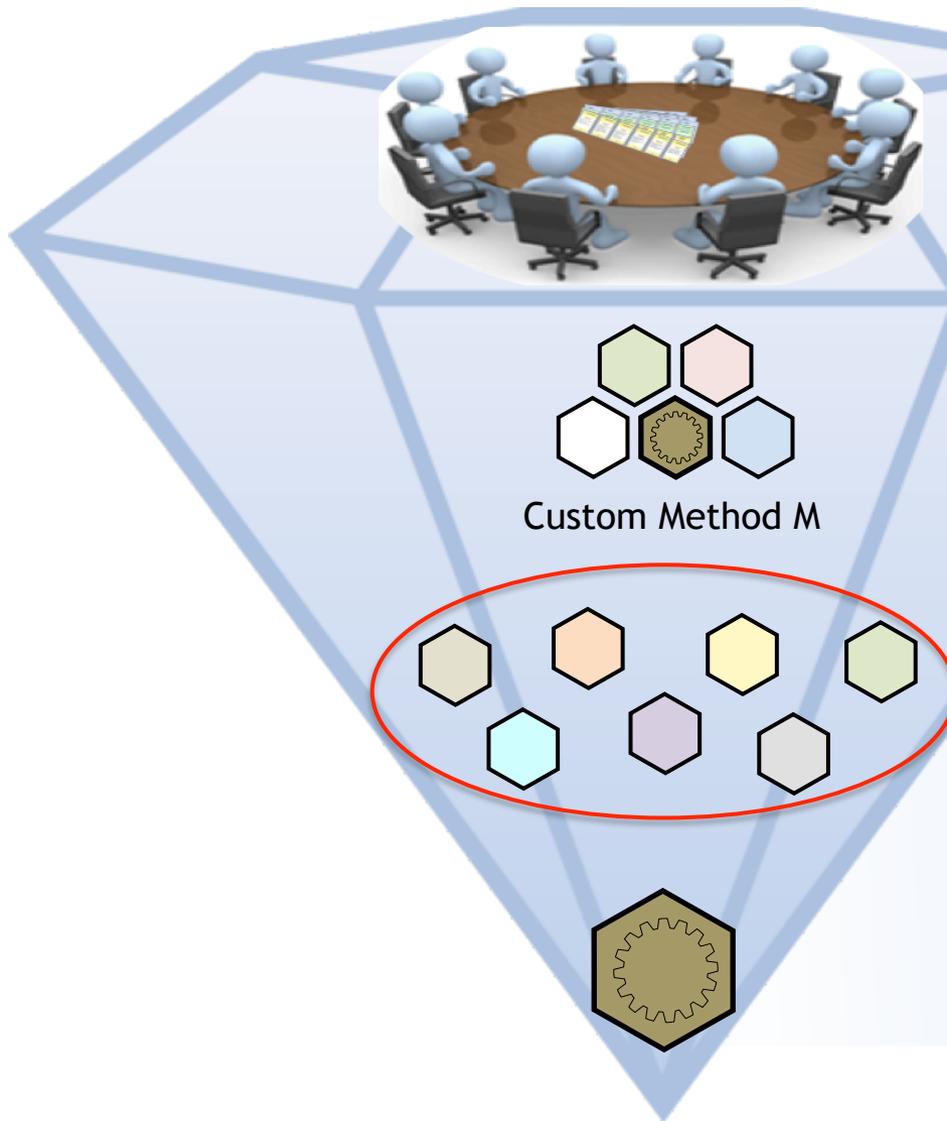
- Challenges in SE Education
- What is SEMAT? What is Essence?
- How does the Essence Kernel Work?
- World Tour of SEMAT Educational Activities
- **SEMAT Vision for Education**

SEMAT Vision for Education



Courses are based on
a generally accepted foundation
scientifically validated

SEMAT Vision for Education

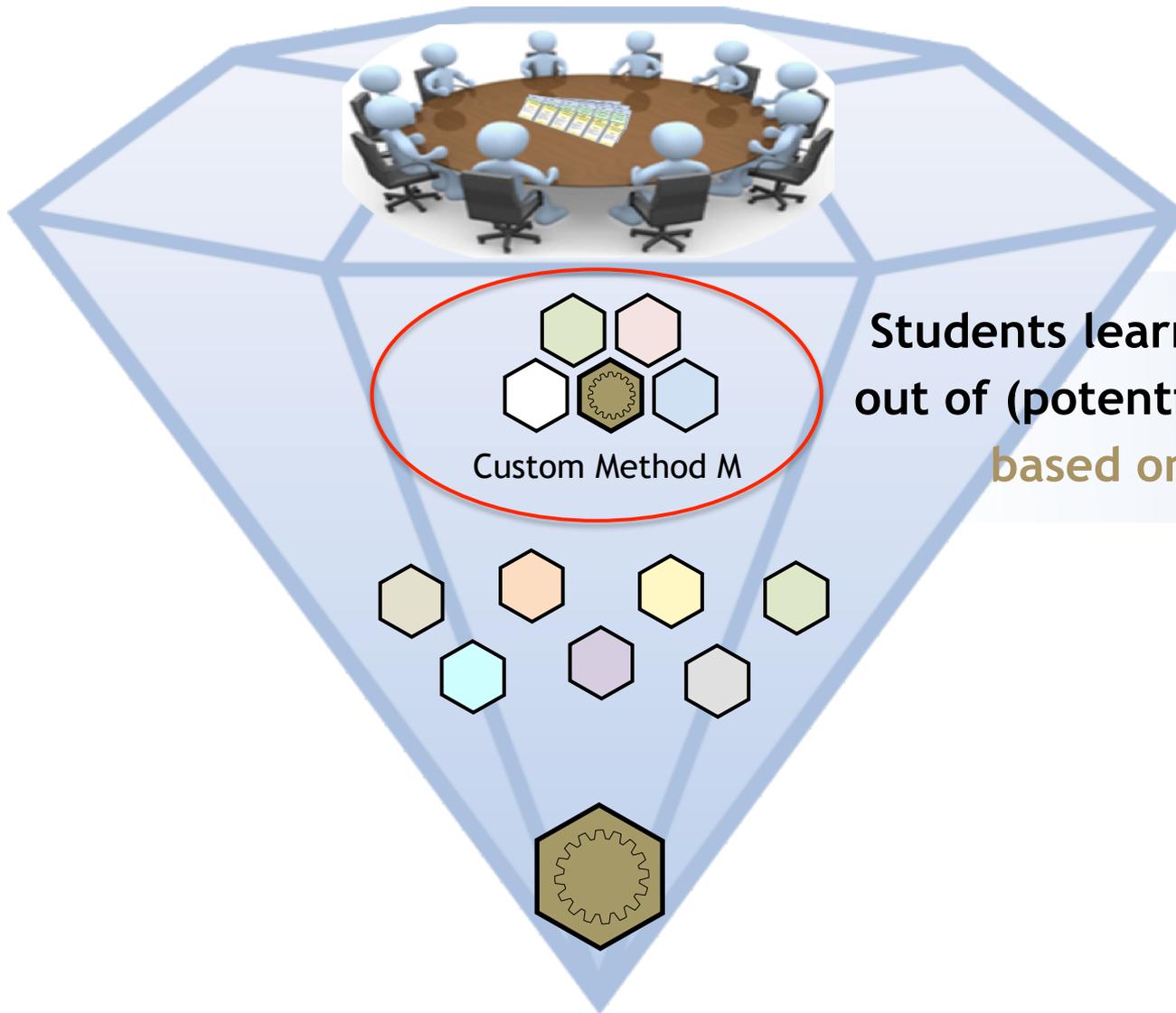


Students learn about generally accepted practices including *measures of effectiveness in context*

Data help educators make informed decisions about what to teach

Modularity facilitates course evolution;
Courses are kept cutting edge with minimum waste/rework

SEMAT Vision for Education



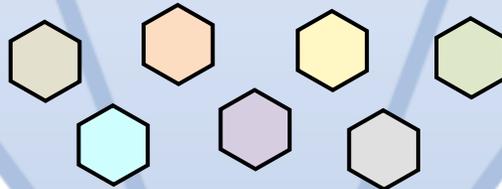
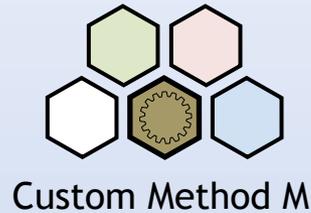
Students learn to compose methods out of (potentially tailored) practices based on project context

SEMAT Vision for Education



Students are trained to become “generalizing specialists” enabling a smoother transition between:

- University and Industry
- Projects
- Organizations
- Positions
- Domains



A Step Forward



References

- Ivar Jacobson and all. The Essence of Software Engineering: The SEMAT Kernel, acmqueue, 2012.
- Ivar Jacobson and all. The Essence of Software Engineering: Applying the SEMAT Kernel, Addison-Wesley, 2013.
- Cécile Péraire and Todd Sedano. State-based Monitoring and Goal-driven Project Steering: Field Study of the SEMAT Essence Framework, CMU-SV-13-1, 2013.
http://works.bepress.com/cecile_peraire/1/
- SEMAT Essence Kernel Tool, <http://essence.sv.cmu.edu>
- Semat.org



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Gracias!

Cécile Péraire - cecile.peraire@sv.cmu.edu

Carlos Zapata - cmzapata@unal.edu.co

