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20 y 21 de Octubre

5° Congreso AACE International de Ingeniería de Costos PERÚ 2017

(ID) Project Risk Quantification: Methods That Work

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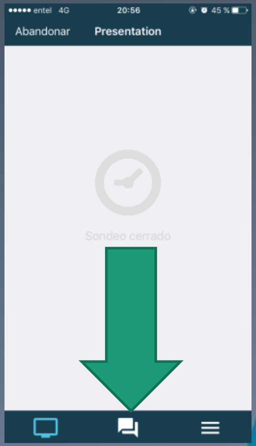

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BIO of John K. Hollmann

- Experience
  - **Owner of Validation Estimating LLC since 2005. Help owner companies improve their Cost Engineering capabilities**
  - **38 years experience for owner, contractor and benchmarking firms in the process industries (oil & gas, chemicals, mining, power, etc.)**
- AACE® International
  - **Fellow, Life Member, Award of Merit, Past Director**
  - **Led *Decision & Risk Management Professional (DRMP)* certification development**
- Book Author
  - ***AACE Total Cost Management Framework***
  - ***Project Risk Quantification***
- Education and Other
  - **BS Mining Engineering, MBA, PE**

“Project Risk Quantification” (PRQ)

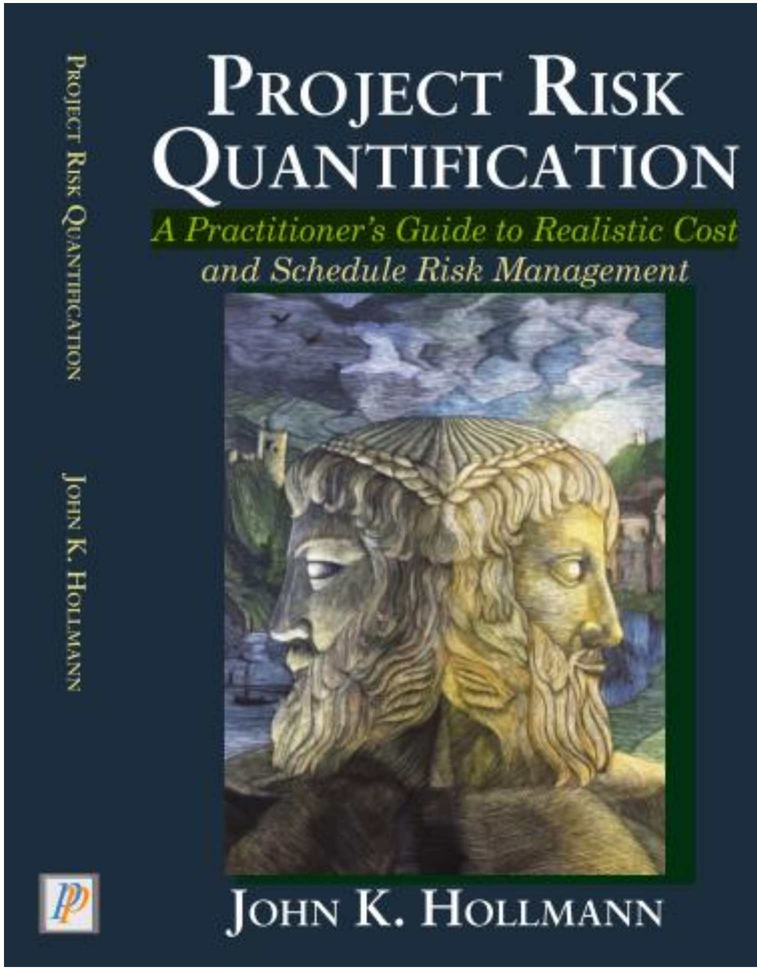
- This presentation is based on

  “Project Risk Quantification: *A Practitioner’s Guide to Realistic Cost and Schedule Risk Management”*

- *Probabilistic Publishing*

  www.decisions-books.com

- Most of the images in this presentation are from the book



INTRODUCTION/BACKGROUND

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Introduction

- Project investment decisions depend on effective project cost and schedule risk quantification
  - **We will review the challenging situations that PRQ must model (and PRQ methods that fail to do so)**
- PRQ must be realistic, practical and integrated
  - **We will walk through <u>“Methods That Work”,</u>**
  - **and present the Top 10 Reasons Risk Quantification Fails**

What is Project Risk Quantification?

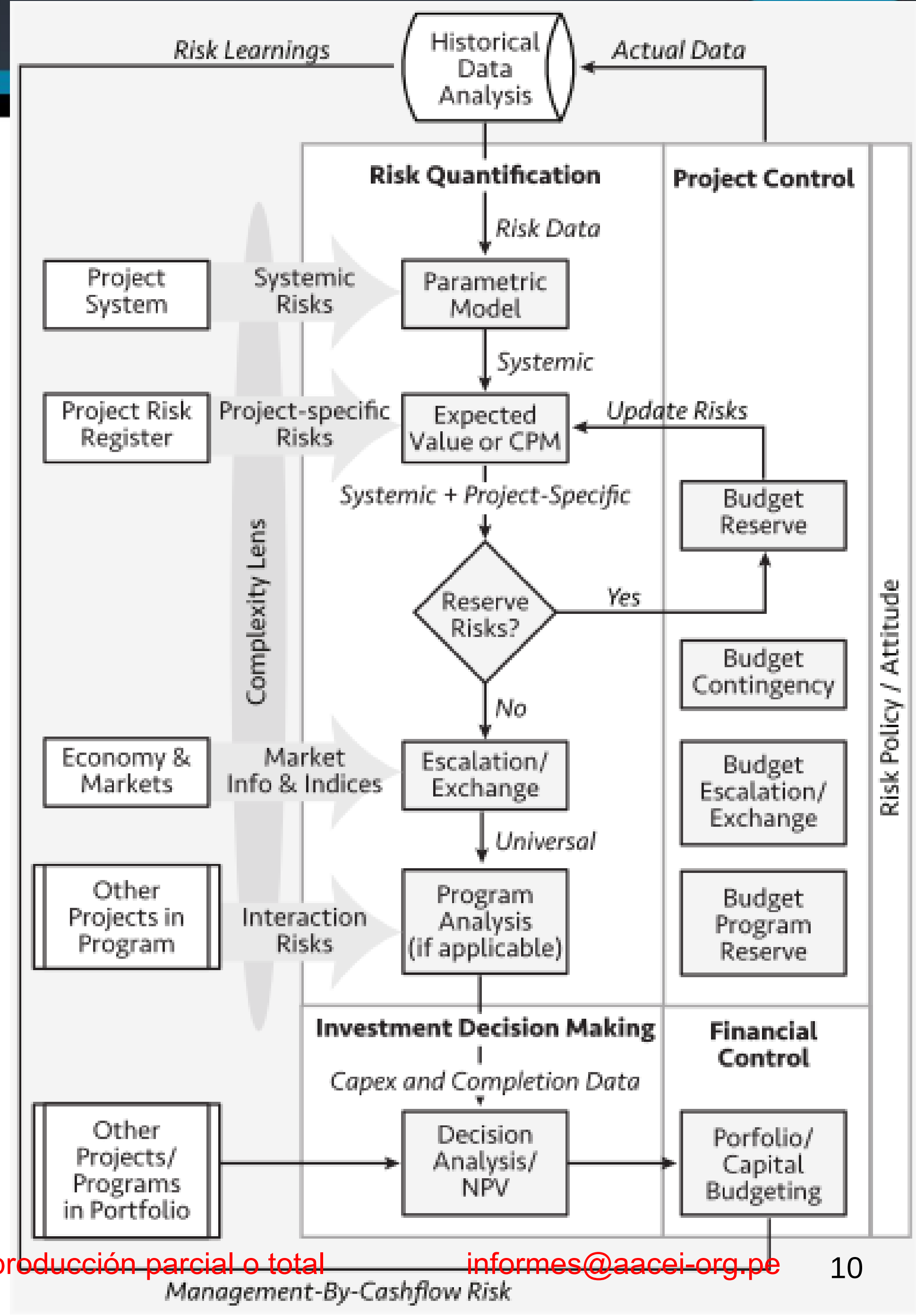
- Integrated, probabilistic modeling of the cost and schedule impact of all identified risks in projects
  - **Integrated with estimating, planning and scheduling**
  - **Provides the basis (distributions with causal info) for incorporating risk in project plans and budgets**
- It is a unique step in the risk management process; it is critical to effective decision making
  - **Provides capital cost (capex) and project duration (start of revenue) inputs to NPV analysis**

Criteria for PRQ "Methods That Work"

- **Realistic**
  - Backed by historical data analysis; you can prove that it works (the book's *Janus* meme reflectsa view to the past and to the future)
- **Practical**
  - Apply to every project; simple or complex, large and small, conceptual or detailed, good or bad quality planning
  - Can be done in-house every day; no special software (other than Excel and an MCS add-on) and no consultants needed other than for the *outside view* for strategic projects
- **Integrated**
  - Addresses all risk types and considers cost and schedule together (i.e., cost and schedule trade-off)

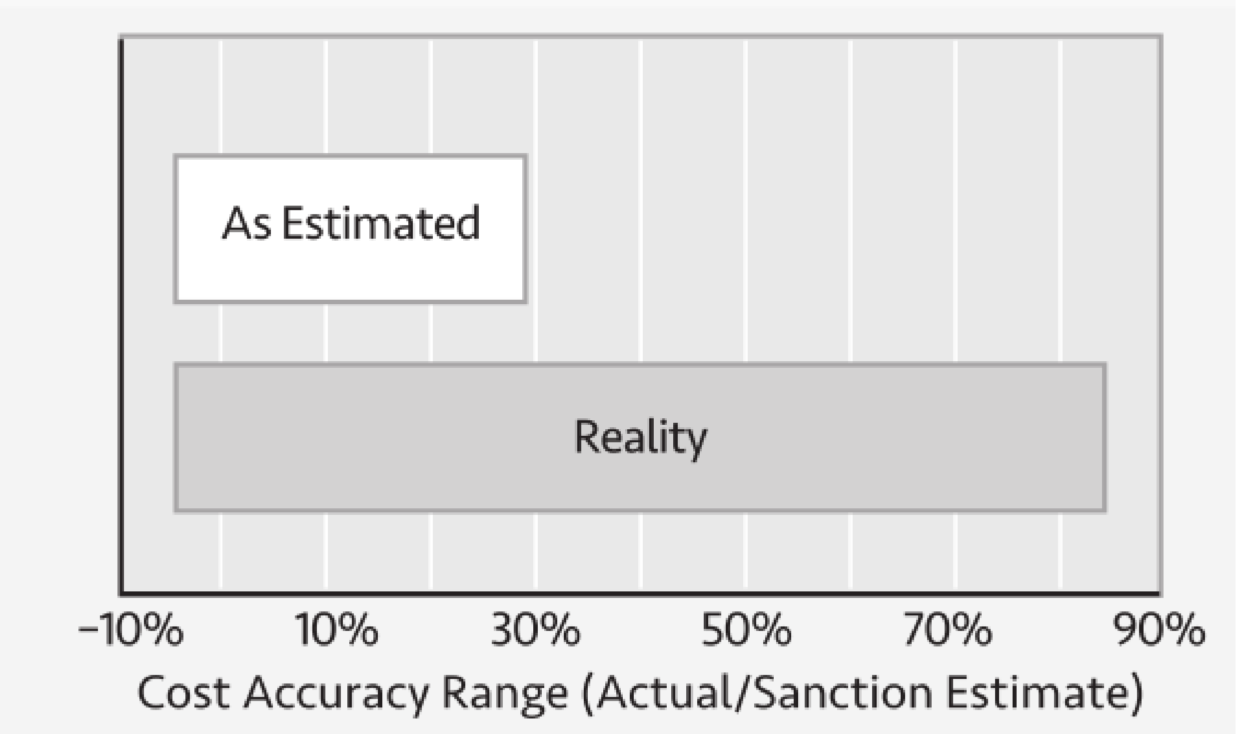
The PRQ Process Map

- This is the PRQ process:
  - Empirically valid
  - Models optimized for each risk type and planning need
  - All risks are covered in a stepped approach
  - Supports NPV modeling
- First, let's review the **challenges** that these models address (why do it this way?)



Challenge #1: Underestimation

- The actual high end (p90) of cost growth is 2x to 3x what we are forecasting for large projects;
- As such, our analysis are irrelevant to decision making



Example of the 2-3x Underestimation

- This overlays RP18R-97 range-of-ranges (shaded bands) with actual results for hydropower projects* (boxes & dashed lines)
- The actual high end overrun is 2 to 3X the 18R-97 expectation
- Under-estimation of contingency is seen in every empirical study!

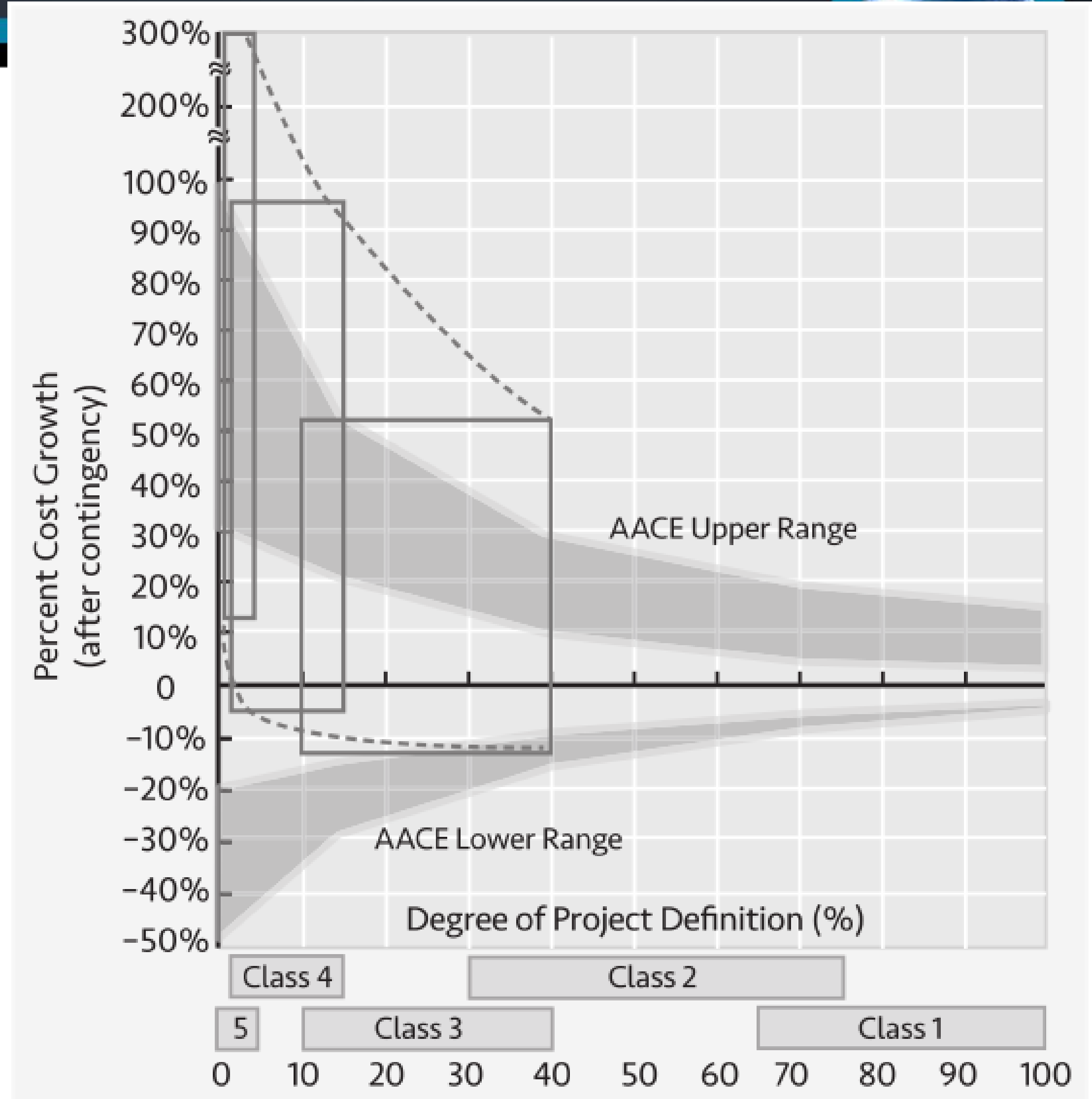
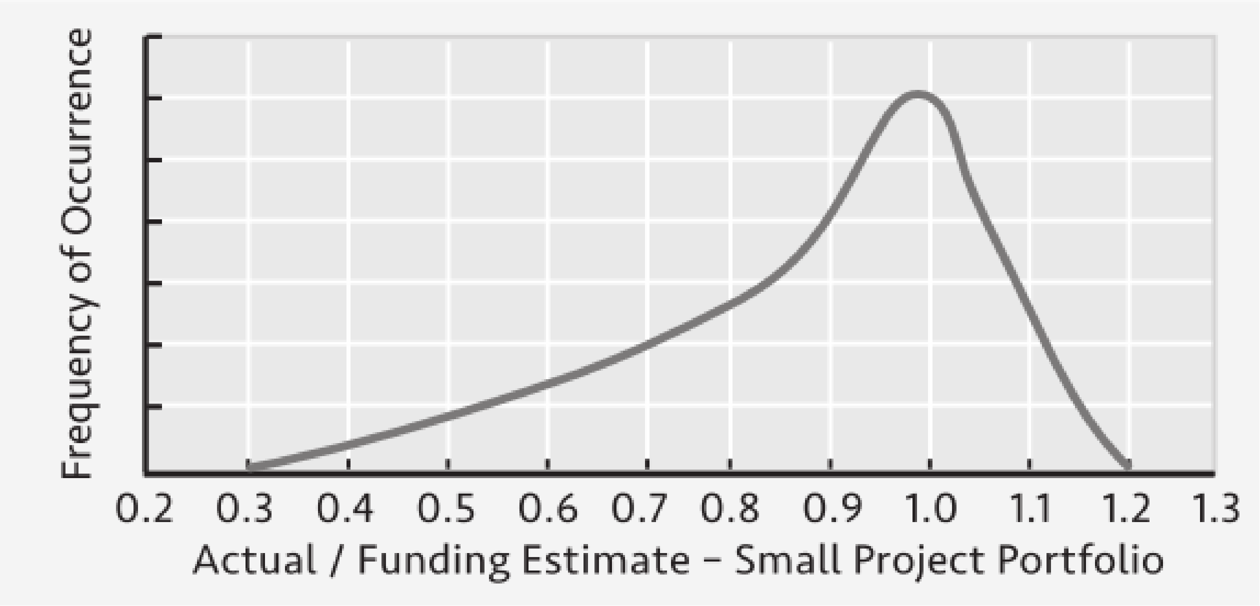


Figure 4.3: AACE Range-of-Ranges (18R-97) vs. Hydropower Project Study (2014)

* Hollmann, J. et. al., "Variability in Accuracy Ranges: A Case Study In the Canadian Hydropower Industry," AACE International Transactions: 2014.

Challenge #2: Overestimation on Small Projects

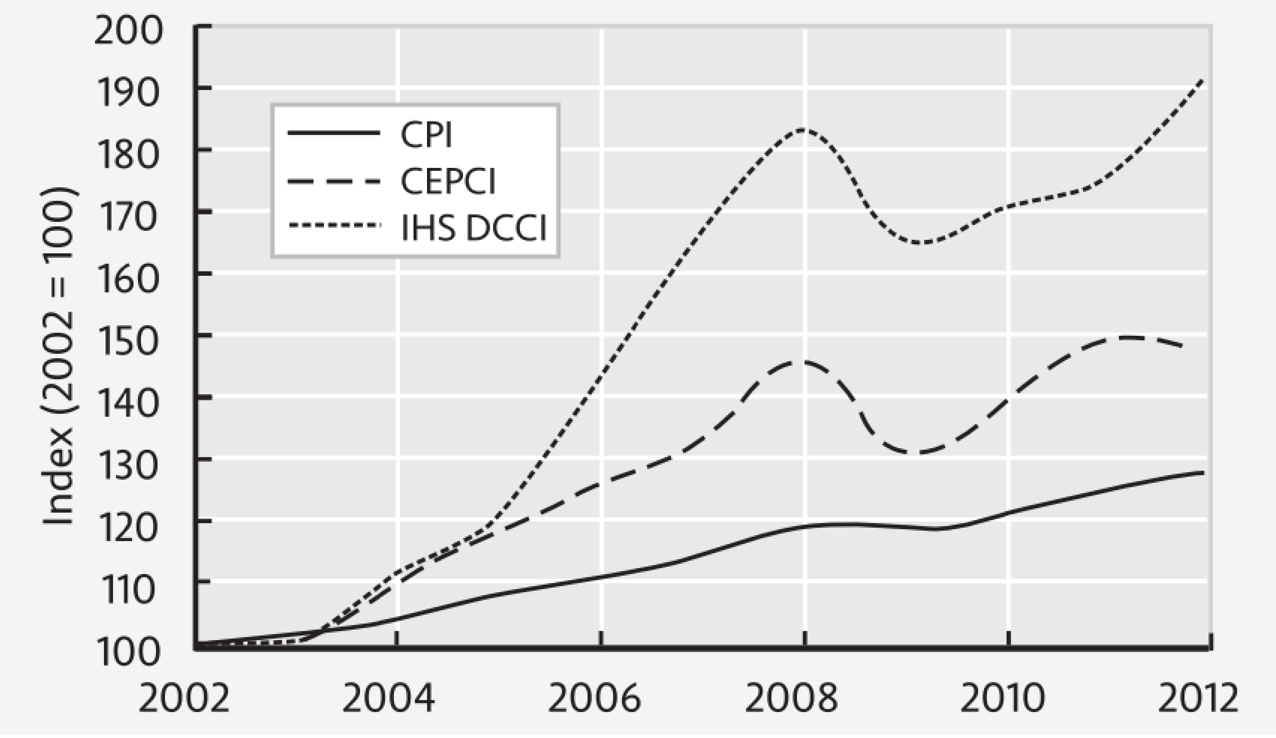
- Small project systems (plant-based where PM and leads each have many projects to manage) then to underrun
  - Few projects overrun by more than 10% (a constraint)
  - Punitive, no BS systems; just "get it done"
  - Defacto policy is to overestimate, but return unused funds



Challenge #3: Underestimation of Escalation

- Many companies use inflation, <u>not escalation</u>
- <u>E</u>scalation can be **3X** inflation and **2X** BLS-based indices
- This chart compares the IHS CERA Downstream cost index (DCCI), the Chemical Engineering Plant Cost Index (CEPCI) and the US Consumer Price Index (CPI: i.e., inflation)

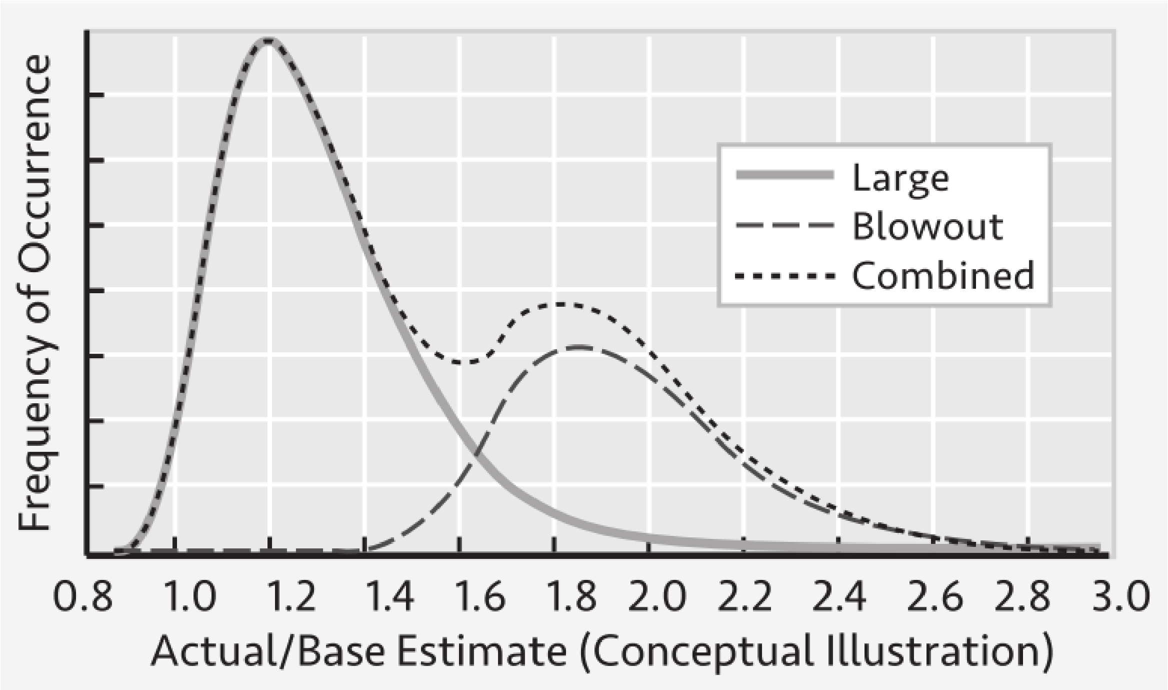
- Worse, **nobody estimates escalation probabilistically!**



Challenge #4: Failure to Address Complexity

- Complexity is now a "buzz" word, but few make any practical attempt to measure or quantify it
- The impact of weak systems + complexity + stressors is often disorder; i.e., a "**blowout**" with labor cost overruns of 50 to 200% (non-linear impact)

- We can model this and **warn** of the imminent crossing of the *tipping point* into chaos



Challenge #5: Cost/Schedule Trade-off Ignored

- We tend to focus on risks that do not matter
- For risks that do matter (**critical** risks), we fail to consider and model our **risk responses** (i.e., what will we do if and when the identified risk happens?)
- Risk response planning (i.e., contingency planning) requires having a project **cost-schedule strategy**; i.e., are we willing to **trade** cost for schedule?
  - ***Schedule-driven*: responses will be fast but expensive**
  - ***Cost-driven*: response will be slow but cheap**
  - **In reality, cost growth is much greater than schedule slip, in large part due to trading of cost for schedule (in the end, strategic projects tend to be schedule driven)**

Challenge #6: Line-Item Ranging Does Not Work

- In LIR, the team assigns ranges to the estimate line-items and runs Monte Carlo Simulation (MCS)
- Research findings: *
  - ***"…contingency estimates are, on average, getting further from the actual contingency required."***
  - **For projects with poor scope definition the common approaches were "*a disaster*"**
- At best, LIR covers "estimating or scheduling uncertainty" which is a relatively minor risk at sanction

* Juntima and Burroughs, "Exploring Techniques for Contingency Setting", 2004 AACE Transactions

Challenge #7; CPM Based Methods Are Problematic

- CPM Challenges:
  - **Quality: CPM schedules typically have poor quality (also see "skills"; a study showed only 13% were suitable for PRQ ***
  - **Applicability: CPM networks are static, but risks are dynamic**
    - **must use branching to be realistic which is not practical**
    - **difficult to address cost/schedule trading (no delay but high cost)**
  - **Availability: no quality CPM at early phases and for small jobs**
  - **Skills: Planning and schedule expertise is in very short supply**
- If all of the above are dealt with (generally for large, strategic projects), CPM can add value if it is integrated with parametric models for systemic risk

* Griffith, Andrew, "Scheduling Practices and Project Success", AACE Transactions, 2005

Question

- *Which best describes the prevailing Contingency method used for large project Cost at your workplace?*

1. Judgment, pre-determined, table-based, rules-of-thumb, or similar non-probabilistic methods
2. Line-Item Ranging (i.e., assign 3-point ranges to estimate items and run Monte-Carlo)
3. Expected-Value (i.e., assign probability of occurrence and 3-point cost impact ranges to risk register items and run Monte-Carlo)
4. Cost loaded CPM model with Monte-Carlo

METHODS THAT WORK

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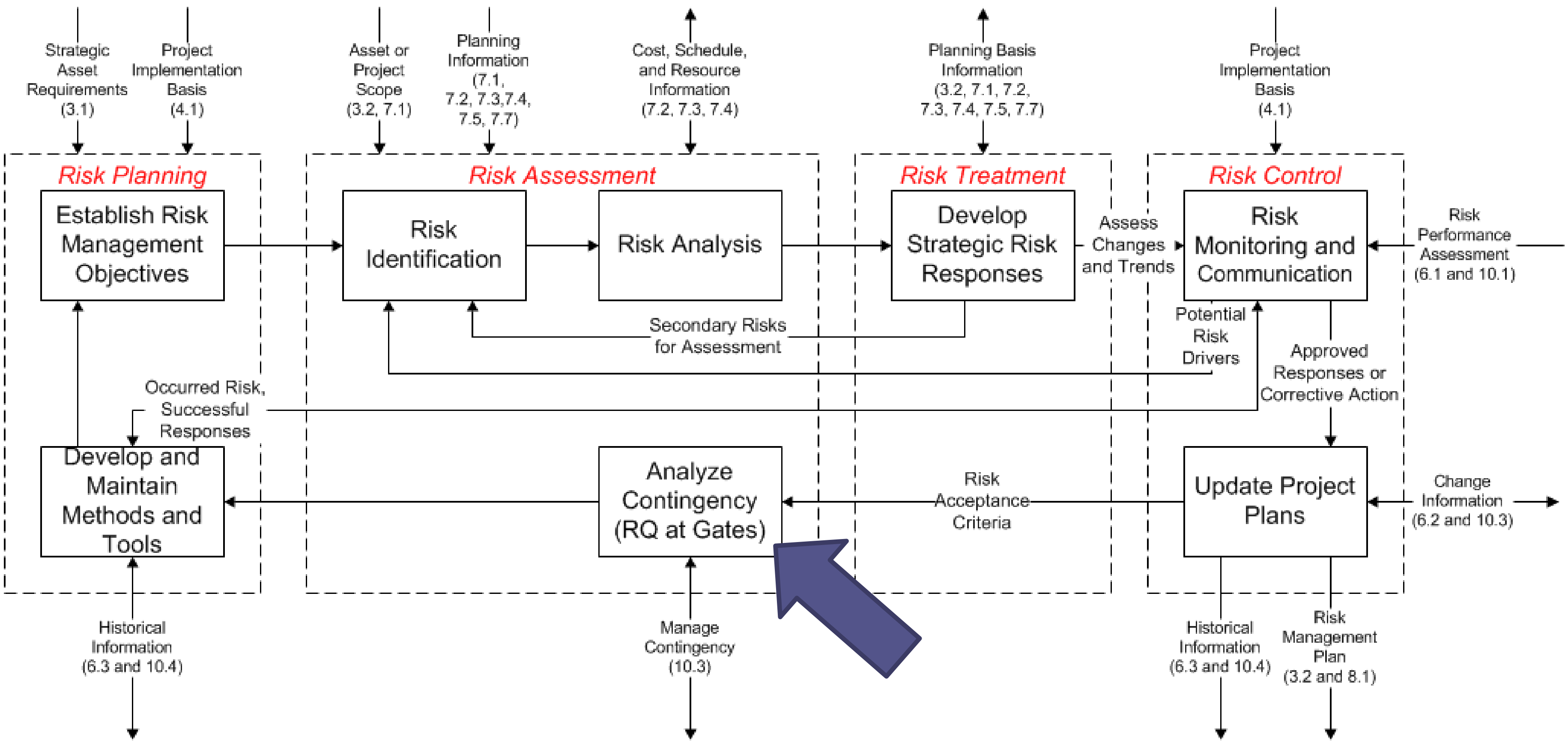
Start with a Robust Risk Management Process

Re: AACE TCM Chapter 7.6

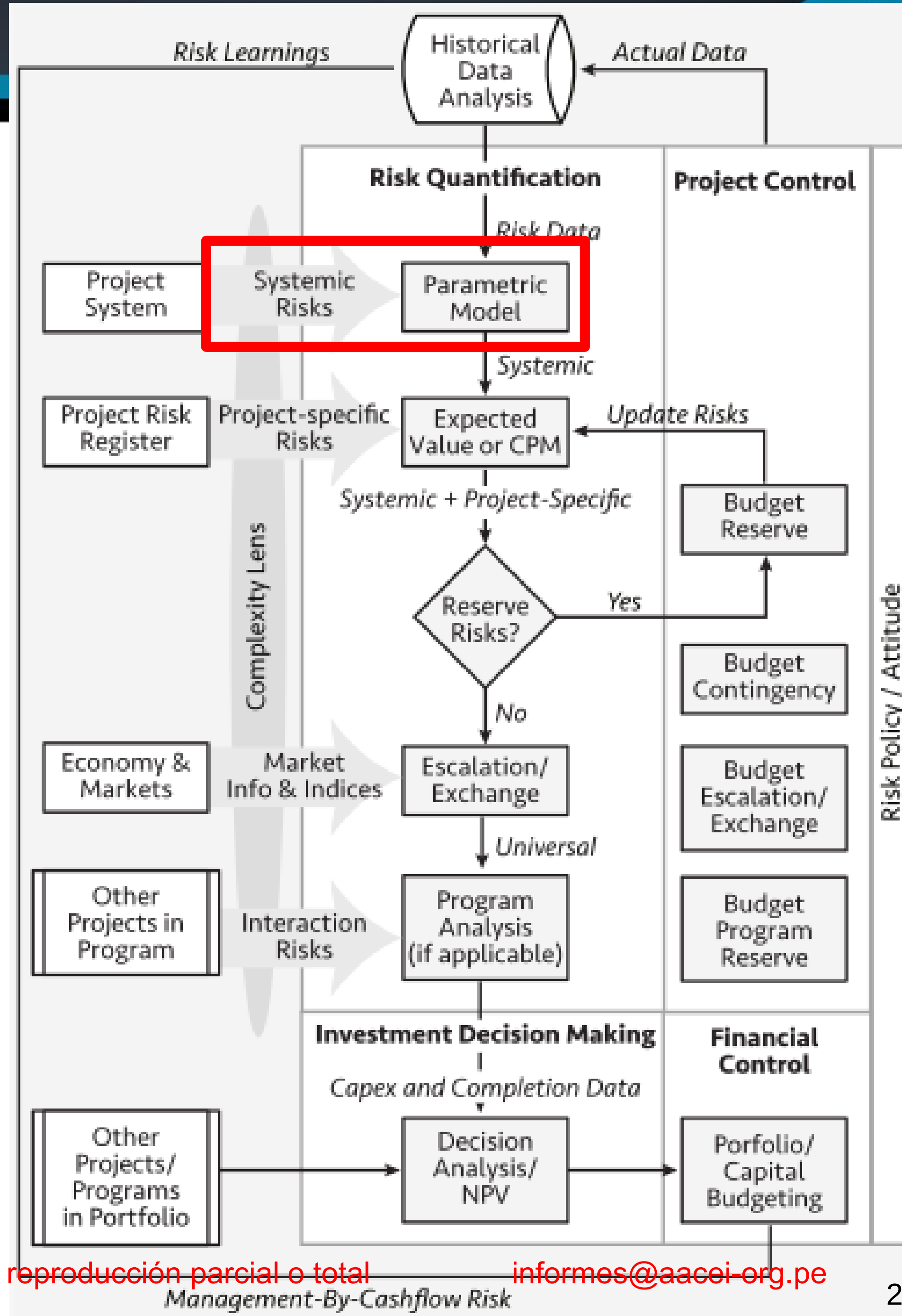
TCM is unique in that it addresses **Risk Quantification** by recycling residual risks through Assessment at the Decision Gates



Step 1

1-Parametric Model for Systemic Risks

- The first analysis step is to quantify **systemic** risks using an empirically-based parametric model
- **Systemic risks** = artifacts of the project system, technology, complexity, teams, etc.
- AACE RPs 42/43R-08



Example Model Applications from the Book

Risk Driver	Enter Parameter (*a*)	Coefficient (*b*)	*a* x *b*
Constant			−30.5
Scope	3		
Planning	4		
Engineering	3		
Scope Definition	3.3	9.8	32.3
New Technology	5%	0.12	0.60
Process Severity	3	1.0	3.0
Complexity	5	1.2	6.0
Subtotal Base (prior to adjustments)			**11.4**
Adjustments			
Team Development	Poor	(assume complex)	+6
Project Control	Poor	(assume complex)	+6
Estimate Basis	Fair		0
Equipment	15%		+2
Fixed Price	<10%		0
Total Base (prior to basis adjustment; rounded to whole number)			**25**
Bias	Low		+5
Systemic Cost Contingency			
Mean	25 + 5		**30%**
p10	25 x (−0.5) + 5		**−7%**
p70 (indicated funding)	25 x 1.5 + 5		**43%**
p90	25 x 2.6 + 5		**72%**

Cost

Execution Schedule Duration

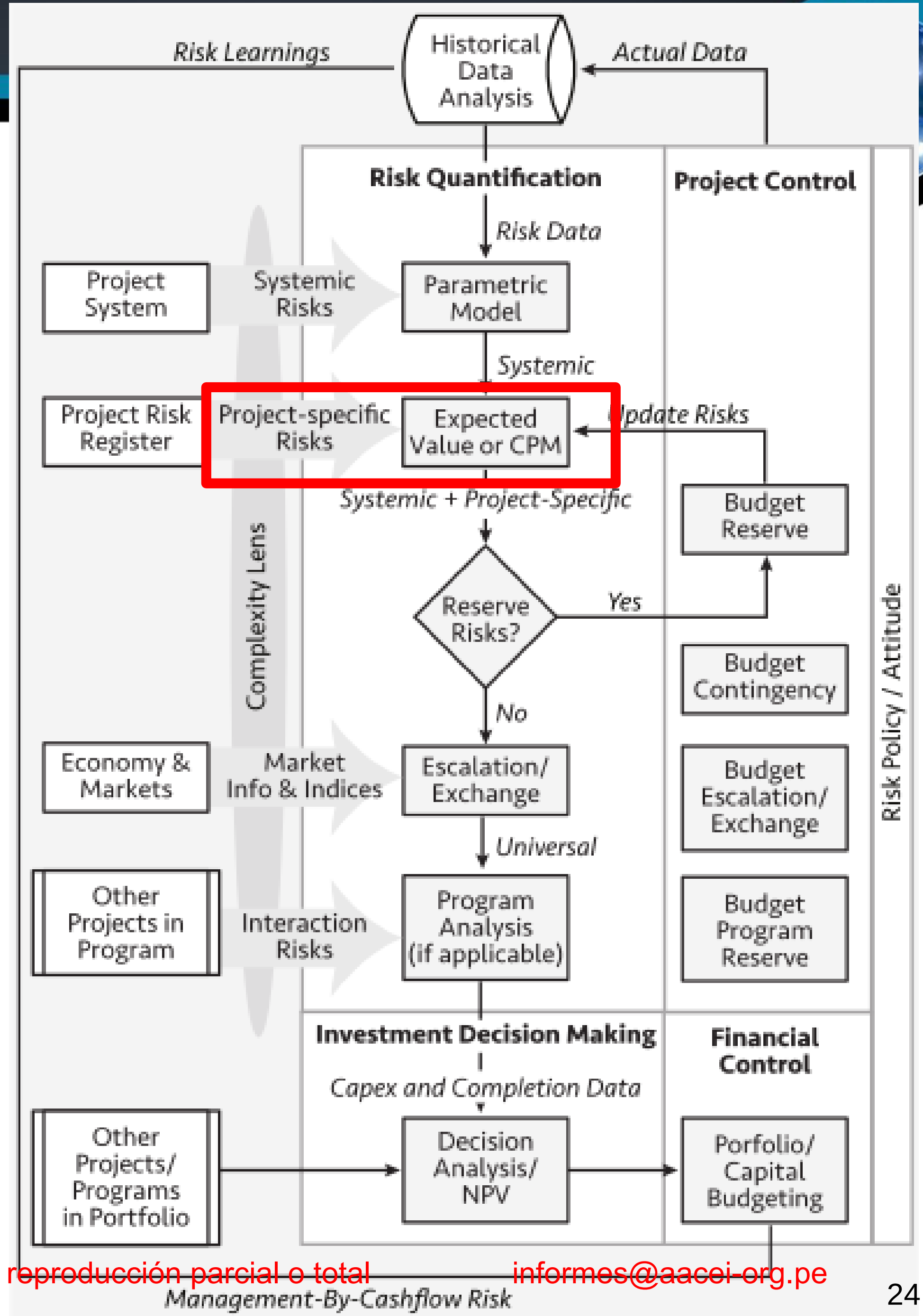
Risk Driver	Parameter (*a*)	Coefficient (*b*)	*a* x *b*
Constant			−23.5
Scope Definition	Average 3.3	9.6	31.7
New Technology	5%	0.10	0.5
Process Severity	3	0.50	1.5
Complexity	5	0.50	2.5
Subtotal Base (prior to adjustments)			**12.7**
Adjustments			
Schedule Basis	Good		0
Total Base (prior to bias adjustment; rounded to whole number)			**13**
Bias	Low		+3
Systemic Execution *Schedule Duration* Contingency			
Mean	13 + 3		**16%**
p10	10 x (−0.2) + 3		**0%**
p50 completion	13 x 0.9 + 3		**15%**
p90	13 x 2.3 + 3		**33%**

This model in Excel is available with the PRQ book; also, AACE RP 43R-08 has working Rand & Hackney Models

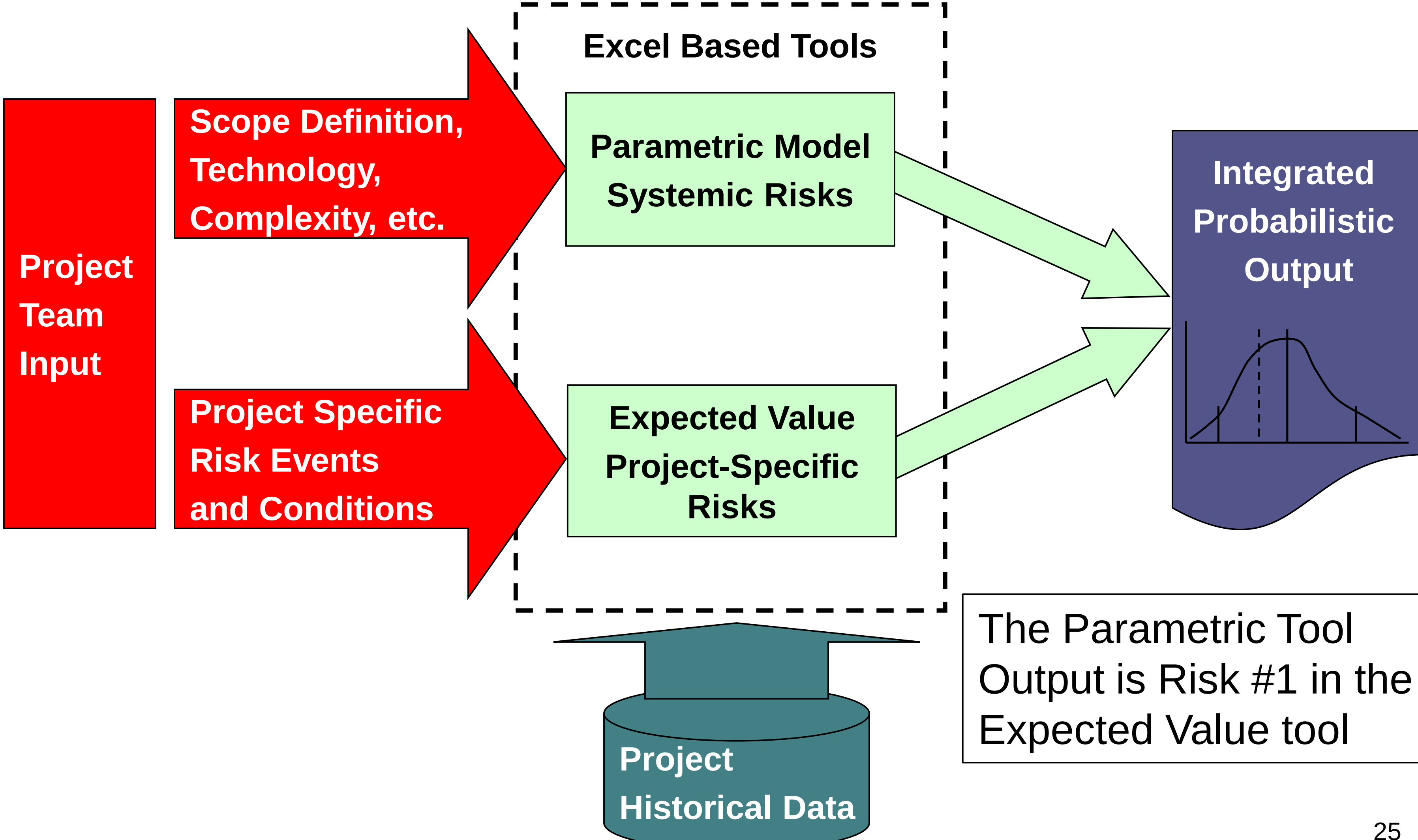
Step 2

2-Expected Value w/MCS for Project-Specific Risks

- Next, quantify **project-specific** risks using Expected Value (EV) with MCS
  - and/or CPM for strategic projects
- **Project-Specific** = critical risk events and uncertainty of conditions
- AACE RP 65R-11



Parametric & Expected Value Used Together

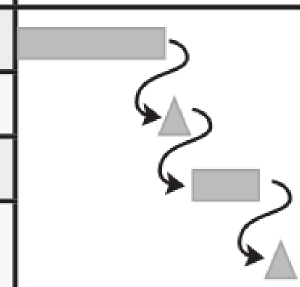


The Parametric Tool Output is Risk #1 in the Expected Value tool

Option: CPM Modeling + Parametric Model

- Strategic projects at sanction often to have the money, time and expertise to do quality CPM modeling
- To use CPM + Parametrics, start with AACE RP 57R-09 and instead of quantifying "uncertainties", apply a parametric model to address systemic risks as a buffer at the end

ID	Description	Remaining Duration	Start	Finish	Cost
0050	Commissioning	100	20-Jan-13	29-Apr-13	$16,500
0060	Project Turnover	0		29-Apr-13	$0
	Systemic Risk	30	29-Apr-13	29-May-13	$3,000
0080	Final Completion	0		29-May-13	$0



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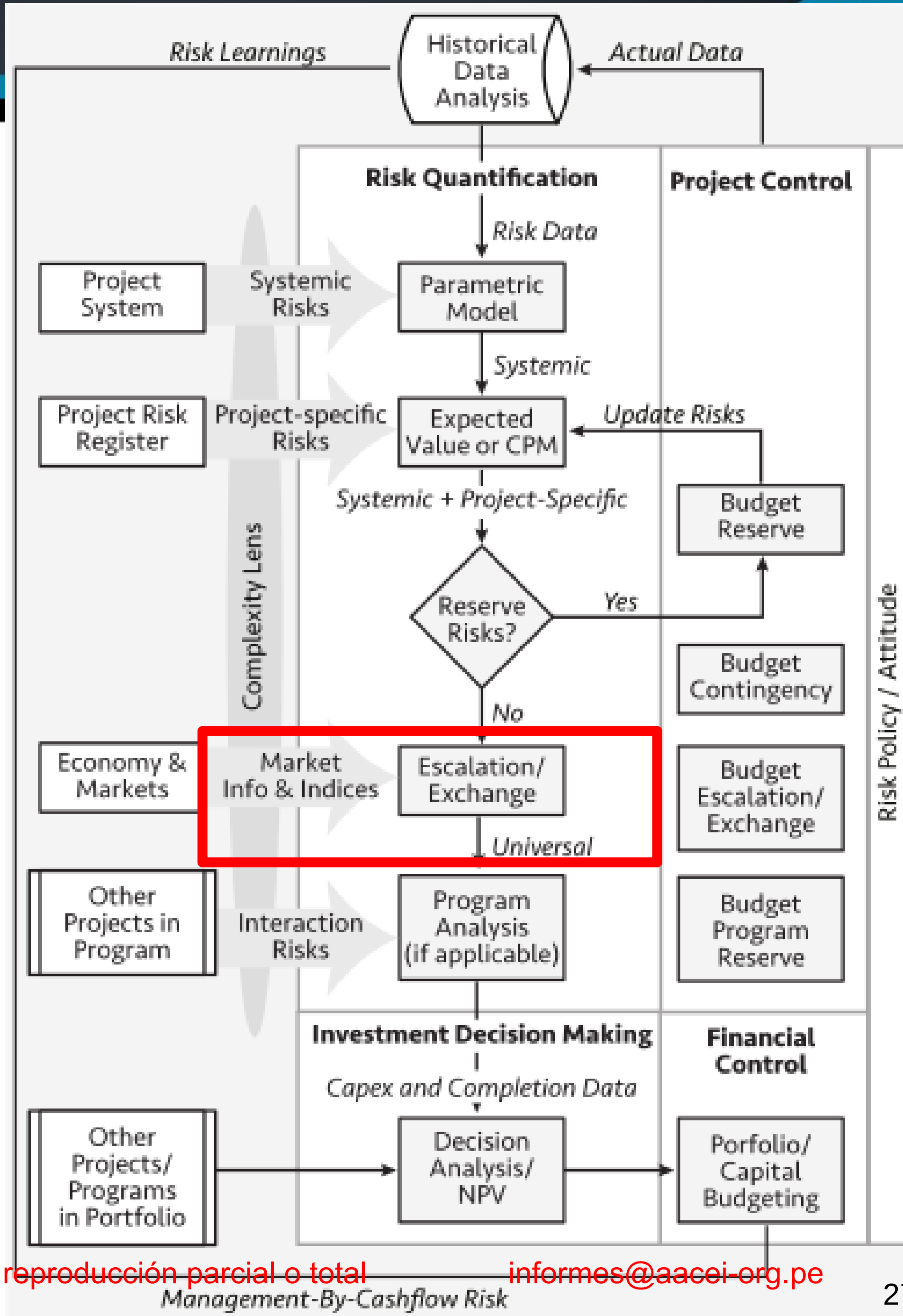
3-Escalation/Exchange Estimating with MCS

- The next step is to quantify *escalation and exchange* risks by applying MCS to the deterministic model
- Base cost and schedule uncertainty are included as inputs to this step
- Therefore, the output covers ALL capex risk
- AACE RP 68R-11

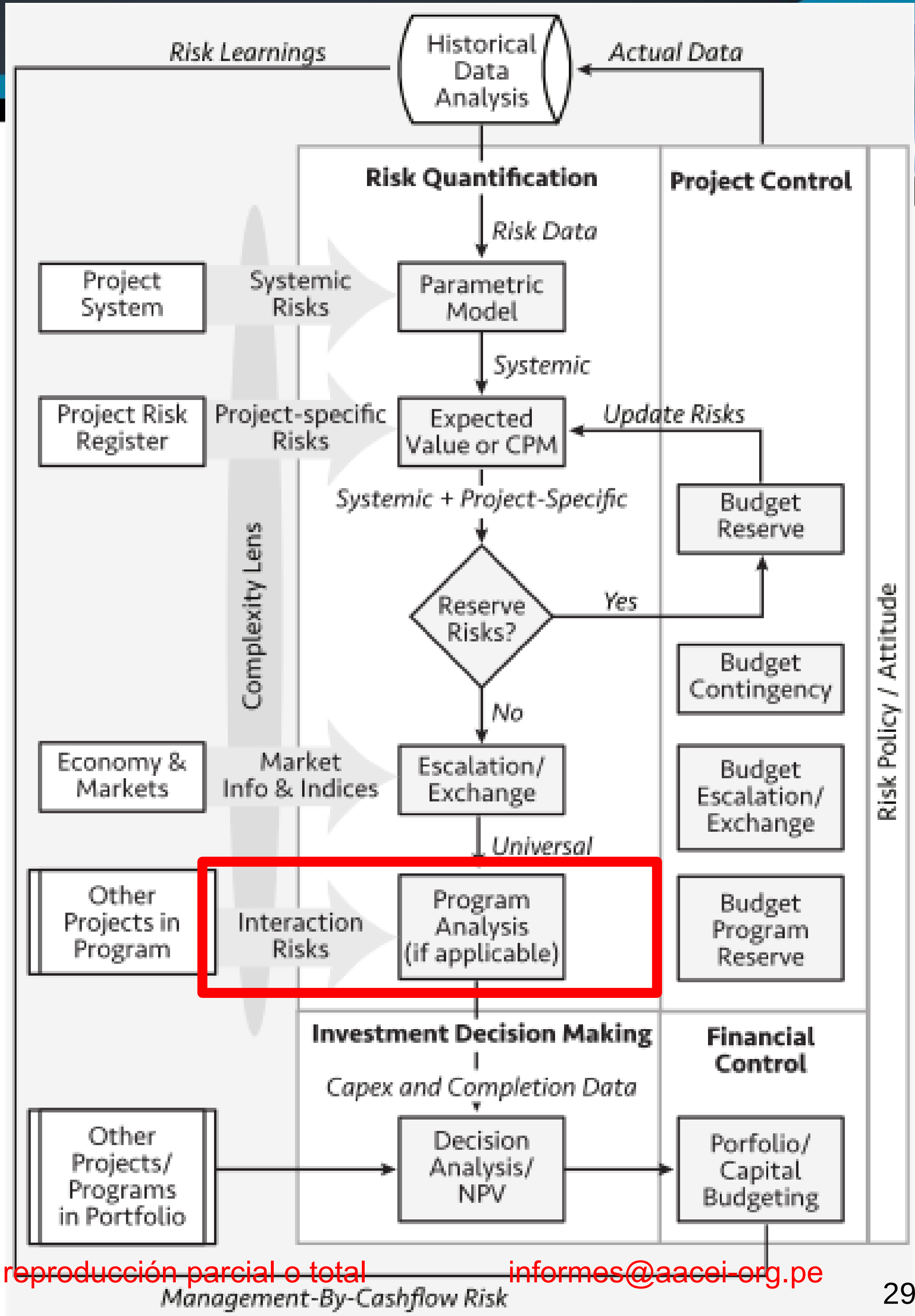


Escalation

- Changes in price levels driven by economic conditions
- Includes economic conditions that prevail in your micro-economy such as:
  - Industry productivity and technology
  - Industry and regional market conditions (demand, labor shortages, margins, etc.)
- Includes, but differs from inflation which is a caused by debasement of a currency
- Varies for different cost items, regions, procurement strategy, etc.

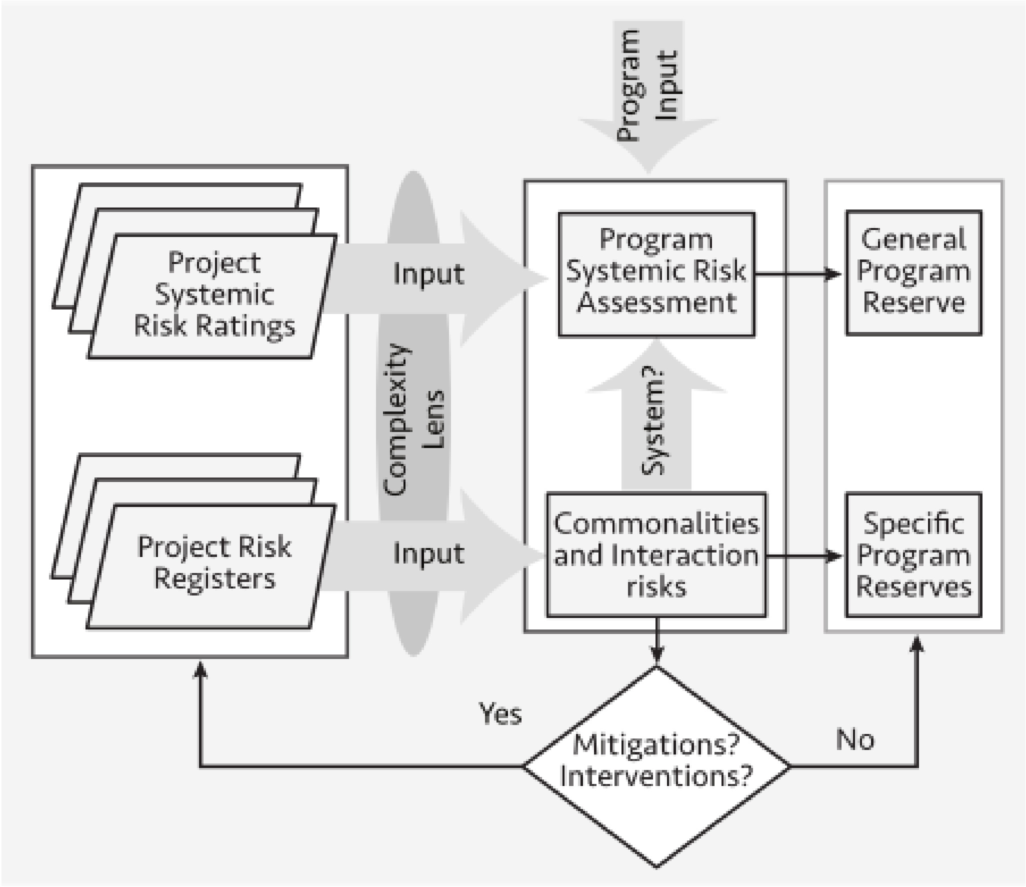
4-Program Level Analysis

- The next step is to quantify *additional program level* risks (i.e., interaction risks)
- This involves making a program level analysis "pass" using the Parametric and EV w/MCS methods



Program Level Analysis Flowchart

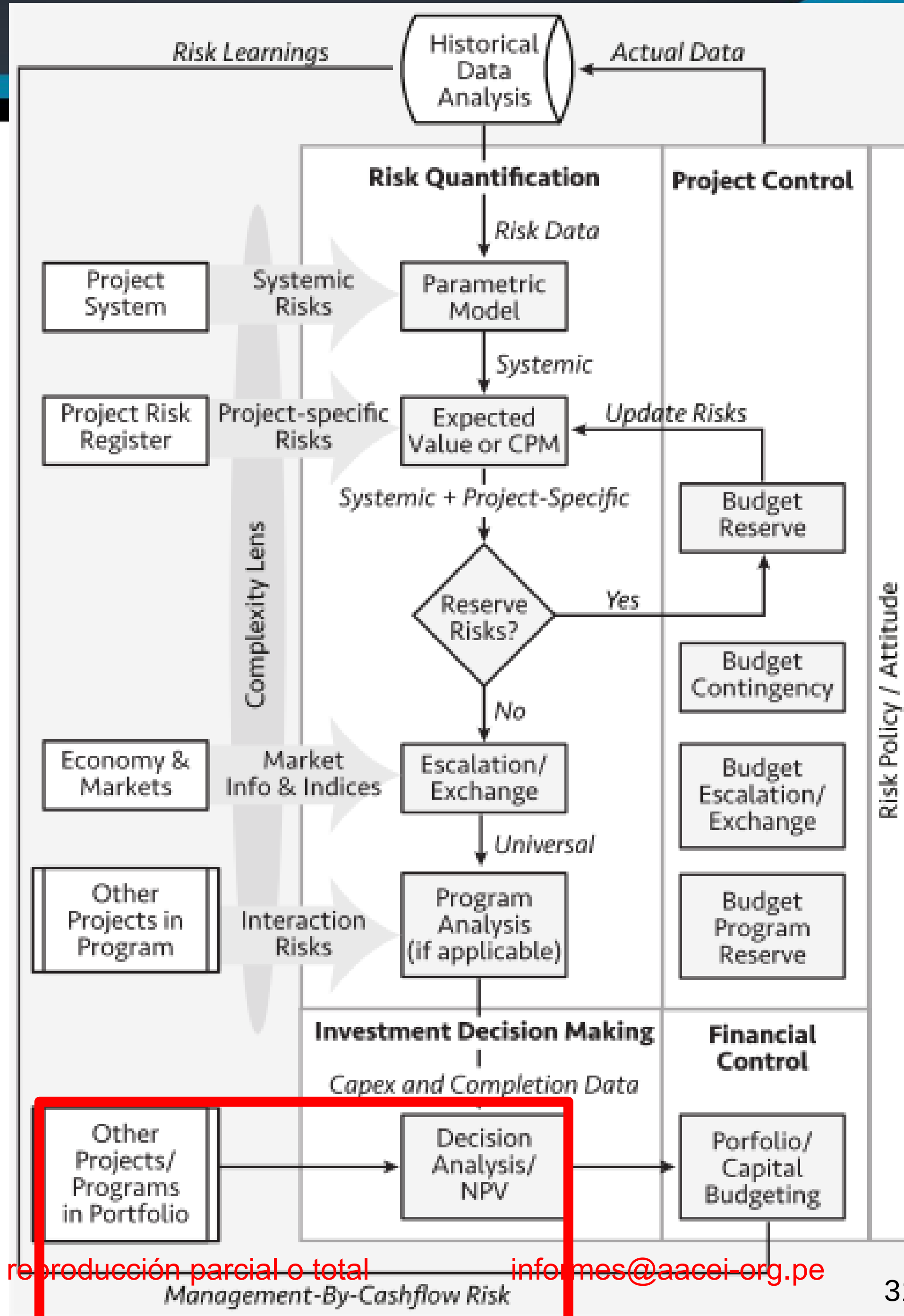
- Separate but cumulative analysis of systemic and project specific risk analyses
- Focused on commonalities and interaction risks as well as added complexity



Step 5

5-Portfolio Level Analysis

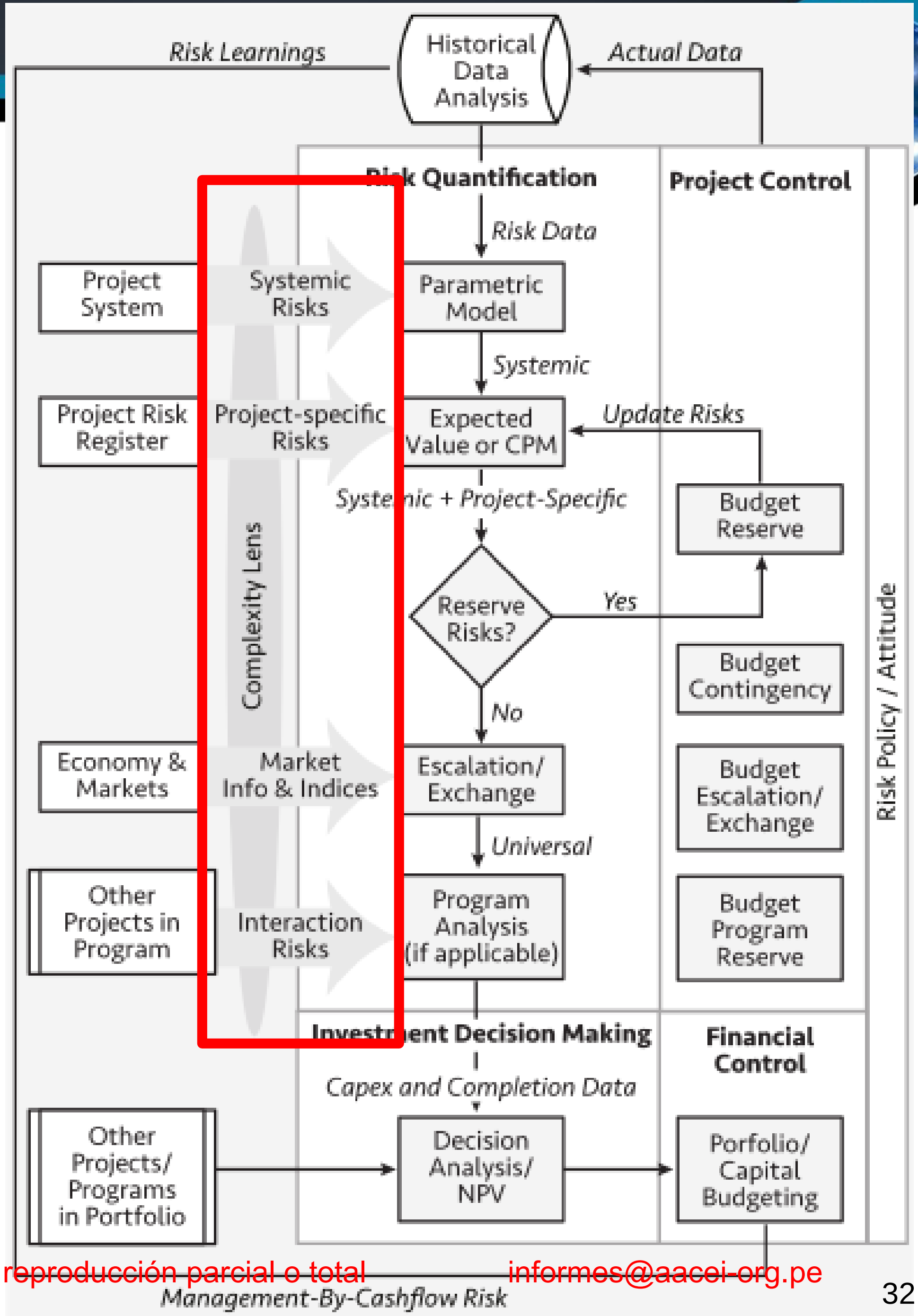
- The next step is to quantify additional *portfolio level* risks
- Similar to a program level analysis "pass"
- A common risk is "*management by cashflow*"
  - **Funding constraints dictate manipulation of projects in portfolio**
  - **The defacto norm for government**



Step 6

6-Complexity (Tipping Point) Analysis

- Complexity, stressors (e.g., multiple risk events) and a weak system can push a project into disorderly behavior (a blowout)
- Control does not work in a disordered regime
- Complexity/stressors are measured and the impact quantified as a **warning**



The Tipping Point Indicator

- This warns management that the project may be approaching the tipping point into a blowout
- Contingency values do not tell the potential disaster story…a wake-up call is needed! For example….

Complexity/Stress Factors (Tipping Point Factors)						
Systemic Risk Factors	**Size**	**Decisiveness**	**Team**	**Aggressiveness**	**Complexity**	**Overall**
Systemic Risk Indicators						
Project Specific Risks	considers whether top risk events or conditions might consume contingency					
OVERALL						
EXPLANATION: The distribution of project cost outcomes is bimodal or discontinuous. At some point, certain risks may push a project into a chaotic regime with significantly worse outcomes than forecast. The factors above represent complexity/stressor risks associated with the "tipping point" into chaotic, unpredictable behavior. The base contingency model does not cover chaotic outcomes; the potential occurrence if such outcomes is flagged by this indicator.						

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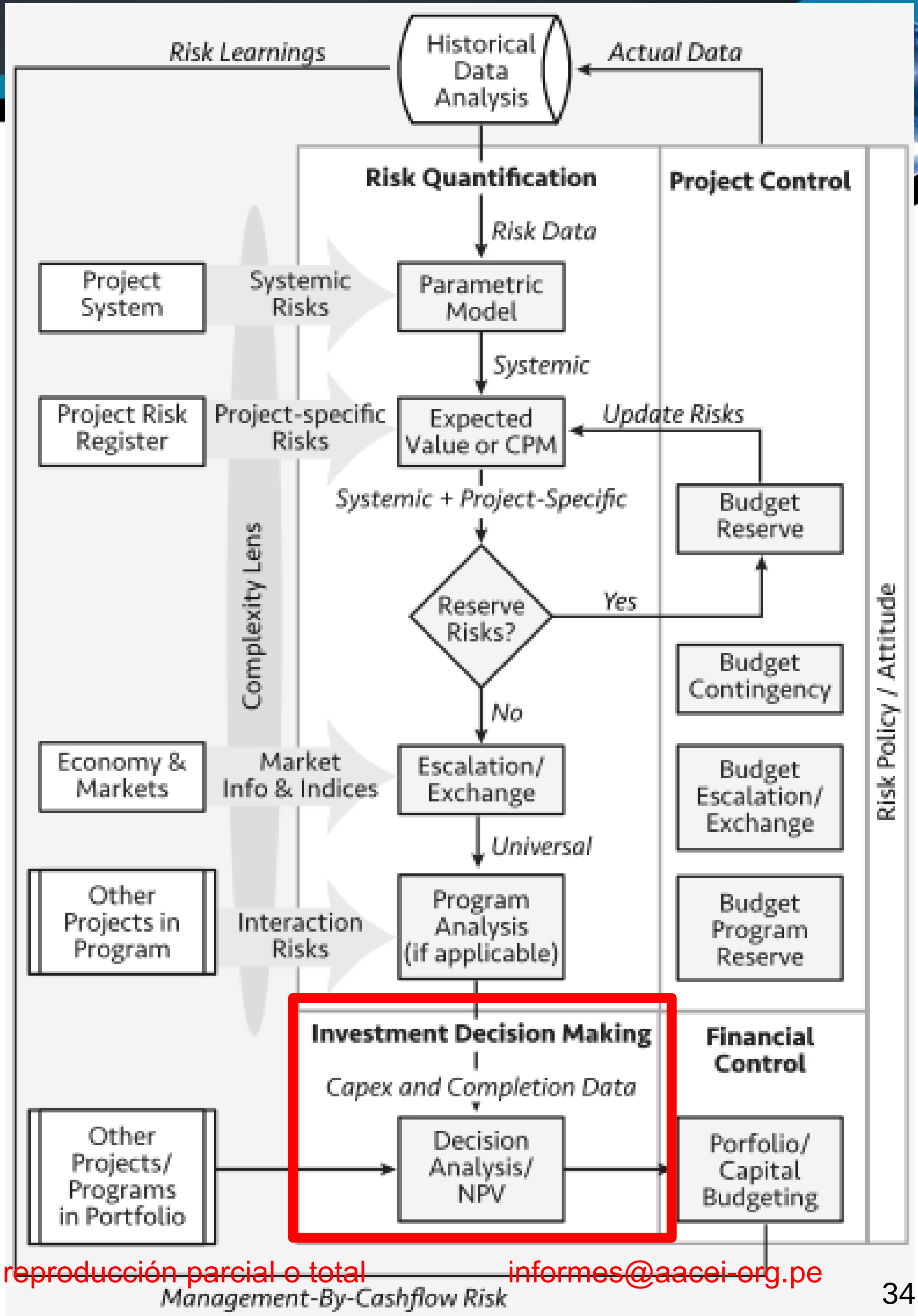
End Use #1

Decision Analysis

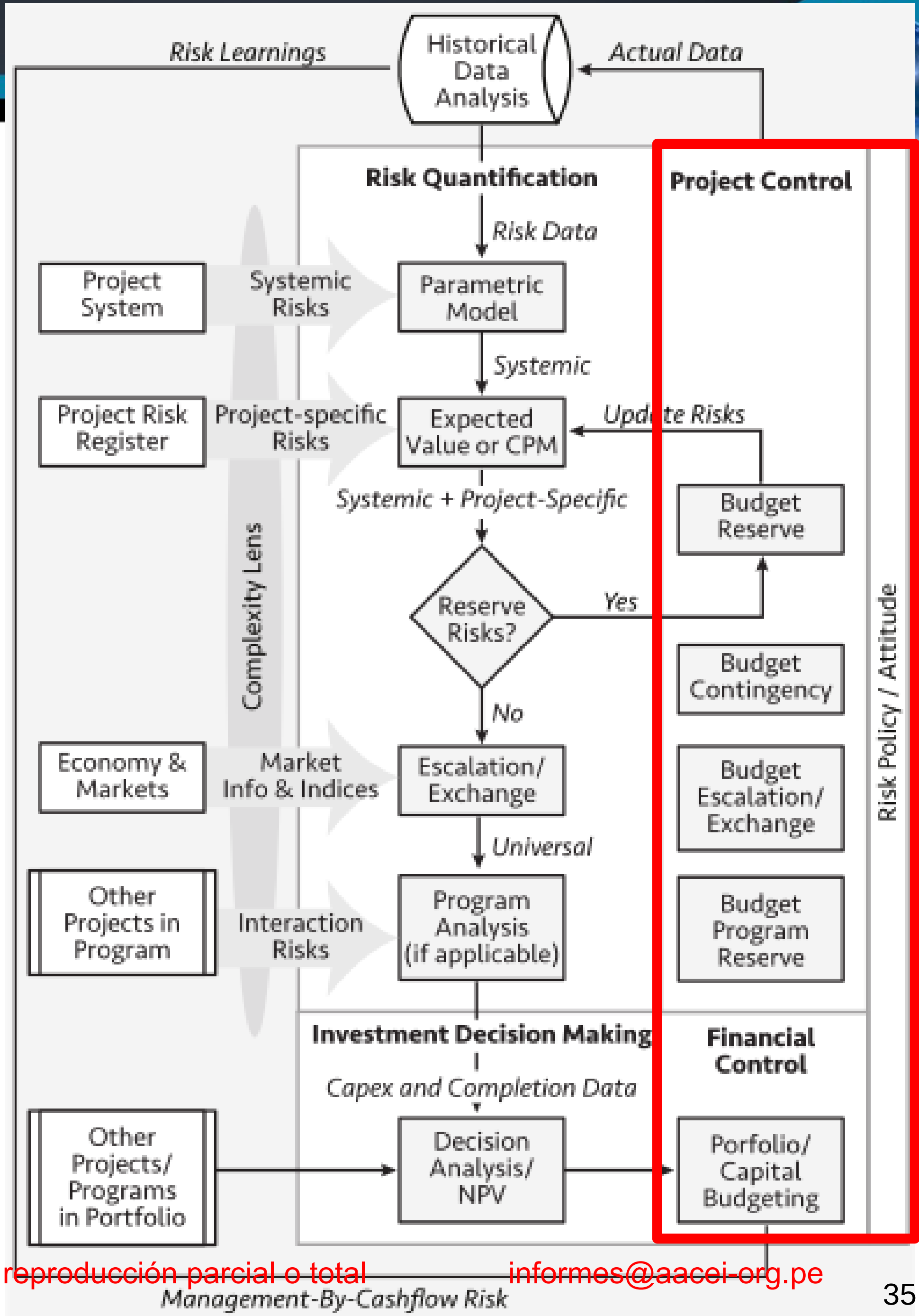
- Decision Analysis requires integrated inputs for CAPEX risks
- Create a single CAPEX cost distribution plus an integrated schedule distribution (NPV is highly sensitive to the start of revenue stream)



End Use #2

Planning & Budgeting

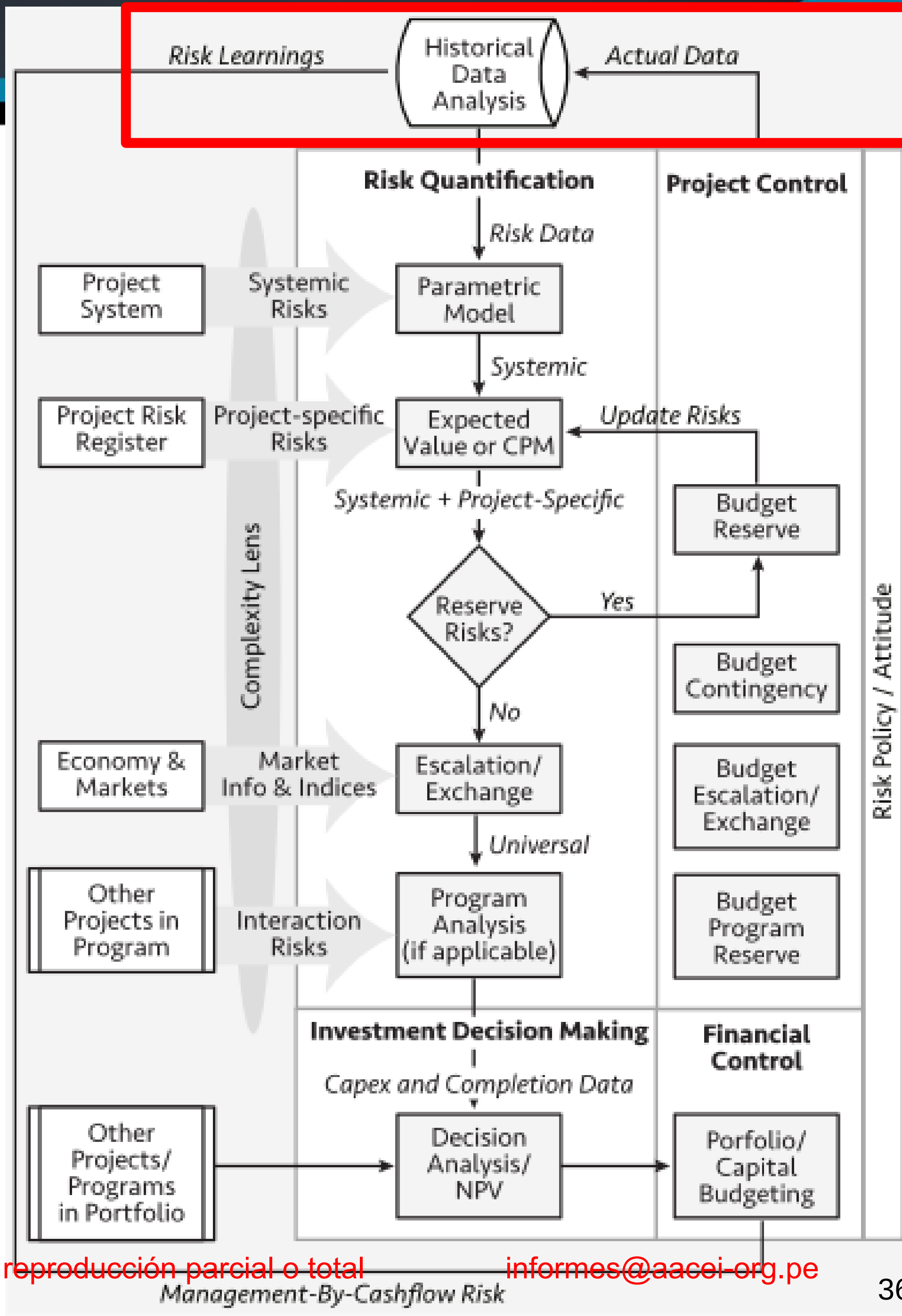
- Once the investment decision is made, one must budget and control the approved money and time
- This needs to be done in an integrated, disciplined manner



Closing the Loop

Historical Data

- Historical Data management is mandatory for empirically valid risk quantification
- It is also needed to improve the project "system" which is the ultimate objective
  - i.e., this PRQ method explicitly drives process improvement!



Process is Generically Applicable

Applies to Any Industry with Construction and to Both Owners and Contractors

- The book focuses on process industry projects from the owner perspective (e.g., oil & gas, chemical, mining, metals, pipeline, power, etc.)
- However, it also benchmarks the method against published accuracy data in other industries (e.g., nuclear, transportation, etc.); it works!
- For contractors, the focus and use can differ
  - **E.g., assess owner exposure to cost growth and schedule slip in respect to how that may drive bidding (and claims) strategy**

Question

- *What do you think is most important in regards to Contingency estimating methods? (pick one)*

1. Realistic: best prediction of actual outcome
2. Practical: can use on every project
3. Integrated Cost & Schedule: consider cost/schedule trading
4. Consistent with the way most others do it

Top Ten Reasons Risk Quantification Fails

1) **"I want it fast and cheap!"**
   - The pressures to complete a project as early as possible and to keep costs low are immense. This results in a bias towards aggressive cost and schedule targets and increases risks that nobody talks about.
2) **"If you miss the milestone or overrun >10%, your career is over!"**
   - Punitive cultures destroy capital discipline by turning the system into a game with unrealistic budgets and plans that nobody buys into and analyses that nobody believes in.
3) **"My projects never overrun…oh, that one was an exception!"**
   - Most companies have a total lack of project history to realistically judge the risk; everything is based on selective memory that differs markedly from reality (most large projects overrun, and the average is over budget by 20%).
4) **"If you were a better estimator, the range would be +/-10%"**
   - Other than some minor uncertainty resulting from the estimating process, the estimator has little to no influence on or control of the range.
5) **"The more rigorous the model, the better the analysis will be"**
   - Many become enamored with methodological elegance, complexity, and/or arcane statistics. However, they never ask "does it work!"

Top Ten Reasons Risk Quantification Fails

6) **"Let the contractors do it; they are the experts!"**
   - EPC contractors simply do not have the empirical knowledge or incentive to perform valid cost and schedule risk quantification for owners.
7) **"It's Lump Sum; therefore, this is all the contractor's risk"**
   - Lump Sum only transfers a nominal portion of the risk to the contractors; e.g., about 10-20% is locked in; after that, owners tend to pay anyway.
8) **"Escalation is Inflation (just ask Finance)"**
   - Finance departments insist that project teams fund "escalation" using their internal "inflation" guidelines; inflation is often only a fraction of escalation (also few companies estimate escalation probabilistically)
9) **"The Standards say so; what more is there to talk about?"**
   - There are no industry accuracy standards. Once a company sets pre-determined ranges as policy, meaningful discussion about risk ends.
10) **"You talkin' to me?**
   - The greatest project risks belong to the business! "Systemic" risks (immature project systems, indecisiveness, poor communication, weak skills, etc.) are what kill projects and Senior Management are the risk owners, not teams.

Presentation Summary

- Covered the challenges we face: the history of our past and current failure to realistically model risks
- Covered the criteria for "Methods that Work" (realistic, practical and integrated covering all risks)
  - **Are your current methods working?**
- Covered the methods that best quantify each risk type and highlighted AACE® RPs where applicable
- As a last note, please consider the AACE® DRMP certification

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