1er Congreso Latinoamericano
AACE International
Ingeniería de Costos

AACE COLOMBIA SECTION

Project Risk Quantification: Methods That Work *and Start Towards AI*

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Reviews research on cost growth and accuracy and presents integrated PRQ methods “that work” for projects, programs and portfolios of every description for both owners and contractors.

FAVOR USAR EL MICRÓFONO PARA TODAS LAS PREGUNTAS Y COMENTARIOS!

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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 owner, contractor and benchmarking firms in the process industries (oil and gas, chemicals, mining, power, etc.)**
- AACE® International
  - **Fellow, Honorary Life Member, Award of Merit, Past Director**
  - **Led Decision & Risk Management Professional (DRMP) certification**
- Book Author
  - **AACE Total Cost Management Framework**
  - **Project Risk Quantification**
- Education and Other
  - **BS Mining Engineering and MBA**
  - **PE CCP CEP DRMP**

"Project Risk Quantification" (PRQ)

- This presentation is based on

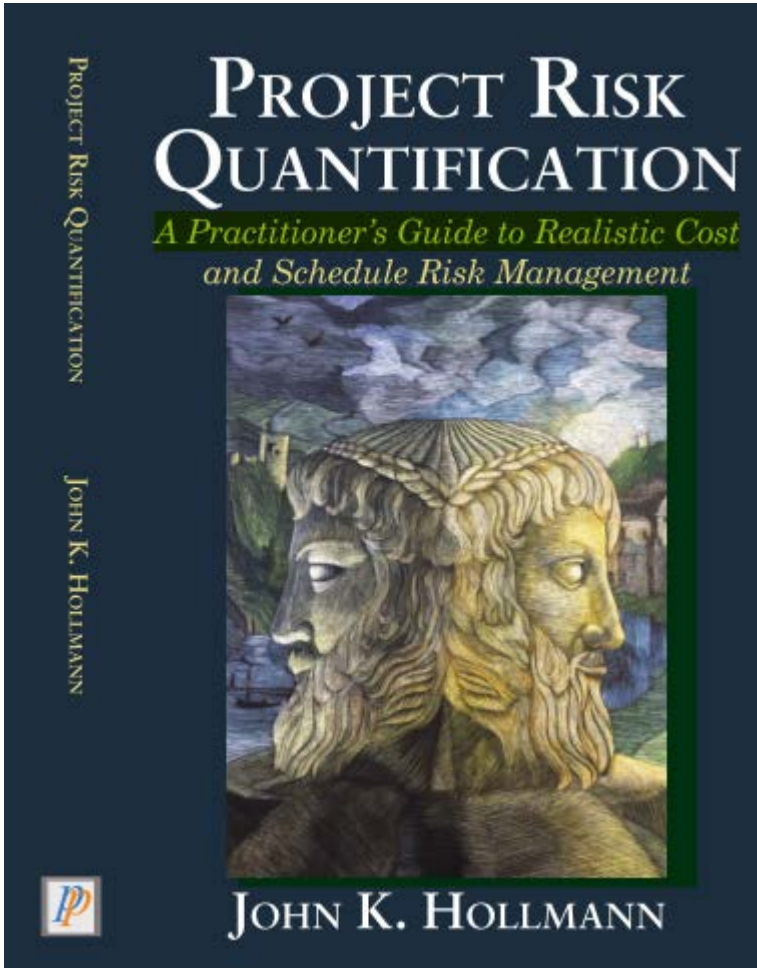
  "Project Risk Quantification:

  A Practitioner's Guide to Realistic Cost and Schedule Risk Management"

- Probabilistic Publishing

  www.decisions-books.com

- Most of the images are from the book



INTRODUCTION/BACKGROUND

Research findings and challenges our traditional methods are not addressing

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Introduction

- Investment and bidding decisions depend on effective cost and schedule risk *quantification*
- Quantification methods must be.....

  …realistic, practical and integrated

- Methods must be all three to of real value

What is Project Risk Quantification (PRQ)?

- Integrated, **probabilistic** modeling of the cost and schedule impact of **all** identified risks in projects
  - **Integrates cost and schedule**
  - **Integrated with *project control* (provide basis for incorporating risk in project plans and budgets)**
  - **Integrated with *business* (provide capex and start of revenue input to NPV analysis)**
  - **Integrated with *commercial* (provide insight for bid pricing strategy)**

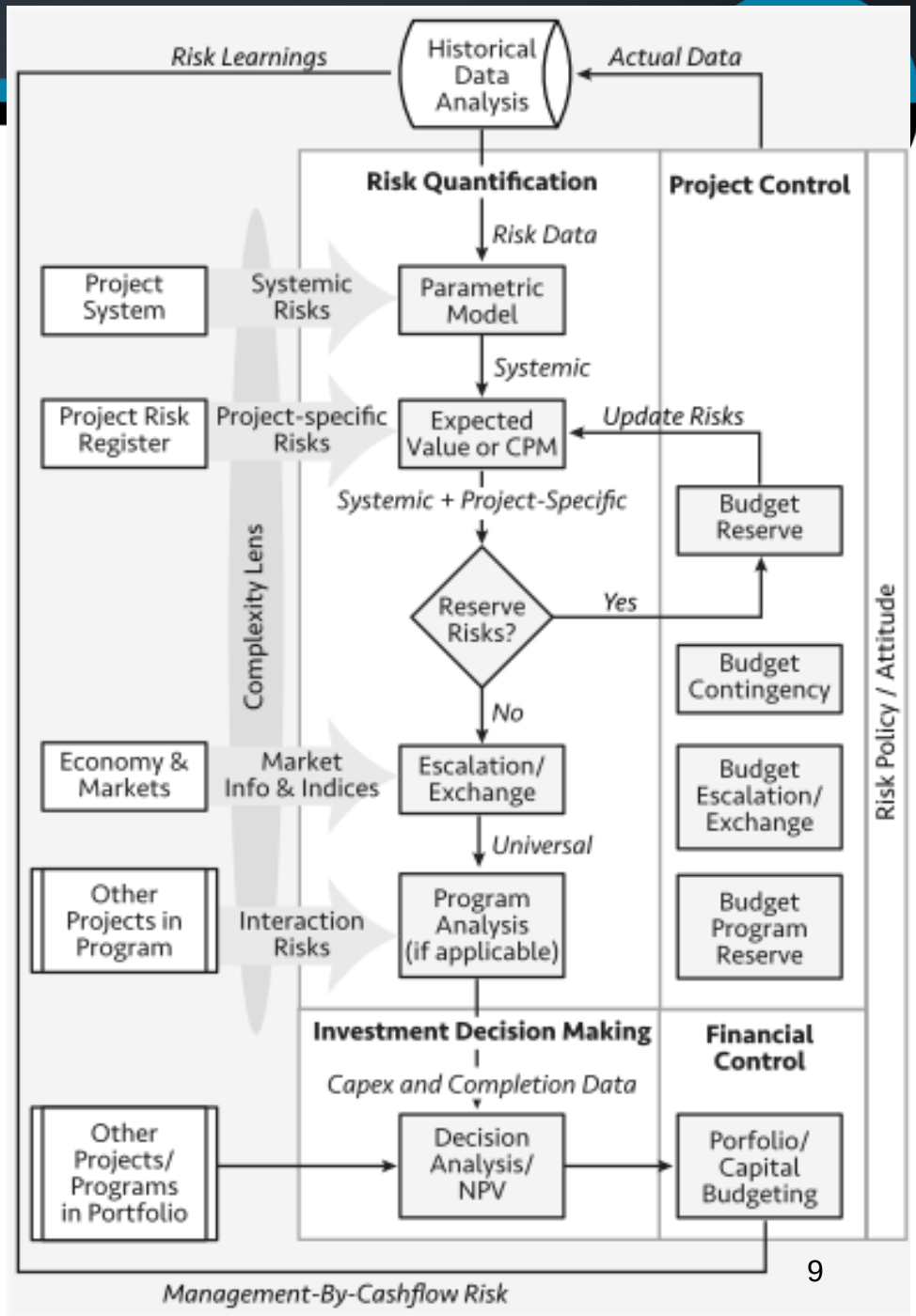
Criteria for "Methods That Work"

- **Realistic**
  - Backed by historical data; evidence that it works
  - *Janus* views the past (pessimism) & future (optimism)
- **Practical**
  - Apply to every project; simple or complex, large and small, conceptual or detailed, good or bad quality planning
  - Apply in-house every day, no consultants other than for the *outside view* for strategic projects
- **Integrated**
  - Address all risk types and considers cost & schedule together (i.e., consider *cost and schedule trade-off*)

The PRQ Process Map

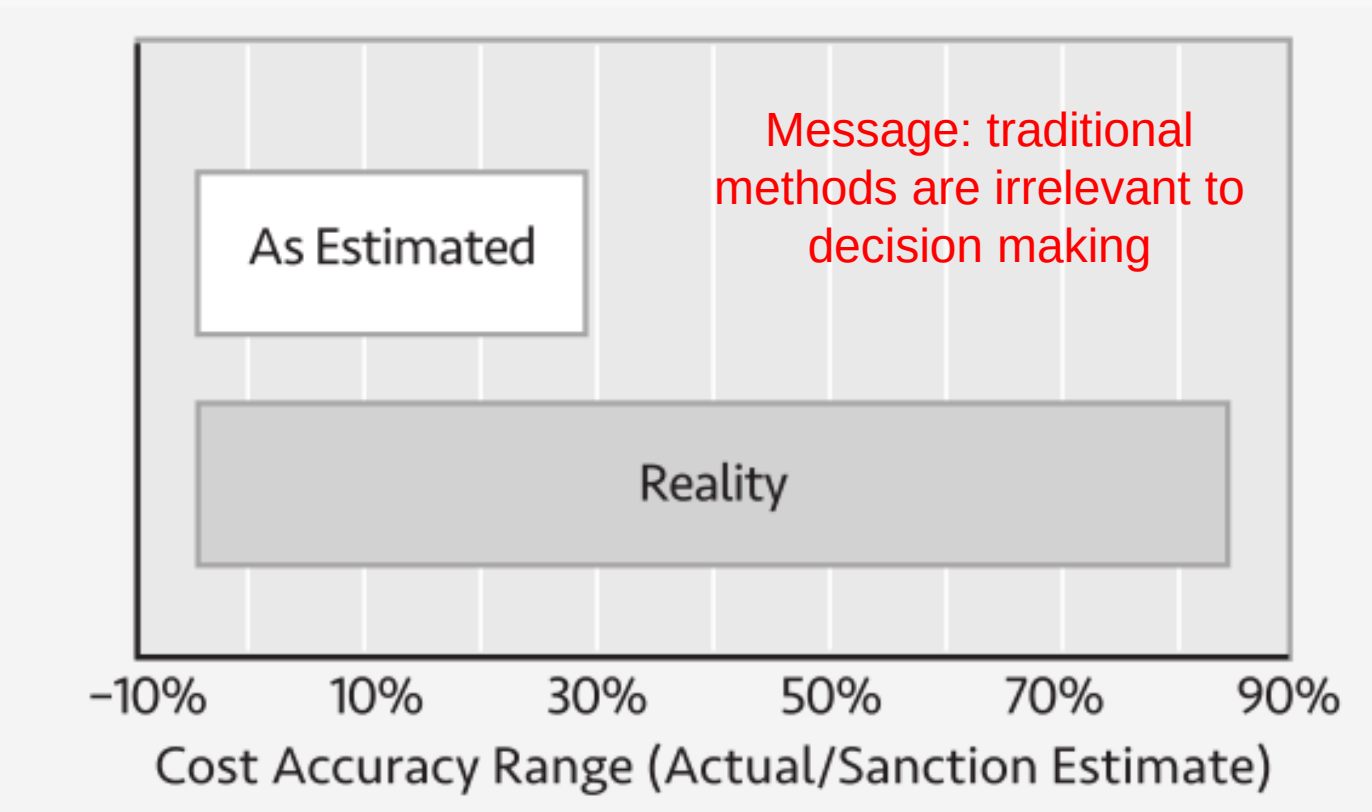
- **Empirically valid**
- **Models matched to risk type & plan need**
- **All risks covered step-by-step (not complicated)**
- **Supports budgeting and NPV modeling**

- Why do it this way?...the next slides review history



Challenge #1: **Under**estimation

- The actual high end (p90) of cost growth is 2x to 3x what we are forecasting for large projects



Example – Contingency Underestimation

- Actual accuracy (dashed lines) overlaid on AACE RP 18R-97 theoretical ranges (shaded bands)
- Actual high end overrun is 2X to 3X the 18R-97 expectation (we never underrun Class 5)
- Contingency under-estimation is seen in <u>every</u> empirical study!

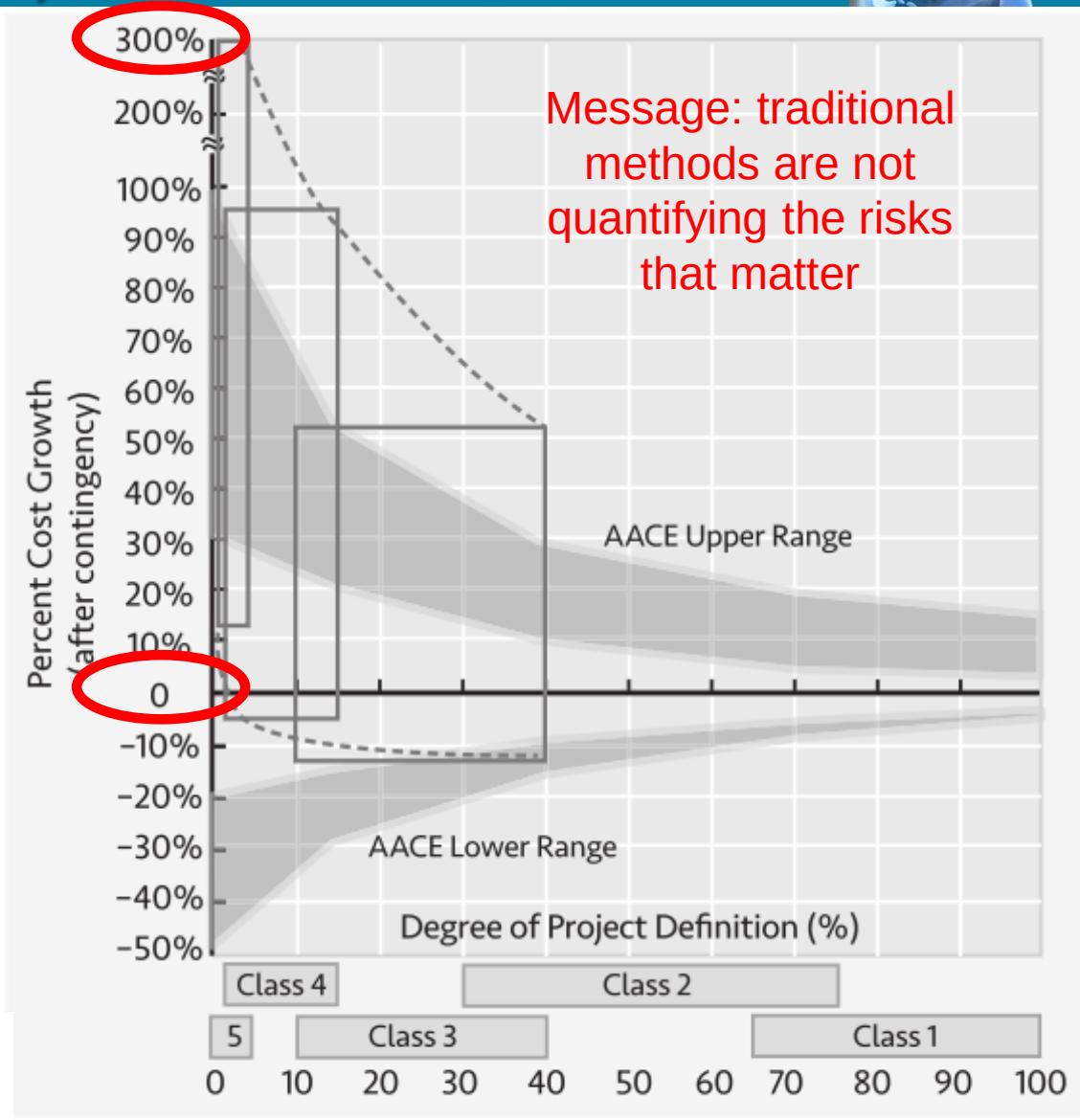
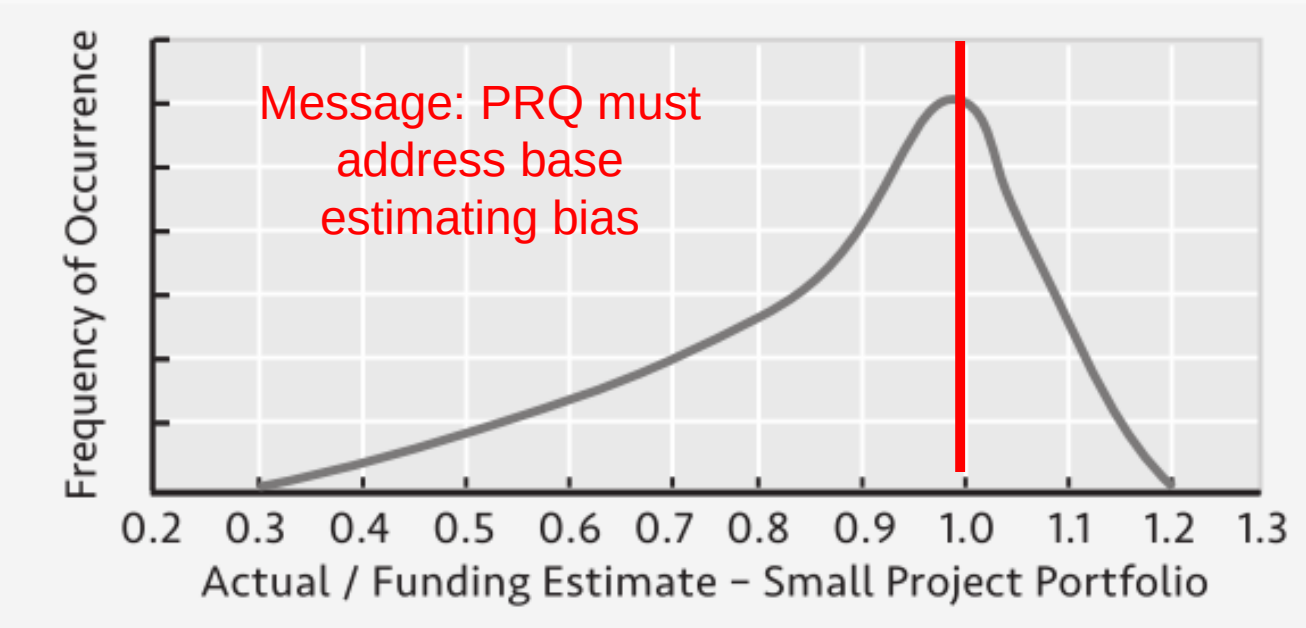


Figure 4.3: AACE Range-of-Ranges (18R-97) vs. Hydropower Project Study (2014)

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

Challenge #2: **Over**estimation on Small Projects

- Small projects: PM has many projects to manage
- Small projects are usually overfunded and underrun
  - **Few overrun by more than 10% (finance constraint)**
  - **Punitive, "get it done" culture (safety and operations driven)**
  - **Can be economical IF unused funds are returned**



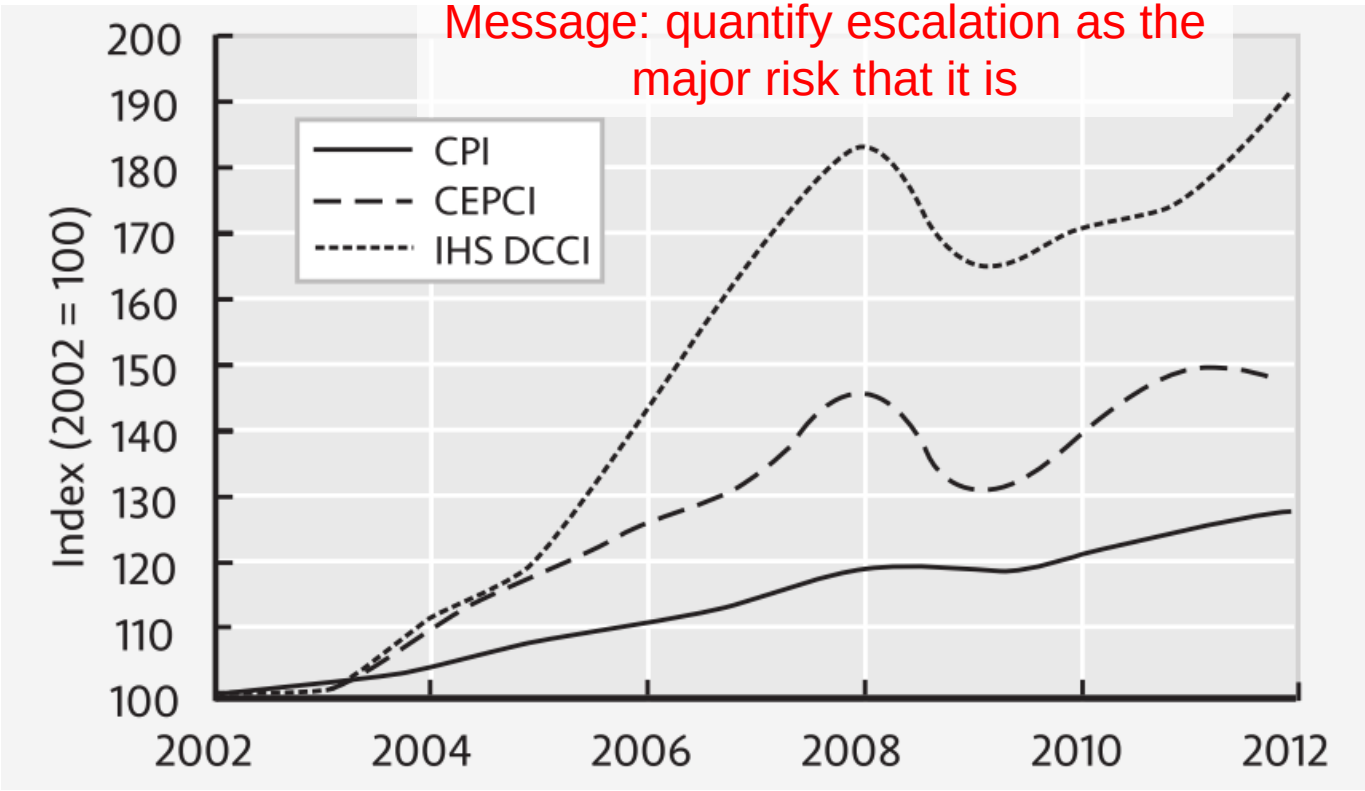
Challenge #3: Underestimation of Escalation

- Many confuse escalation with inflation
- Escalation can be **2X to 3X** inflation and other indices
- Few see escalation as a risk (no probabilistic methods)

Chart compares the:

- IHS CERA Downstream cost index (DCCI)
- Chemical Eng Plant Cost Index (CEPCI)
- US Consumer Price Index (CPI)

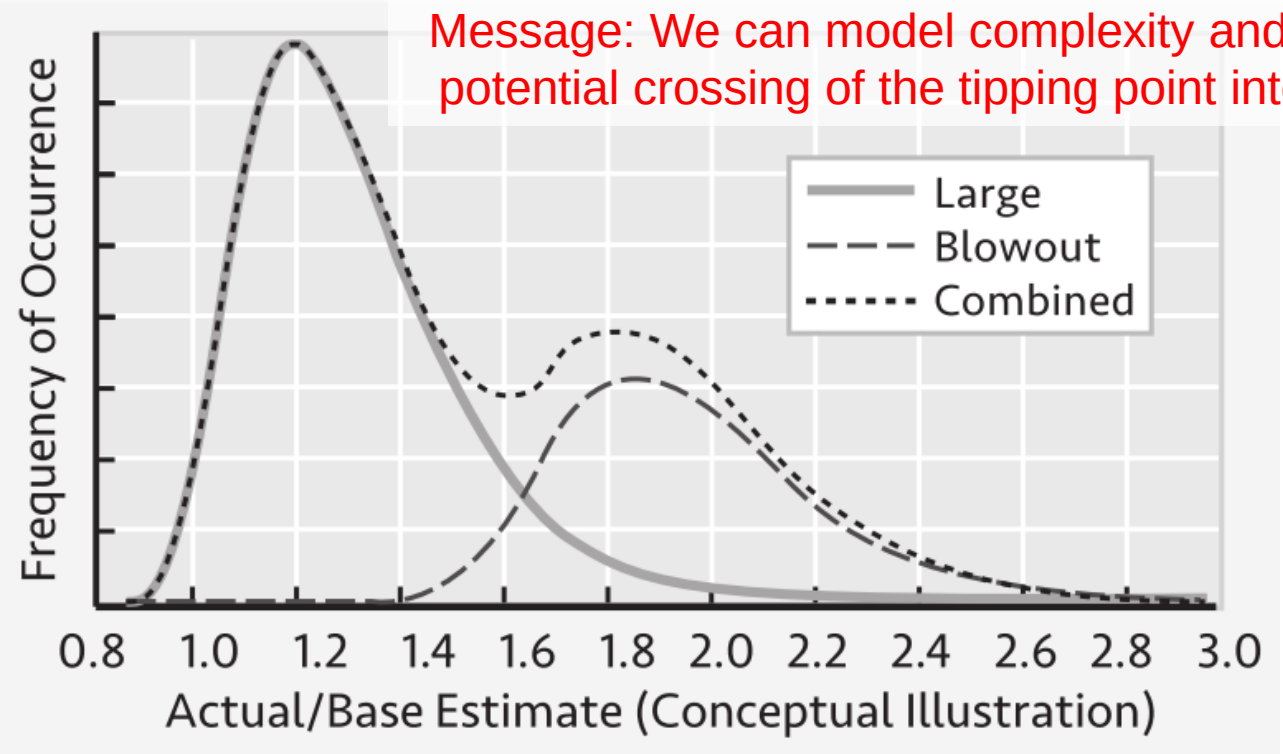
Message: quantify escalation as the major risk that it is



Challenge #4: Failure to Address Complexity

- Complexity is a hot topic but few offer a practical way to quantify it (do not leave it to the academics)
- Weak systems + complexity + stressors = disorder
- Labor related cost overruns of 50 to 200%

Message: We can model complexity and warn of potential crossing of the tipping point into chaos



Challenge #5: Cost/Schedule Trade-off Ignored

- We fail to plan or model **risk responses**
- *Response* = action **after** risk event happens (*treatment is* prior)
- *Response* plan = **scope** to quantify (one cannot estimate cost/schedule without a scope – correct?)
- *Response* plan (i.e., contingency plan) starts with **cost-schedule strategy** (i.e., are we willing to **trade** cost for schedule?)
  - ***Schedule-driven* = fast response but costly**
  - ***Cost-driven* = cheap response but slow**
- Historically, cost growth > schedule slip: we spend money to get done on time (NPV is highly sensitive to *start of revenue*)

Message: if we model cost/schedule tradeoff, that means business must be part of the analysis as only they can make tradeoff decisions

Challenge #6: Line-Item Ranging Fails

- 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 and systemic risks the common approaches were *"a disaster"***
- LIR covers "estimating uncertainty" which only matters to the estimators, not to decision makers who must consider all risks

Message: if research shows LIR does not work,
is it ethical to continue using it?

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

Challenge #7; CPM-Based Methods Are Problematic

- CPM Practicality and Realism Challenges:
  - ***Quality*: CPM schedules are of poor quality (a study showed only 13% of schedules were suitable for PRQ *)**
  - ***Applicability*: CPM networks are static; risks are dynamic**
    - **Dynamic = branching which is typically impractical**
    - **Few 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 above are dealt with (generally for strategic projects), CPM can add value if one also quantifies *systemic* risk

Message: If you need a base method that can be used for every estimate, this is not a choice

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

METHODS THAT WORK

High level summary of the PRQ approach

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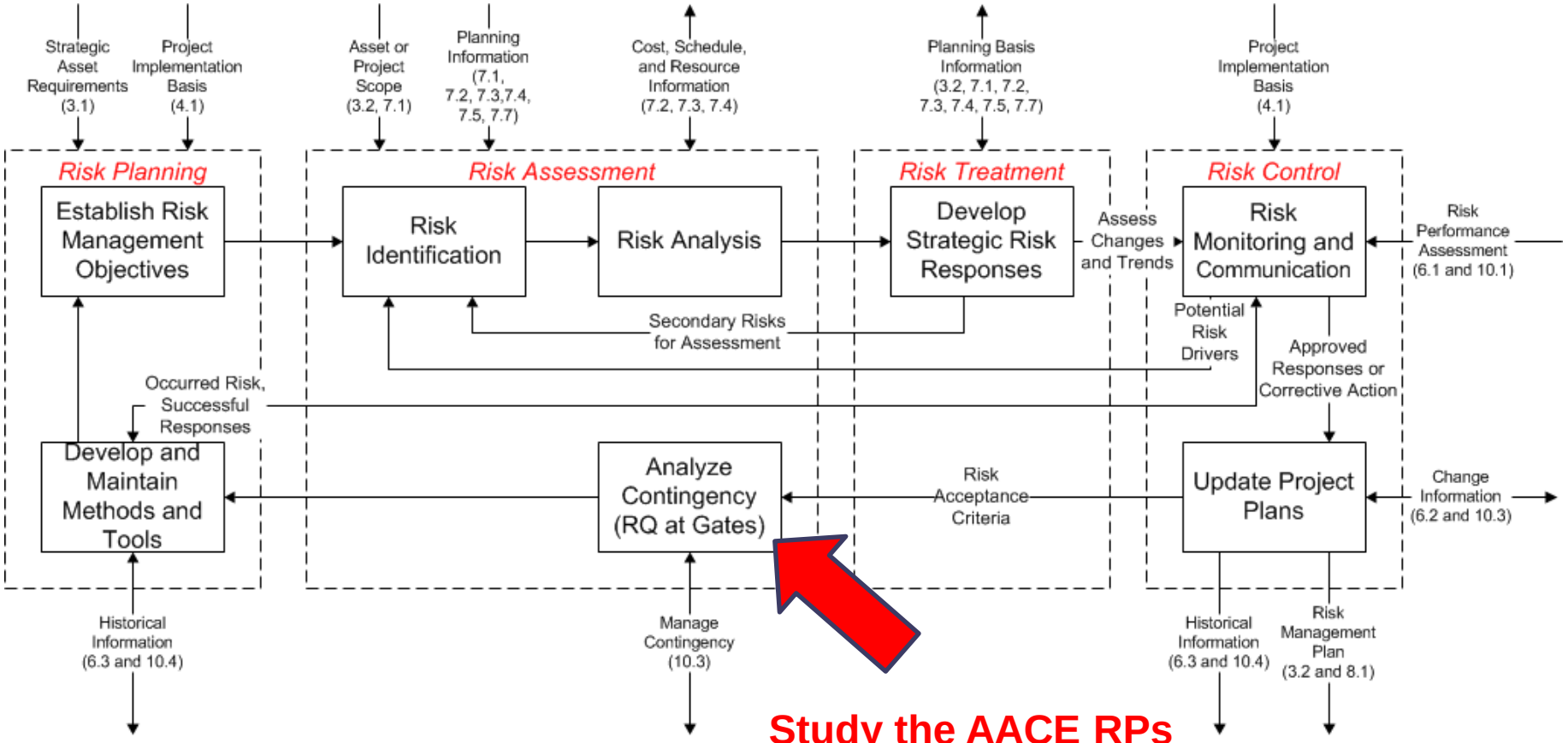
Start with a Robust Risk Management Process

Re: AACE TCM Chapter 7.6

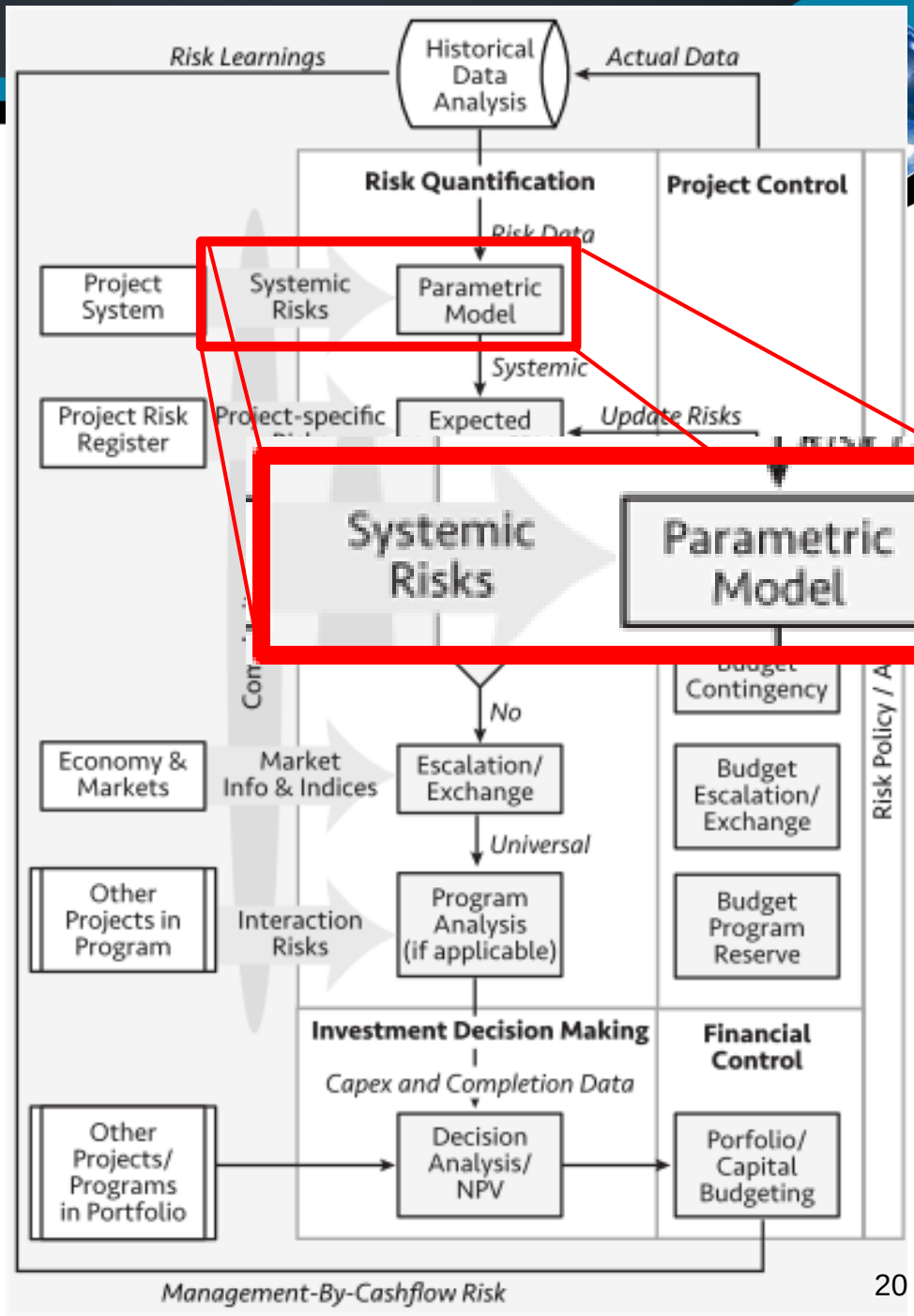
TCM addresses **Risk Quantification** by recycling residual risks through Assessment at the Decision Gates



Study the AACE RPs

1-Parametric Model for Systemic Risks

- Quantify **systemic** risks with an empirically-based parametric model
- **Systemic risks** = artifacts of the project system, technology, complexity, teams, etc.
  - **uncertainties & bias**
- Reference:
  - **AACE RPs 42/43R-08**



Example Model (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%**
*p*10	25 x (-0.5) + 5		**-7%**
*p*70 (indicated funding)	25 x 1.5 + 5		**43%**
*p*90	25 x 2.6 + 5		**72%**

STEPS:

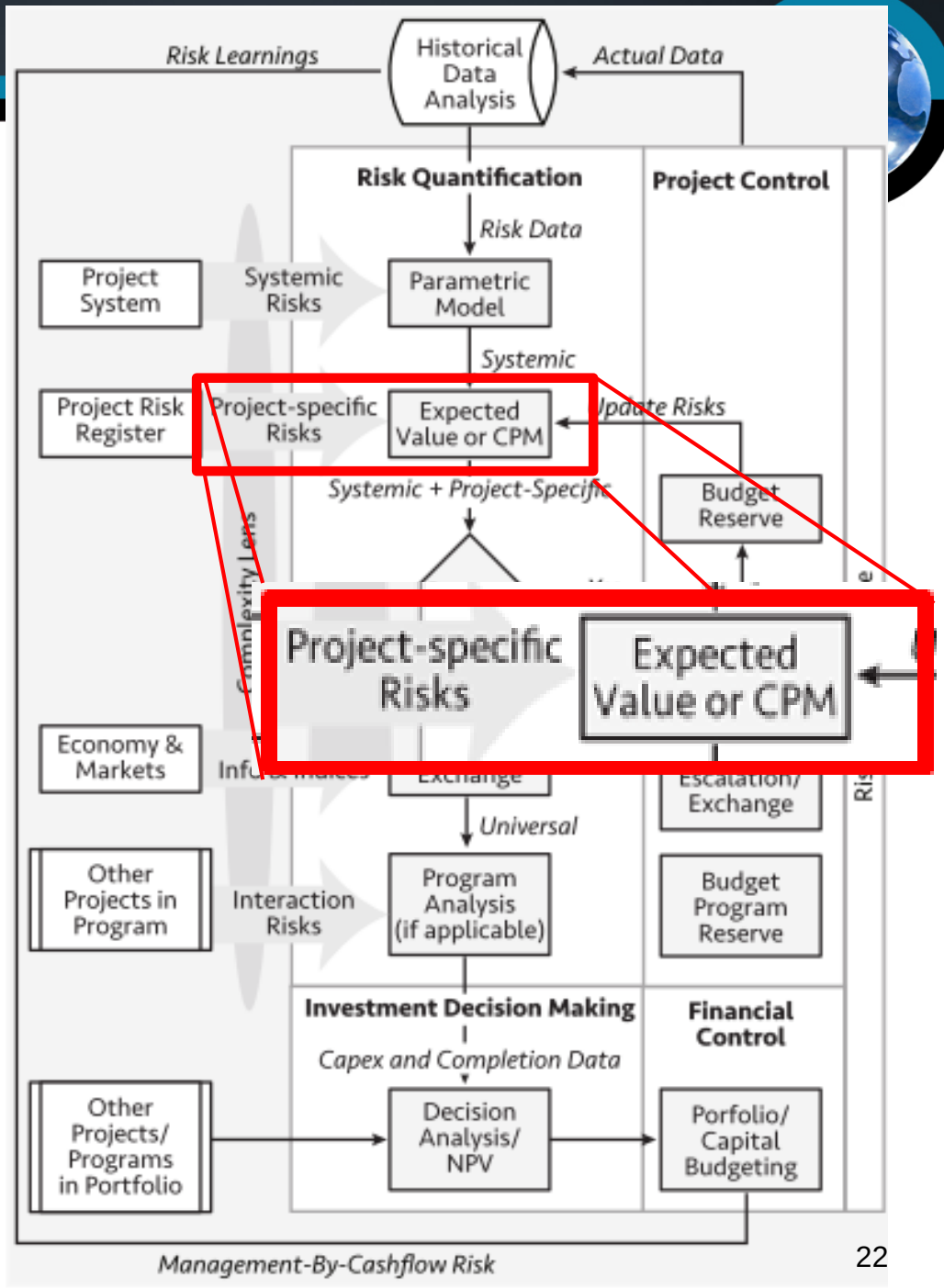
1) Rate the systemic risk parameters

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

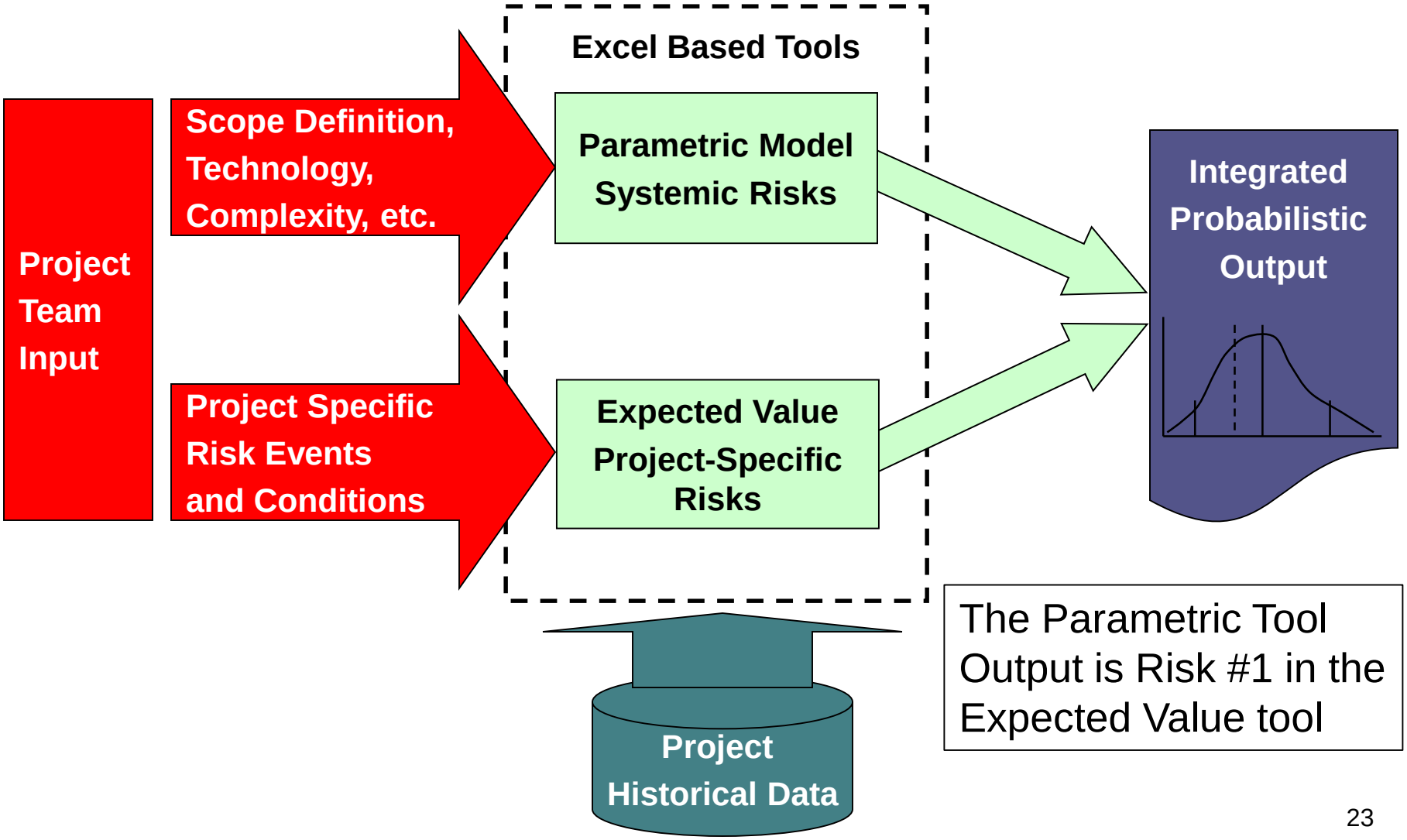
2) Probabilistic Output (no MCS)

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

- Quantify **project-specific** risks w/Expected Value with MCS
  - **and/or CPM for strategic projects**
- **Project-Specific** = <u>critical</u> risk events & uncertainty of specific conditions
- Reference:
  - **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

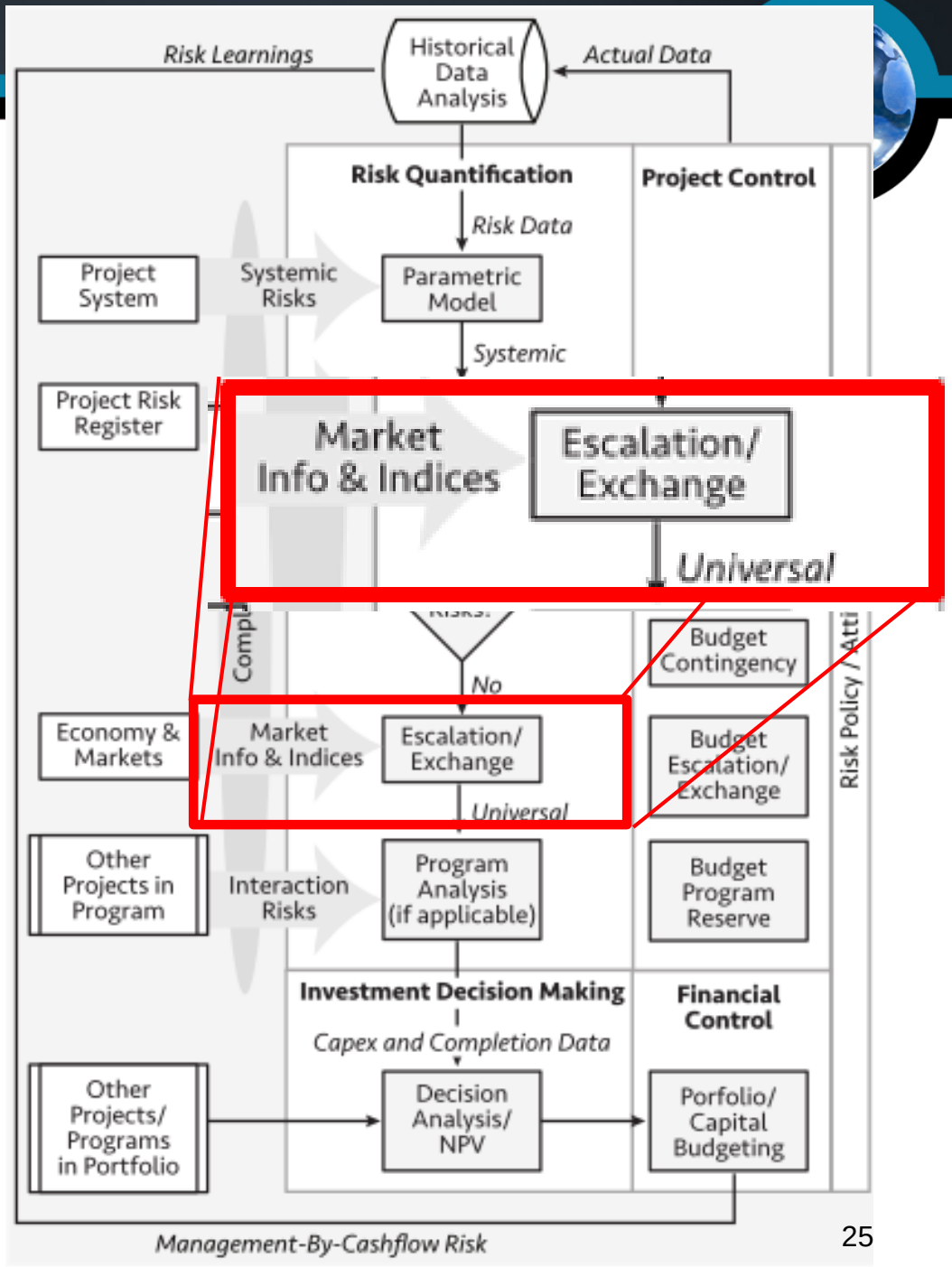
- CPM + Parametric Model:
- Start with AACE RP 57R-09
- For “uncertainties”, apply the parametric models for systemic risks instead of ranging

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	

Step 3

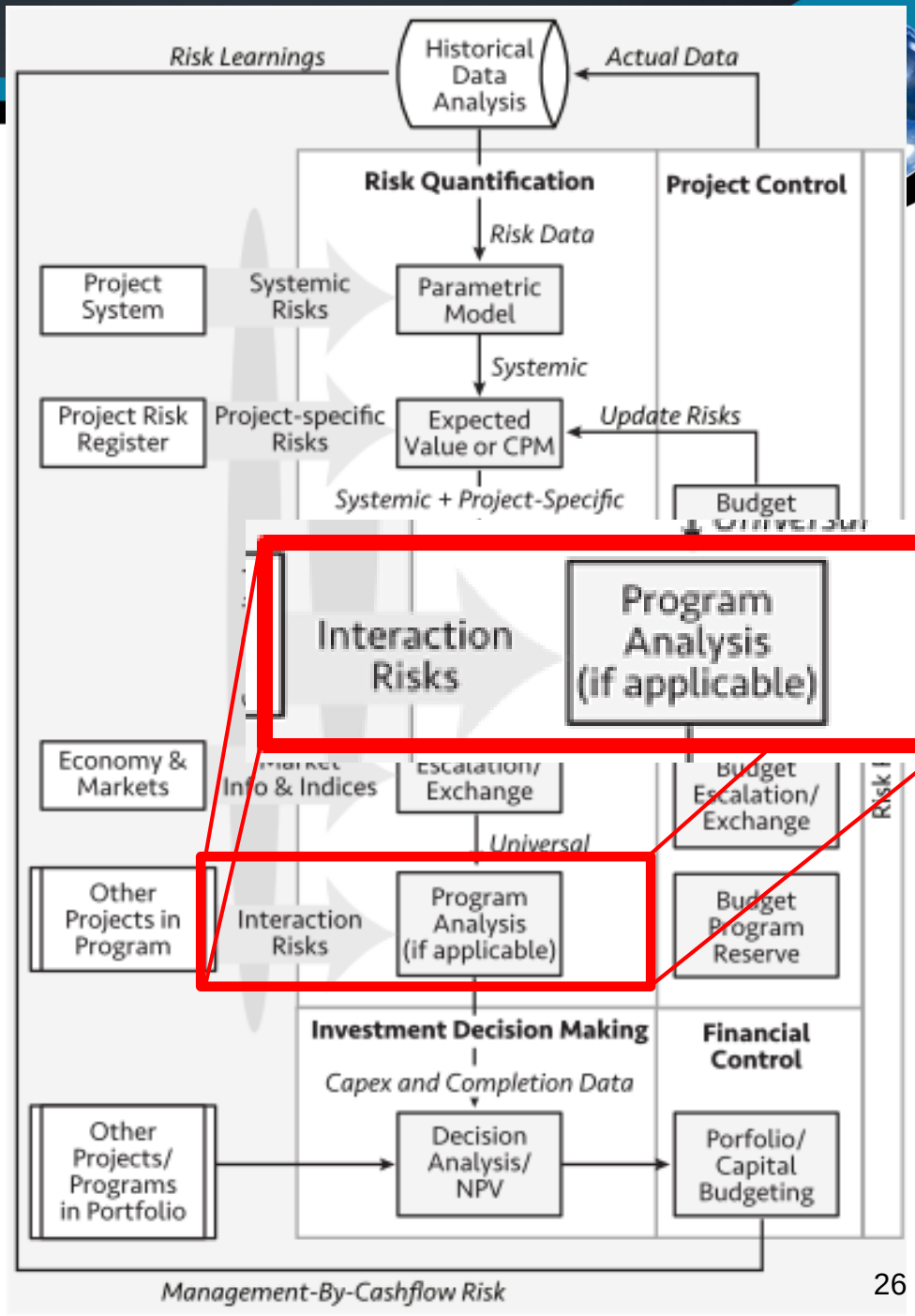
3-Escalation/Exchange Estimating with MCS

- Quantify *escalation and exchange* risks by applying MCS to the deterministic models
- Other risks are inputs to this step; therefore, it quantifies ALL capex risk
- Reference:
  - **AACE RP 68R-11**



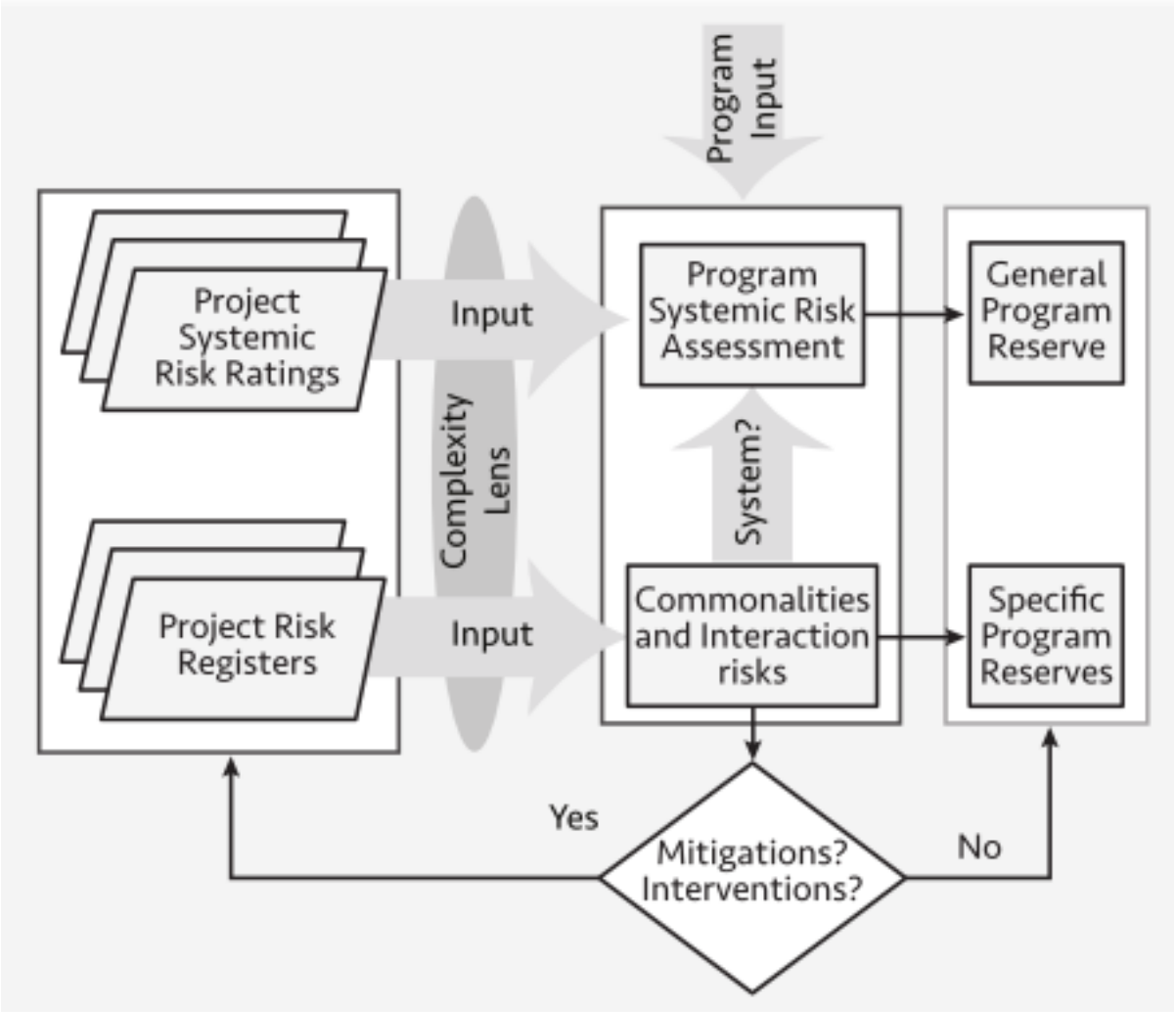
4-Program Level Analysis

- Quantify *additional program level* risks
- Program = group of related projects
  - **Focus: interaction risks**
- Make a program level "pass" using parametric and EV w/MCS methods
  - **No AACE RP at this time**



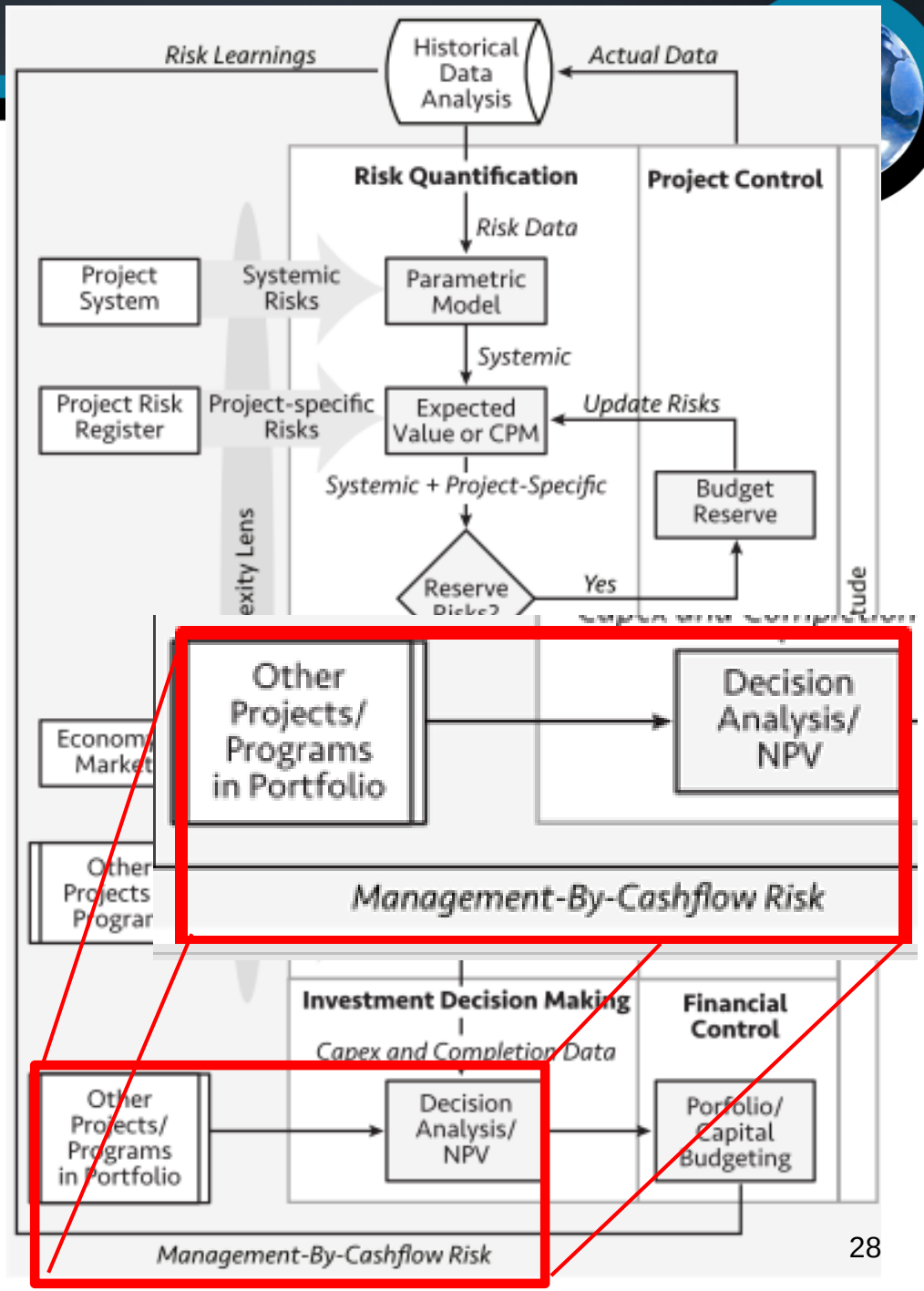
Program Level Analysis Flowchart

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



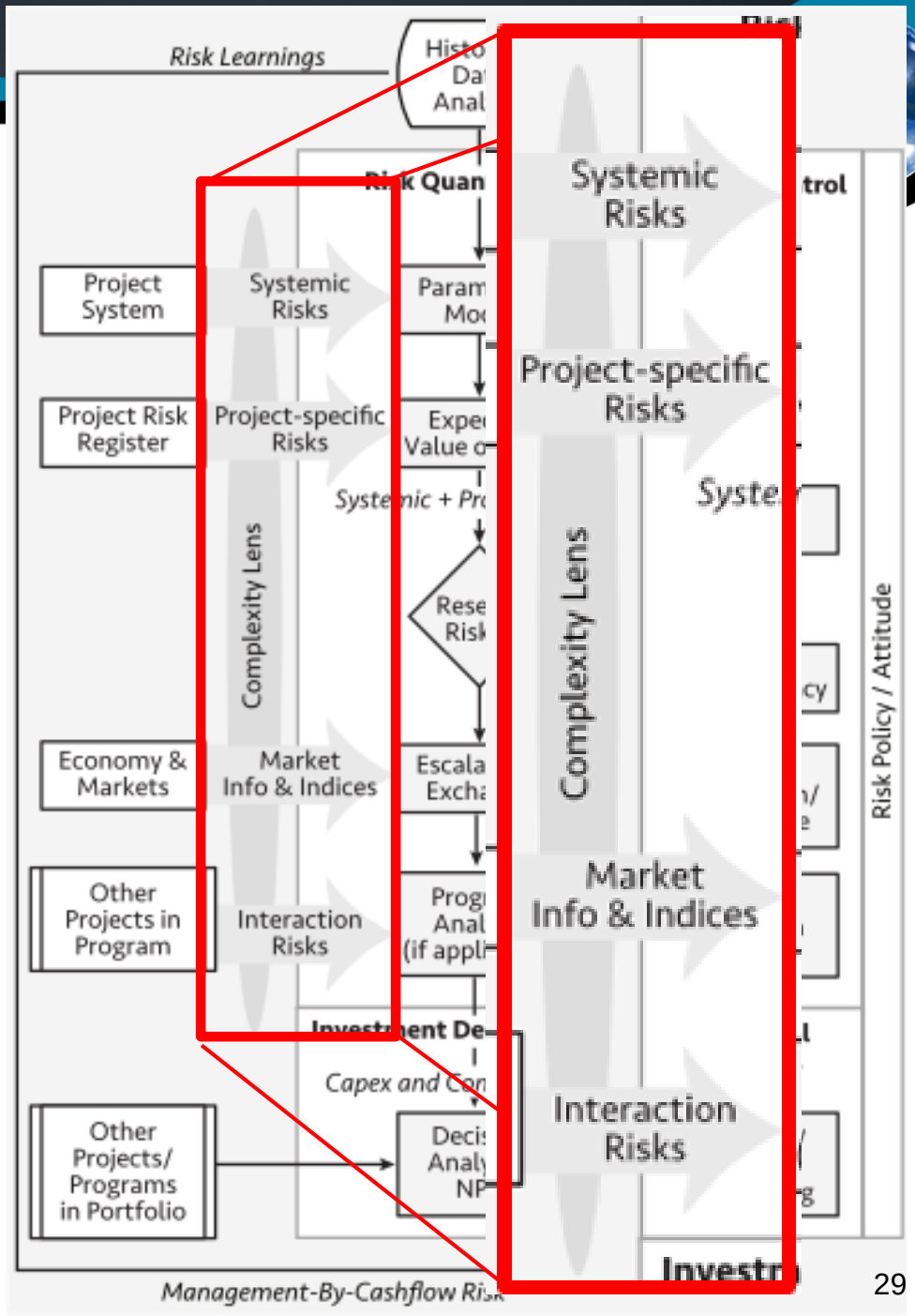
5-Portfolio Level Analysis

- Quantify additional *portfolio level* risks
- Portfolio = all projects
- Similar to program "pass"
  - **Focus: "*Management by Cashflow*"**
  - **Annual funding (e.g., government) forces manipulation of projects**



6-Complexity Lens/ Tipping Point Analysis

- Complexity + stressors + weak system = disorderly behavior (a blowout)
  - **Control does not work in a disordered regime**
- Complexity measure and impact quantified as a warning and possible management reserve
  - **No AACE RP at this time**



The Tipping Point Indicator

- Warns management that the project may be approaching a tipping point into a blowout
- Contingency values do not tell this disaster story…a wake-up call is needed!

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.

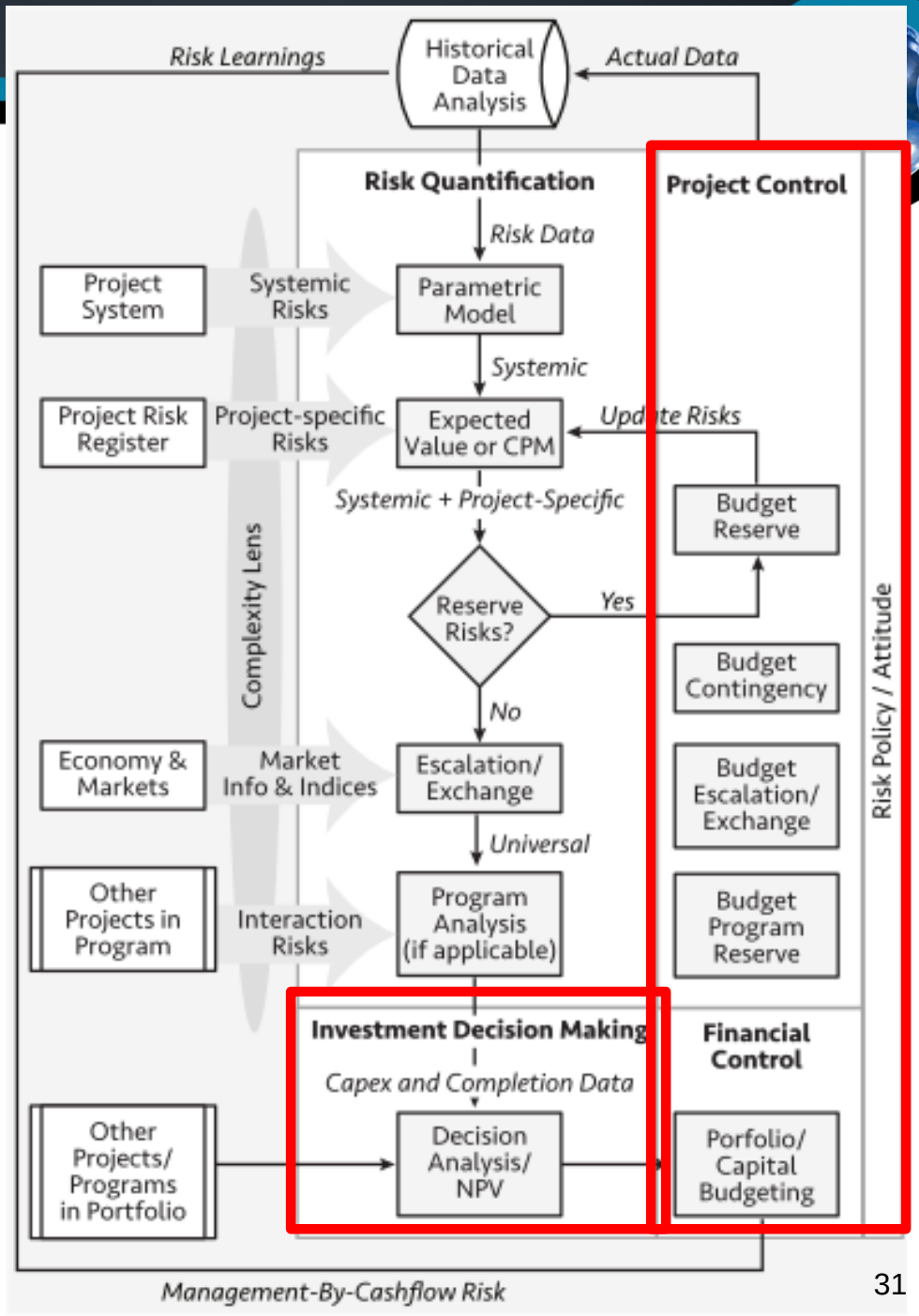
End Uses

1-Decision Analysis (NPV)

- CAPEX and start of revenue distributions

2-Planning and Budgeting

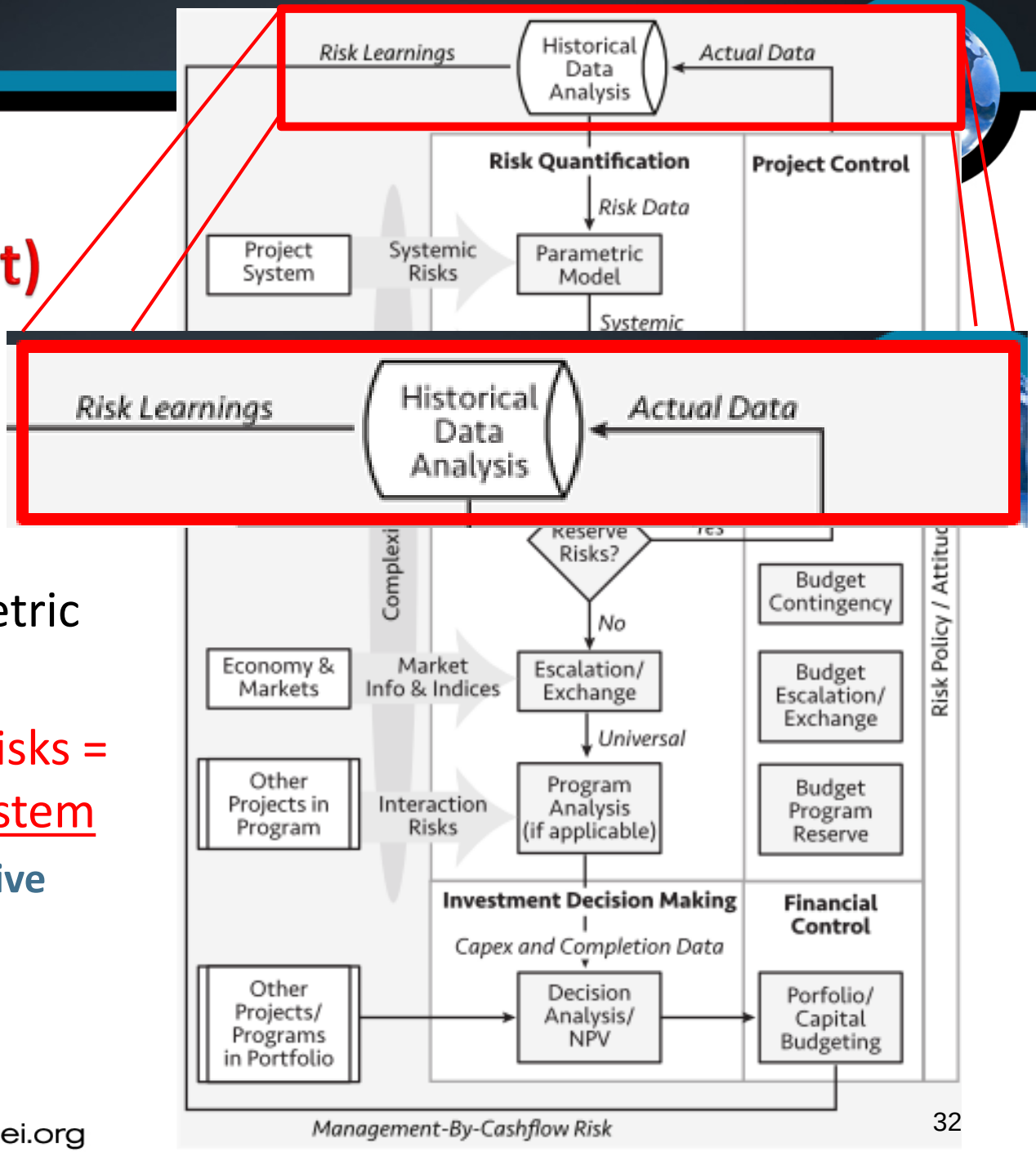
- Budget and control the approved money & time
- In an integrated way



Closing the Loop

Historical Data (last but not least)

- Required for parametric model validation
- Managed systemic risks = improved project system
  - **The ultimate objective**



Process is Generically Applicable

- Has been applied by Both Owners and Contractors
  - **A tip for contractors: assess the owner's risk exposure to gain insight for formulating bid pricing strategy**
- Has been benchmarked for projects in all industries with engineering and construction
  - **"Parameters" (e.g., complexity, technology, and so on) result in a "self correcting" model for scope differences**
  - **Tested on examples from transportation to nuclear**
  - **Use your own historical data to "calibrate"**

AI and Risk Quantification

- Big data feeding AI and machine learning will make the parametric method seem quaint in my lifetime
- However, empirically-based methods and parametrics are an entry point, and it is ready now
- Those who fail to at least understand regression (and other data analysis methods) and historical data management, will be left behind

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 complex 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.

Conclusion

- Covered the **history** of and research on our failure to realistically model risks
- Covered the **criteria** for "Methods that Work"
  - **Realistic, Practical and Integrated (cover all risks)**
- Covered the **methods** that best quantify each risk type and highlighted AACE® RPs where applicable
  - **Are your current methods working?**
- Please consider the AACE® DRMP certification

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