
Maintaining CoBRA Models

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Agenda

Time	Activity
09:30-09:45	Welcome
09:45-10:30	Presentation of industrial challenges and approaches to applying and maintaining CoBRA
10:30-10:45	<i>Coffee break</i>
10:45-11:15	Presentation of the CoBRA maintenance approach by CoBRA Study Group
11:15-12:30	Presentation of CoBRA maintenance approach by IESE (1)
12:30-13:30	<i>Lunch break</i>
13:30-14:45	Presentation of CoBRA maintenance approach by IESE (2)
14:45-15:00	<i>Coffee break</i>
15:00-17:30	Discussing industrial challenges and needs with respect to maintaining CoBRA models
17:30-17:45	Closing

IESE Approach for Maintaining CoBRA Models

► Maintenance Process

- Organizational vs. project level
- Maintenance Scenarios
 - Corrective, preventive, adaptive, and perfective maintenance
- Model Adjustment Process
 - Adapting model development process
- Elementary Model Adjustments
 - Modifying basic elements of a CoBRA model
- Summary



CoBRA Maintenance

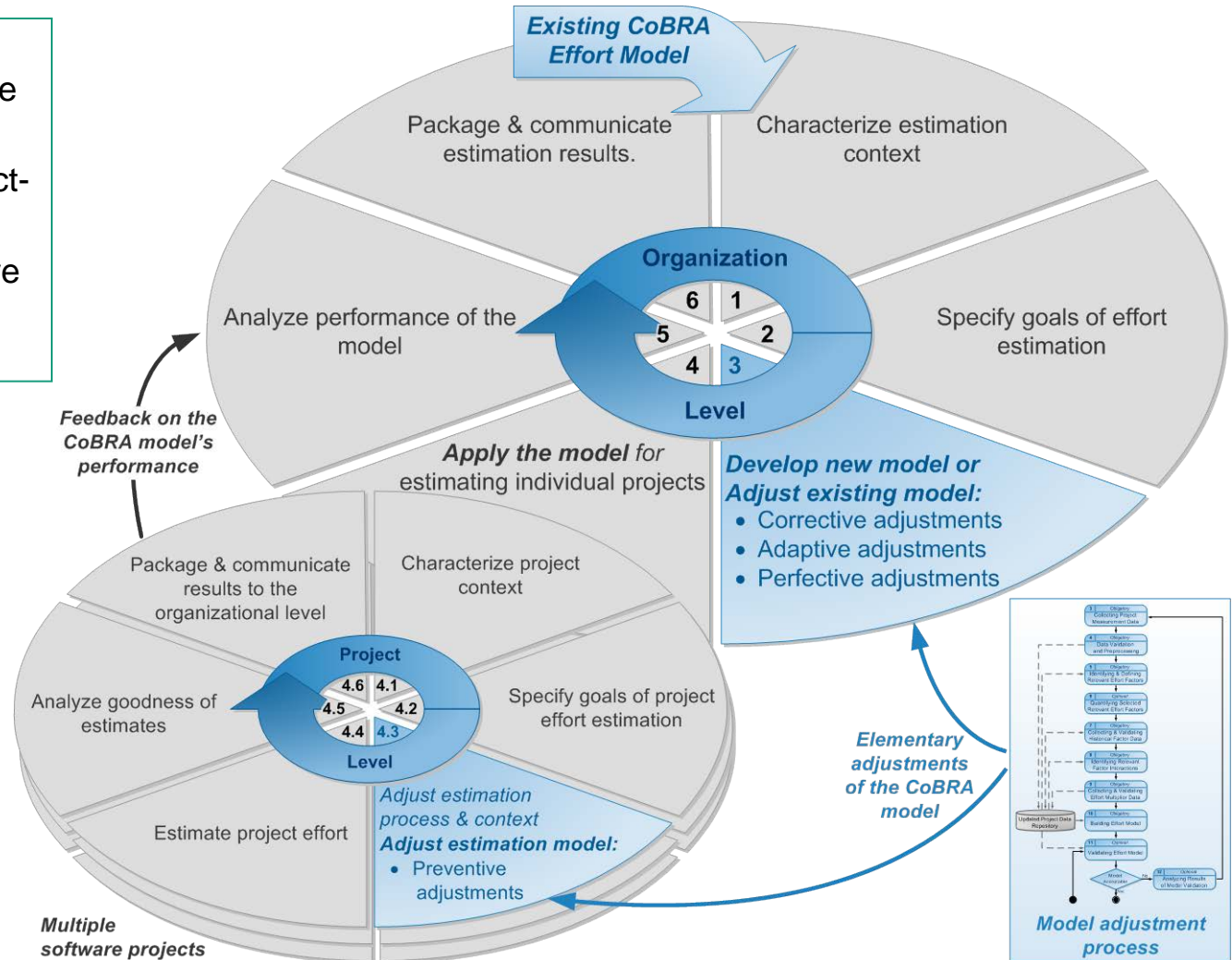
- In principle, CoBRA maintenance encompasses:
 - Maintaining the model development process
 - Maintaining the CoBRA effort model
 - Maintaining the model application process

- Typical use of the CoBRA method encompasses maintenance of the CoBRA model and its application process
 - Maintaining the CoBRA model development process requires great expertise in the method and its theoretical foundations → should take place very rarely

- ▶ We focus on maintaining the CoBRA model

Overview

- ▶ Maintain CoBRA models mainly on the organizational level
- Avoid multiple project-specific models
- Exception: preventive maintenance



1. Characterize Estimation Context_(1/2)

■ Context is a part of the overall estimation situation

- Estimation situation = estimation context + estimation objectives

■ Context determines applicability of the CoBRA method

- Organizational constraints and capabilities with respect to developing, maintaining, and applying the CoBRA effort estimation model
- Example: availability of measurement data and human experts determines feasibility of building and applying CoBRA models

■ Context determines the shape and applicability of CoBRA models

- Determines relevant effort drivers, their impact on effort and their interactions
- Example: CoBRA model built for embedded software domain will not be suitable for estimating management and information software

1. Characterize Estimation Context_(2/2)

- ▶ Consider trade-off between the scope of the model's applicability and its complexity
- One generic model
 - Wide applicability → Applicable to wide range of estimation situations (context and objectives)
 - Limited feasibility → Covering a large variety of effort dependencies observed in different contexts is either not feasible or requires a large and complex CoBRA model
- Multiple specific models
 - Limited applicability → Applicable to very specific estimation situations
 - High maintenance cost → Large number of models
 - Limited feasibility → Small/insufficient number of historical projects to build/adjust models on

2. Specify Goals of Effort Estimation

- Estimation goals refer to objectives of effort estimation we want to achieve using the CoBRA model
- Estimation objectives result (at least partially) from:
 - *Estimation purposes*: point estimation, risk analysis, process improvement
 - *Estimation constraints*: limited availability of measurement data, limited availability of domain experts
- Example estimation objectives:
 - *Predictive power*: estimation accuracy/error (e.g., $MRE < 10\%$)
 - *Informative power*: information about those factors that actually have the greatest impact on project effort
 - *Uncertainty assessment*: probability of exceeding a certain project effort
- ▶ Ensure that estimation goals are quantitatively verifiable and aligned to other organizational objectives (e.g., using the GQM+Strategies method[®])

3. Develop New or Adjust Existing CoBRA Model

- Using the information about estimation context and estimation objectives:
 - *Develop a new CoBRA model*
 - *from scratch* if no suitable model exists
 - *by reusing one or more existing models* (or model parts) that partially cover the given estimation situation
 - *Adjust an existing CoBRA model* if it covers the given estimation situation with minor exceptions

- Adjust an existing CoBRA model in order to
 - correct its faults that have already resulted in poor project estimates
 - adapt it to changes in the estimation situation (context and/or objectives)
 - optimize it with respect to estimation benefits and costs

4. Apply the Model for Estimating Individual Projects

- 4.1 Characterize project context
- 4.2 Specify goals of project effort estimation
- 4.3 Adjust estimation model, context, and process
 - *Adjust estimation process* in order to achieve project-specific estimation objectives
 - *Adjust project estimation context* if it deviates from the range of contexts covered by the CoBRA model used
 - *Adjust the CoBRA model* in order to prevent poor performance if the project-specific estimation situation differs from the range of situations covered by the CoBRA model and the previous two adjustments are either not feasible or insufficient
- 4.4 Estimate project effort
- 4.5 Analyze estimation performance
- 4.6 Package and communicate the results to the organizational level

5. Analyze the Performance of the Model

Analyze the CoBRA model using the information gathered on:

■ Project level

- Project-specific estimation situation (estimation context and goals)
- Performance of the model (achievement of project-specific estimation goals)
- Identified deficits of the model and corresponding improvement suggestions

■ Organizational level

- Range of estimation situations the model has been developed for

■ Investigate the model with regard to:

- What needs corrections?
- What needs adaptations?
- What can be optimized?

6. Package and Communicate the Estimation Results

- ▶ Synthesize the information gained throughout the organizational maintenance cycle and communicate it to all interested parties

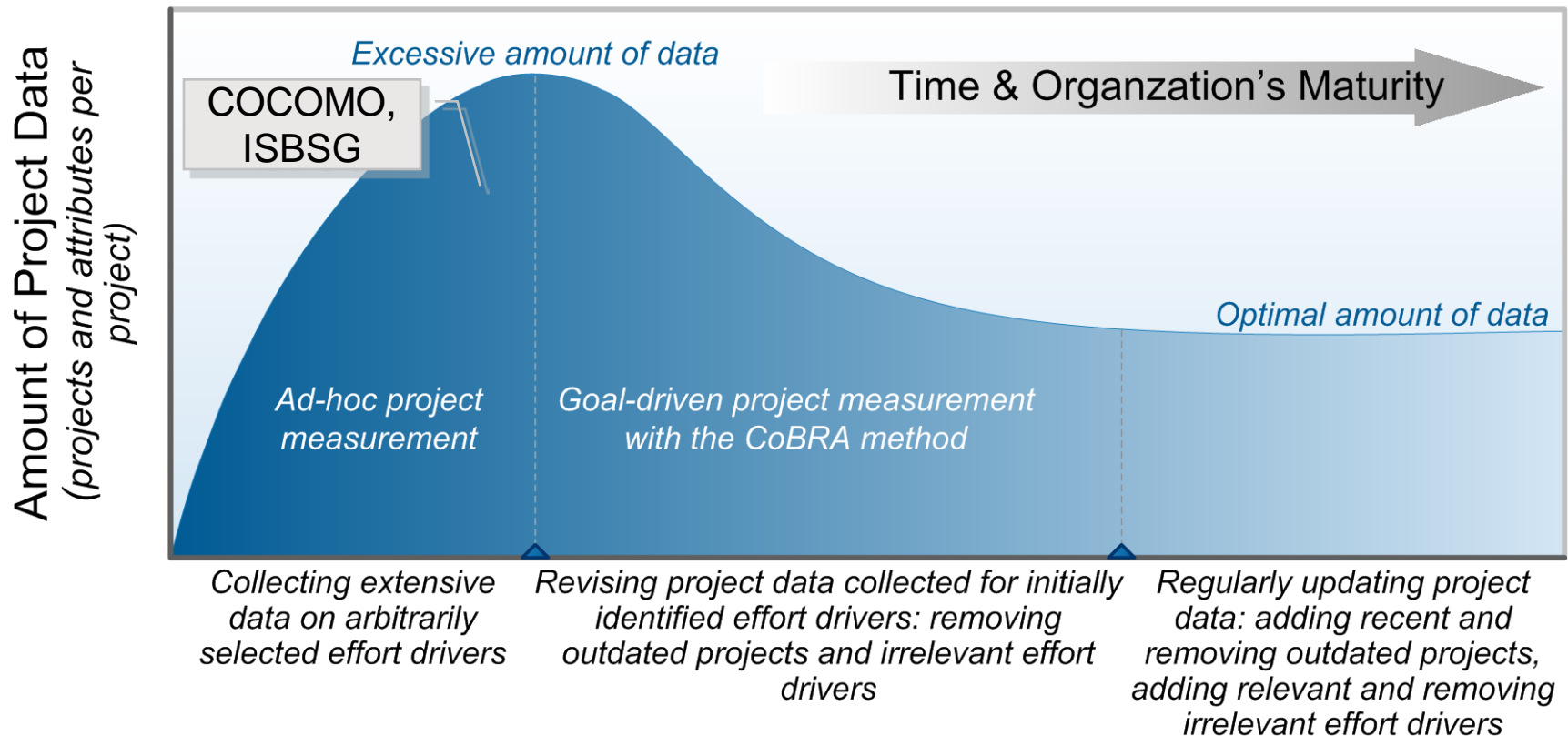
■ Quantitative data

- measurement data collected from the project with respect to relevant effort factors covered by the CoBRA model
- project-specific context characteristics
- quantitative estimation objectives defined in the project
- results of project estimation

■ Qualitative information

- model improvement suggestions
- experiences with respect to using and maintaining CoBRA models, e.g., patterns: “model deficiency → effective model improvements”

Updating Organizational Knowledge



- ▶ Proper maintenance of organizational knowledge is a key to successful estimation
- ▶ Inconsistent and invalid information is a common source of poor effort models and failed project estimates

IESE Approach for Maintaining CoBRA Models

- Maintenance Process

- Organizational vs. project level

- ▶ **Maintenance Scenarios**

- Corrective, preventive, adaptive, and perfective maintenance

- Model Adjustment Process

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Maintaining CoBRA Models – Scenarios

- Corrections - modifications of the model's deficits (faults) that may lead or have already led to poor estimates (failures).
 - *Corrective modifications* – Eliminate the model's deficits that have already been manifested in poor estimates of individual software projects (although their matched estimation situation was covered by the model).
 - *Preventive modifications* - Eliminate the model's deficits within the scope of a specific project to avoid poor estimates it may potentially deliver if not adjusted.

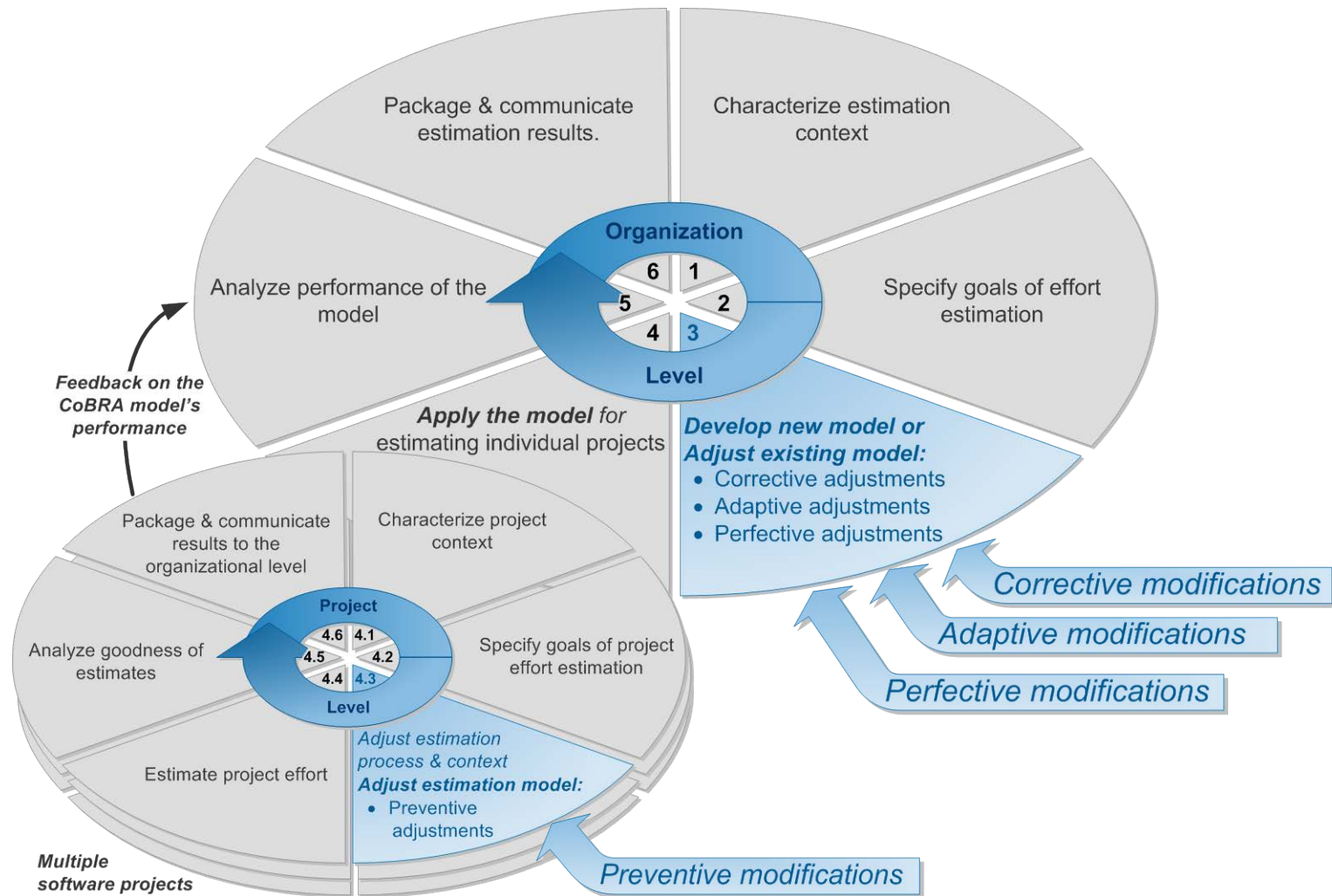
- Enhancements - modifications that aim at improving the model's capabilities.
 - *Adaptive modifications* - Tailor model to changed estimation situation (estimation context and objectives).
 - *Perfective modifications* – Revise model on regular basis to optimize its performance (increase estimation benefits and reduce estimation costs).

Maintaining CoBRA Models – Scenarios

Scenario	Trigger	Purpose
Corrective	Actually observed poor performance of a CoBRA model	Correct model to avoid failed estimation objectives before using it in next projects.
Preventive	Expected poor performance of a CoBRA model	Correct model to avoid failed estimation objectives before using it in a specific project.
Adaptive	Change in the estimation situation or reuse of CoBRA model for new situation	Tailor model to changed estimation situation to avoid failed estimation objectives.
Perfective	None. Maintenance performed on regular basis.	Optimize model's performance (cost-benefit)

- ▶ In general, maintenance modifications may refer to:
 - ▶ CoBRA model
 - ▶ Estimation context (input data, organizational constraints and capabilities)
 - ▶ Estimation objectives
 - ▶ Estimation process (process of applying CoBRA model for estimation purposes)

Maintaining CoBRA Models – When?



Maintaining CoBRA Models – How Often?

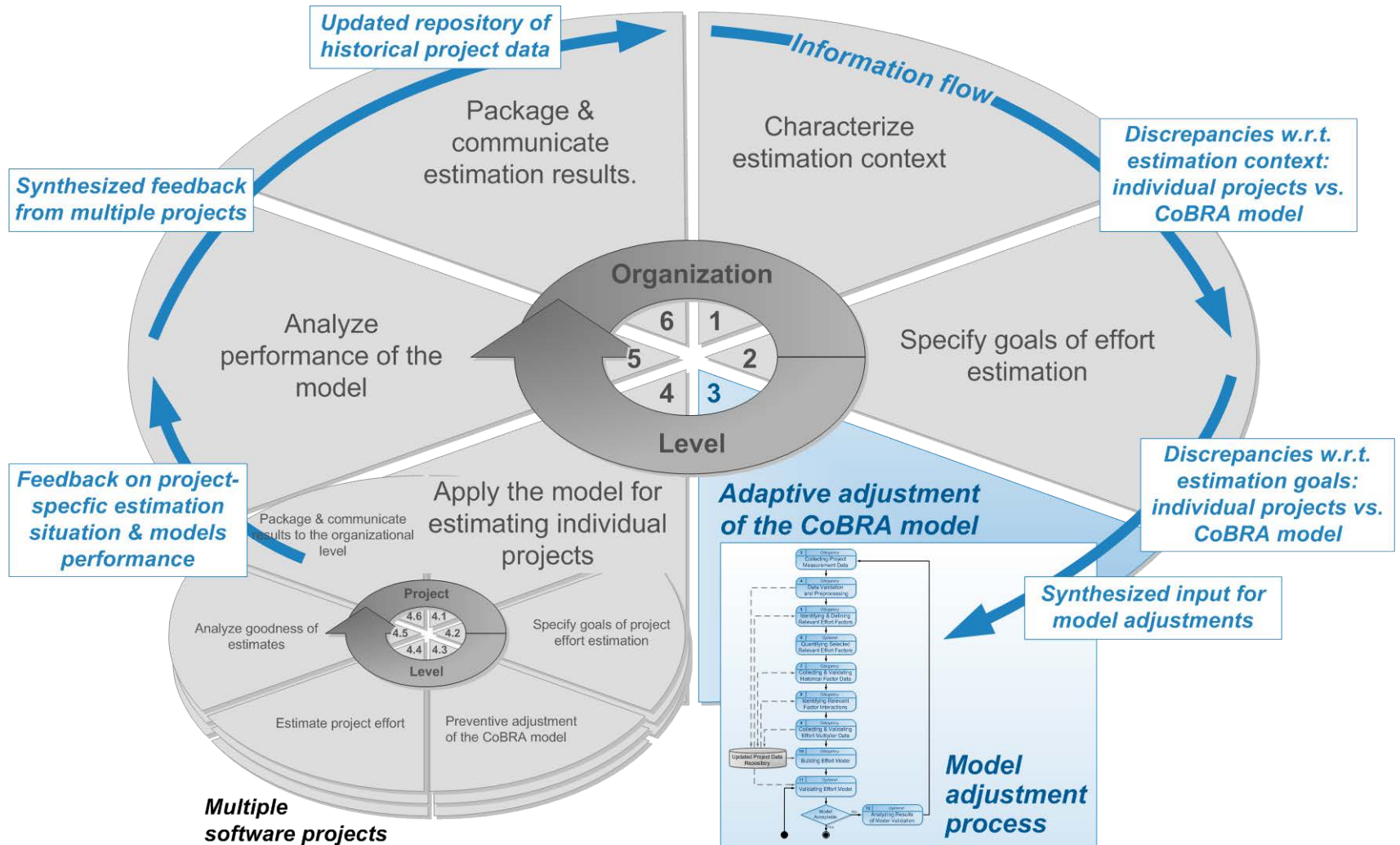
■ Regular basis

- *Perfective maintenance* – Revise CoBRA model after updating historical project database (e.g., every 5 new projects) in order to:
 - Optimize (perfect) the model: increase performance & reduce costs
 - Catch changes in estimation situation that have not been explicitly noticed

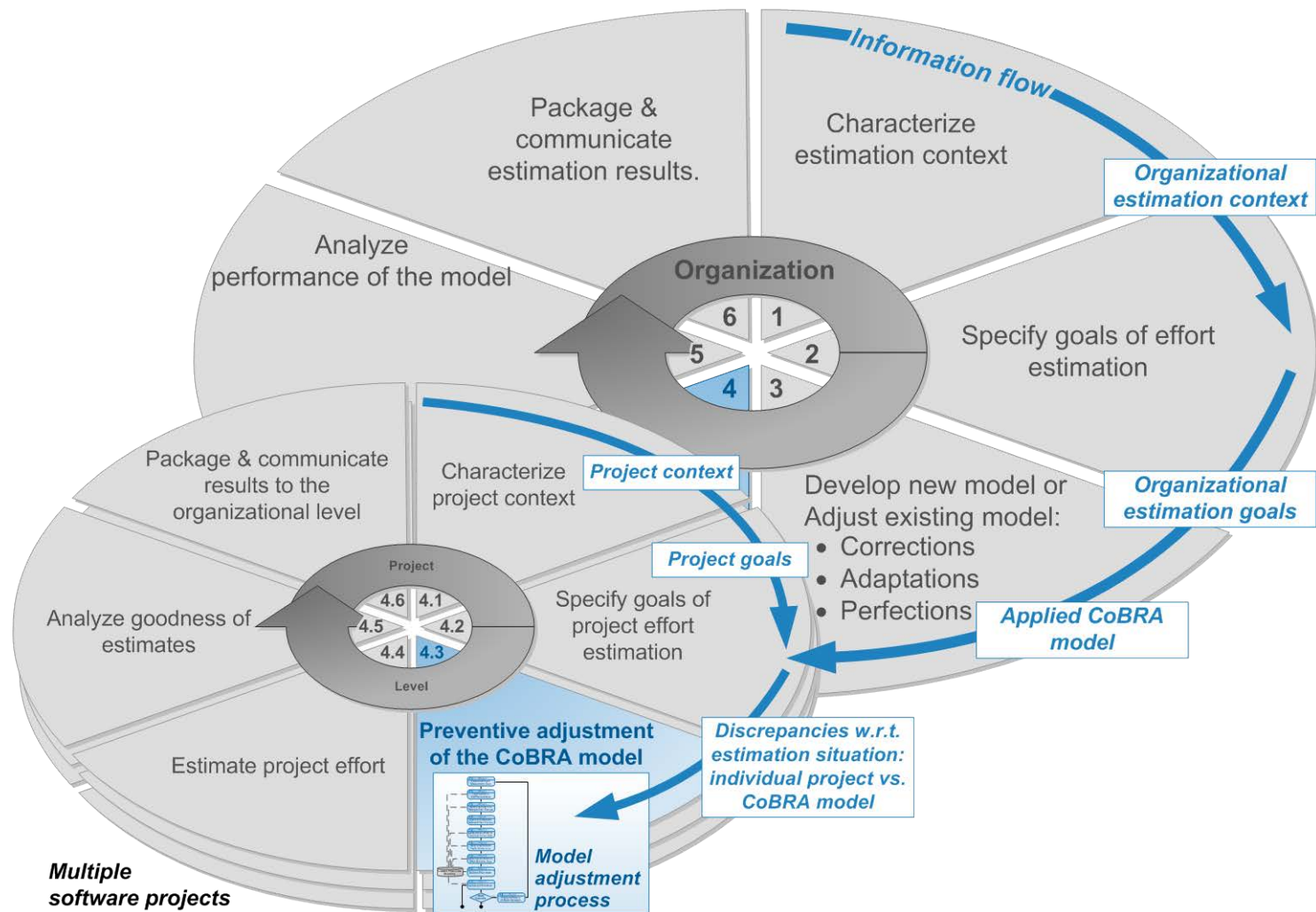
■ Need-to-do basis

- *Corrective maintenance* – Revise CoBRA model in response to its actual poor performance (failed estimates) in an individual project
- *Preventive maintenance* – “Quick fix” CoBRA model in response to its likely poor performance in an individual project
- *Adaptive maintenance* – Revise CoBRA model in response to explicit change in organizational estimation situation (context and/or goals)

Maintenance Inputs – Organizational Level



Maintenance Inputs – Project Level



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- ▶ **Model Adjustment Process**

- Adapting model development process

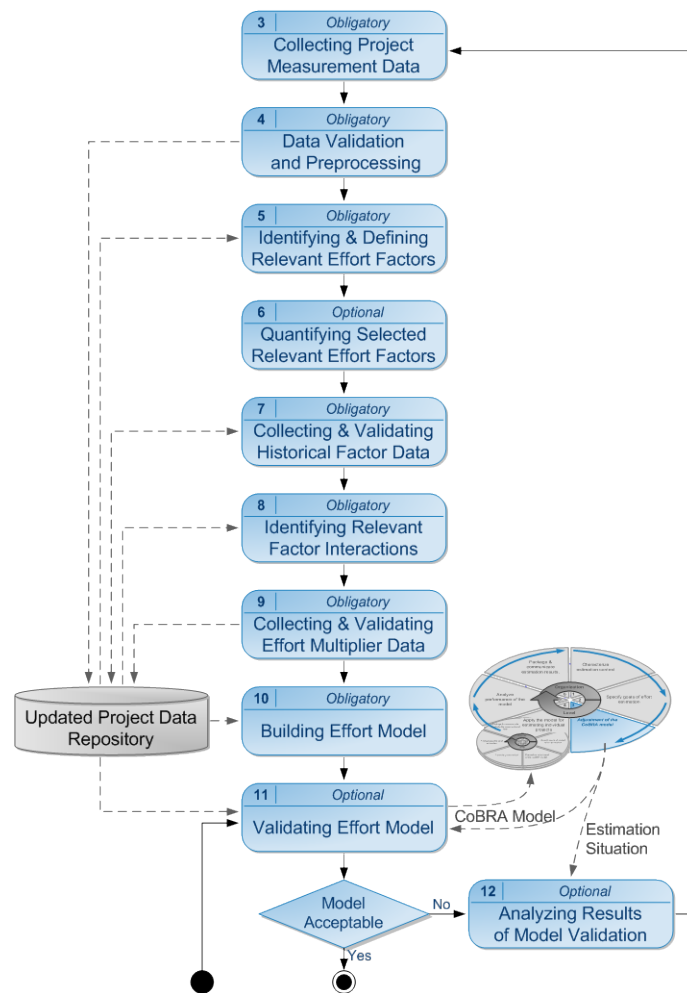
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Process for Model Adjustments – Overview



- Model is revised after being used for estimating individual projects
- Model adjustment process corresponds to subsequent iterations of model development
- Inputs to the model adjustment process
 - Range of estimation situations covered by the CoBRA model
 - Feedback from one or more individual projects
 - Performance of the CoBRA model
 - Project-specific estimation situation (context and objectives)
 - Updated historical project database (data from finished projects)

Process for Model Adjustments₍₁₎

Nominal Productivity



- Median
- ▒ 25% - 75%
- ┤ Non-Outlier
- Outliers
- ✱ Extremes

Step 1 (11) – Validating Effort Model

- Analyze performance of the effort model when applied to historical projects
- Analyze nominal productivity, in particular
 - (Perfective maintenance) most recently completed projects, that is, projects that have been added to the data repository after a recent adjustment of the CoBRA model;
 - (Corrective maintenance) projects for which estimation failed;
 - (Adaptive maintenance); projects that represent a changed estimation situation.
- ▶ Preventive maintenance: analyze potential discrepancies between project and modeled estimation situation
- If valid, then accept and relapse the model

Process for Model Adjustments₍₂₎

Nominal Productivity



- Median
- ▤ 25% - 75%
- ┤ Non-Outlier
- Outliers
- ✱ Extremes

Step 2 (12) – Analyzing the Results of Model Validation

- Identify causes of observed model invalidity
 - Discrepancies in estimation situation (context and objectives)
 - Missing relevant effort factors
 - Discrepancies in definition and/or scaling of effort factors
 - Discrepancies in impact of effort factors
- Use the results of the analysis as a basis for modifying the CoBRA model (steps 3 to 10)

Process for Model Adjustments₍₃₋₄₎

Step 3 – Collecting Project Measurement Data

- Extracting from the project data repository information needed for adjusting the CoBRA model
 - E.g., project context characteristics, effort factors

Step 4 - Data Validation and Preprocessing

- Validate and preprocess data, if necessary
- Notice that data validation should actually be an integral part of maintaining the project data repository

Process for Model Adjustments₍₅₎

Step 5 – Identifying and Defining Relevant Effort Factors

- Review effort factors based on
 - the results of model analysis (step 12)
 - an analysis of historical data (analytical approach)
 - the judgment of domain experts involved in the historical projects (judgmental approach)
 - improvement suggestions from the project-level maintenance cycle
- Adjust effort factors
 - Add relevant effort factors if they are missing in the current model
 - Remove from the model effort factors that are not relevant anymore
 - Modify definitions of effort factors if their interpretation has changed
 - Add/remove/modify component variables for complex effort factors

Process for Model Adjustments₍₆₋₈₎

Step 6 – Quantifying Selected Relevant Effort Factors

- Define scales for newly added effort factors
- Revise scales for other effort factors, if necessary

Step 7 – Collecting and Validating Historical Factor Data

- For all historical projects upon which the CoBRA model is adjusted:
 - Collect project factor data for newly added and modified effort factors
 - Remove project data for effort factors removed from the model

Step 8 – Identifying Relevant Factor Interactions

- Revise interactions between effort factors
 - Remove indirect impacts that are not valid anymore
 - Add new relevant interactions

Process for Model Adjustments₍₉₋₁₀₎

Step 9 – Collecting and Validating Effort Multiplier Data

- Revise effort multiplier data (Min/ML/Max) associated with direct effort factors:
 - Define effort multipliers for newly added effort factors
 - Remove multiplier data for removed effort factors
 - Revise multiplier data for modified direct effort factors
 - Effort factors whose definition or scales has been modified
 - Effort factors for which the associated indirect factor has changed (added/removed/modified)

Step 10 - Building Effort Model

- Synthesize all inputs into the CoBRA effort model
 - Effort overhead model
 - Multiplier and project data
 - Average nominal productivity

Process for Model Adjustments₍₁₁₋₁₂₎

Step 11 – Validating CoBRA Model

- Validate the CoBRA model on historical projects and check if it meets the estimation objectives
 - If yes, then release the model for use in the individual projects (go to phase 4 of the organizational maintenance cycle)
 - If not, then perform next model adjustment iteration
 - analyze potential sources of observed estimation deficits (step 12)
 - refine the model (steps 3-10)

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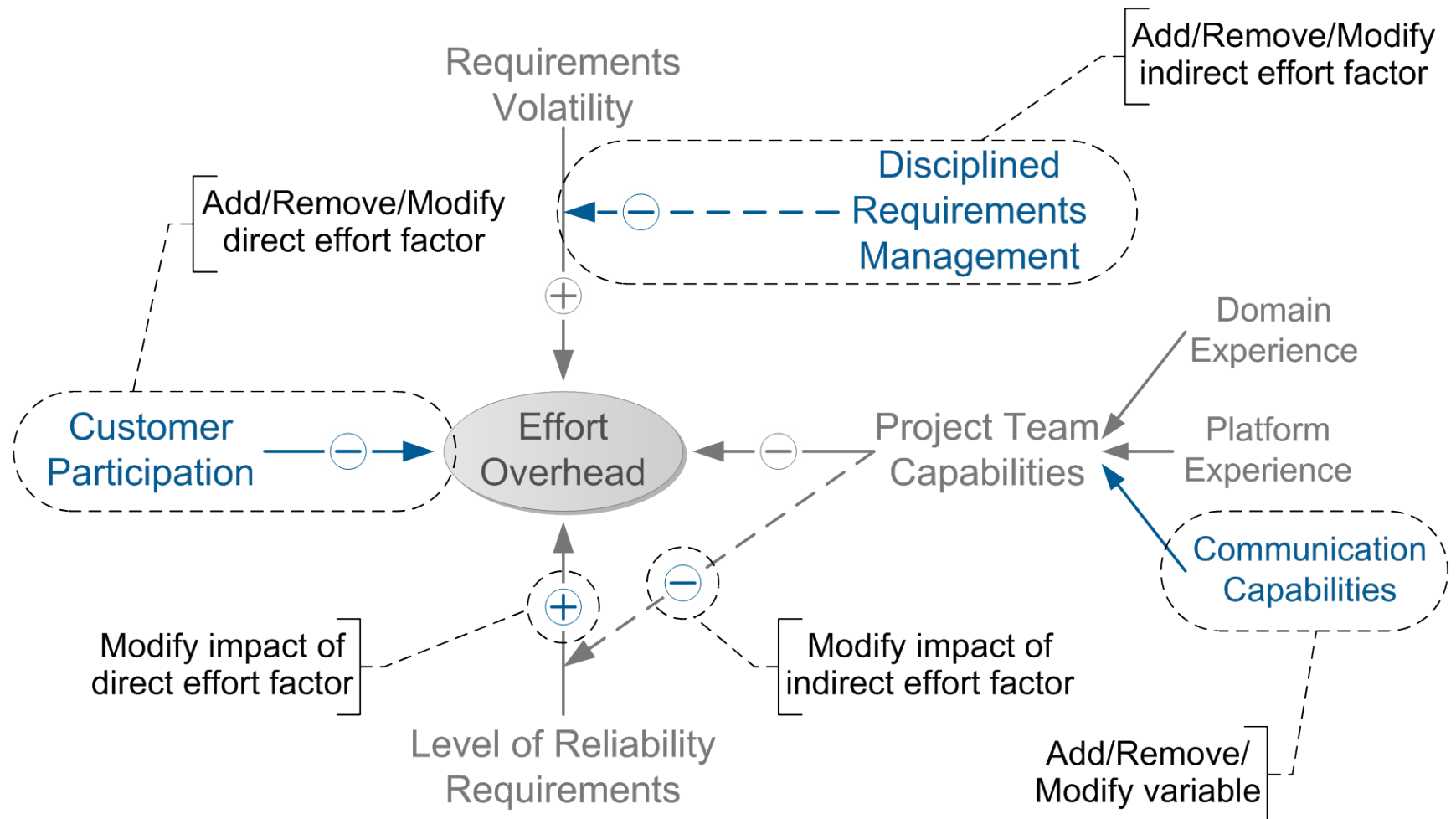
- ▶ **Elementary Model Adjustments**

- Modifying basic elements of a CoBRA model

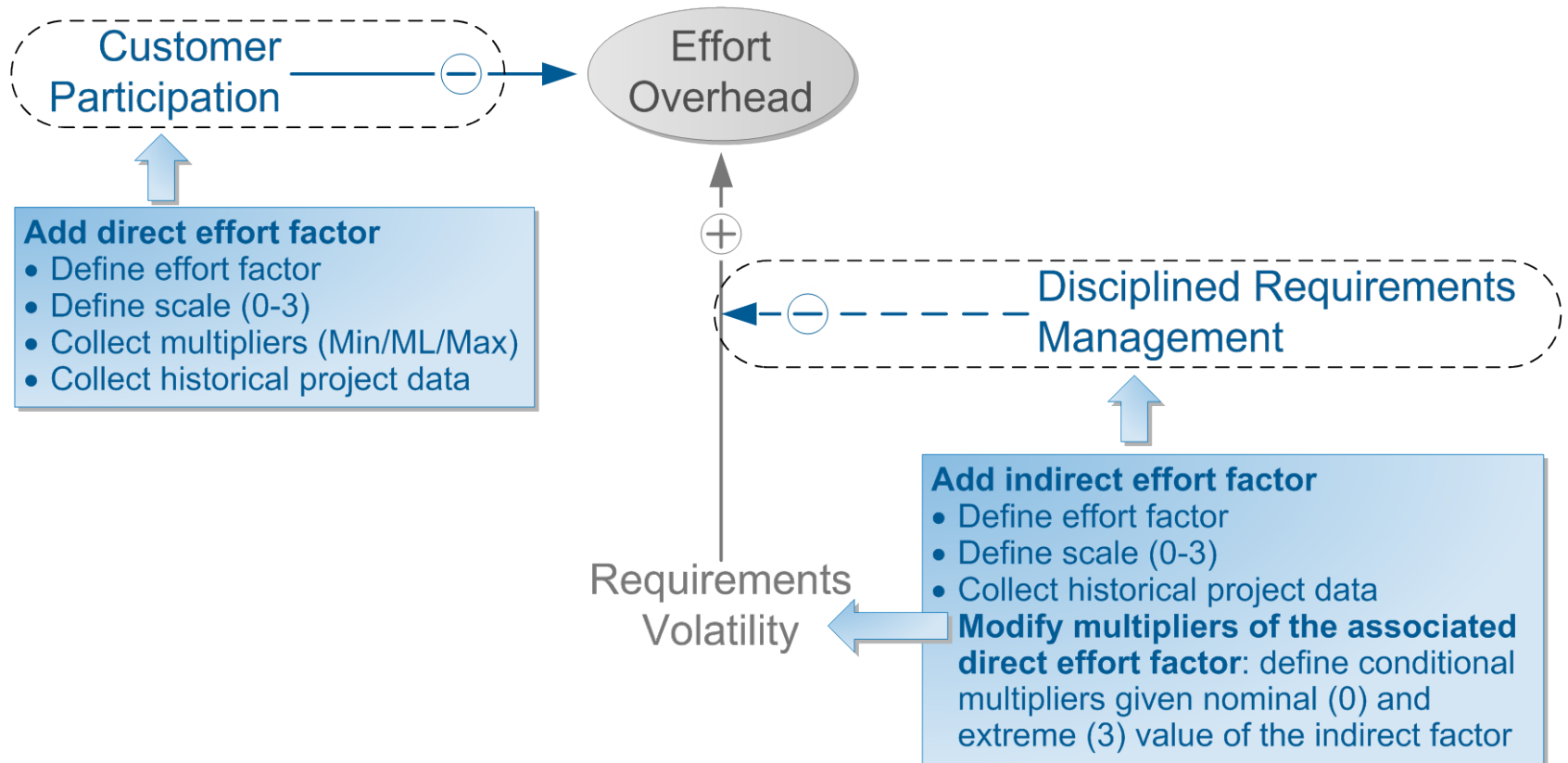
- Summary



Elementary Adjustment of a CoBRA Model – Overview



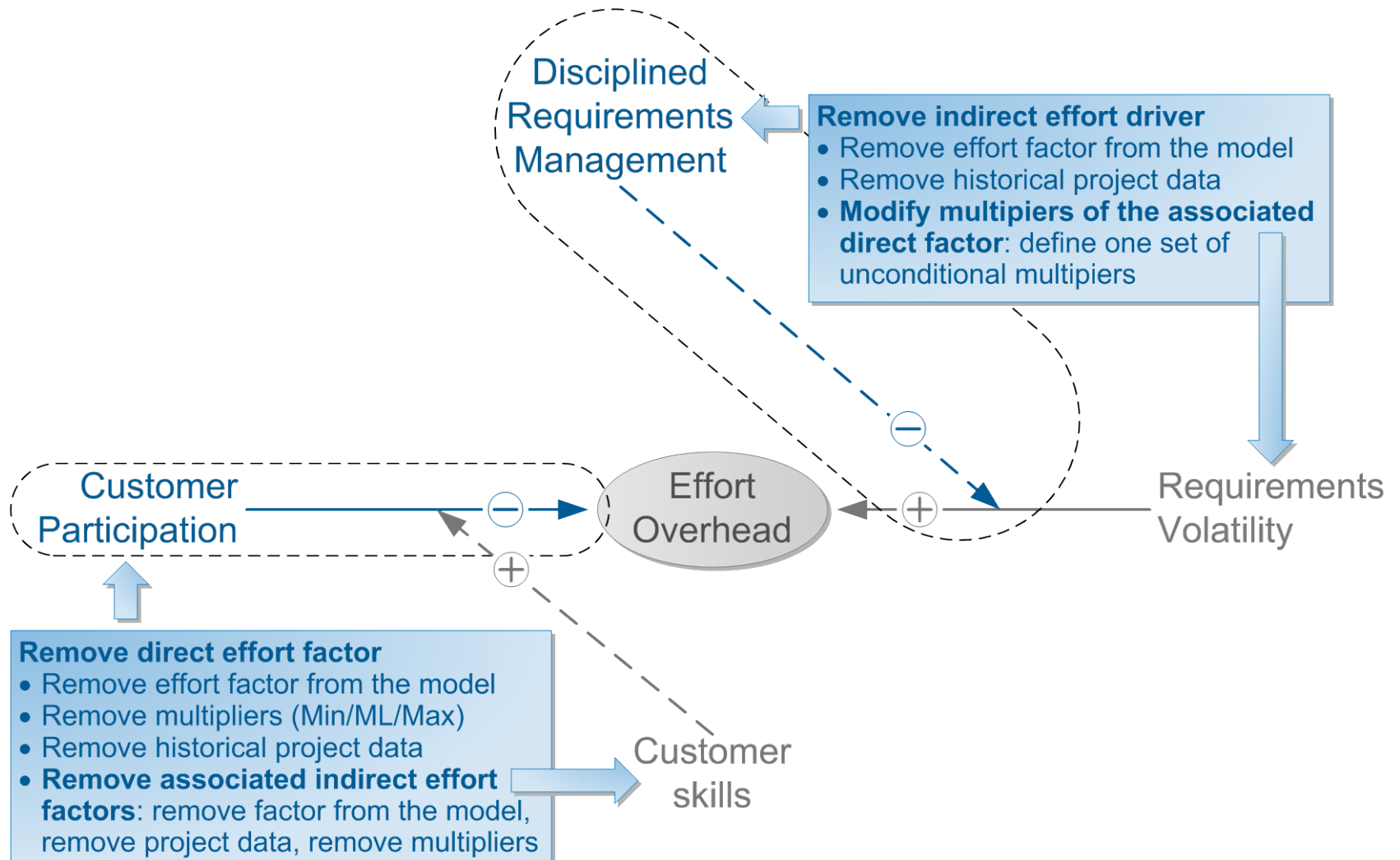
Add Effort Factor – Overview



Add Effort Factor – Activities

- Define new effort factor
- Define scale of a new effort factor:
 - 4-grade Likert: best (0) to worst (3)
- Add the effort factor to the effort overhead model
- Define effort multipliers
 - **Direct effort factor**: define effort multipliers (Min/ML/Max)
 - **Indirect effort factor**: define conditional multipliers for the associated direct effort factor given the nominal (0) and extreme (3) values of the added indirect factor
- Collect historical project data for the effort factor
 - Values of the effort factor for historical projects
- Compute nominal productivity
- Validate model & perform improvement cycle

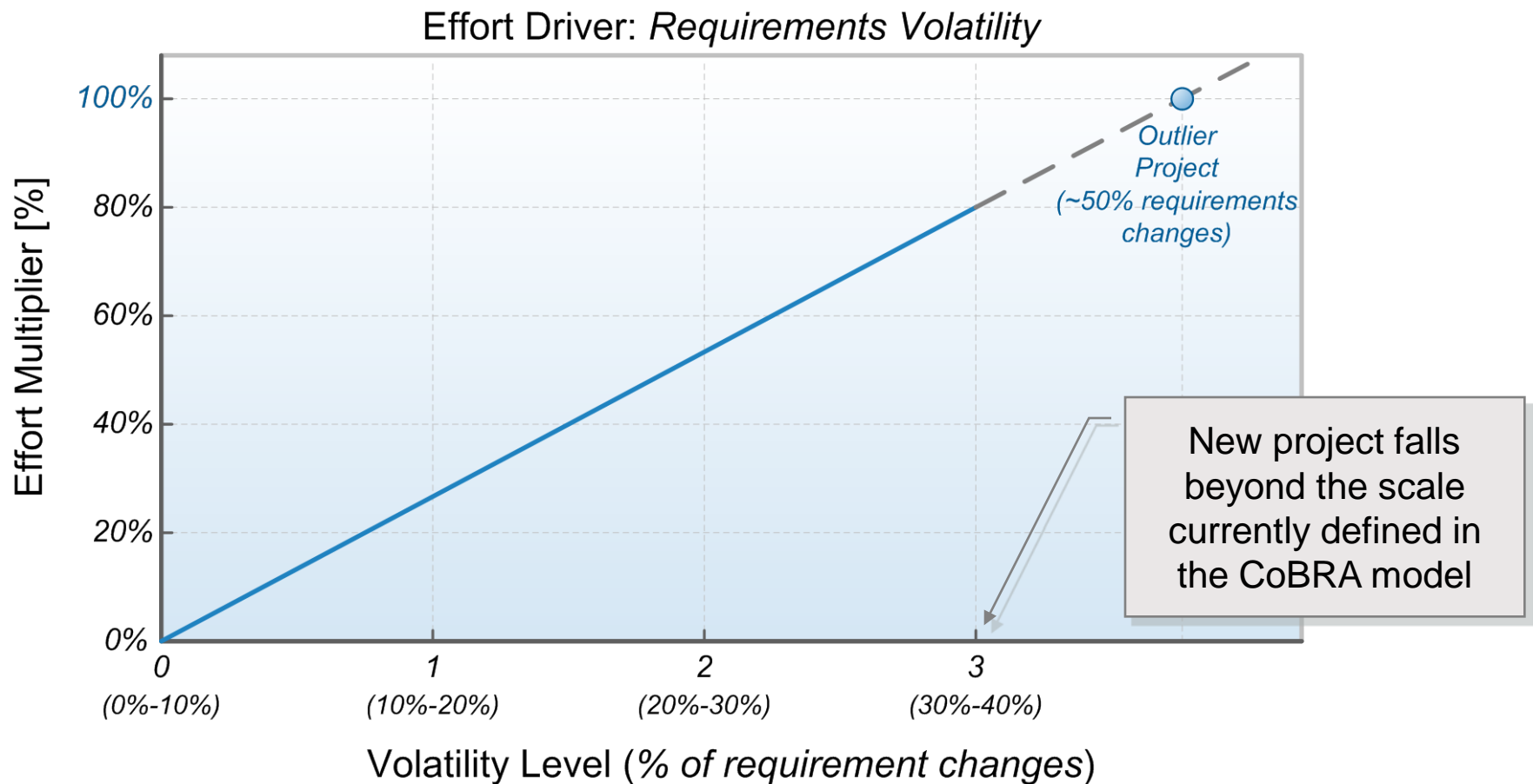
Remove Effort Factor – Overview



Remove Effort Factor – Activities

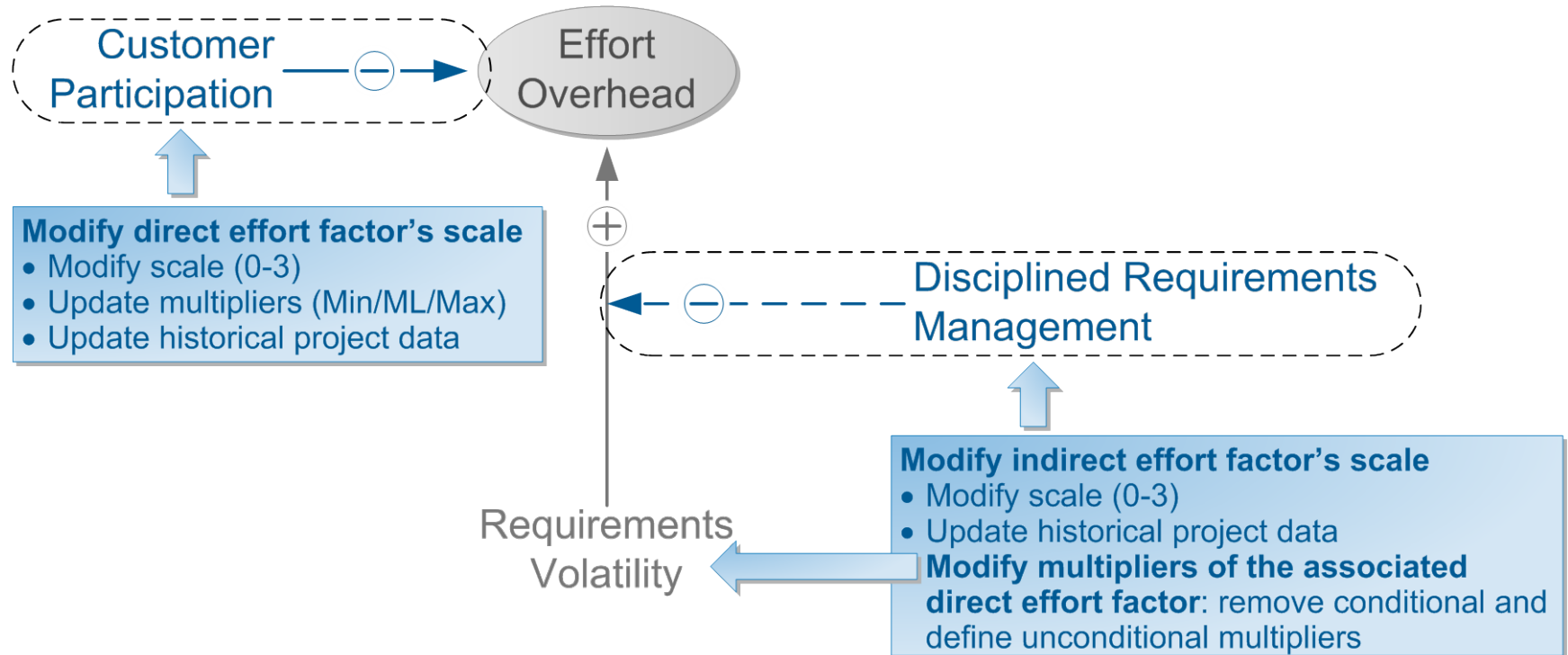
- Remove effort factor from the effort overhead model
- Direct effort factor:
 - Remove associated multipliers (effort overhead data)
 - If there was an indirect effort factor associated with the removed direct factor:
 - Remove indirect factor from the effort overhead model
 - Remove indirect factor's historical project data
- Indirect effort factor
 - Revise multipliers of the associated direct effort factor: remove conditional and define unconditional multipliers
- Remove historical project data associated with the removed factor
- Compute nominal productivity
- Validate model & perform improvement cycle

Modifying Effort Factor's Scale – Example Situation



- ▶ Example corrective maintenance involves modifying scales of an effort factor

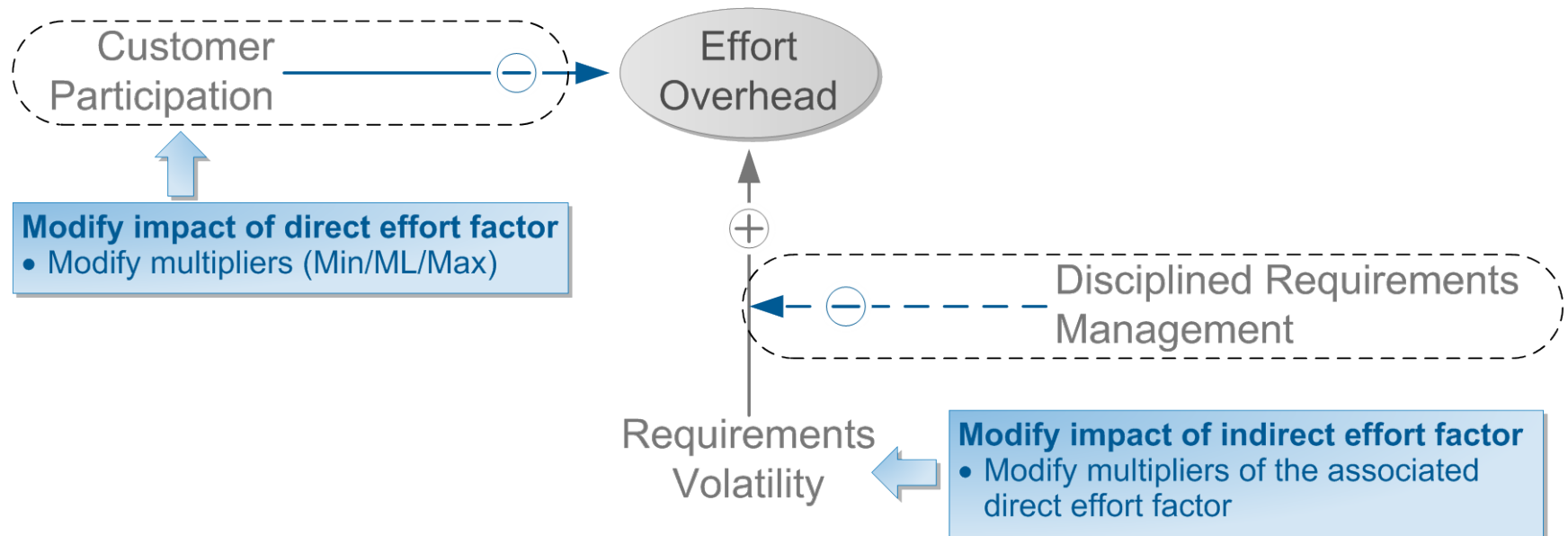
Modifying Effort Factor's Scale – Overview



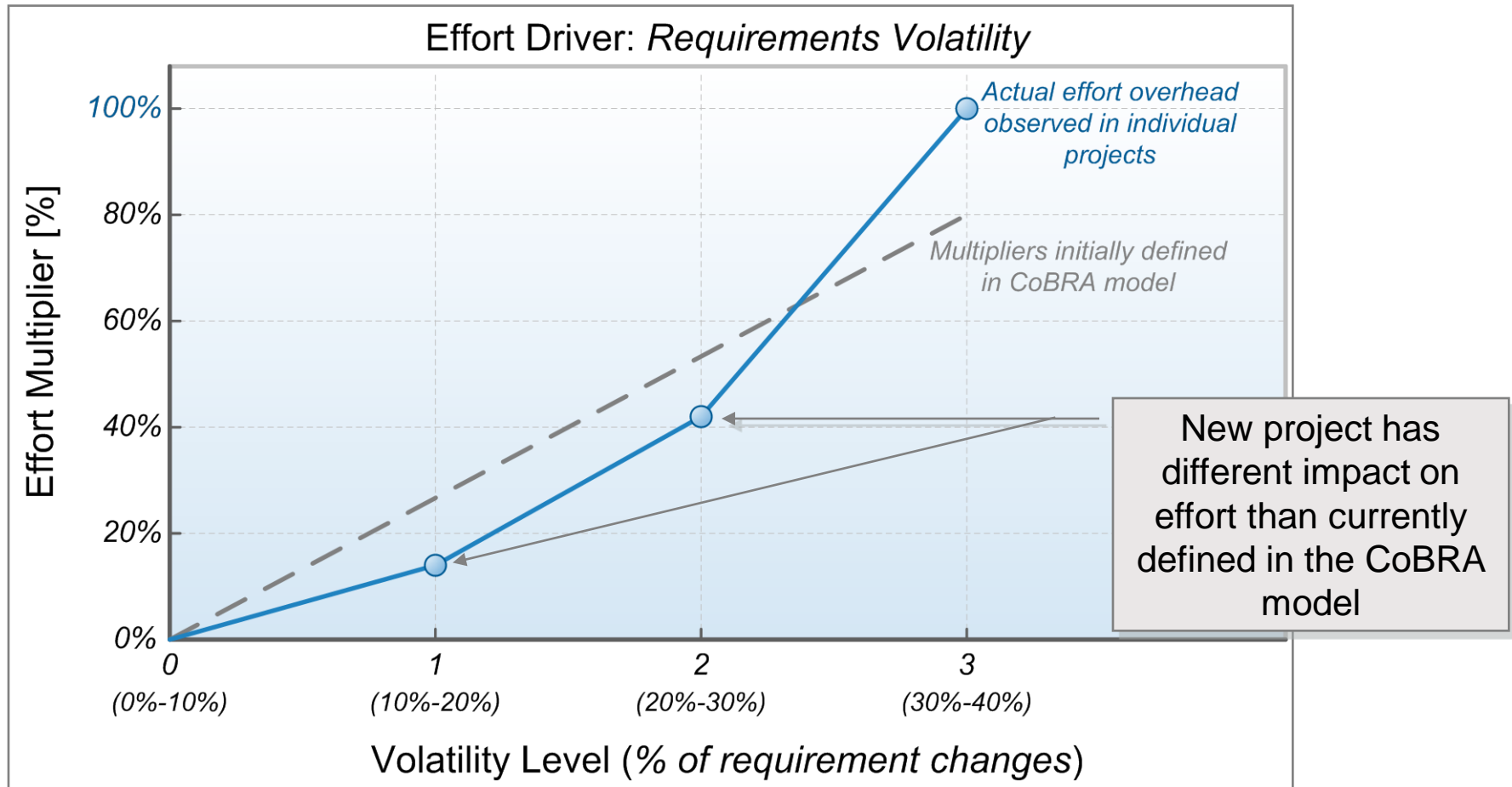
Modifying Effort Factor's Scale – Activities

- Redefine levels (0-3) of the scale associated with the effort driver
 - **TIP:** Whenever possible, define systematic rules for converting old scale into new scale; this allows for easy and reliable transformation of already collected historical project data
 - **TIP:** CoBRIX allows for modeling “intermediate” levels in order to characterize historical software projects
- Revise effort multipliers
 - **Direct effort factor:** multipliers associated with the effort factor
 - **Indirect effort factor:** worst-case multipliers of the associated direct effort factor
- Revise historical data
 - Update data using mapping from old to new scale
- Compute nominal productivity
- Validate model & perform improvement cycle

Modifying Impact of Effort Factor – Overview



Modifying Impact of Effort Factor – Example Situation



- ▶ Example corrective maintenance involves modifying multipliers for an effort factor

Modifying Impact of Effort Factor – Activities

- Direct Factor:

- Modify min-mi-max multipliers of the effort factor

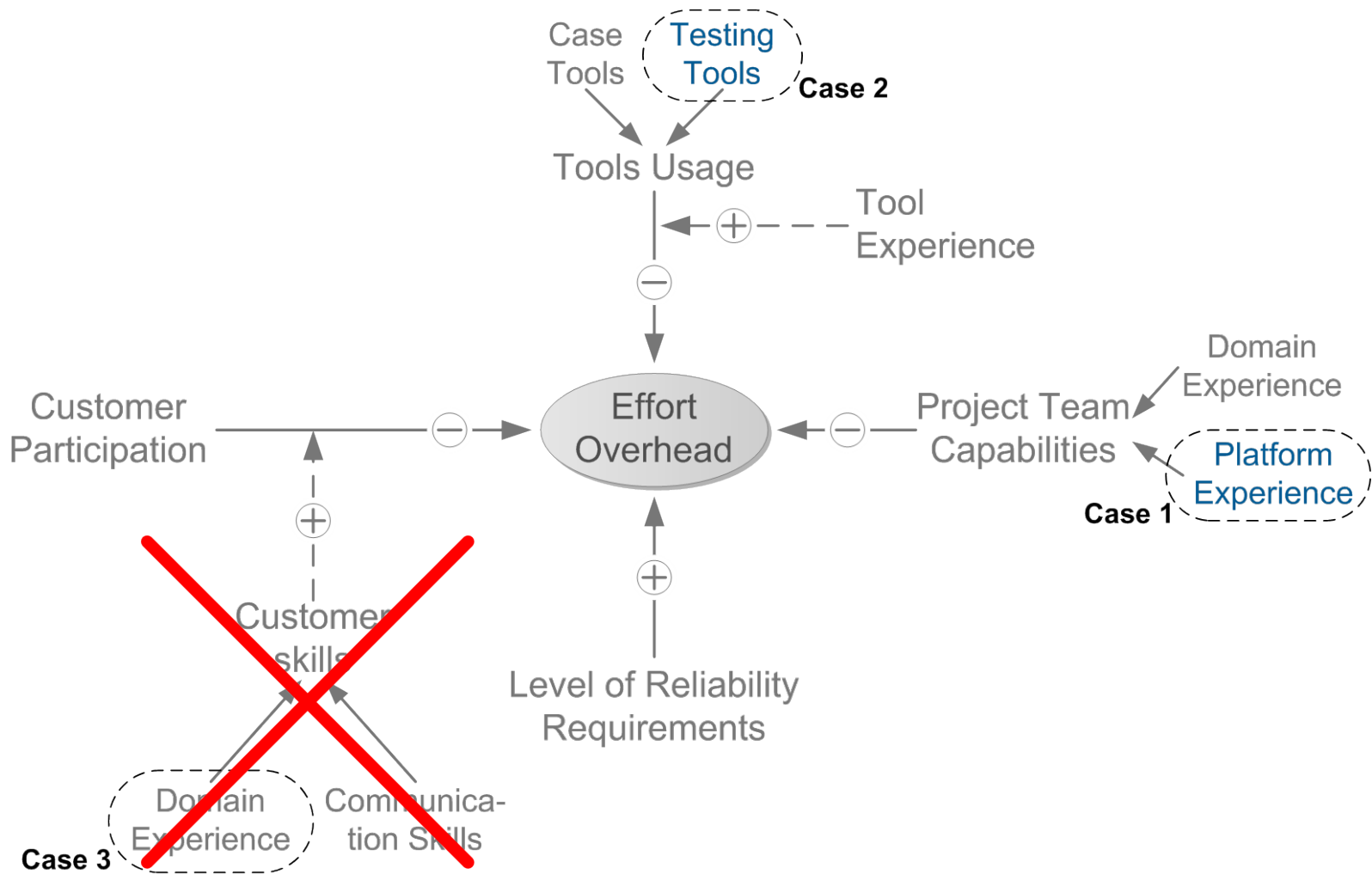
- Indirect factor:

- Modify multipliers of the associated direct effort factor(s)

- Compute nominal productivity using historical data

- Validate model & perform improvement cycle

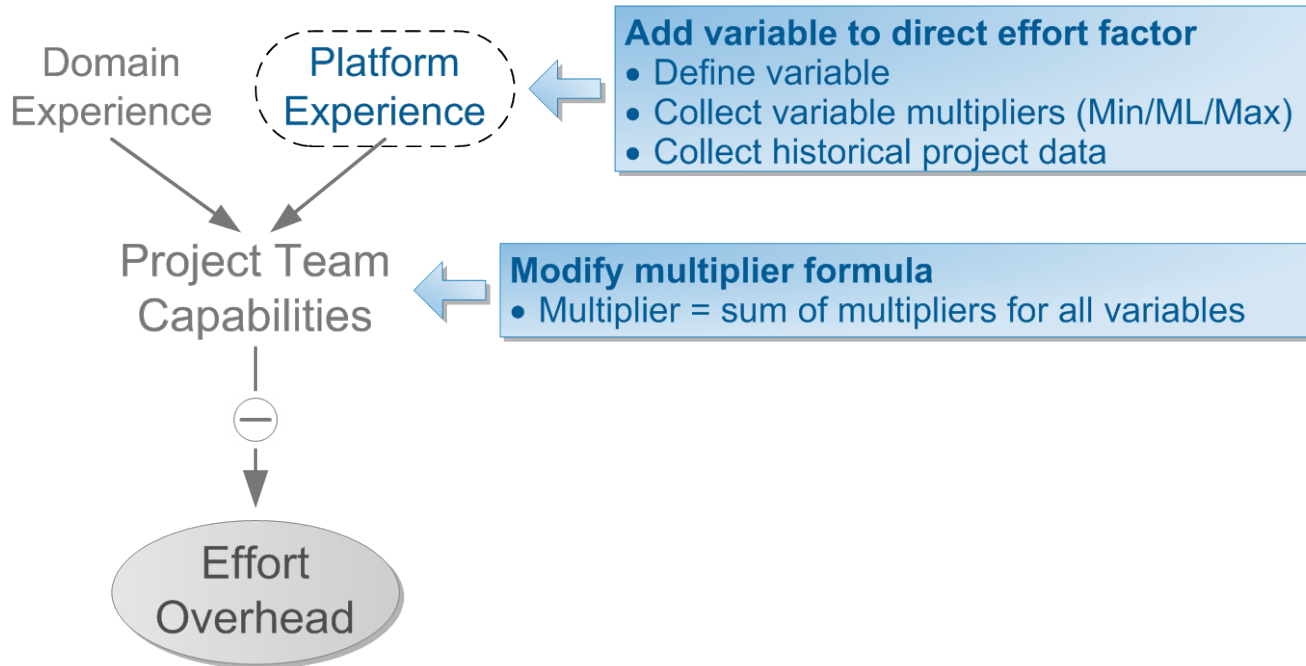
Adding/Removing Variable – Overview



Adding (Removing) Variable – Case 1

■ Direct effort factor with no indirect influence

■ Activities

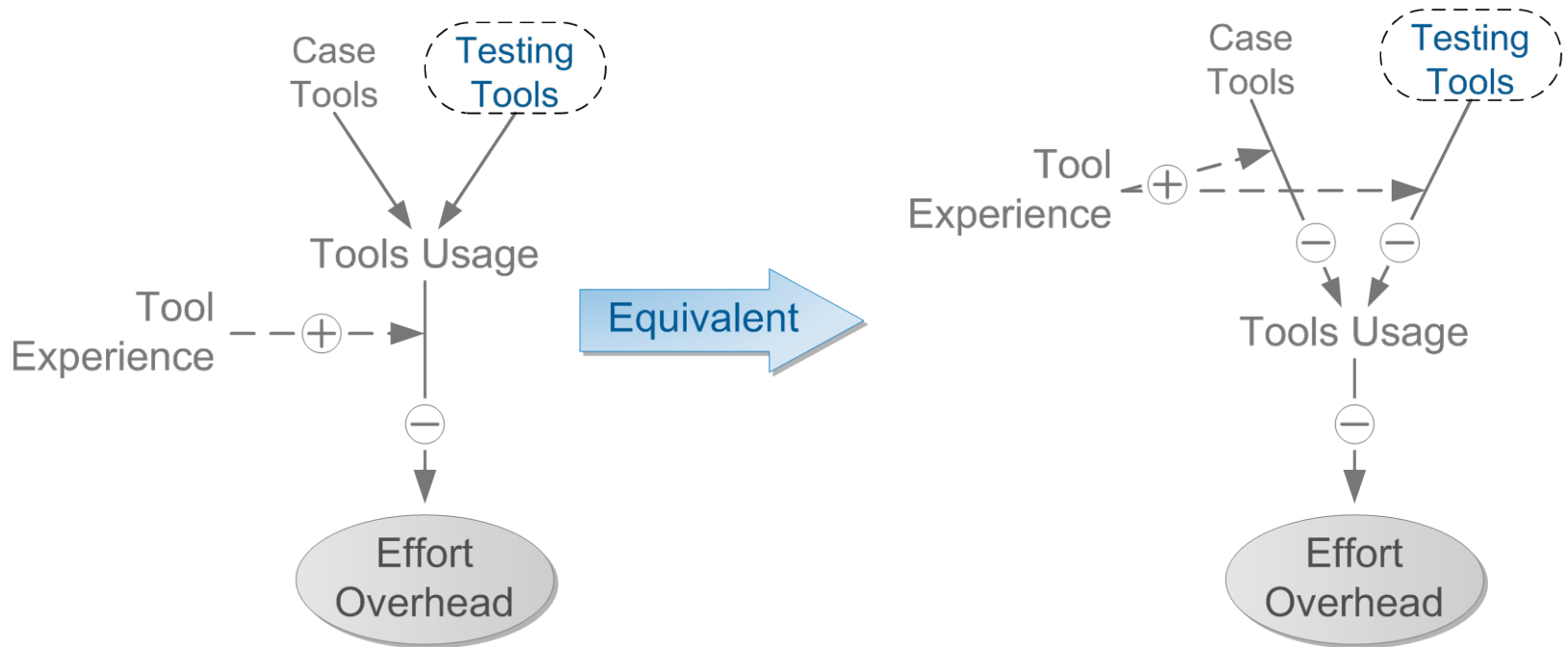


► We remove the variable in an analogical way (using similar activities)

Adding (Removing) Variable – Case 2

■ Direct effort factor with indirect influence

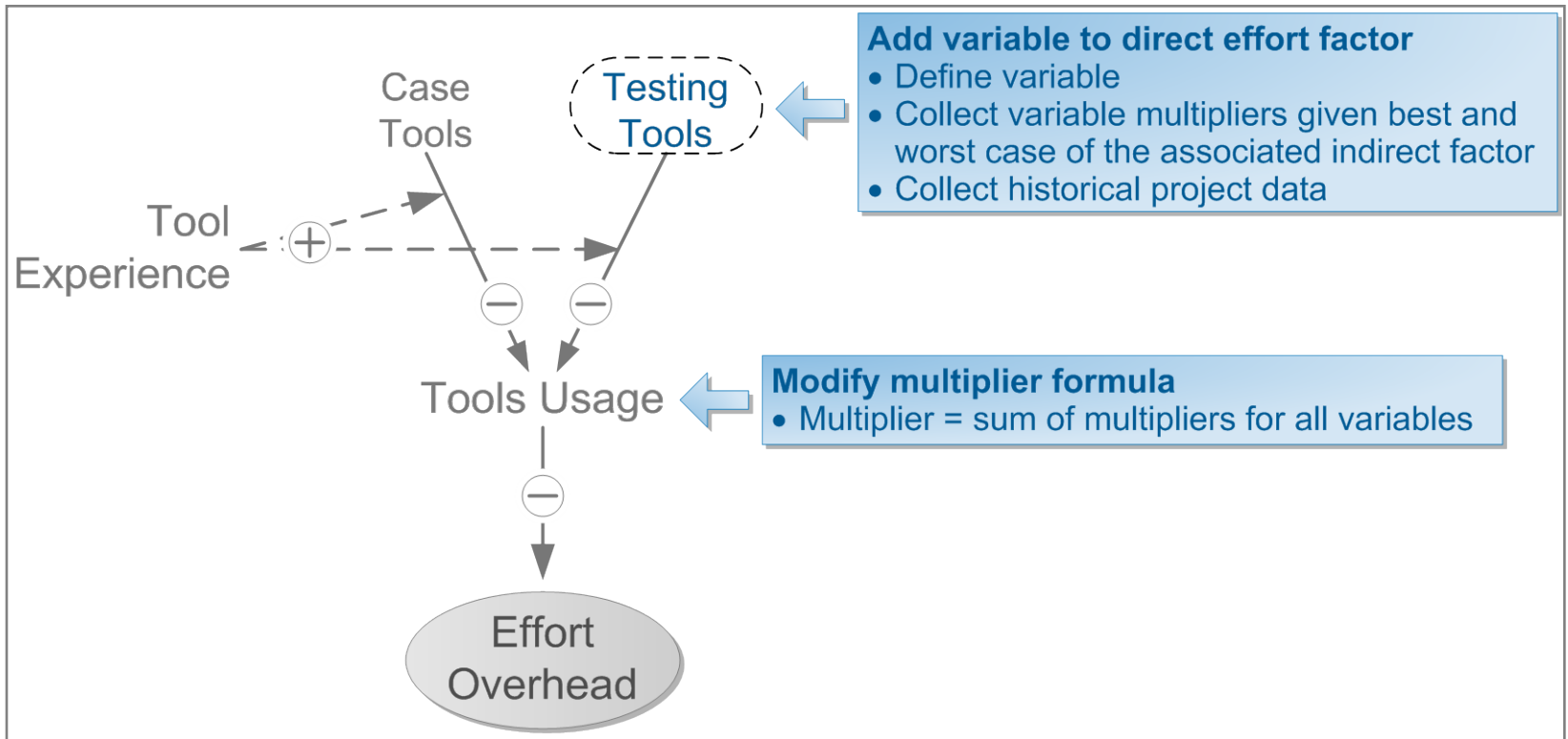
■ Model equivalence



Adding (Removing) Variable – Case 2

■ Direct effort factor with indirect influence

■ Activities

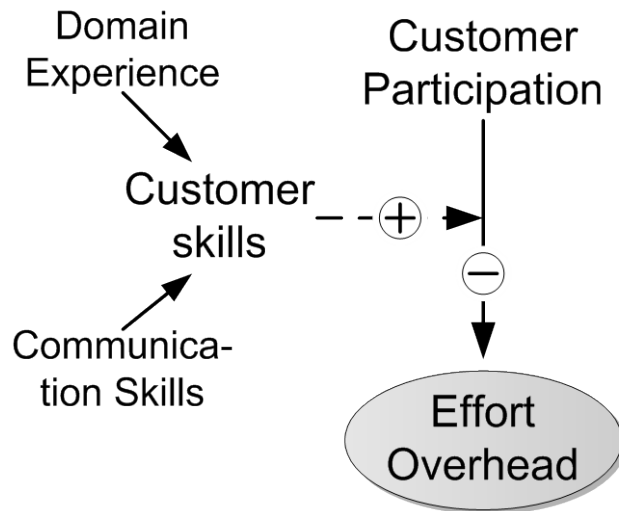


▶ We remove the variable in an analogical way (using similar activities)

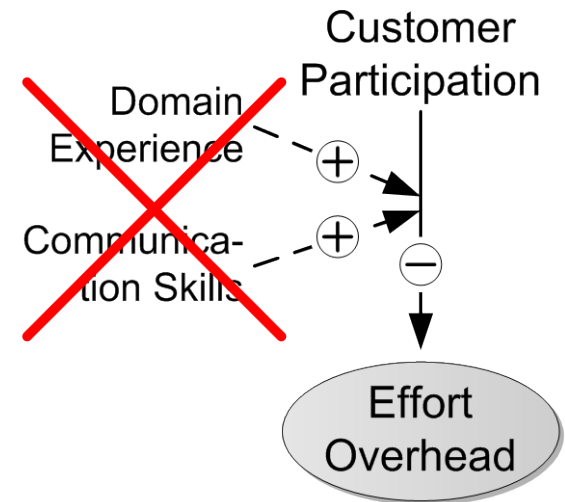
Adding/Removing Variable – Case 3

■ Indirect effort factor

■ Activities



Equivalent



► We do not consider multiple indirect factors

► Increases cost of modeling cost

► Doubtful reliability and benefits

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- ▶ **Summary**



Summary

- Maintenance is essential for keeping prediction models useful – being effective for estimating new software projects
- In order to be effective, maintenance must follow a systematic and rigorous approach
- In order to keep the effort model effective for future projects, it should be adjusted on the organizational level
- Consider trade-off between universality of the model and cost of its development and maintenance
 - Avoid multiple specific models
 - Avoid complex generic models
- Systematically collect and analyze project feedback
 - Performance of the CoBRA model
 - Estimation situation
 - Lessons learned

Thank You!



Questions, Comments?



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