BIM, Computational Materiality, and Performance Design Simulation in the Early Stage Design

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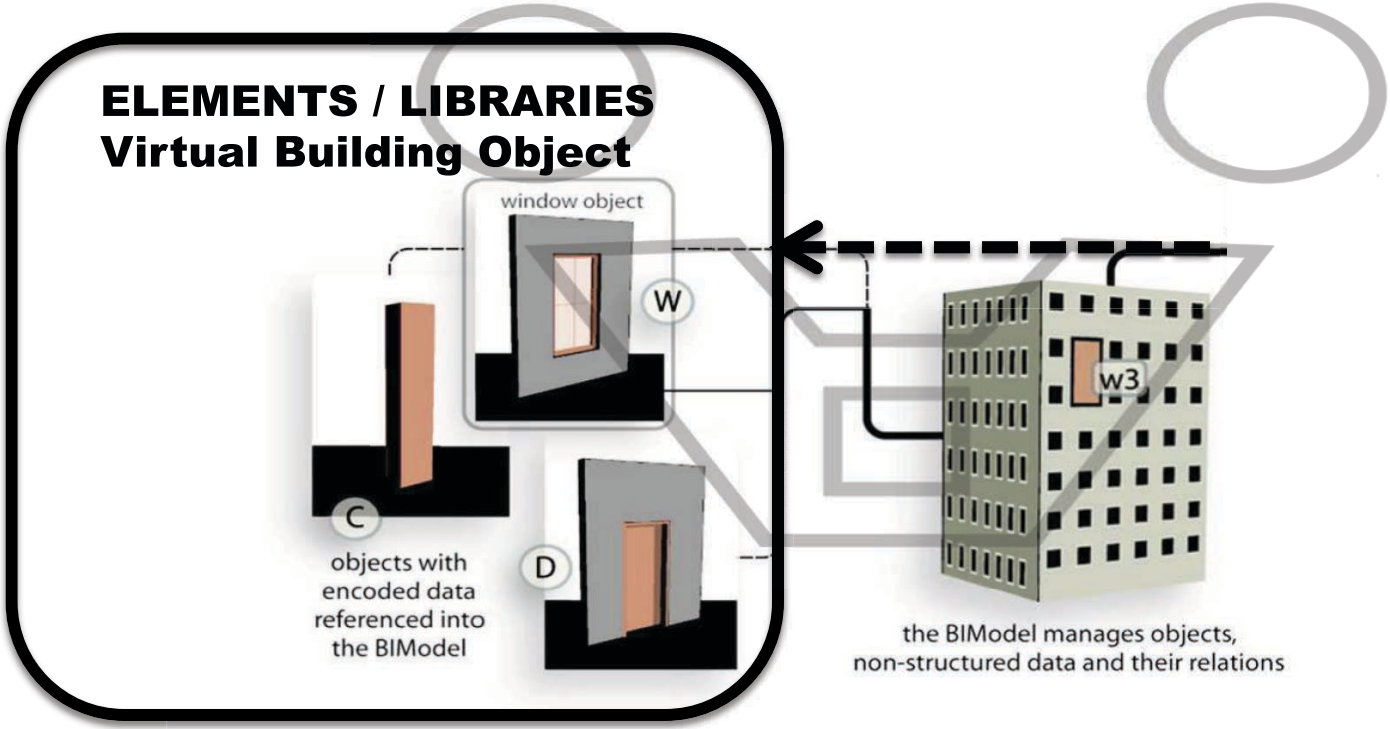
BIM

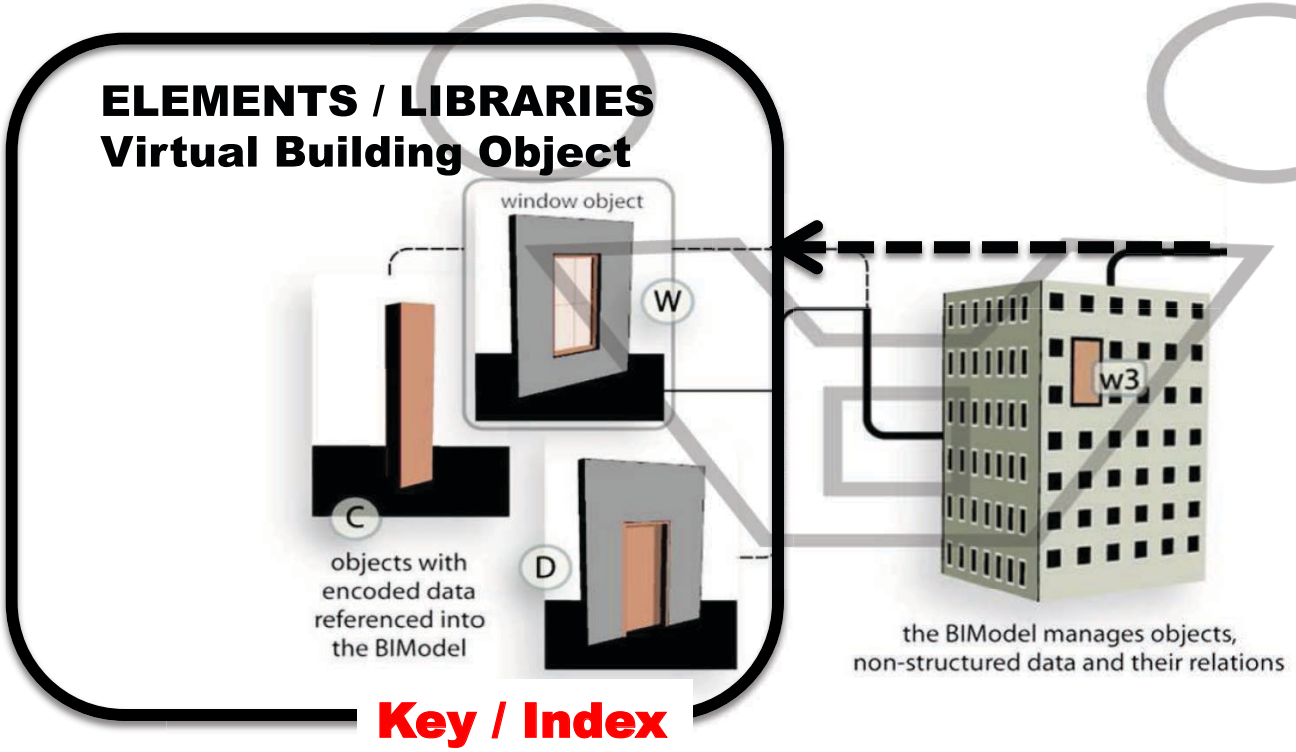
BUILDING a usually roofed and walled structure assembling materials for permanent/temporary use

INFORMATION: entity or form that resolves uncertainty related to data and kowledge as data represents values attributed to parameters, and knowledge signifies understending of real or abstract phenomena. Discipline of telecommunication founded on mathematic with application on artifcial intelligence, complex system , and cybenrnetic

MODEL: a simplified representation, a construction with cognitive and operable functions

ELEMENTS / LIBRARIES
Virtual Building Object

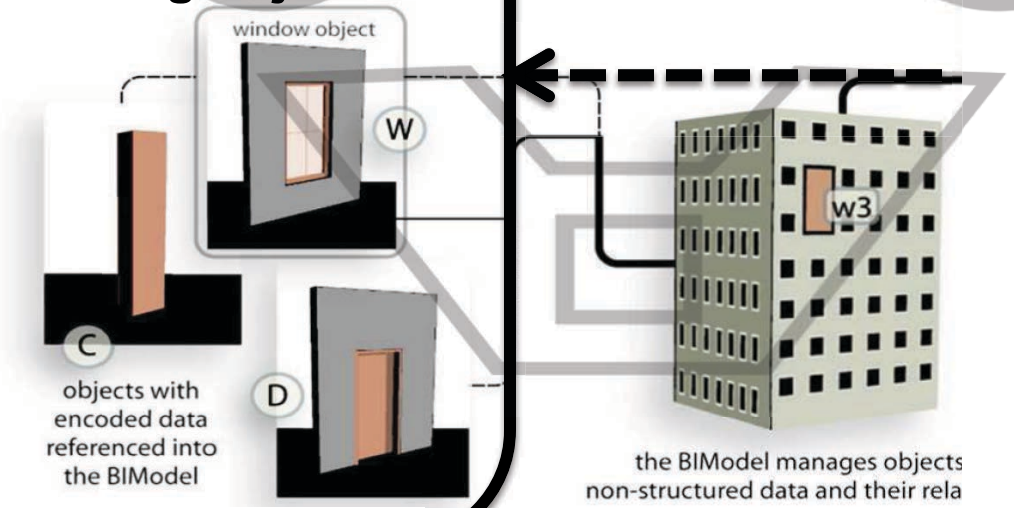




TAXONOMY

La programmazione orientata agli oggetti applicata alle costruzioni impiega un **codice organizzato per classi** che fornisce un supporto naturale alla modellazione software degli oggetti del mondo reale (o del modello astratto); ne favorisce la modularità e il riuso; permette una più facile gestione e manutenzione di progetti di grandi dimensioni.

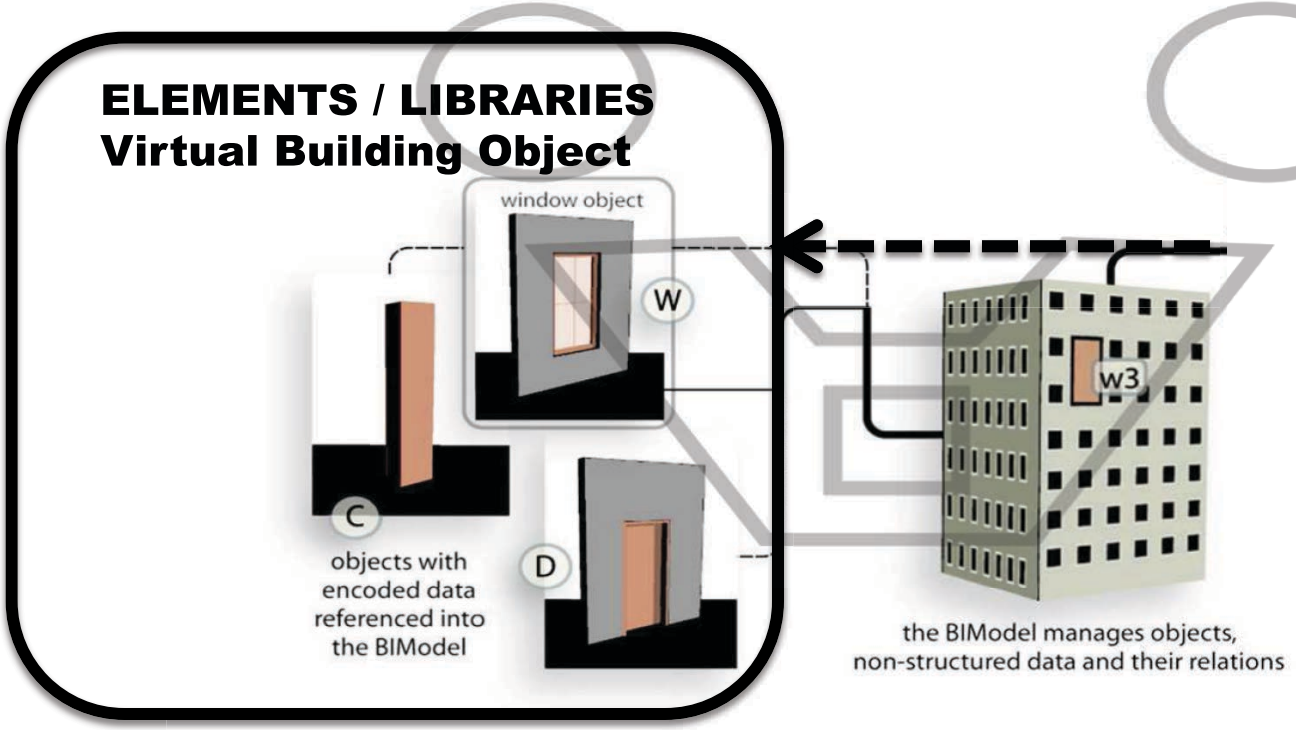
ELEMENTS / LIBRARIES
Virtual Building Object



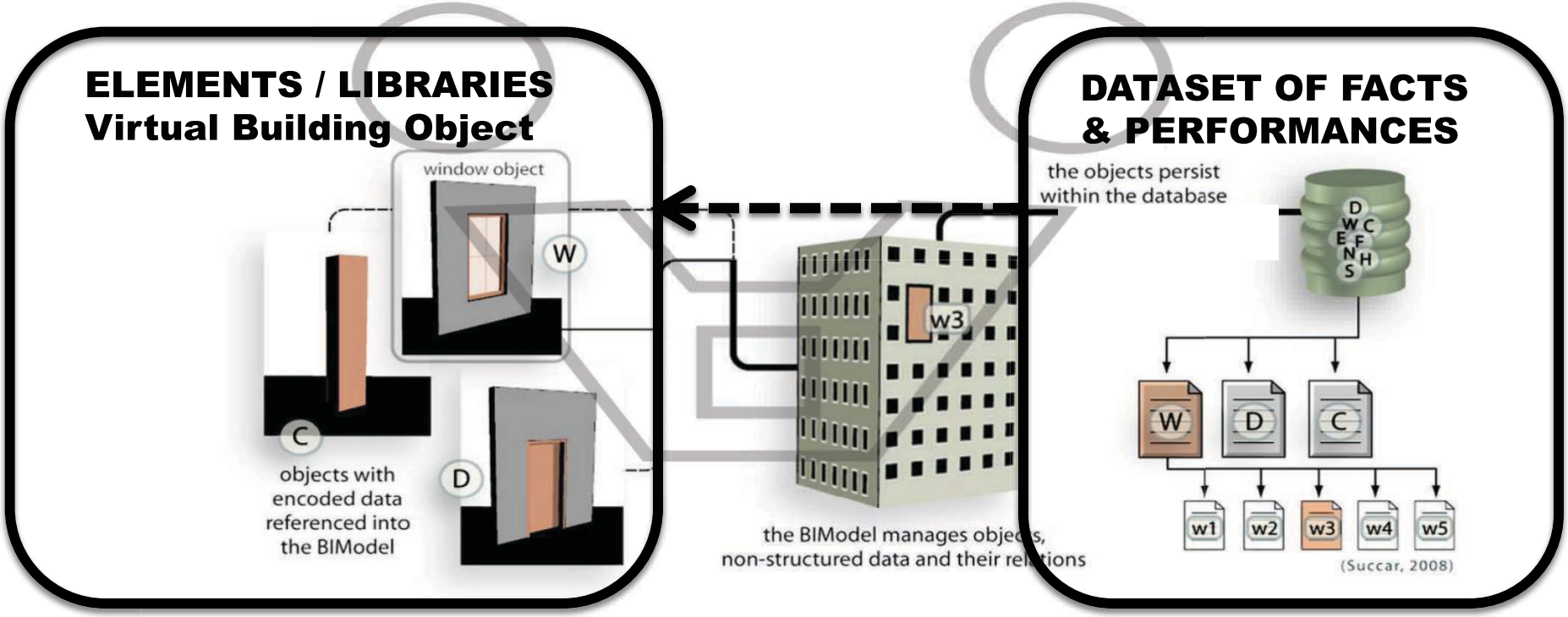
TAXONOMY

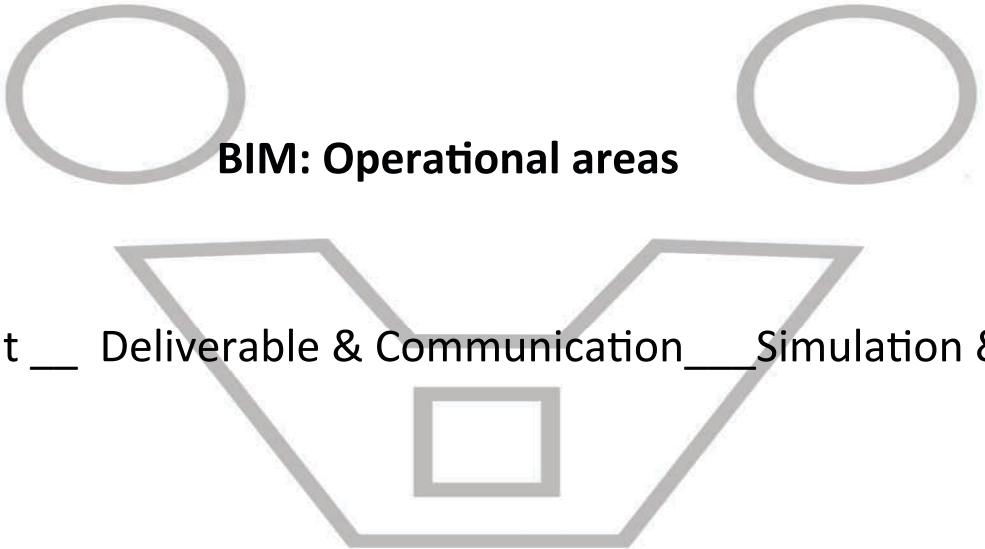
Key / Index

Building elements, Components, Materials, Operations,...



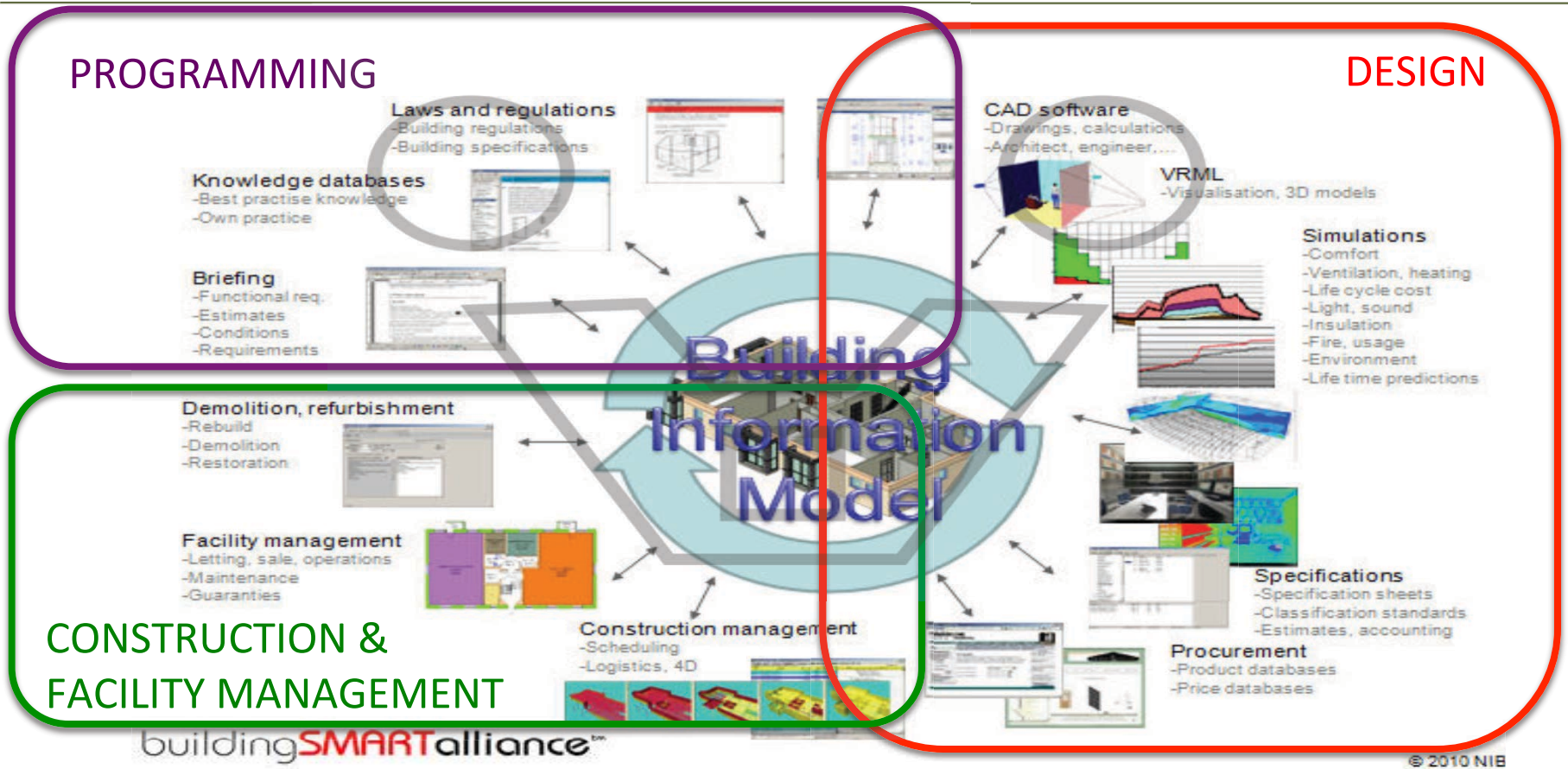
as Louis Kahn said, a column really knows that it is a column because it is informed of all the ontological attributes (natural and social);
It is no longer a graphic convention that asks to be filled with its meanings and materiality (Levy 2012: 14).


ELEMENTS / LIBRARIES
Virtual Building Object
window object
W
C
D
objects with encoded data referenced into the BIModel
w3
the BIModel manages objects, non-structured data and their relations
DATASET OF FACTS & PERFORMANCES
the objects persist within the database
D W C F H E N S
W
D
C
w1
w2
w3
w4
w5
(Succar, 2008)



BIM: Operational areas

Management __ Deliverable & Communication___Simulation & Design


PROGRAMMING
DESIGN
CONSTRUCTION & FACILITY MANAGEMENT
Laws and regulations
-Building regulations
-Building specifications
Knowledge databases
-Best practise knowledge
-Own practice
Briefing
-Functional req.
-Estimates
-Conditions
-Requirements
CAD software
-Drawings, calculations
-Architect, engineer,...
VRML
-Visualisation, 3D models
Simulations
-Comfort
-Ventilation, heating
-Life cycle cost
-Light, sound
-Insulation
-Fire, usage
-Environment
-Life time predictions
Building Information Model
Demolition, refurbishment
-Rebuild
-Demolition
-Restoration
Facility management
-Letting, sale, operations
-Maintenance
-Guaranties
Construction management
-Scheduling
-Logistics, 4D
Specifications
-Specification sheets
-Classification standards
-Estimates, accounting
Procurement
-Product databases
-Price databases
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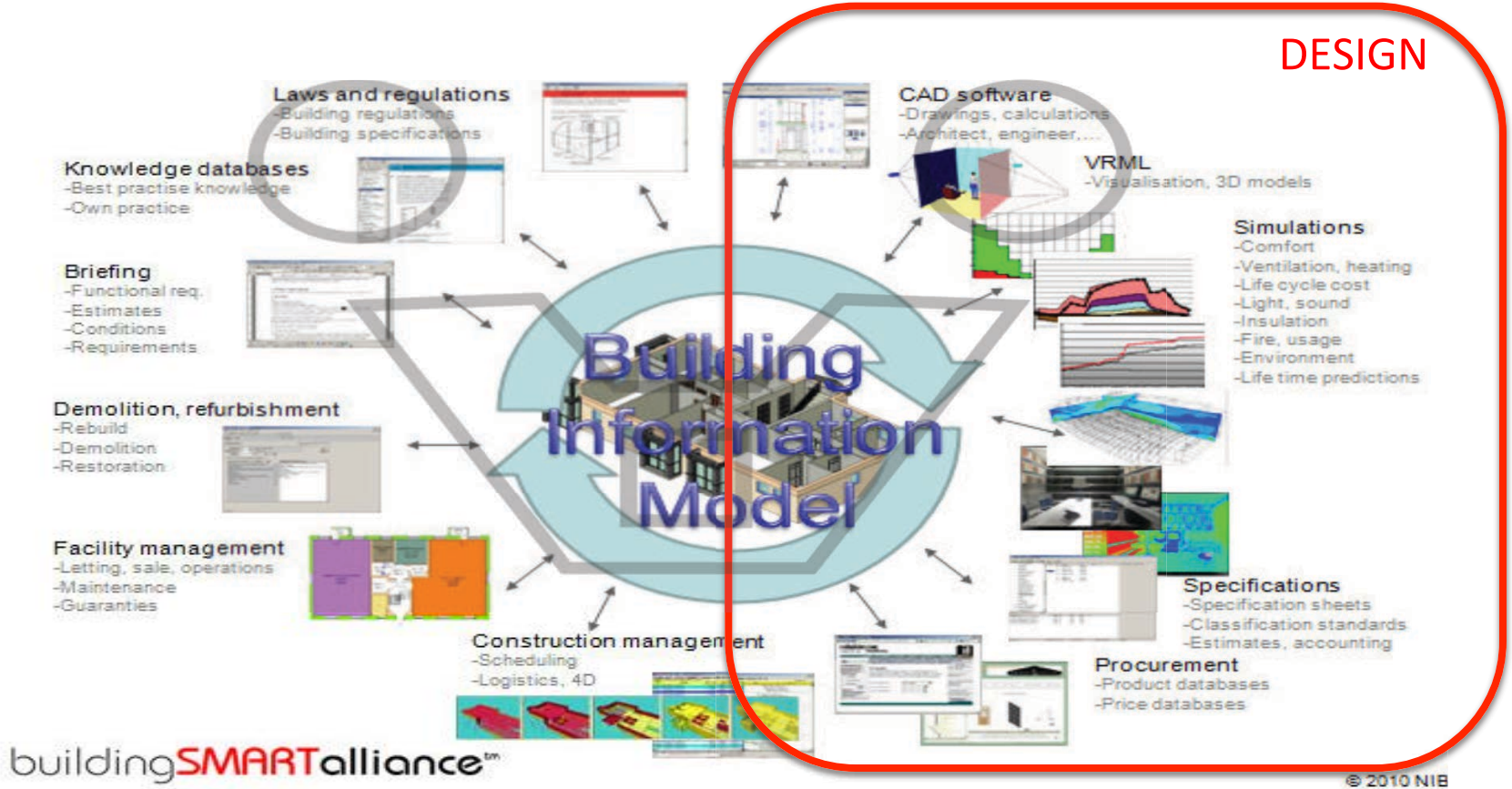
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-Scheduling
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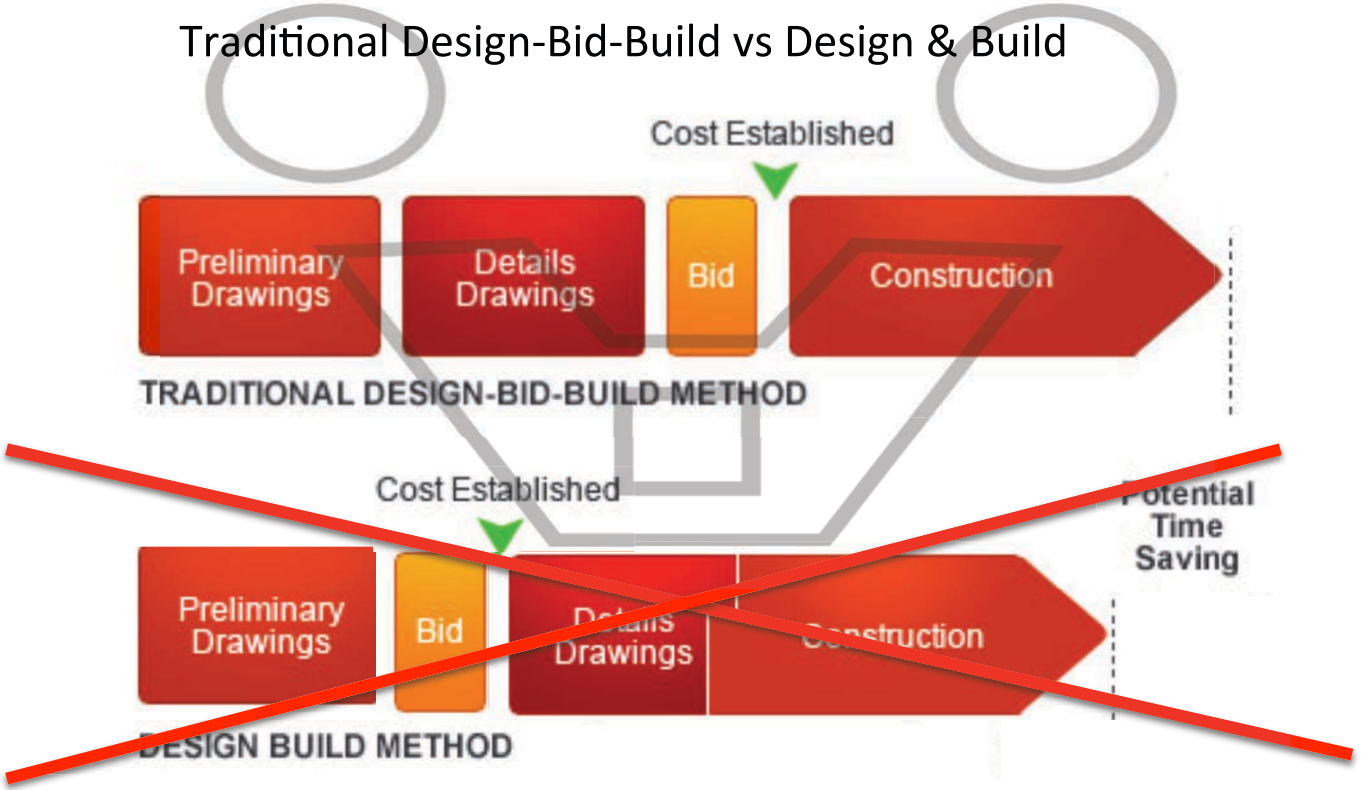
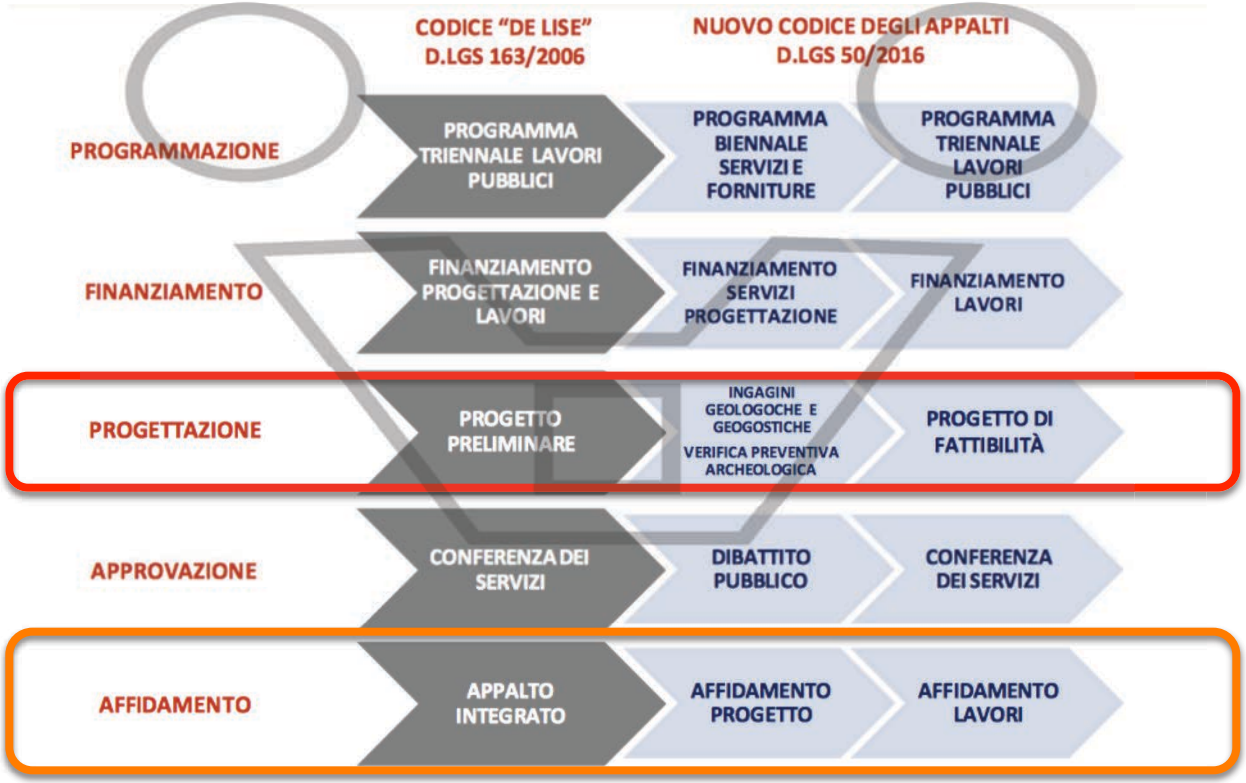
DESIGN in the EU Procedural Context: the Italian example

Traditional Design-Bid-Build vs Design & Build

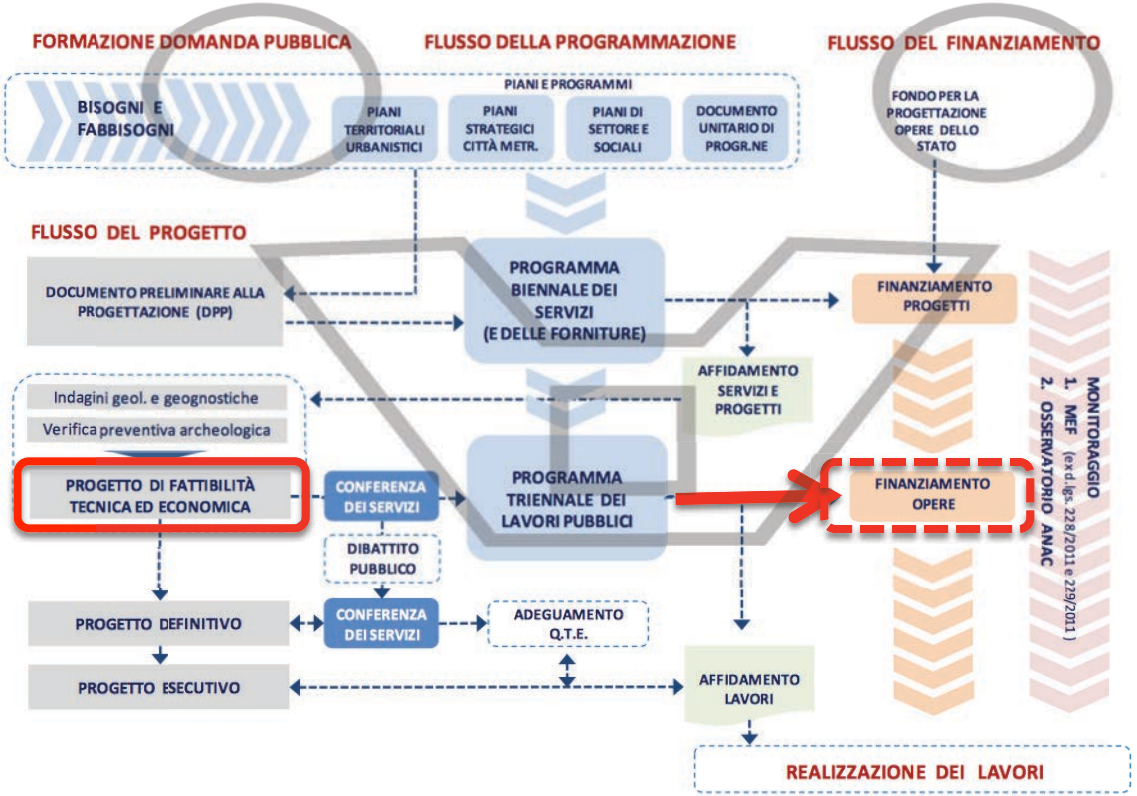


Preliminary Design in Italy after the new regulation



Preliminary Design in Italy after the new regulation

Preliminary Design



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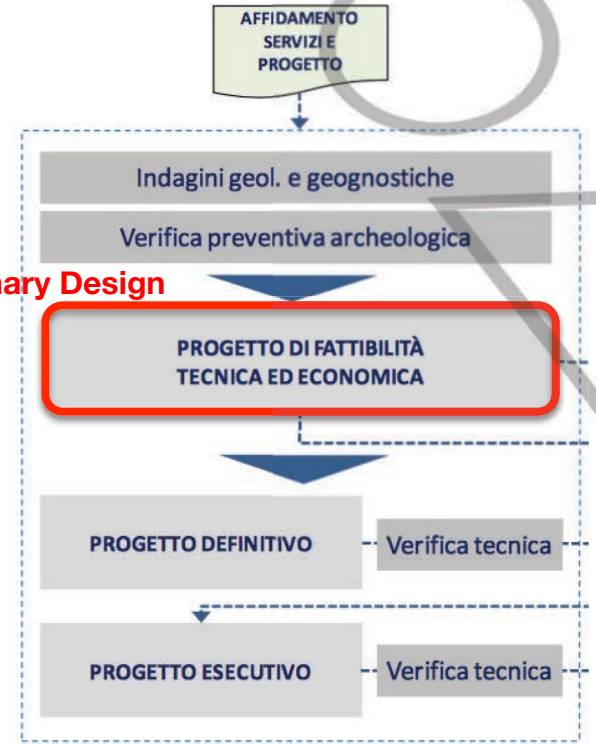


Preliminary Design

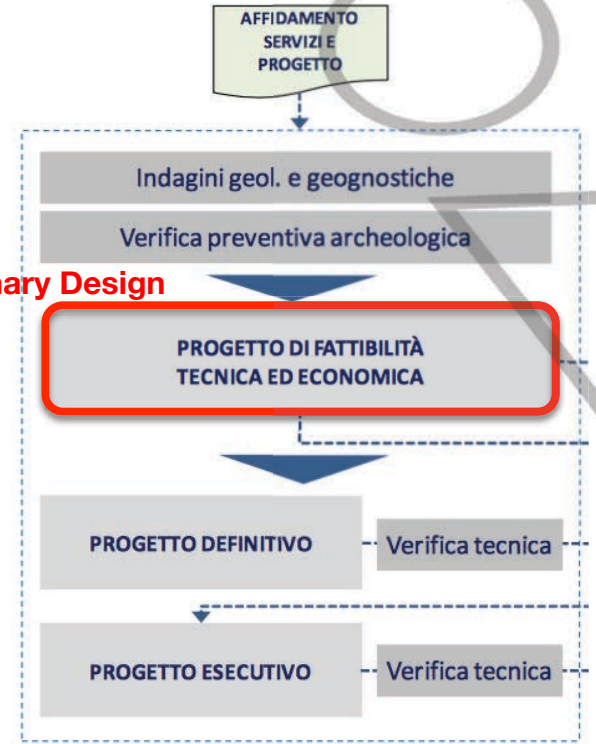
The design of public works is structured according to three levels of subsequent technical insights into

progetto di fattibilità tecnica ed economica

progetto definitivo

progetto esecutivo (Art 21. 3)

Preliminary design in Italy after the new regulation



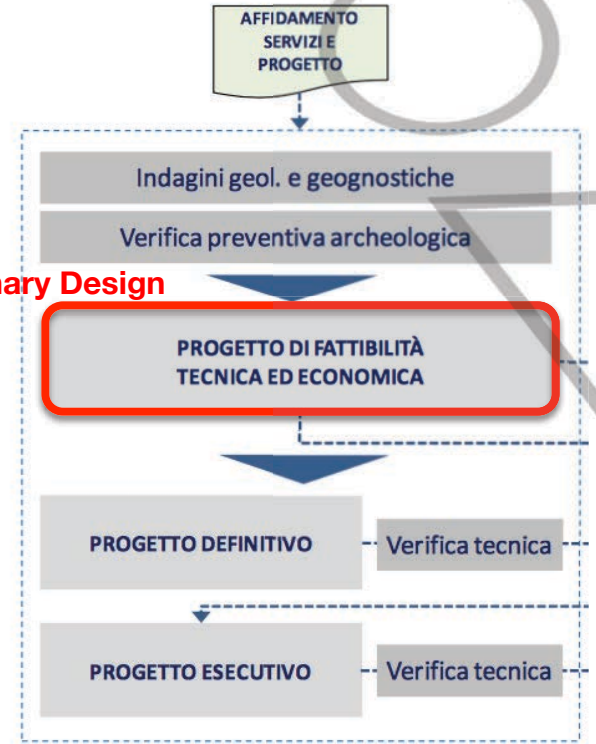
It is required an integration of conceptual design and feasibility study

progetto di fattibilità tecnica ed economica
(Art 21. 3)

L'accorpamento di studio di fattibilità e progetto preliminare in **progetto di fattibilità tecnica ed economica**

And as a consequence an anticipation of soil investigation

Preliminary design in Italy after the new regulation



Preliminary Design

The solution must be define through the analysis of different alternatives

documento di fattibilità delle alternative progettuali
il documento in cui sono individuate ed analizzate:
- le possibili soluzioni progettuali alternative ed in cui
- si dà conto della valutazione di ciascuna alternativa, sotto il profilo

concernig the environment

- qualitativo, anche in termini ambientali,
- nonché sotto il profilo tecnico ed economico (8);

and technical-economic feasibility

Preliminary design in Italy after the new regulation

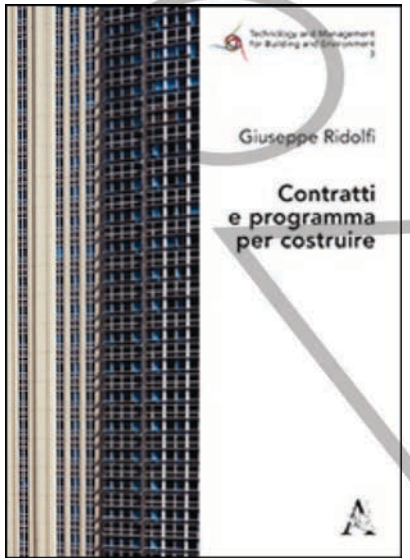
6. Il **progetto di fattibilità** è redatto sulla base dell'avvenuto svolgimento di indagini geologiche, idrogeologiche, idrologiche, idrauliche, geotecniche, sismiche, storiche, paesaggistiche ed urbanistiche, di verifiche preventive dell'interesse archeologico, di studi preliminari sull'impatto ambientale e evidenzia, con apposito adeguato elaborato cartografico, le aree impegnate, le relative eventuali fasce di rispetto e le occorrenti misure di salvaguardia; **deve, altresì, ricomprendere le valutazioni ovvero le eventuali diagnosi energetiche dell'opera in progetto, con riferimento al contenimento dei consumi energetici e alle eventuali misure per la produzione e il recupero di energia anche con riferimento all'impatto sul piano economico-finanziario dell'opera**; indica, inoltre, le **caratteristiche prestazionali**, le **specifiche funzionali, le esigenze di compensazioni e di mitigazione dell'impatto ambientale, nonché i limiti di spesa,** calcolati secondo le modalità indicate dal decreto di cui al comma 3, dell'infrastruttura da realizzare ad un livello tale da consentire, già in sede di approvazione del progetto medesimo, salvo circostanze imprevedibili, l'individuazione della localizzazione o del tracciato dell'infrastruttura nonché delle opere compensative o di mitigazione dell'impatto ambientale e sociale necessarie

- Energy analysis incuding
  - Consumption
  - Saving strategies
  - Economical impact
- Space and functional program
- environmental impact
- cost

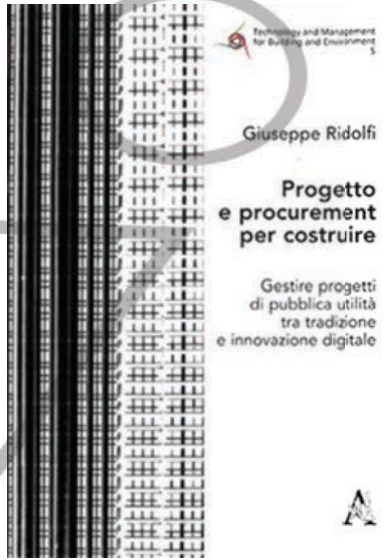
Preliminary design in Italy after the new regulation

5. Il progetto di fattibilità tecnica ed economica individua, tra più soluzioni, quella che presenta il miglior rapporto tra costi e benefici per la collettività, in relazione alle specifiche esigenze da soddisfare e prestazioni da fornire.

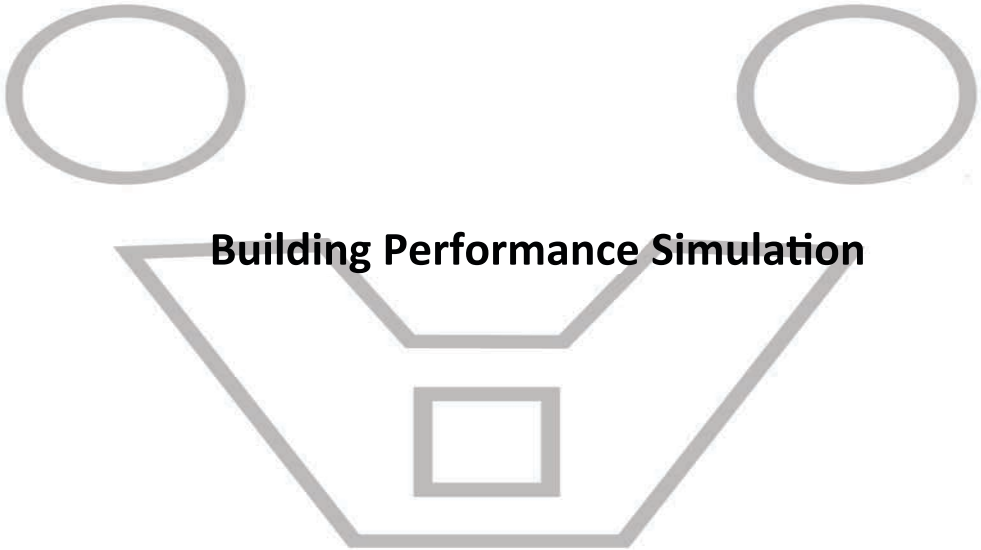
Ai soli fini delle attività di programmazione triennale dei lavori pubblici e dell'espletamento delle procedure di dibattito pubblico di cui all'articolo 22 nonché dei concorsi di progettazione e di idee di cui all'articolo 152, il progetto di fattibilità può essere articolato in due fasi successive di elaborazione. In tutti gli altri casi, il progetto di fattibilità è sempre redatto in un'unica fase di elaborazione. Nel caso di elaborazione in due fasi, nella prima fase il progettista, individua ed analizza le possibili soluzioni progettuali alternative, ove esistenti, sulla base dei principi di cui al comma 1, e redige il documento di fattibilità delle alternative progettuali secondo le modalità indicate dal decreto di cui al comma 3. Nella seconda fase di elaborazione, ovvero nell'unica fase, qualora non sia redatto in due fasi, il progettista incaricato sviluppa, nel rispetto dei contenuti del documento di indirizzo alla progettazione e secondo le modalità indicate dal decreto di cui al comma 3, tutte le indagini e gli studi necessari per la definizione degli aspetti di cui al comma 1, **nonché elaborati grafici per l'individuazione delle caratteristiche dimensionali, volumetriche, tipologiche, funzionali e tecnologiche dei lavori da realizzare e le relative stime economiche,** ivi compresa la scelta in merito alla possibile suddivisione in lotti funzionali. Il progetto di fattibilità deve consentire, ove necessario, l'avvio della procedura espropriativa (5).



https://www.researchgate.net/publication/295010496_Contratti_e_programma_per_costruire



https://www.researchgate.net/publication/295010765_Progetto_e_procurement_per_costruire_Gestire_progetti_di_pubblica_utilita_tra_tradizione_e_innovazione_digitale



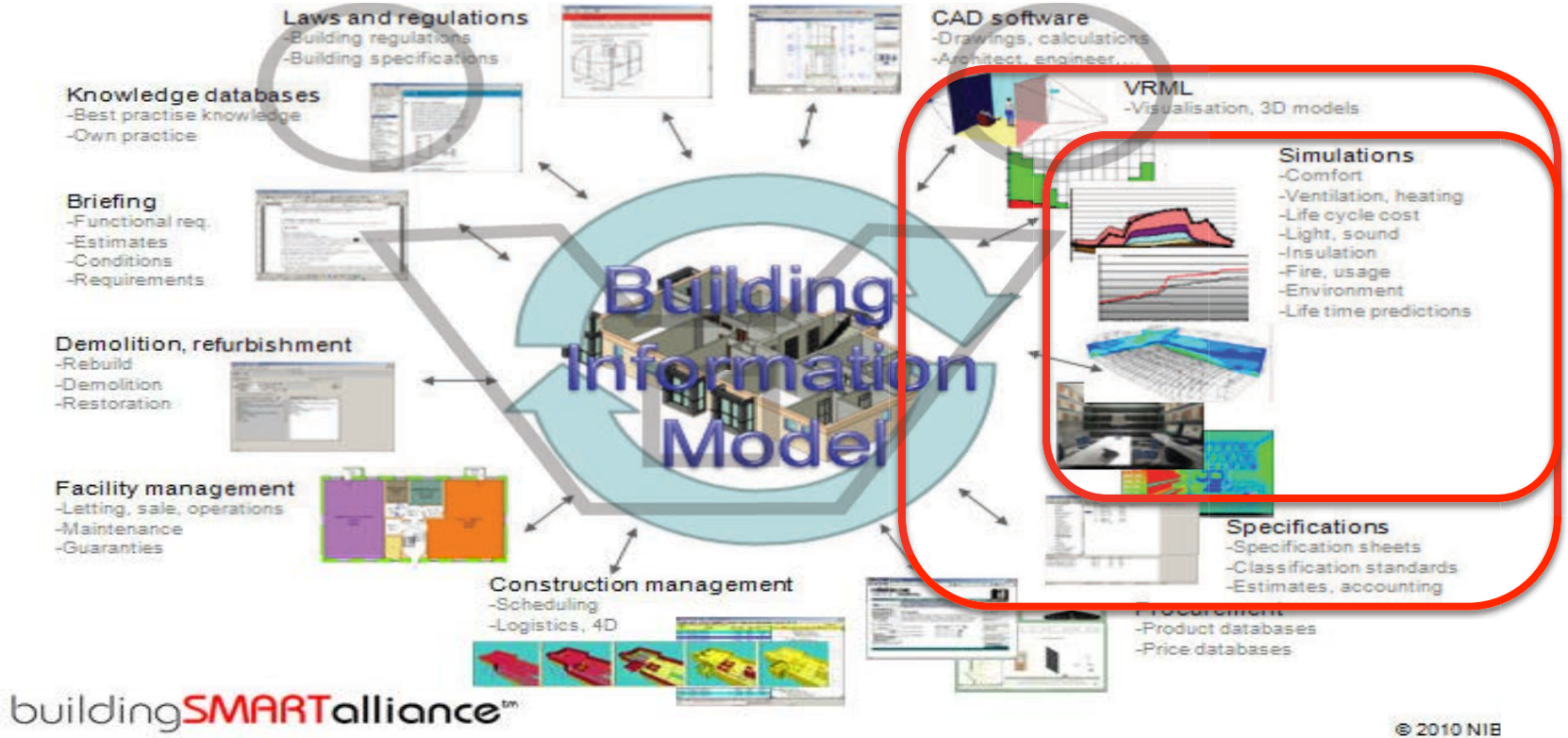
Building Performance Simulation

Building Performance Simulation

Object oriented design

... to the modules drawn by the compasses, to the numerical measurements and then to the mathematical equations we replace parametric functions able to describe morphological and semantic possibilities. (Kolarevic 2000: 2)

Their formalization evolves from syntactic structures of solid modeling and object-oriented modeling, integrating information of various nature, types and sizes that are interactive and operable through the indexing of the geometric representation of the building


Laws and regulations
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-Best practise knowledge
-Own practice
Briefing
-Functional req.
-Estimates
-Conditions
-Requirements
Demolition, refurbishment
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-Demolition
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-Life time predictions
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-Classification standards
-Estimates, accounting
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-Price databases
Construction management
-Scheduling
-Logistics, 4D
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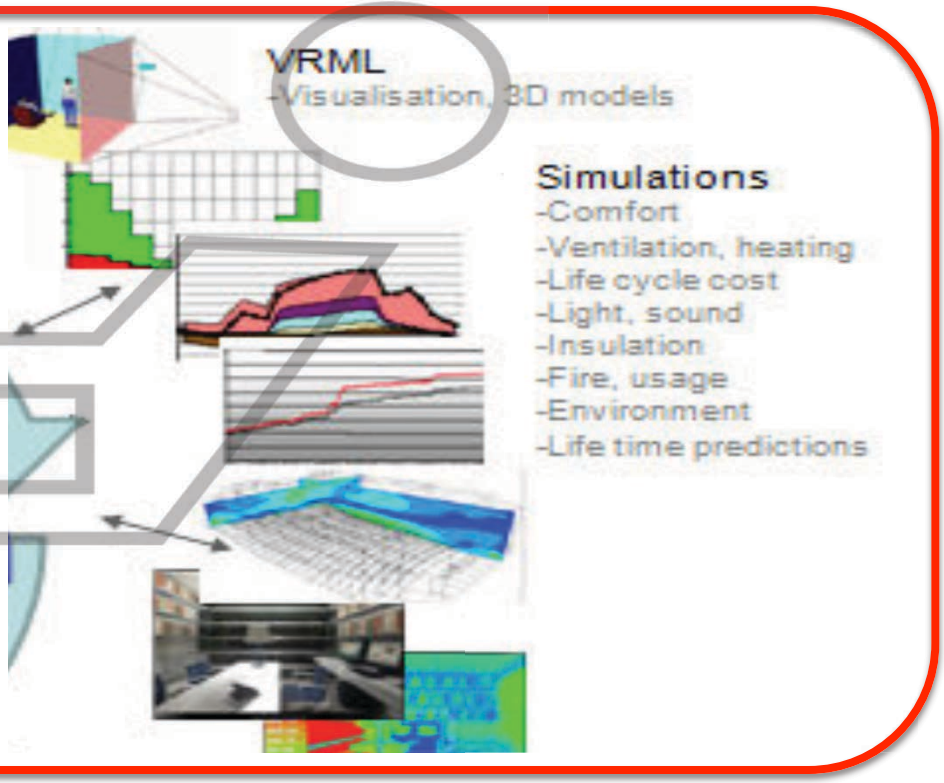
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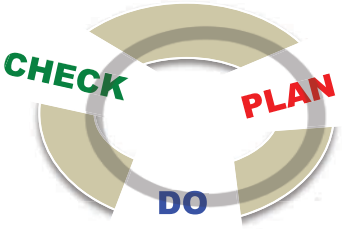
WHICH KIND OF INTERACTIONS DOES BIM ALLOW?



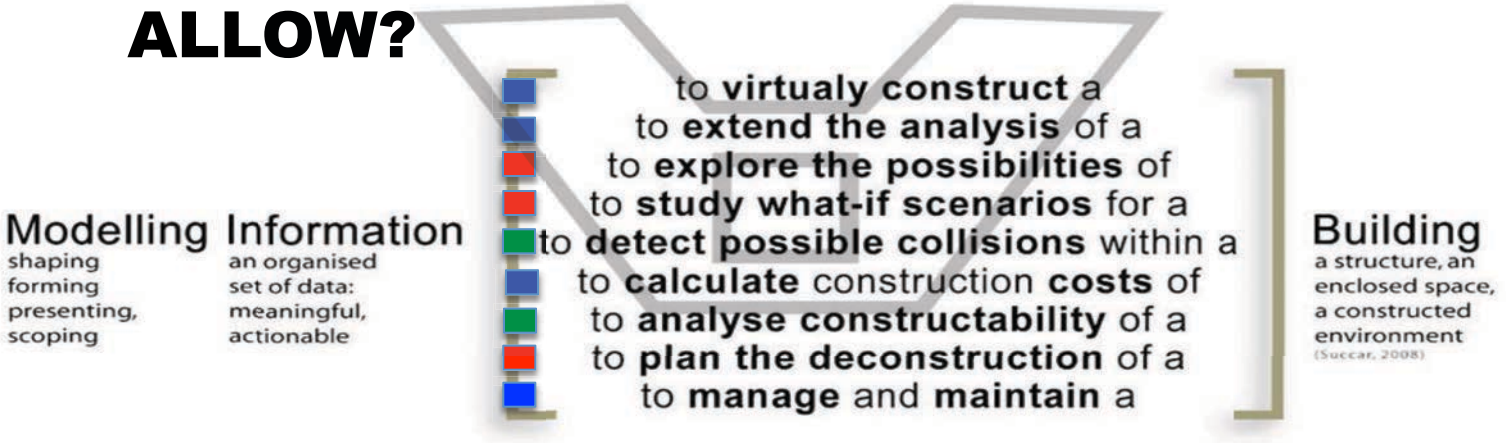
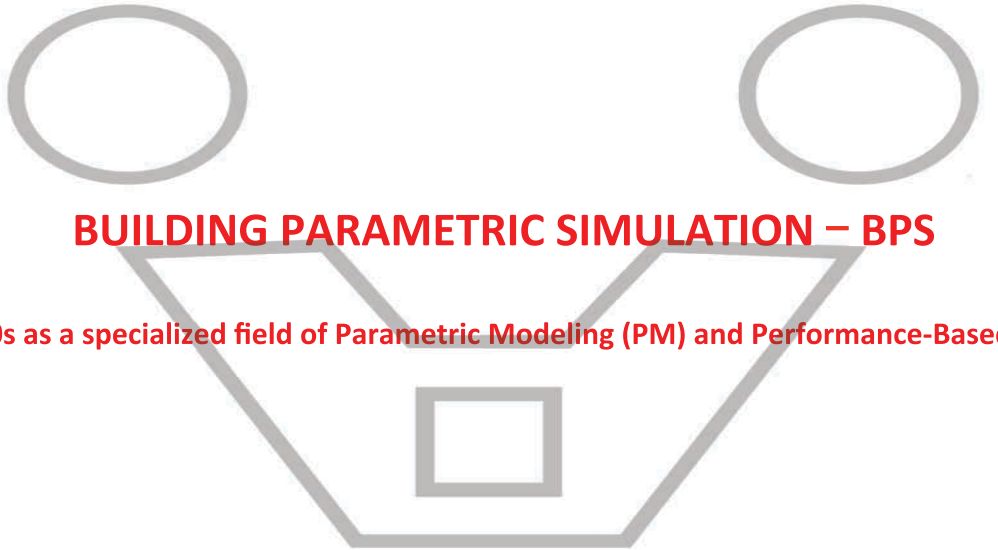


Fig. 2. Some common connotations of multiple BIM terms.



BUILDING PARAMETRIC SIMULATION – BPS

born in the 70s as a specialized field of Parametric Modeling (PM) and Performance-Based Design (PBD)

From *what the building will look like* (Garber 2014:184),

To *What the building will work*

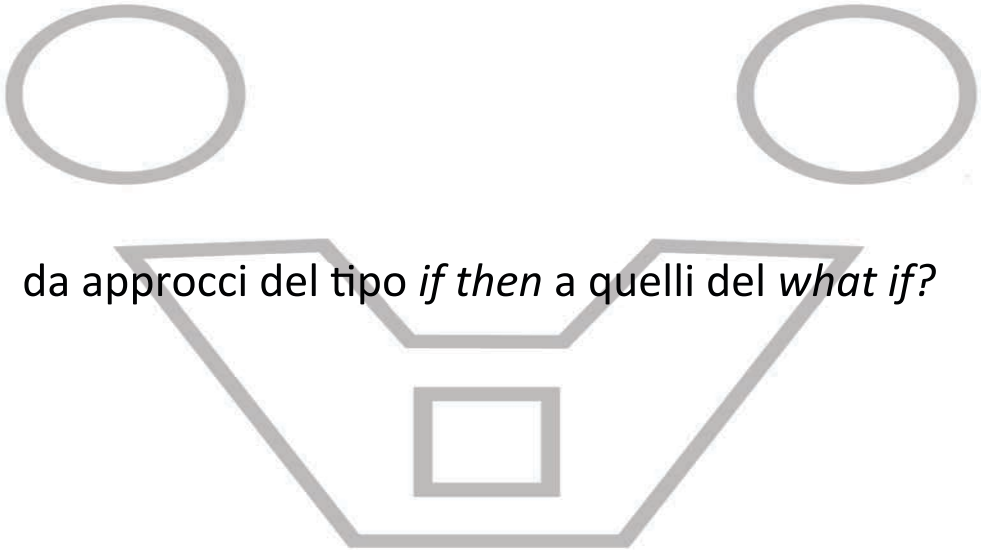
based on performance specification
(Kolarevic 2002).

In the last twenty years the parametric simulation has evolved in different fields reaching a satisfactory level of maturity and above all for the activities verification / validation of the executive design until it became an indispensable aid in the project engineering and one of the new frontiers of BIM as highlighted from the race of the major software-houses in the integration of these features in their products.

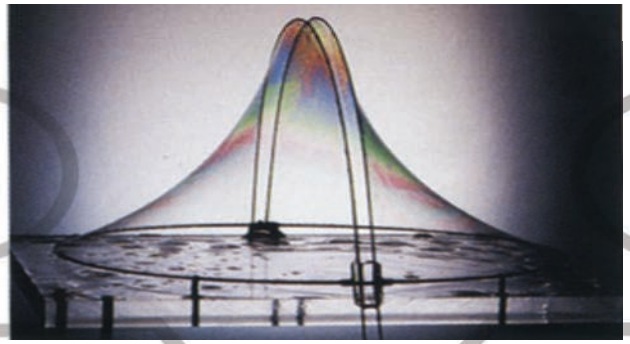
Conclusa una prima fase che si è concentrata sui motori di calcolo (***kernel***), l'attenzione si è spostata **sulle interfacce** con l'obiettivo di semplificare l'operabilità e la leggibilità dei risultati allo scopo di incorporare questi strumenti all'interno dei propri prodotti di modellazione BIM. Questa tendenza convive ed è alimentata dalla parallela diffusione **del *cloud-computing*** oggi sostenuta da precise logiche commerciali e da infrastrutture e protocolli telematici oggi in rapida evoluzione.

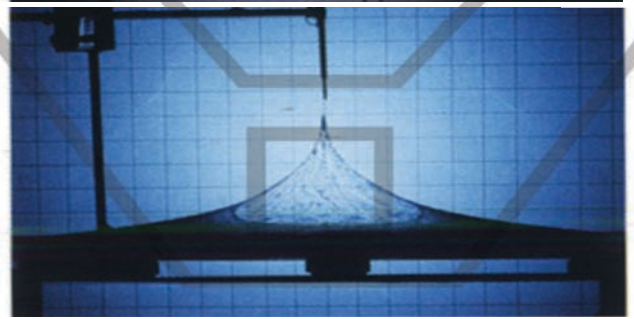
Un'altra area di sviluppo finalizzata all'integrazione si è concentrata sull'***interoperabilità***, sui protocolli d'interscambio dei dati

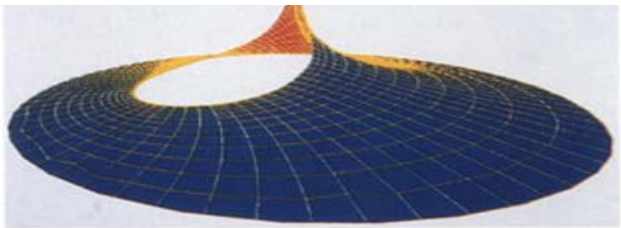
.... e parallelamente sulla realizzazione di un'innumerevole quantità di ***plug-in*** **e** ***add-on*** **dedicati a specifici aspetti della simulazione energetica e ambientale** a dimostrazione che non esiste un software in grado di risolvere tutti gli aspetti della simulazione energetica (Anderson 2014: 172).
Essi includono *l'illuminamento e la ventilazione degli ambienti interni; le prestazioni acustiche; la geometria solare e l'ombreggiamento, gli impatti dei venti, …: una vastità di strumenti che consente di condurre valutazioni di tipo prestazionale in maniera parametricamente interrelata alla geometria, ai modi occupare e usare gli ambienti, ai livelli di benessere attesi, al clima, alle caratteristiche tecnologiche della costruzione.* (Mahadavi, 2003:162).



da approcci del tipo *if then* a quelli del *what if?*







VISUALIZING MATTER

Functionality and Performance Design

arches

1 Soap film model of an arch-supported membrane.

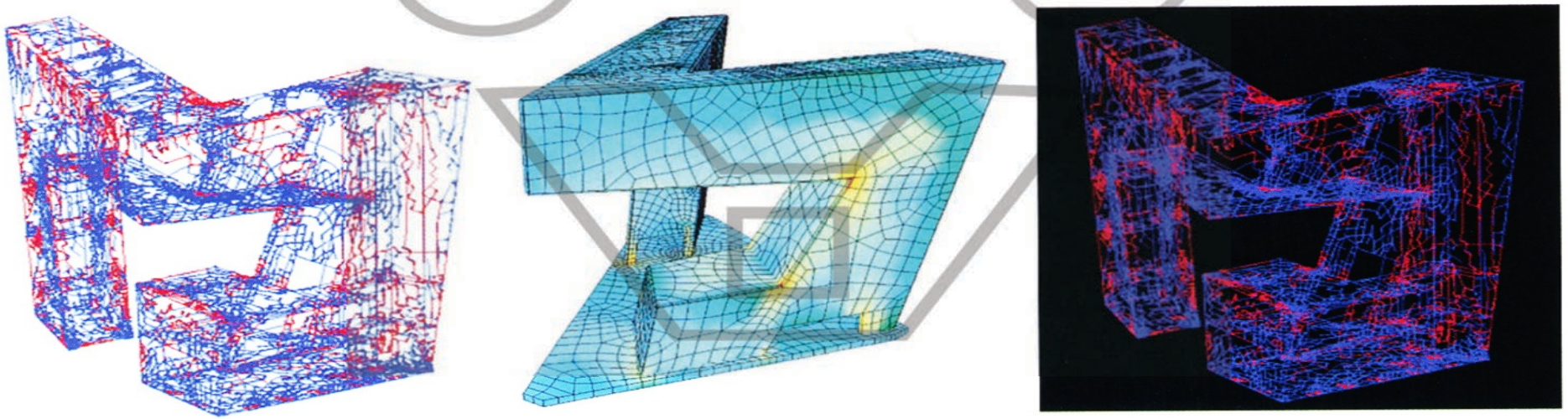
2 Soap-film model of a membrane surface with rope loop as its high point.

3 Computer simulation of a minimal surface with rope loop.

DIAGRAM:
THE ABSTRACT MACHINE

..a map of relations between forces"

Deleuze, A Thousand Plateaus (1988)



AKT, South Bank Pavilion (Zaha Hadid). Load paths. © Adams Kara Taylor (AKT).


The race for the sky

Empire State Building

Designed by: Shreve, Lamb and Harmon

Facts:

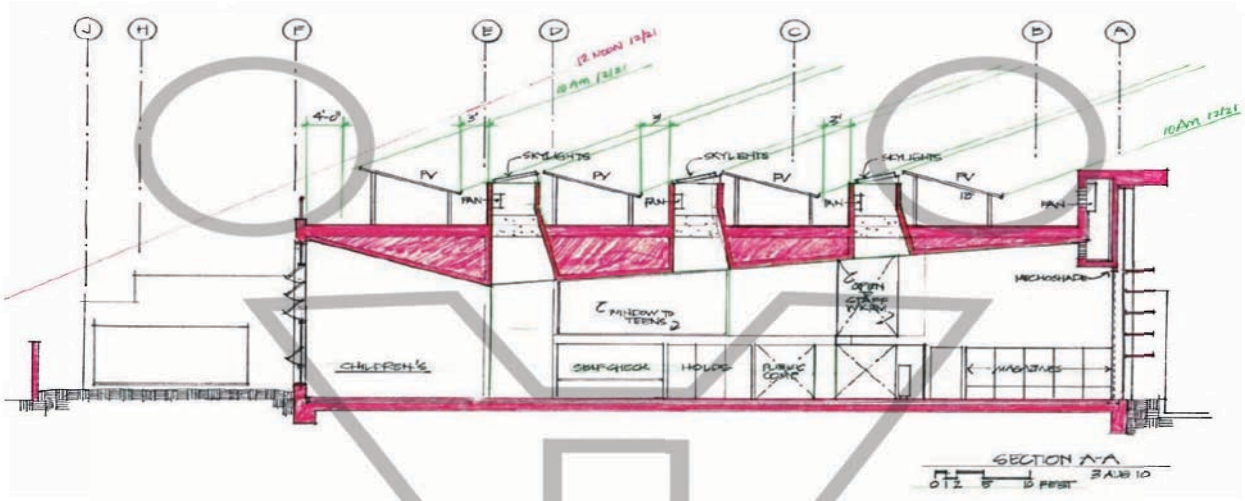
102 storeys

381 m. tall

(443.2 m including the antenna)

20 months to open it

- Demolition of Waldorf Astoria Hotel
- Design
- Authorizations
- Financing
- Construction (1 year and 45 days)



1.6

Early design section through the reading room of the Net Zero Energy-designed West Berkeley Library. The design team used a combination of intuition and design simulation to create a roof form that correctly balanced the space for renewable energy, deep light wells, and natural ventilation. See case studies 8.2 and 9.1.

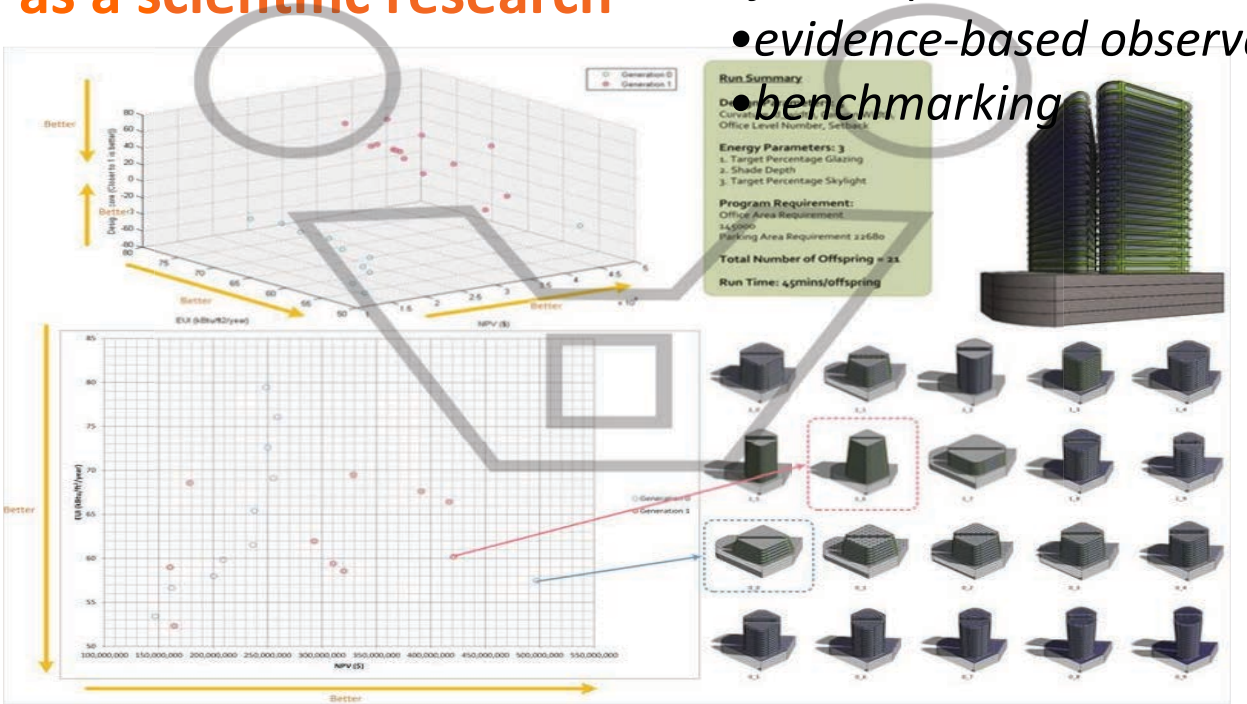
Source: Concept sketch by Edward Dean, courtesy of Harley Ellis Devereaux Architects.

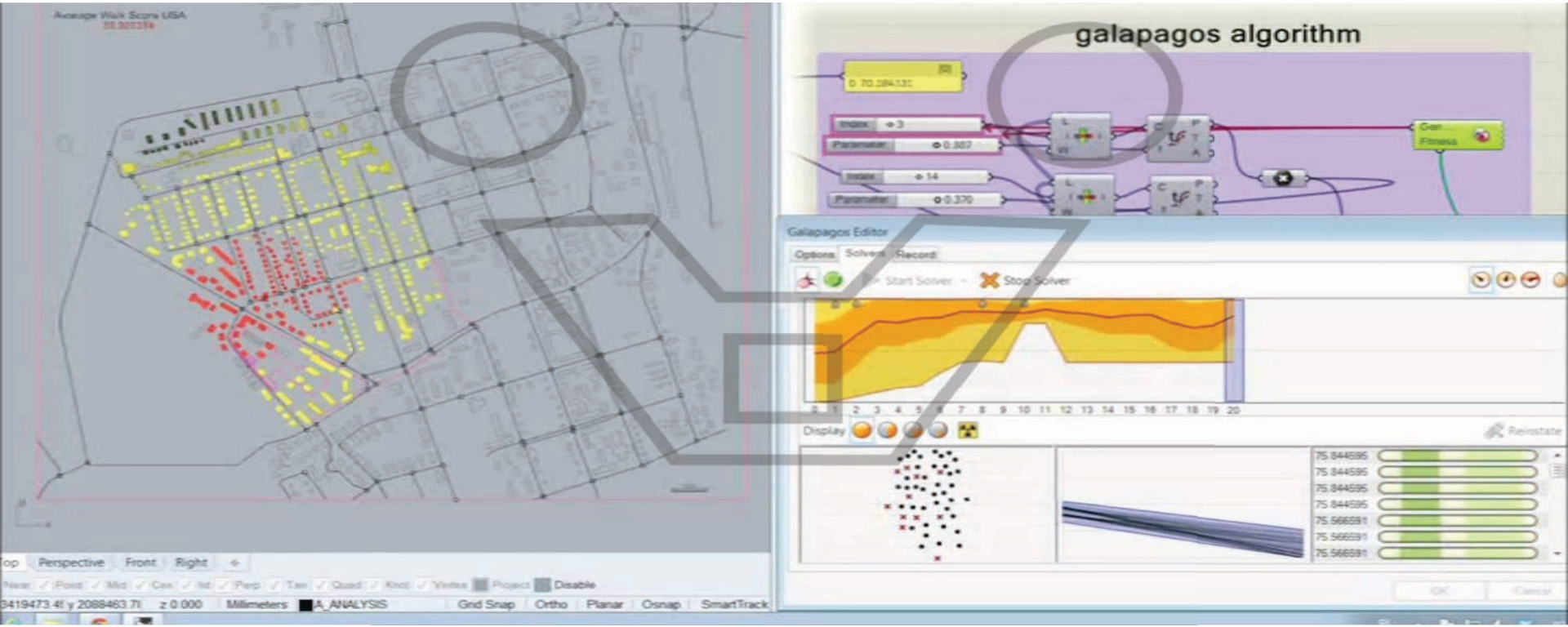
The traditional architectural approach is a limited iterative process based on qualitative analogies

Computational Design as a scientific research

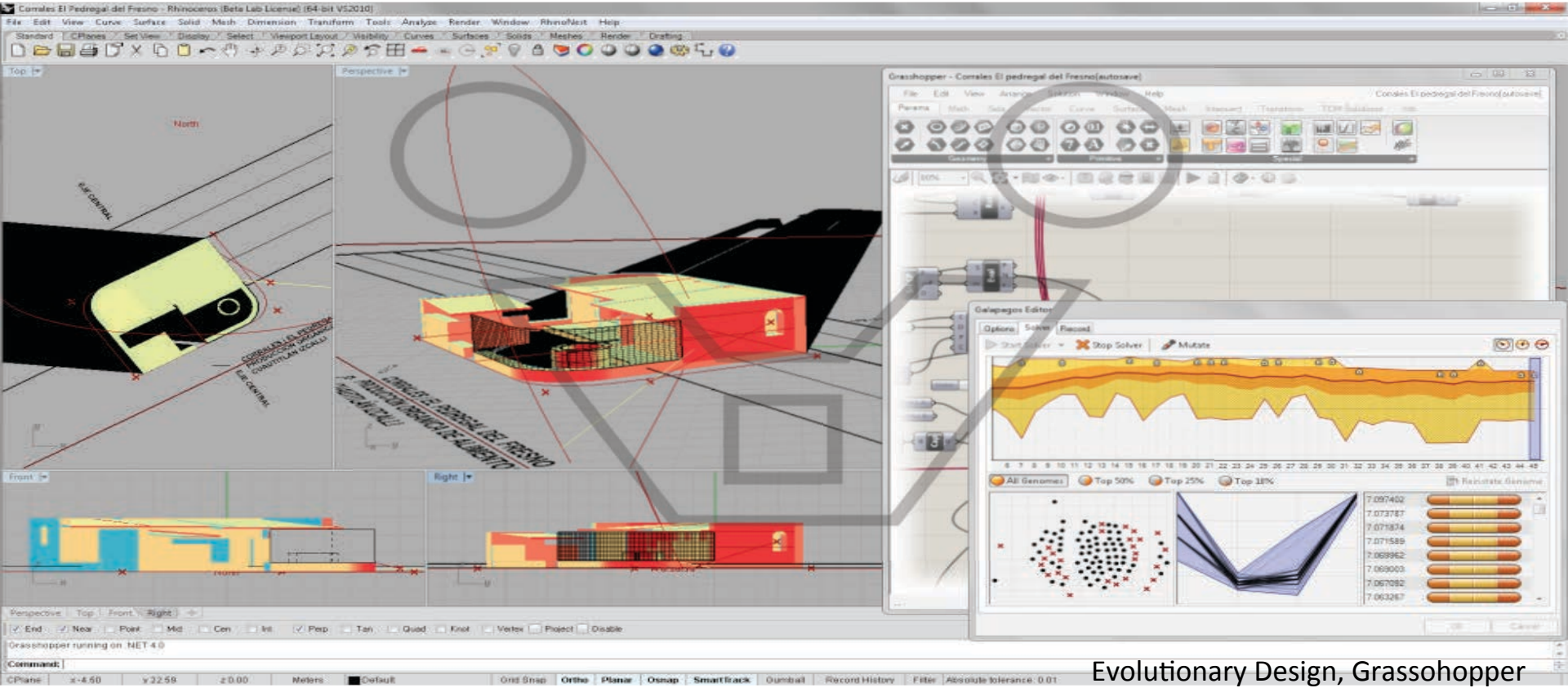
Decision-Making through:

- *formal procedures*
- *evidence-based observation*
- *benchmarking*

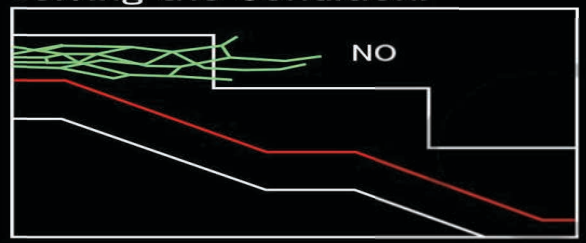


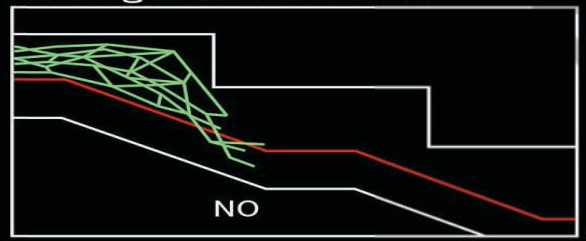


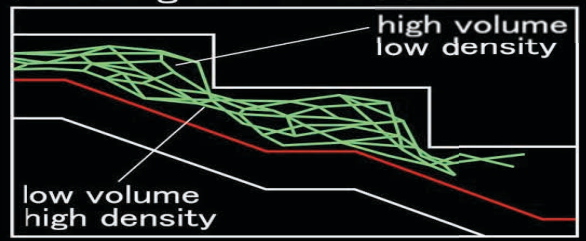
Evolutionary Design, Grassohopper

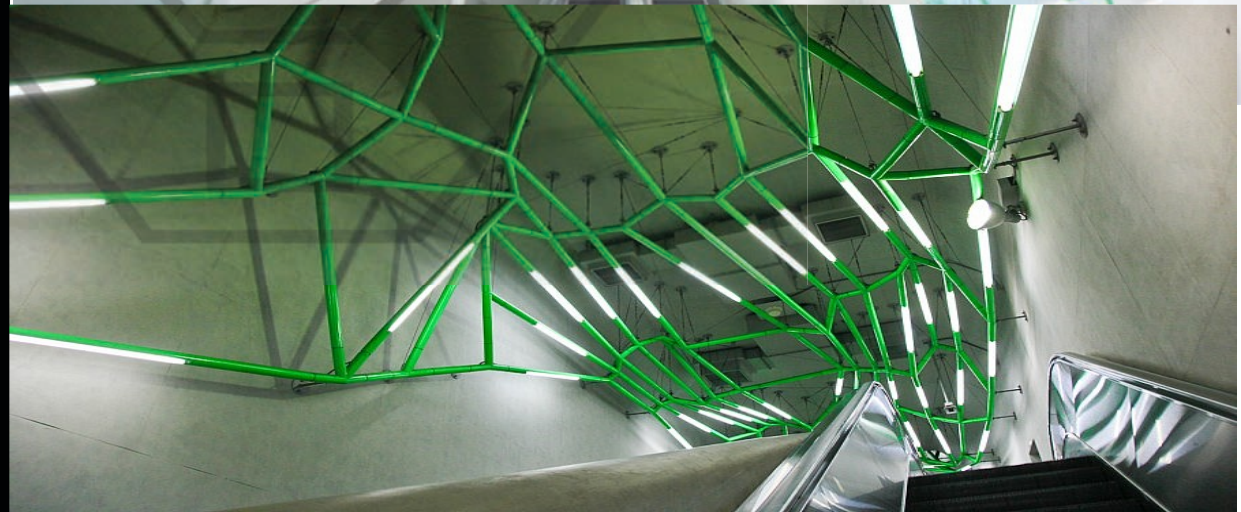


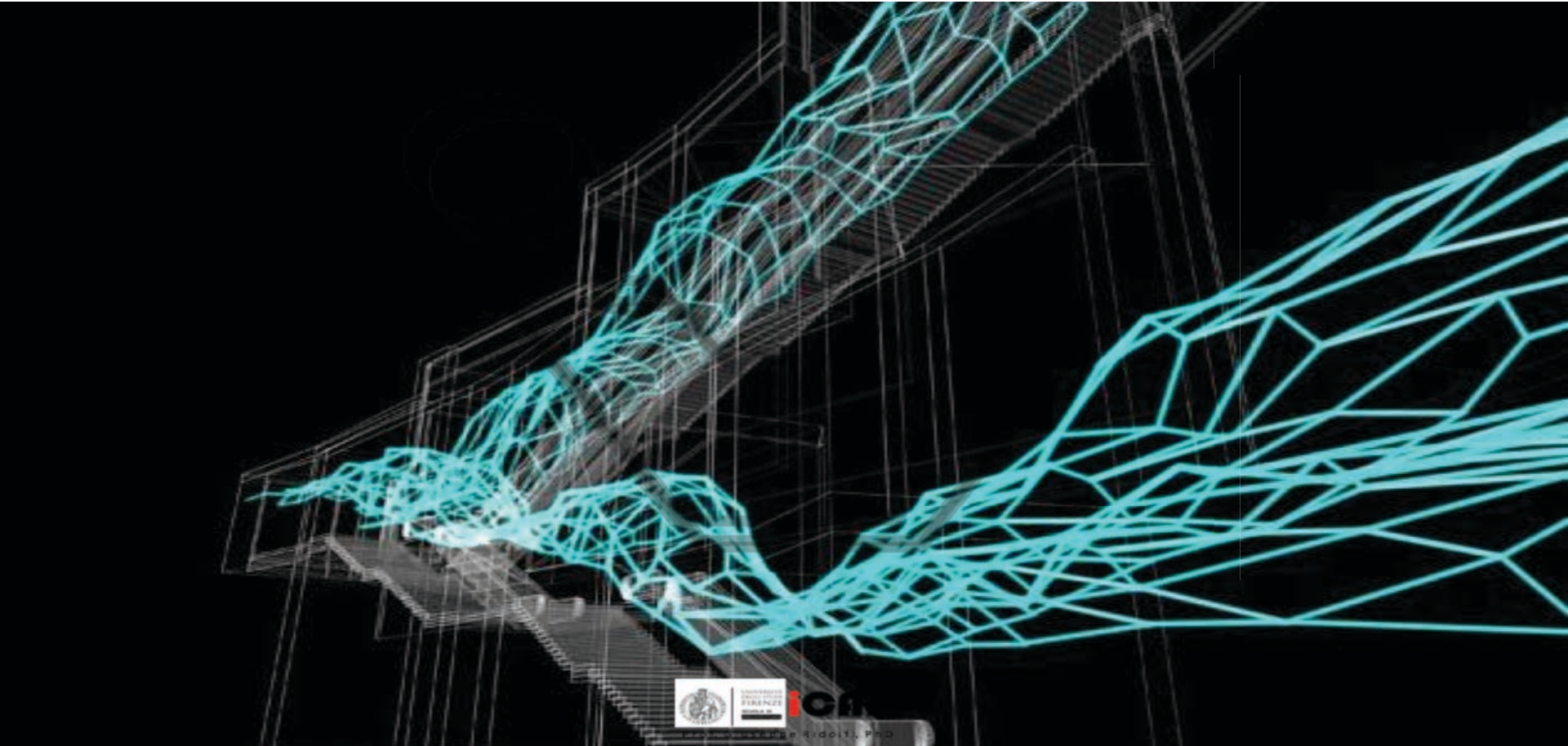
Evolutionary Design, Grassohopper

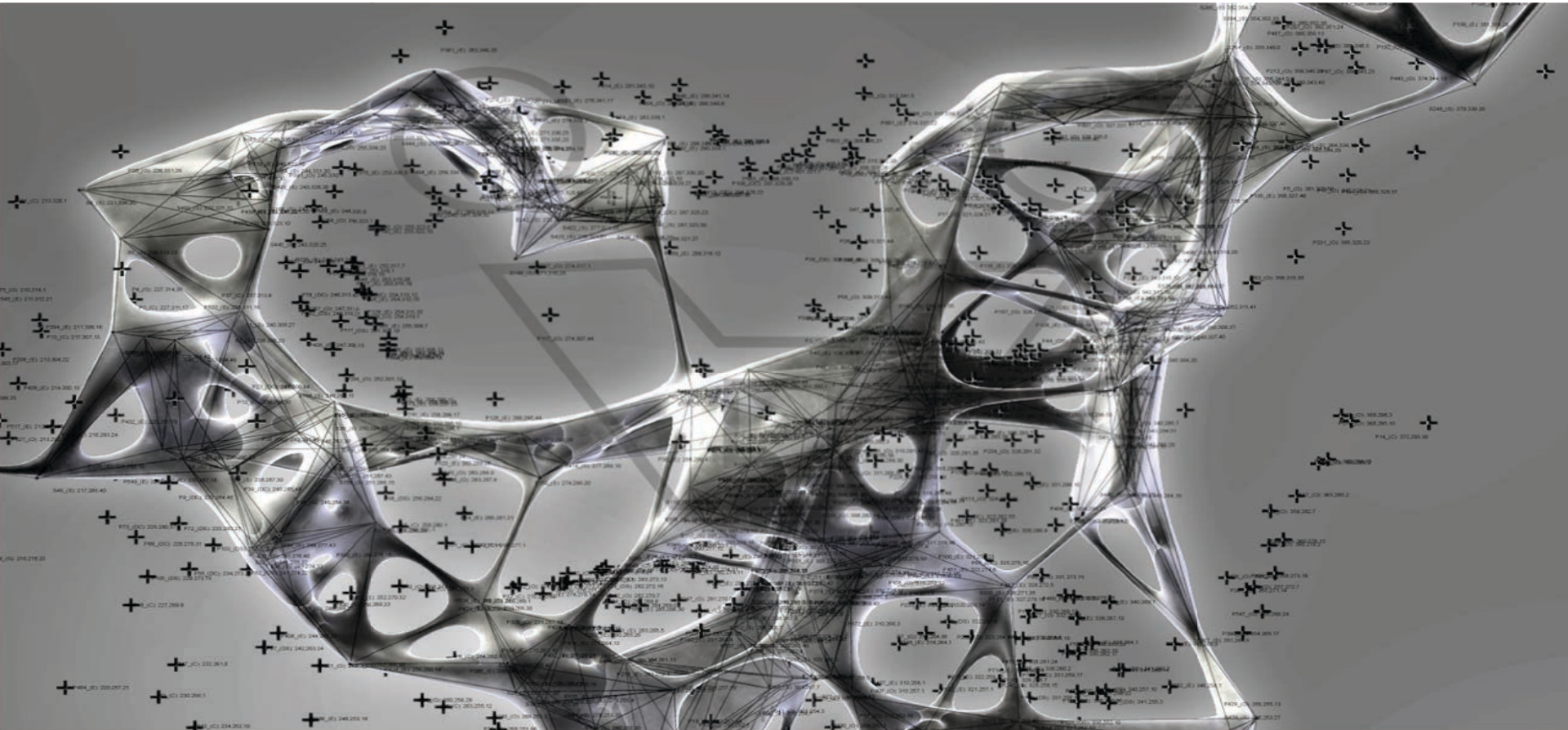

solving the condition:
NO


solving the condition:
NO


following the direction:
high volume
low density
low volume
high density







"For me, it is calculus that was the subject of the issuu and it is the discovery and implementation of calculus by architects that continue to drive the field in terms of formal and constructed complexity" (G. Lynn)

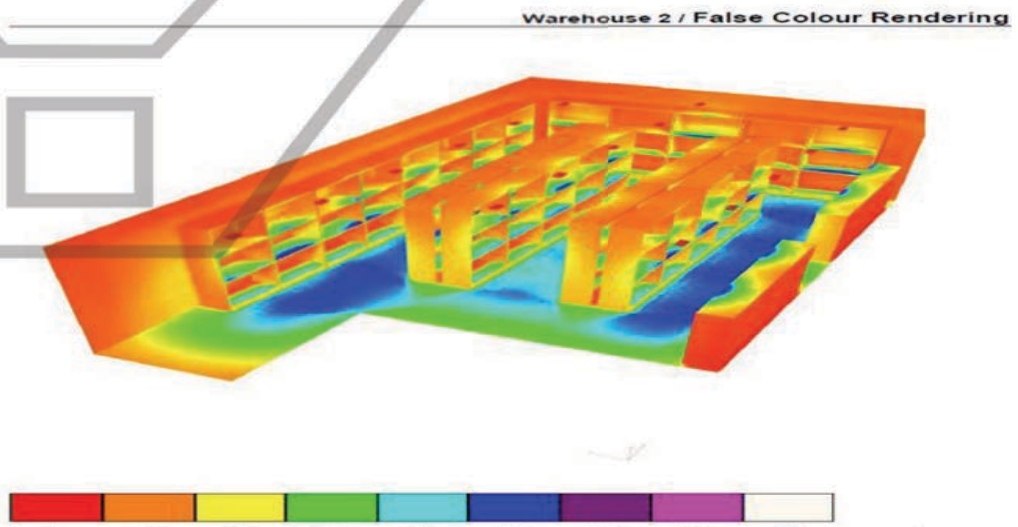
" We are at the point that is possible to inform matter for predictable behaviors.
Informing matter is not anymore and only the production of materials with predictable or definitive forms; materials do not come to live through designing forms, assigning meaningful, visible and understandable forms to matter, assigning univocity, and worshipping the aura.
Today, mastering the matter, is an activity that takes place at the structural level, dealing with relationships, parameters, forces, and energy fields expressed and formulated through the numerical *matema*.
With new technological abilities we are now able to produce *materia operata* (materials), and even *materia prima* (matters), that can be invisible, with multiple possible shapes, able to incorporate performative (more than connotative) information.
As a result we deal with «performative informed un-materiality»: materials «farcé» of that special untouchable matter that is the knowledge; for this reason we can define objects mainly made of un-materiality, able to incorporate information, memories; able to mutate dynamically presences and attitudes, to respond under complex and interrelated conditions, variables, parameters."
-G.Ridolfi

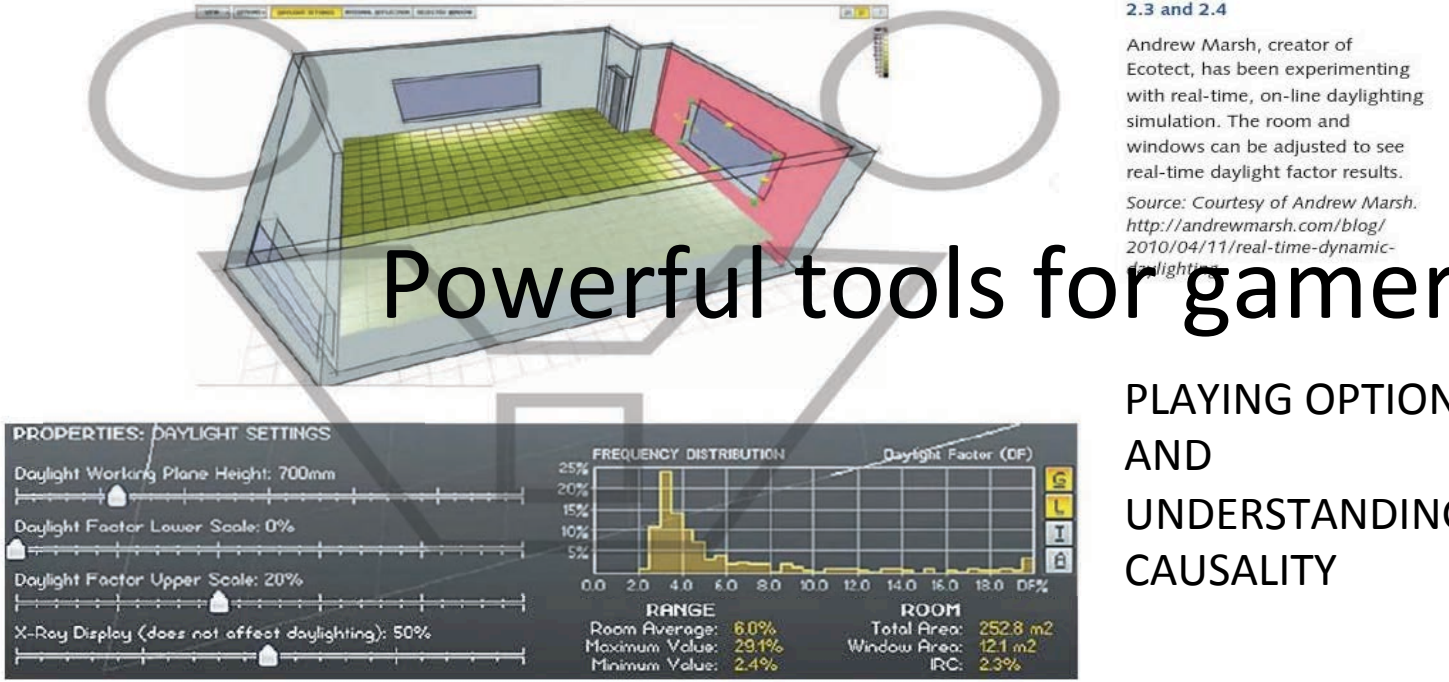
MODELING FOR SIMULATION NUMERICALLY PERFORMANCE BASED

features:

precision
objectivity
replicability
communicability

"... More than that digital tools give us an holistic and visual perception of fenomena in order to have a faster comprehension of a large quantity of aspects" G.Ridolfi





2.3 and 2.4

Andrew Marsh, creator of Ecotect, has been experimenting with real-time, on-line daylighting simulation. The room and windows can be adjusted to see real-time daylight factor results.

Source: Courtesy of Andrew Marsh. http://andrewmarsh.com/blog/2010/04/11/real-time-dynamic-daylighting

Powerful tools for gamers

PLAYING OPTIONS AND UNDERSTANDING CAUSALITY

http://andrewmarsh.com

The art of digital modeling for evaluation purpose

MAIN ASPECTS TO CONSIDER IN DIGITAL MODELING FOR SIMULATION

- Extension
- Deepeness
- Operability

- Accuracy
- Reliability

Level of details => run time* vs accuracy

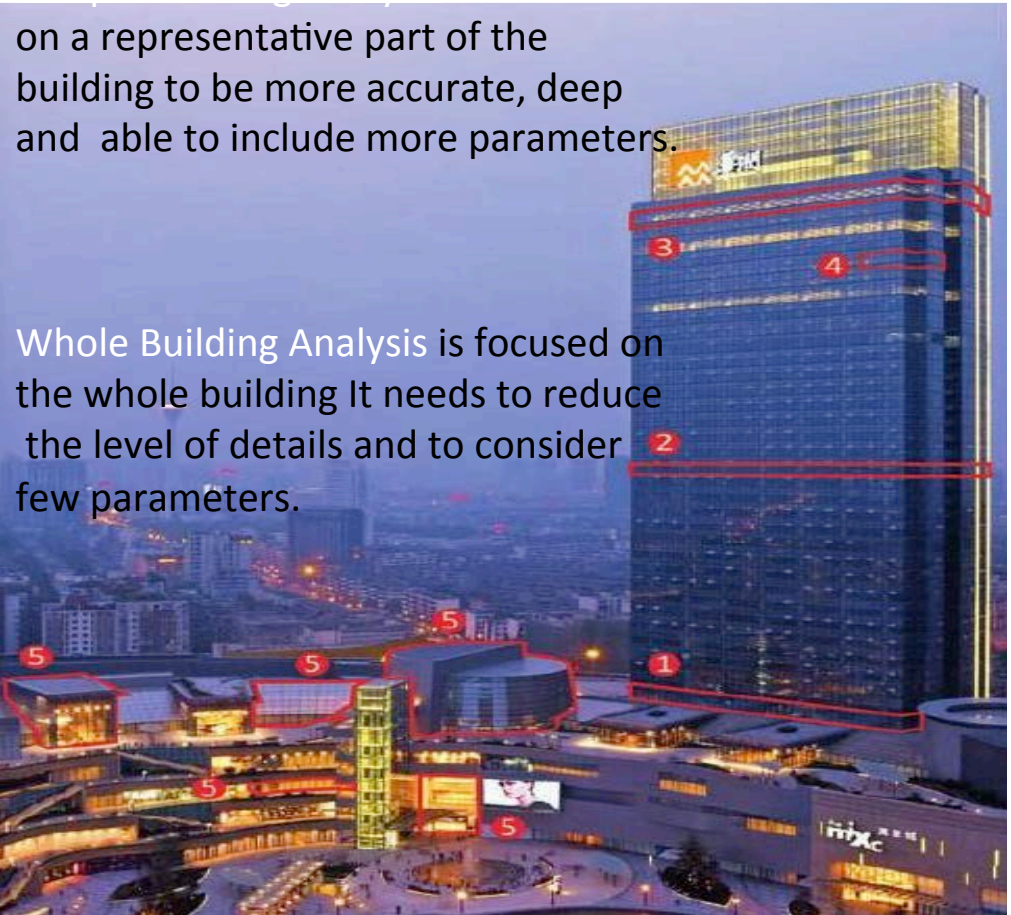
> many tests vs few detailed solutions

***Run time**= amount of time that a computer needs to run the task*

It is important to note that Building Energy Modeling is a computer program and the accuracy of results would largely depend on the inputs provided to the model. In this context, one should be mindful of the expression 'garbage-in-garbage-out'.

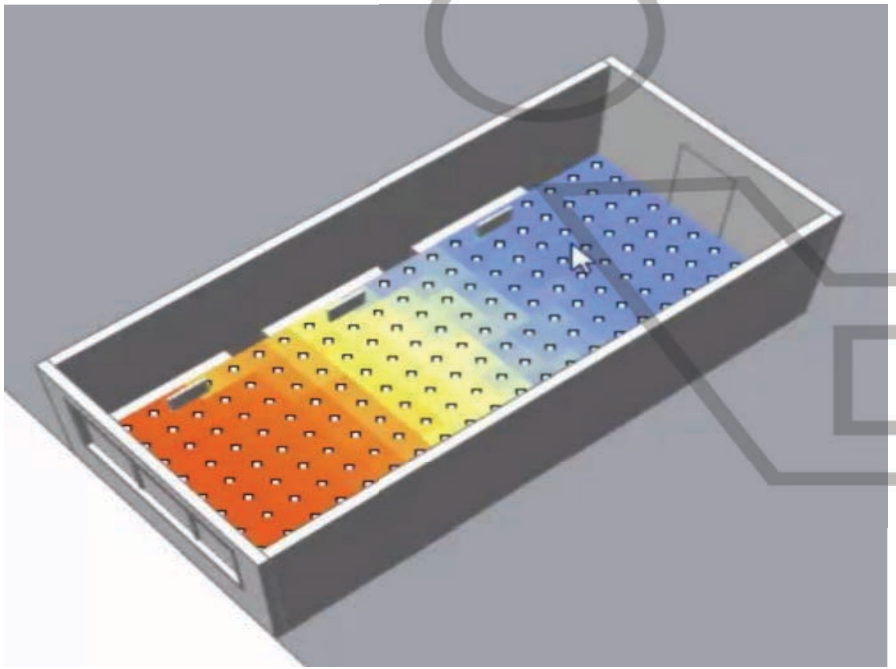
on a representative part of the building to be more accurate, deep and able to include more parameters.

Whole Building Analysis is focused on the whole building It needs to reduce the level of details and to consider few parameters.



While a whole building energy simulation estimates the performance for an entire building, representative floors are typically modeled, including the lowest (1), middle (2), and top floors (3) of a high-rise, with multipliers being used to account for the other floors. Each atypical floor is modeled separately. Shoebox modeling analyzes a single floor or space within a floor for energy performance. For instance, a corner of a building (4) that may be exposed to solar energy from multiple directions can be tested for comfort and energy performance. A shoebox model can also be used to estimate and improve the energy use of smaller or unique spaces (5). Any scale can be studied more quickly with a single-aspect analysis, including an entire building, a single floor, or unique condition.

Source: Photo of LEED Gold certified MixC Chengdu © 2012 Callison LLC.



SHOEBOX ANALYSIS

1-Set boundary conditions able to represent meaningful or critical parts, systems, aspects of the building

2-Set adiabatic perimeters

3-Iterative input of different conditions in order to test different behaviours

4. Run analysis

5. Analize and evaluate

OTHER TYPES OF MODELING FOR SIMULATION

STATIC

DINAMIC

TIME-STEP analysis = over a period of time hour season, year

POINT-IN-TIME (PIT) analysis= in a precise single moment segment like hottest hours