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## ***3D Substation Design at Hydro-Québec***

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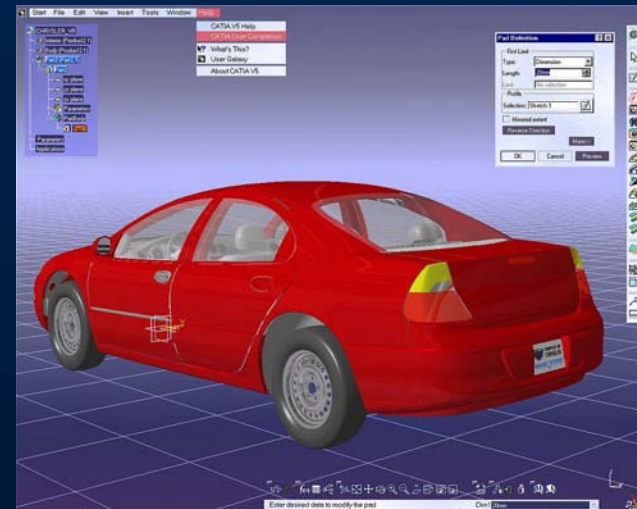
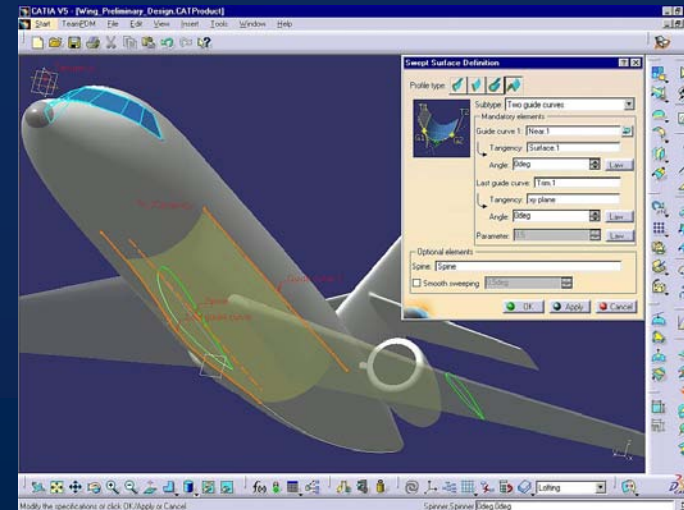
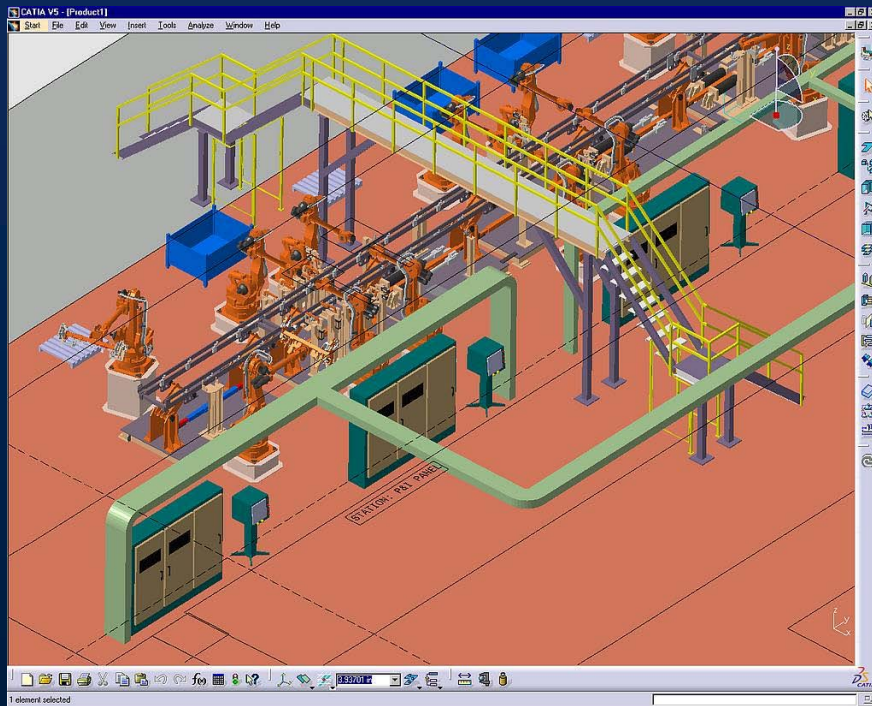
*By Sylvain Lamothe, Eng.*

**IEEE PES Substations Committee Annual Meeting, Montreal 2010**

## ***Presentation Summary***

- **How do we apply 3D CAD at HQ?**
- **History of 3D in substation design**
- **Some examples of developments**
- **Conclusion**

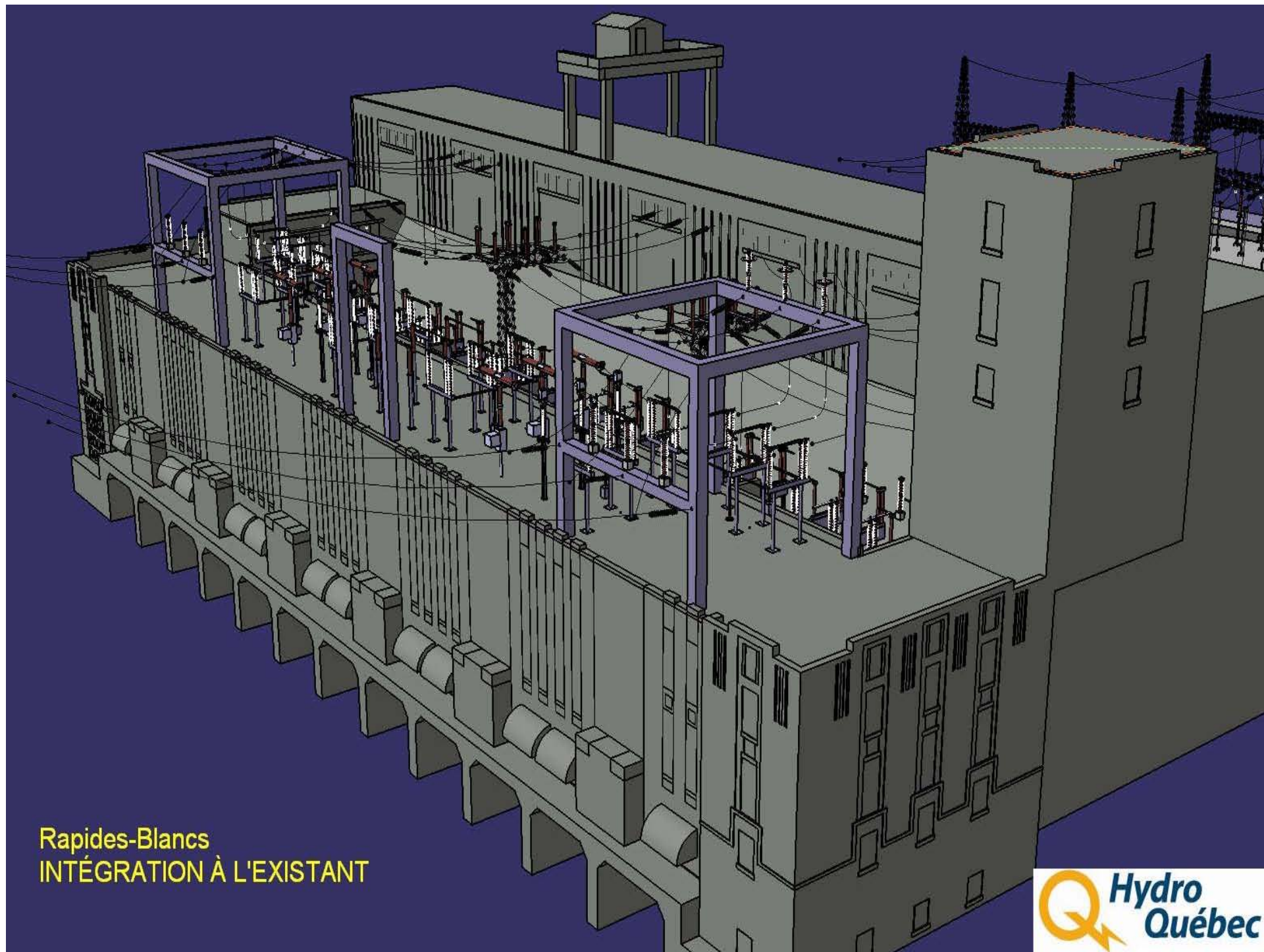
# What is 3D CAD?



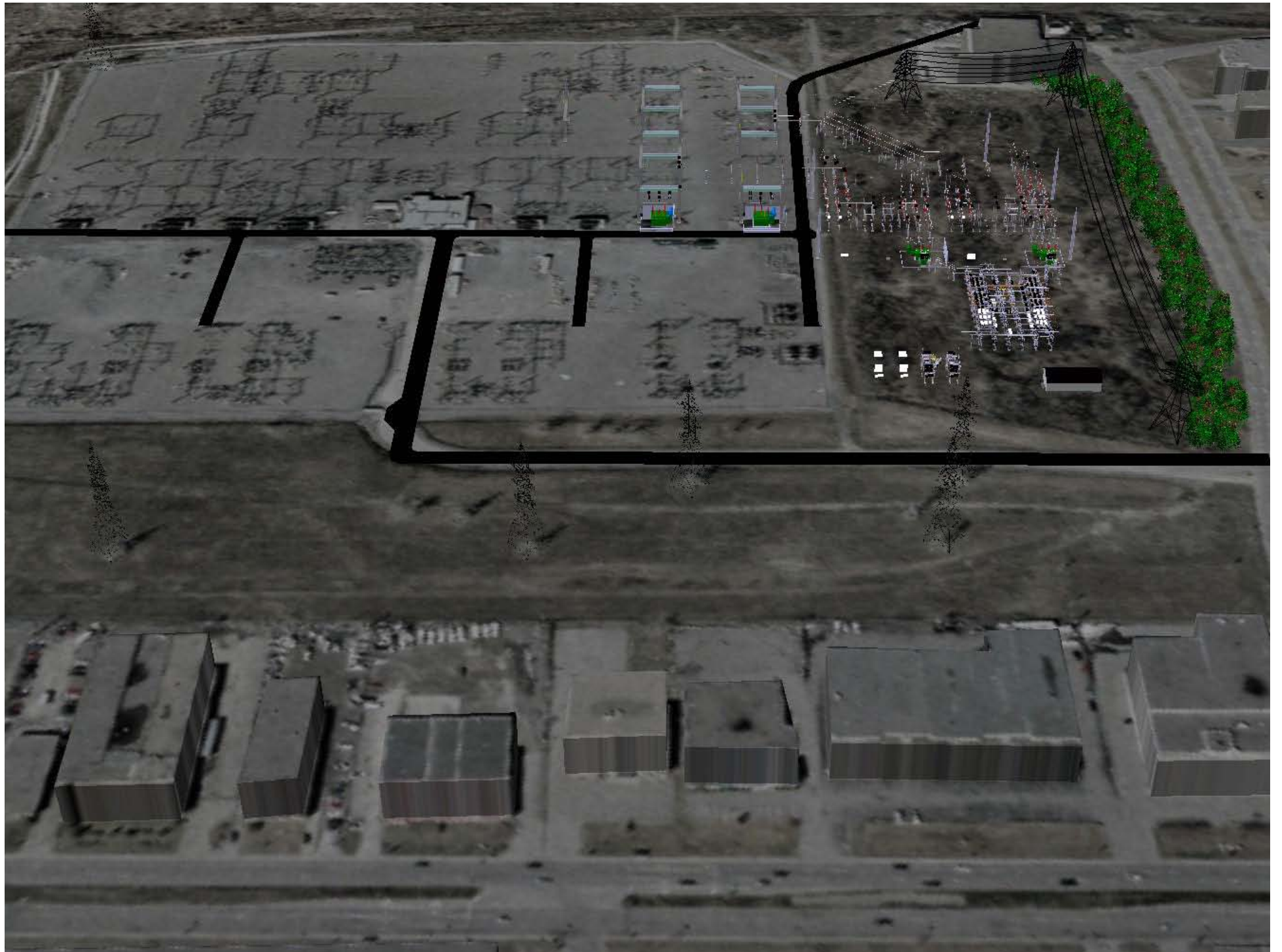
## *How do we apply this technology at Hydro-Québec?*

- We use 3D CAD software to design our new substations and new powerhouses (CATIA V5 from Dassault Systemes).
- Presently, more than 40 substations are modelled in 3D
- Most of the engineering of the various departments are joined together in a unique 3D model.
- Automatic generation of the 2D drawings from the 3D model.





Rapides-Blancs  
INTÉGRATION À L'EXISTANT



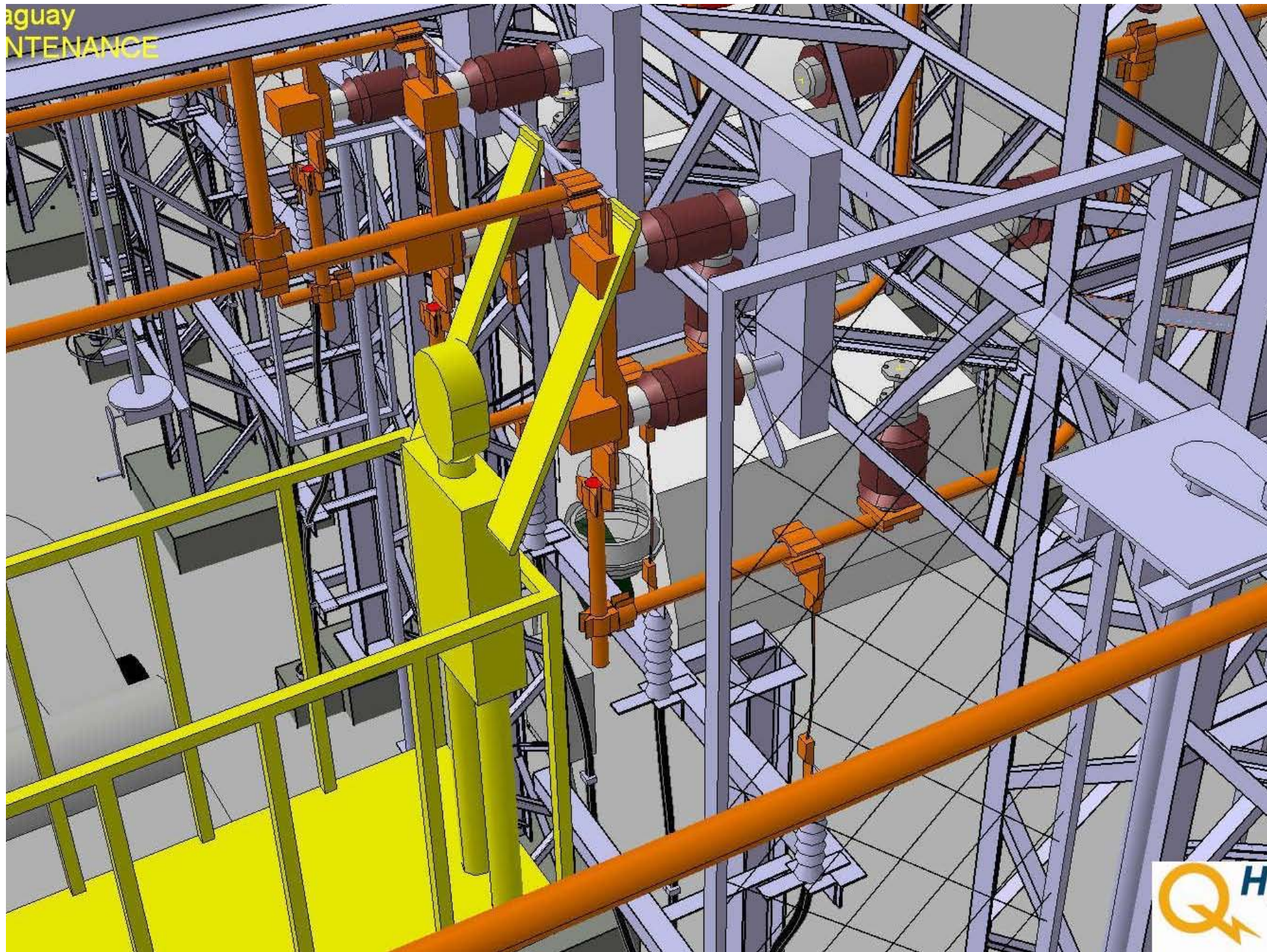




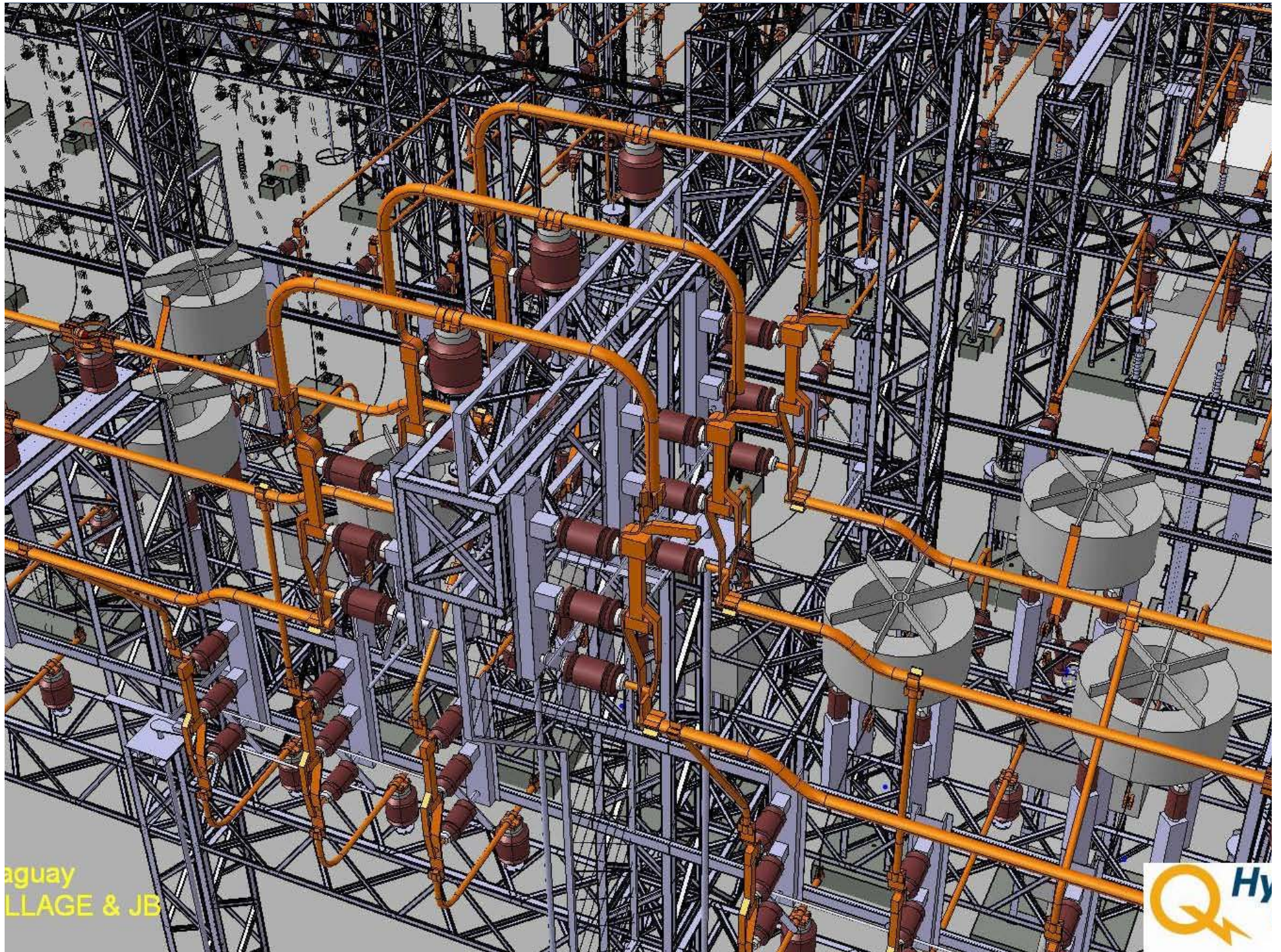




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LLAGE & JB









## ***Advantages of 3D CAD***

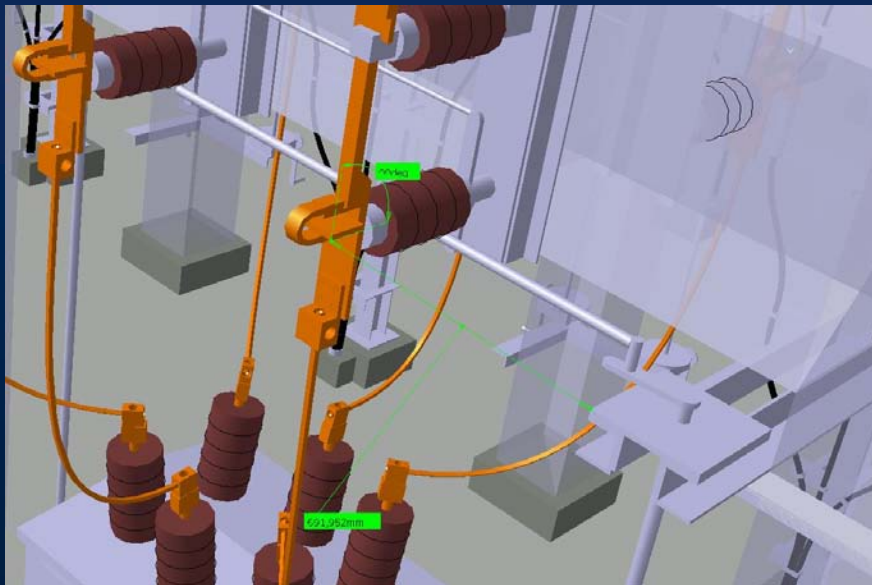
- **The main objectives for the implementation of 3D are the improvement in the quality of the deliverables as well as the improvement in the design's efficiency.**
- **Reduce the amount of changed request on construction site**
- **Design review on a 3D substation**
- **Easier to do alternative designs**

## *Advantages of 3D CAD*

- **Facilitates the communication and collaboration between the various stakeholders and is particularly useful during public hearings.**



## Advantages of 3D CAD



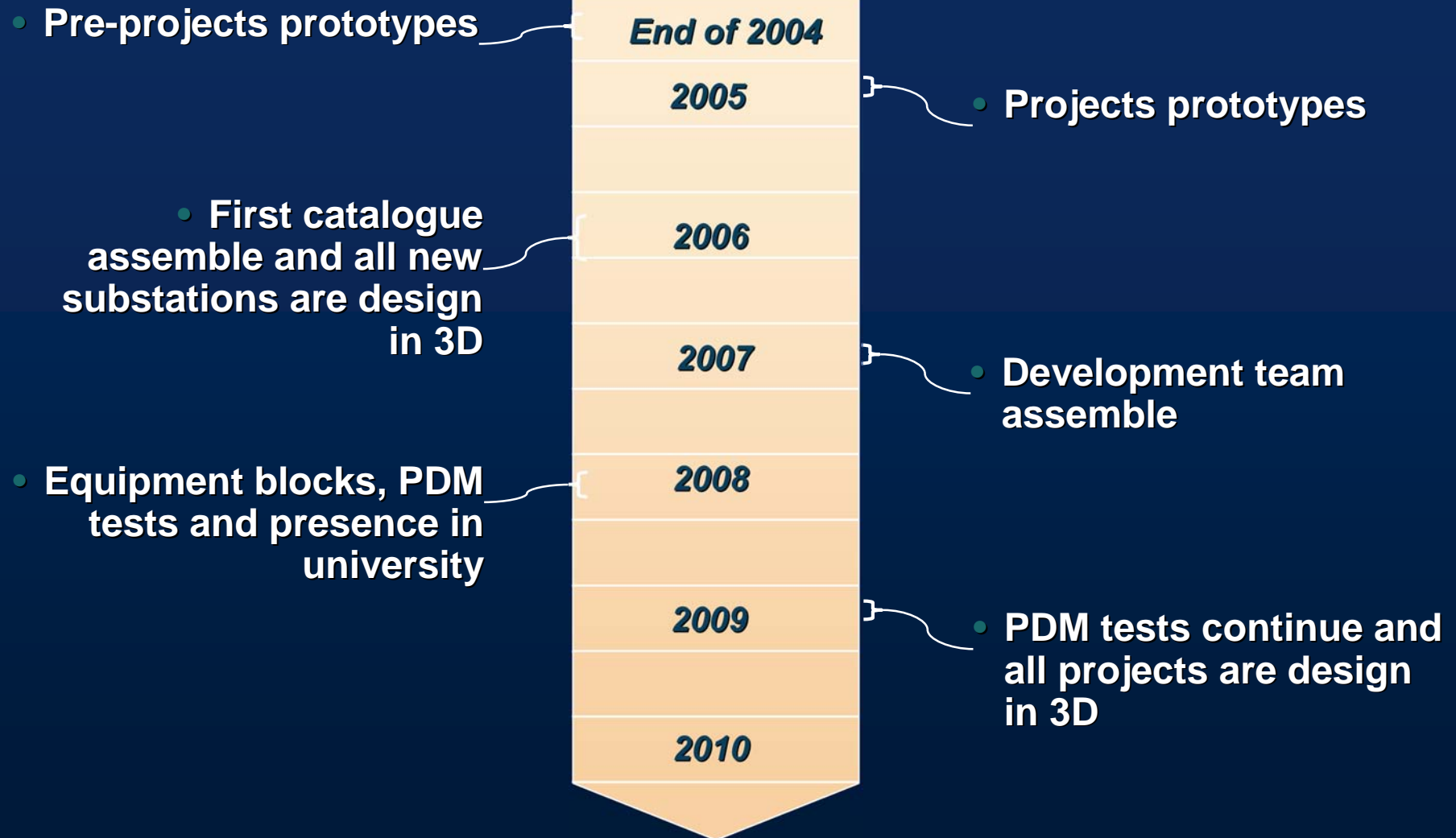
- **Better inter-disciplinary coordination**
- **Electrical clearance can be easily validated.**
- **Conflicts and errors are detected sooner in the engineering process.**



## *History of 3D in substation design*

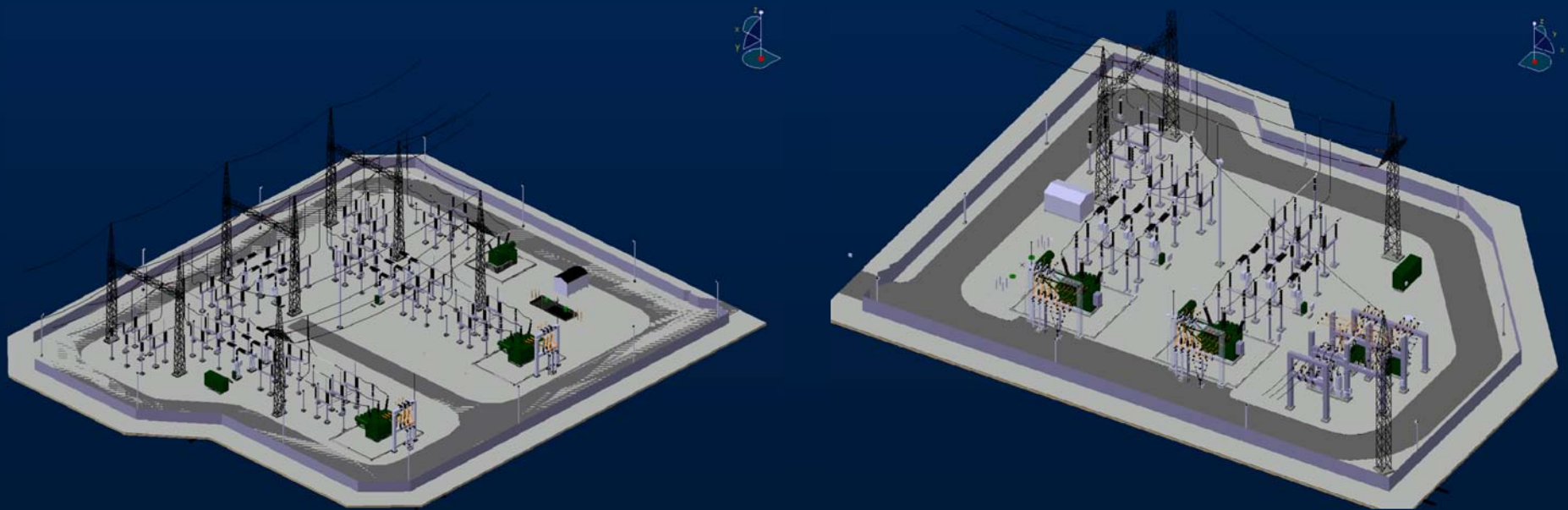
**From 2004 to today...**

## History overview



**2004**

- At the end of 2004, 2 pre-projects were used as prototype for 3D design.
- Chutes-Allard and Rapide-des-Coeurs are powerhouses substations 13.8-230 kV





**2005**

- **Projects: Complete design with 3D CAD software of the 2 substations Rapide-des-Coeurs and Chutes-Allard.**
- **Pre-projects: few new substations are design with 3D CAD.**
- **Getting familiarized with the software.**

**2006**

- Every new substation is design in 3D.
- First version of the catalogue is in use for everyone.
- St-Lin substation: First substation project with 3D CAD design by a engineering consultant (end in early 2007).




**2007**

- **May: A team is created to manage and realize 3D CAD development.**
- **A team leader and a 3D CAD specialist were the permanent members.**
- **5 others persons were part-time members**



2007

- August: Paper presentation at Cigré Canada Conference on Power Systems 2007 in Calgary, AB.
- Paper #438A – Computer Assisted Design (CAD-3D)



SC B3 Substations  
PS2 New Challenges in Substations  
Innovative designs/layout

Computer Assisted Design (CAD-3D)

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CATIA®<sup>1</sup> (Computer Aided Tridimensional Interactive Application) is a 3D modeling software widely used in the automobile and aircraft industry. Lately, the software has been adopted by Hydro-Québec for the design of new power stations and substations.

Hydro-Québec has been testing CATIA® for the last two years for the design of electrical substations. During this time, 24 electrical substations (there is approximately 500 substations on Hydro-Québec's network) were modelled in whole or in part in 3D.

The technical deliverables for an electrical substation consists of numerous drawings from several departments (electrical, civil, architecture, etc). Using CAD tools, all the engineering of the various departments are joined together in a unique 3D model.

The software automatically generates the 2D drawings from the 3D model. This insures coherence between the various 2D drawings, reduces the cost and the time of engineering and allows for a better flexibility when simulating design alternatives.

Advantages of CAD

The main objectives for the implementation of 3D are the improvement in the quality of the deliverables as well as the improvement in the design's efficiency. The advantages of a 3D model when compared to 2D drawings are:

- Facilitates the communication and collaboration between the various stakeholders (engineering, firms, customer, purchasing, management, contractors) and is particularly useful during public hearings.
- Substations are often located in urban areas. The neighbouring populations are naturally worried about the disturbance that the presence of a substation may cause to their life quality. When we use 3D models, concerns are quickly dissipated in most cases. The general public can appreciate more easily how the project can be implemented harmoniously in their environment.
- The 3D model allows to store attributes for each installed equipment. It is therefore possible to automatically generate bill of materials for purchasing.
- 3D models facilitate interdisciplinary integration. Electrical clearances can be easily validated in 3D. In consequence, the early detection of

<sup>1</sup> CATIA is a registered trademark of Dassault Systemes SA.

1

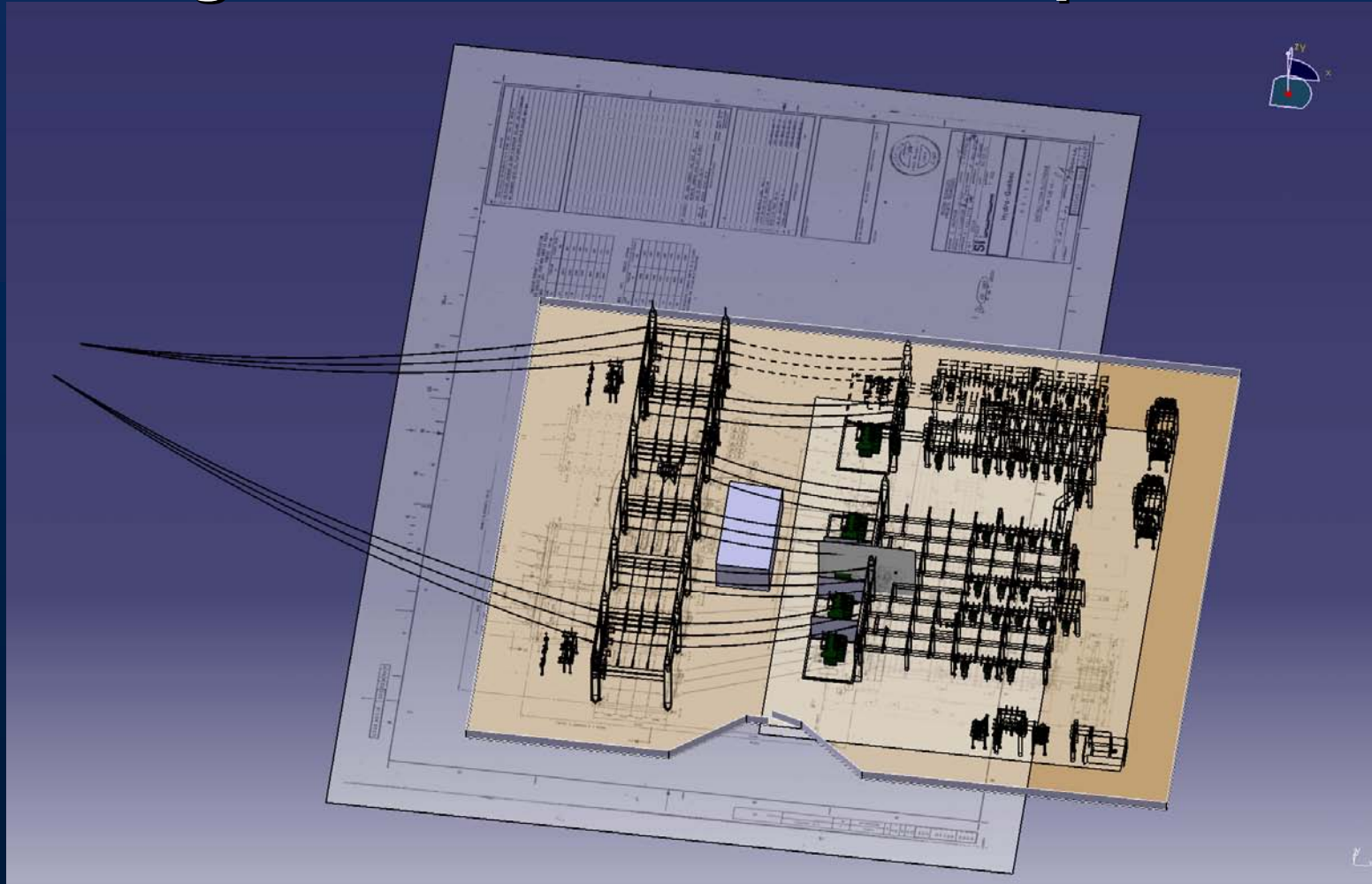
2007

- November: Hiring of Philippe Graveline, P.Eng. Jr. and CATIA V5 specialist.
- Paper published in Utility Automation (now Electric: Light and power)



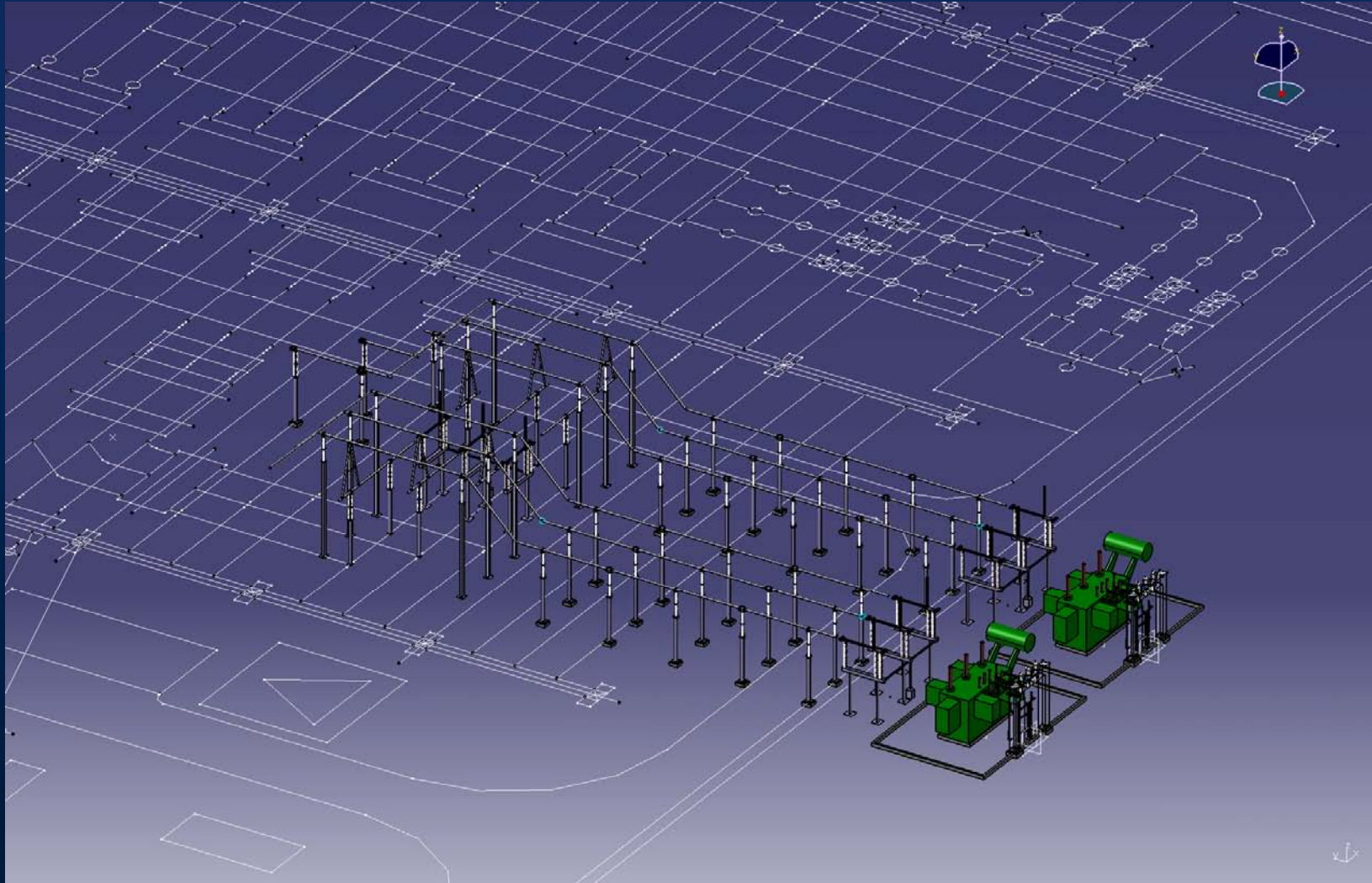
**2007 : End of the year**

**A new method of integration of existing 2D drawings in 3D models is developed.**



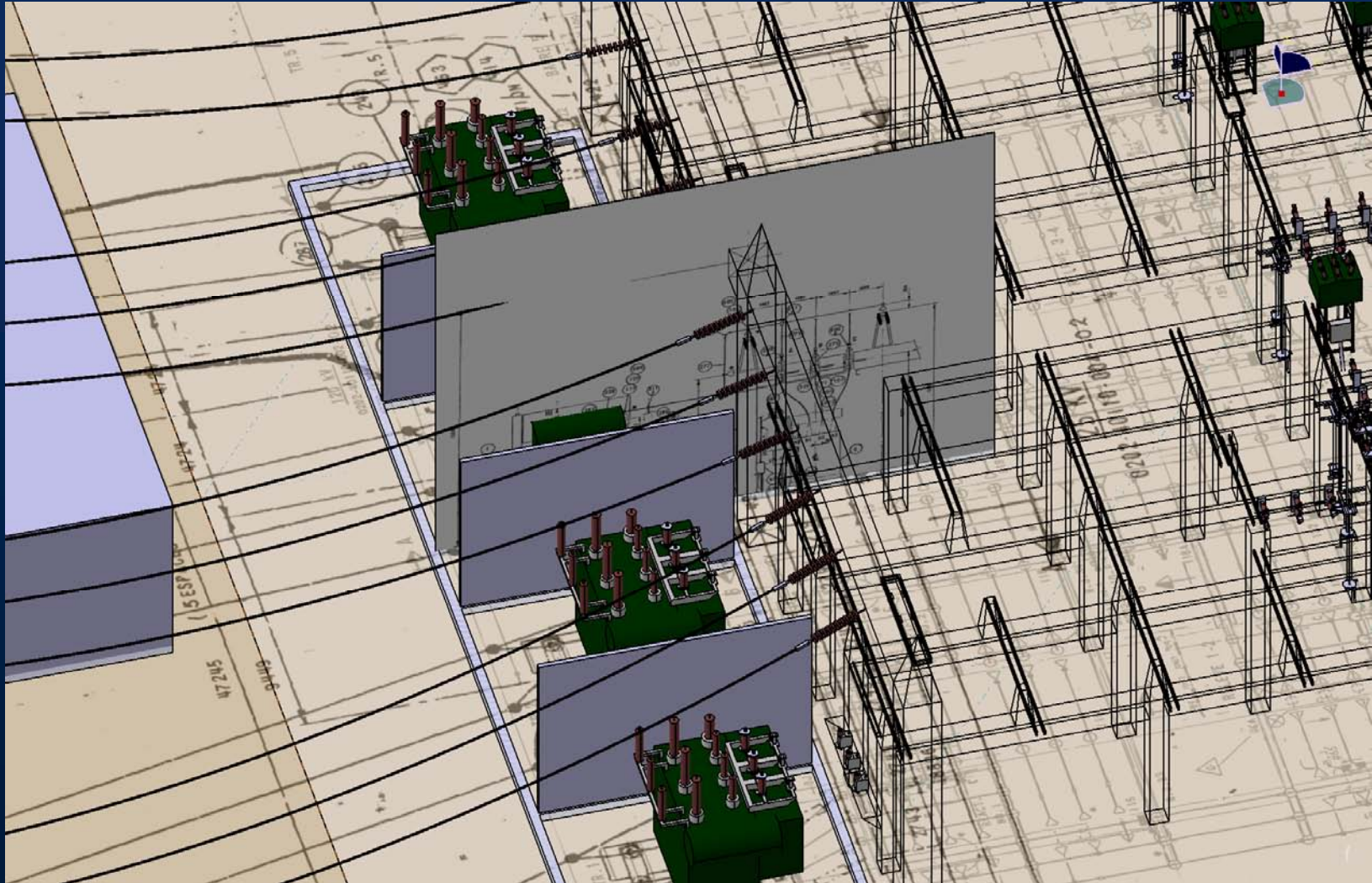


## ***2007: 2D AutoCAD integrated in 3D model***

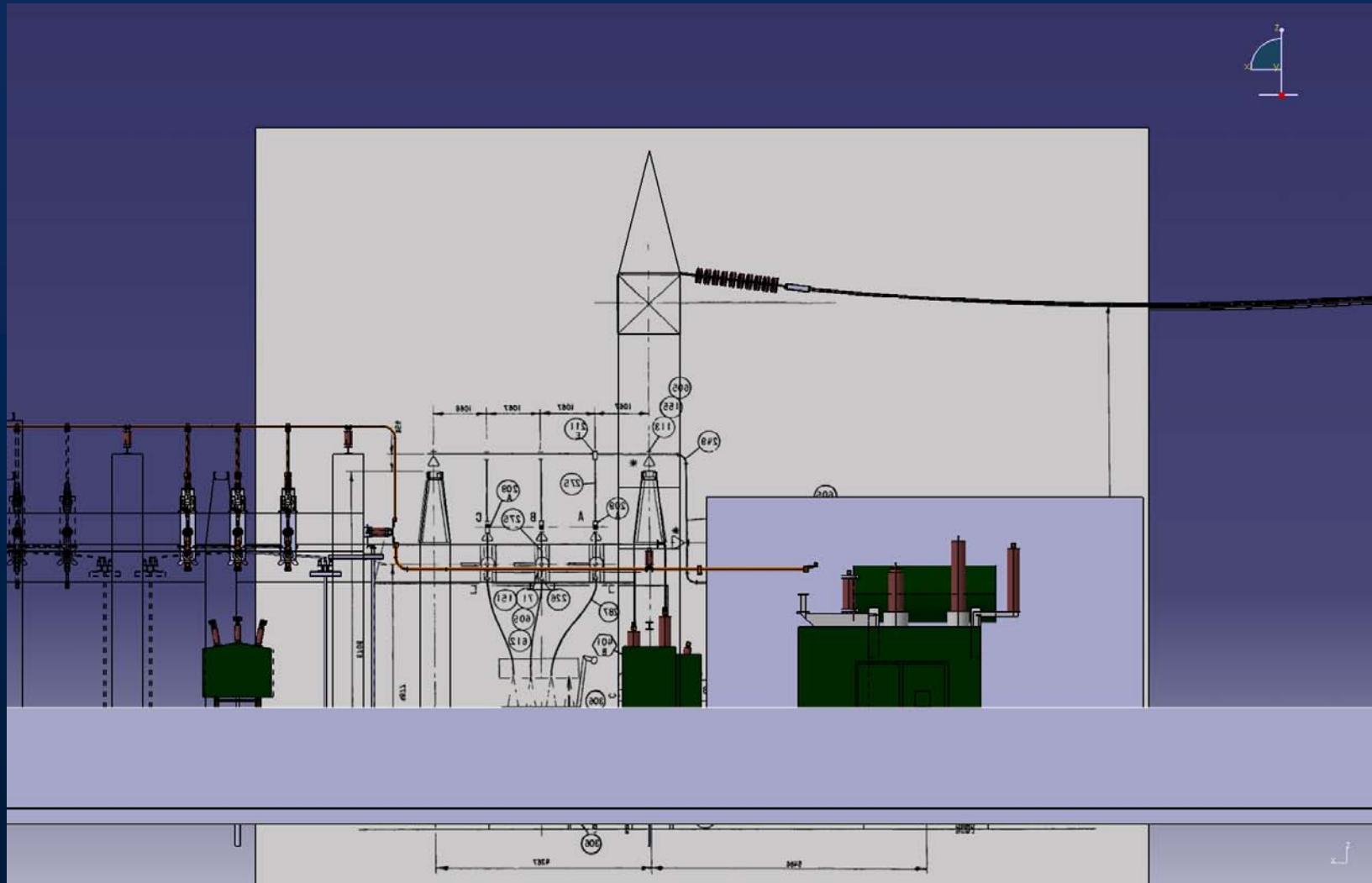




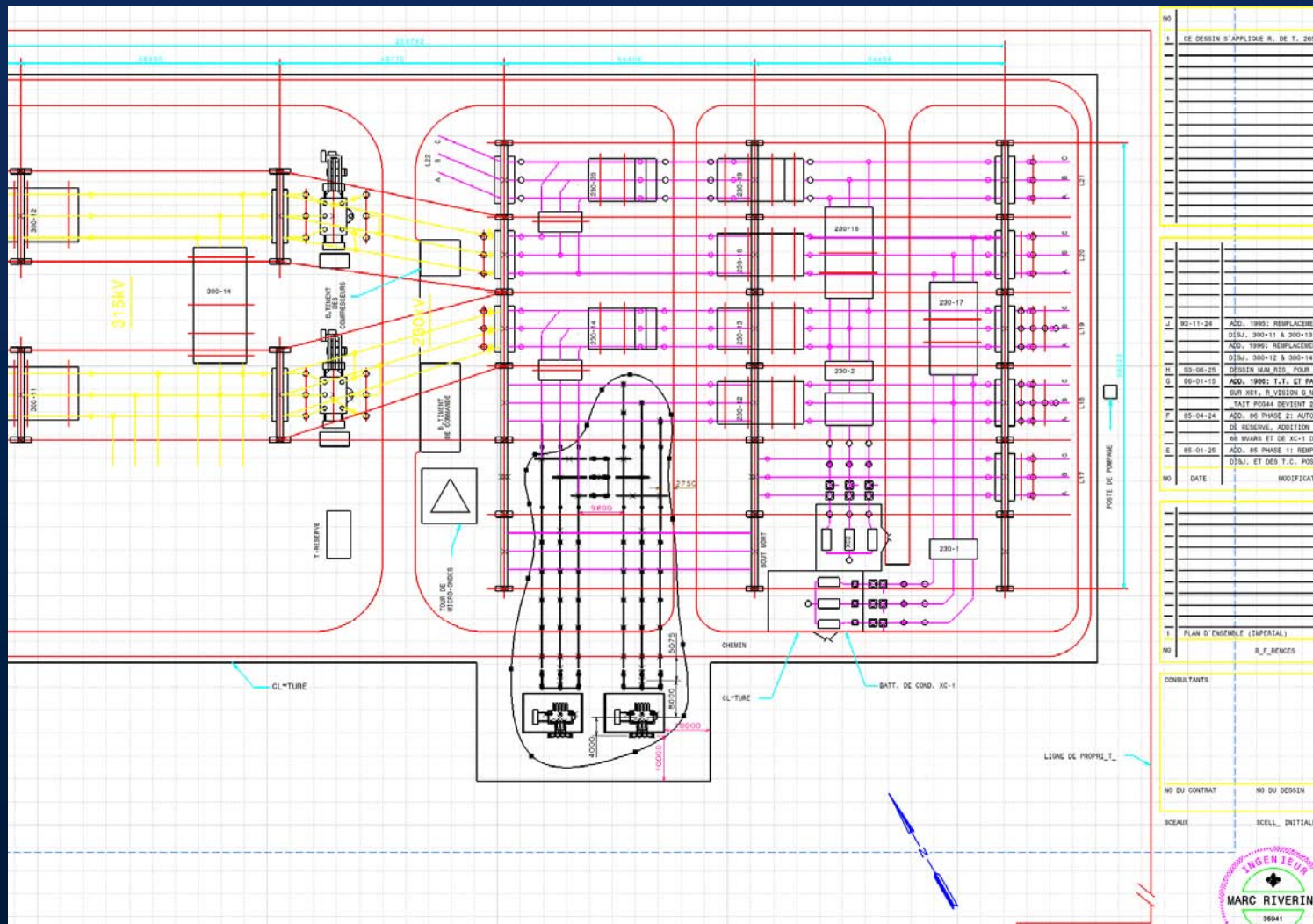
## *2007: 2D scanned integrated in 3D model*



## *2007: 2D scanned integrated in 3D model*



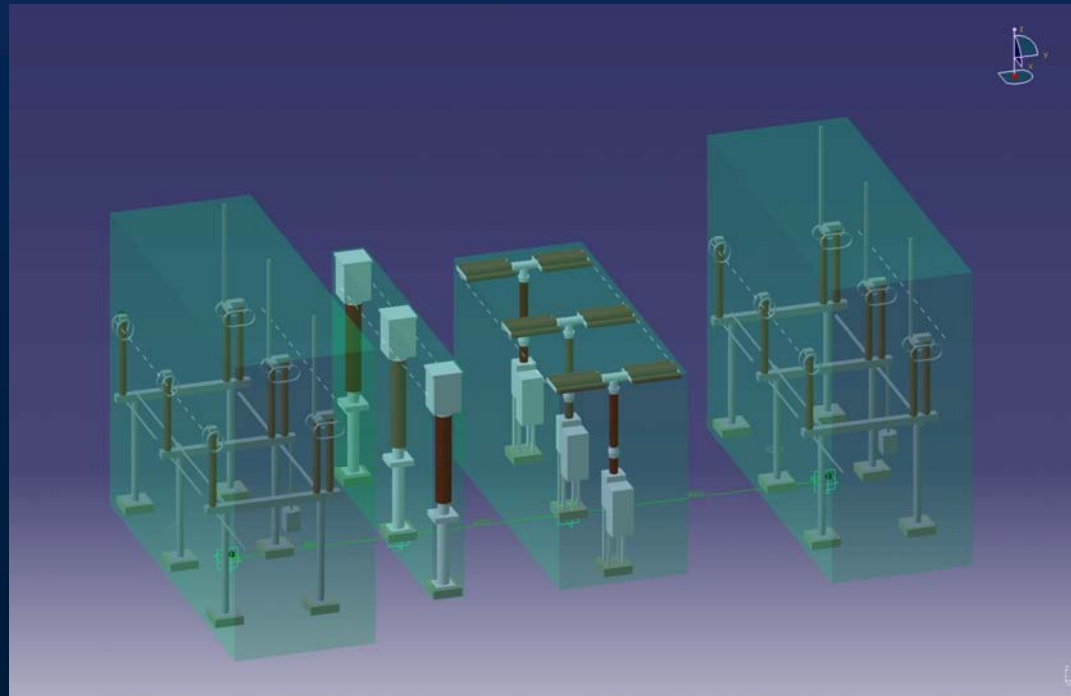
## 2007: 2D plan resulting from the combination





**2008**

- **January: The Equipment block idea is emerging from our minds.**
- **Electrical equipment that are usually used together are grouped in blocks.**





## ***2008: Simplification***

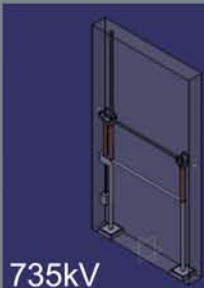
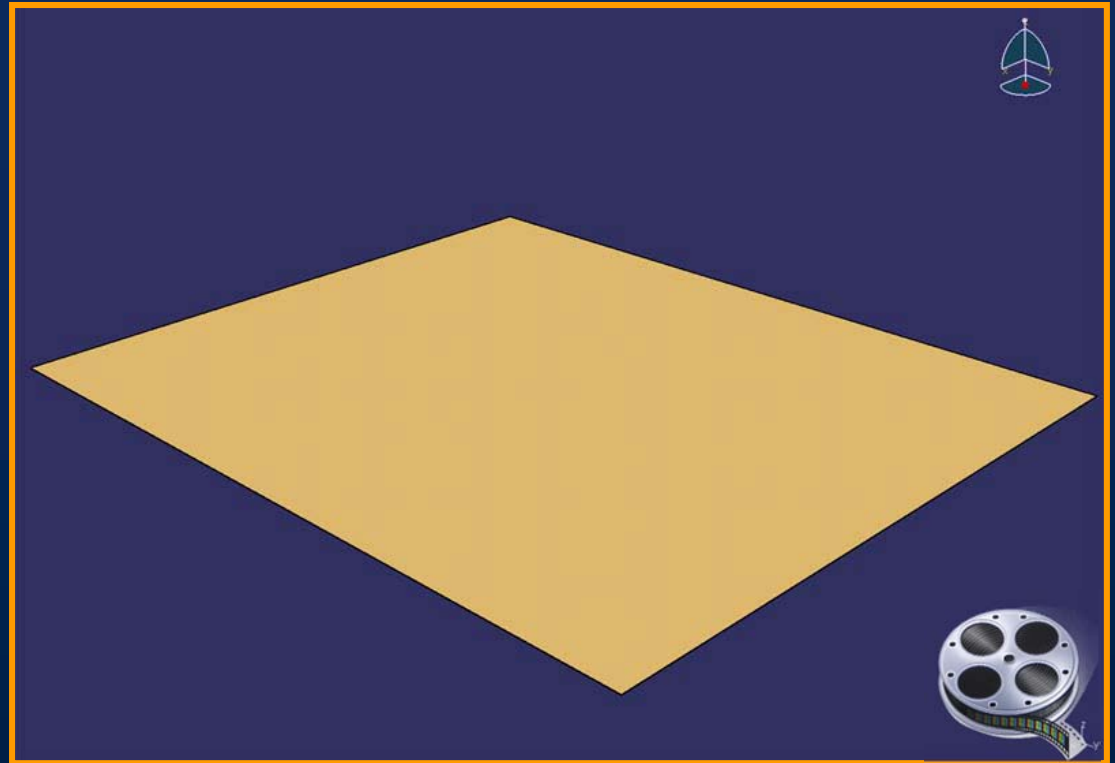
- **Building a 3D substation model is a complex task**
- **The engineer would need a good knowledge of the software and of Hydro-Québec 3D standards.**
- **Also the engineer would have to spend time being up-to-date with the really fast changes in the 3D CAD technology.**

## ***2008: Simplification***

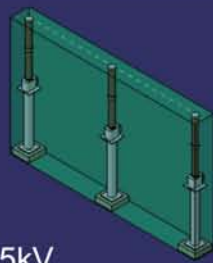
- **Today's engineer isn't knowledgeable enough in 3D CAD to be efficient.**
- **How can engineers use 3D CAD for their projects without costing the utility, time and money?**
- **Our answer: Equipment blocks**

## *Equipment blocs – A tool for the future*

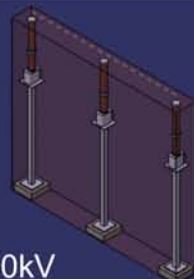
- **Rapidly creates an view of the substation**
- **Allow to study different scenarios easily**
- **Can generate a 2D (top view) faster**



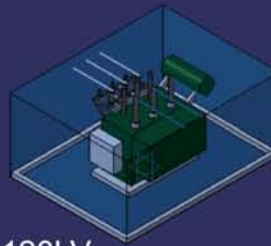
735kV



315kV



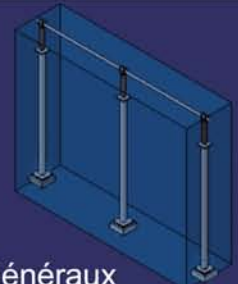
230kV



120kV



25kV



Généraux

***2008: January***

- **Start testing design with the PDM software.**
- **Product Data Management software use at Hydro-Québec is Smarteam.**



## *2008: Teaching 3D CAD to undergraduates*

- Winter 2008 semester, first non formal course for undergraduates in 3D CAD for high-voltage electrical engineering
- Given through IGEE program
- 12 hours optional course

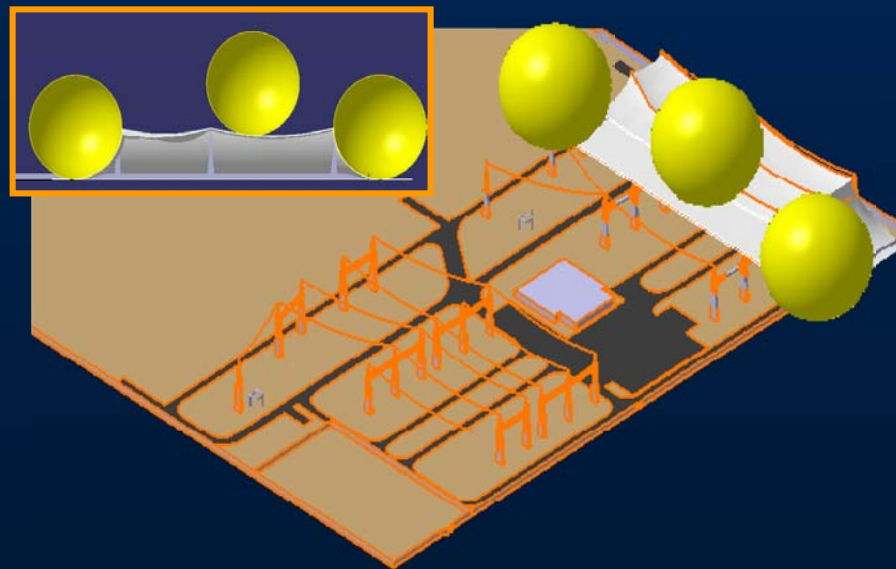


## **2008: 3D CAD course**

- **The primary objective was to interest students in 3D substation design.**
- **The secondary objective was to test our blocks concept.**
- **At the end of the course, students were able to build simple substation models.**

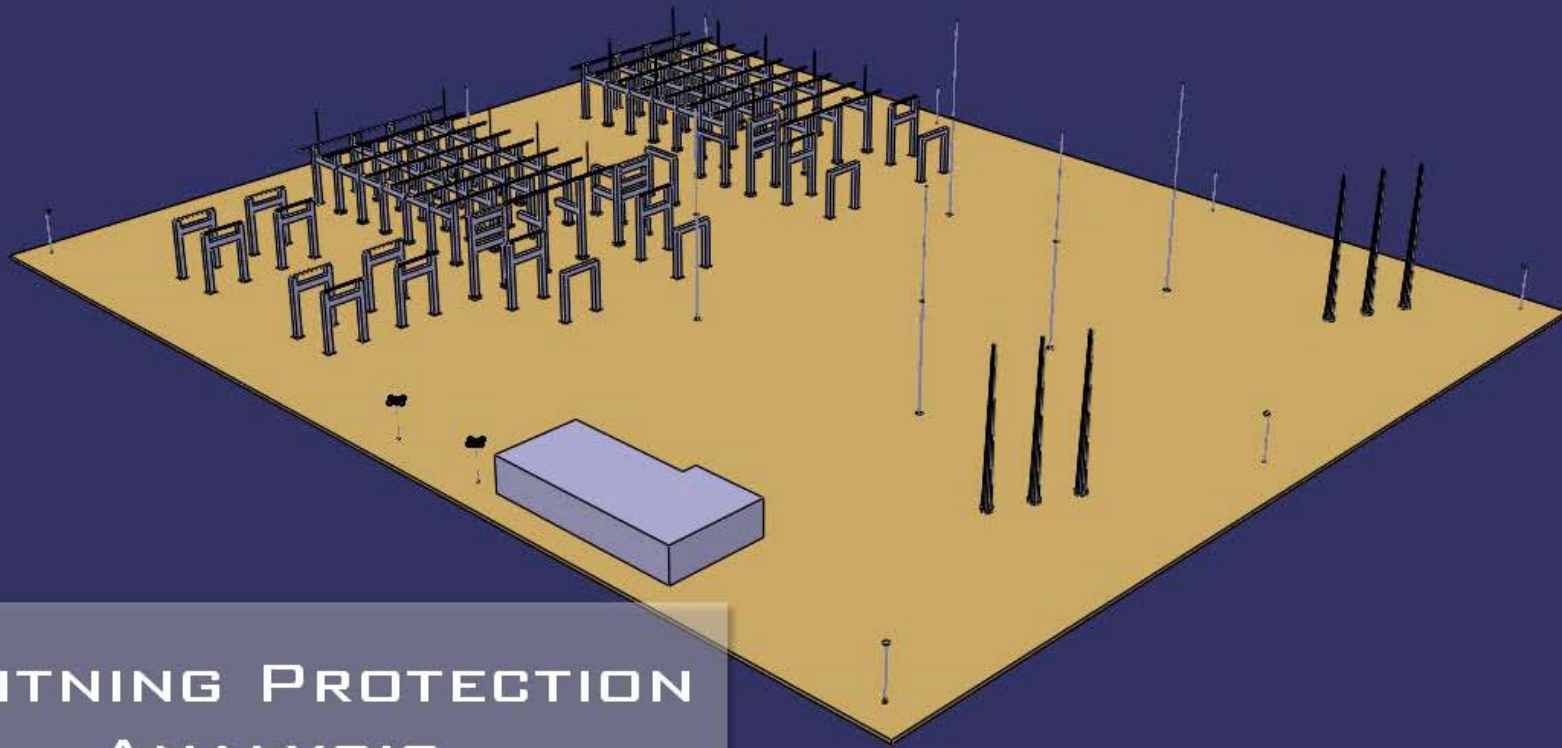
## 2008: *Lightning protection design*

- Modelling with 3D CAD the lightning protection to the standard IEC 62305, 2006-1
- Engineers can optimize lightning protection by rapidly examining different scenarios.
- The application does not have any intelligence.





## 2008: *Lightning protection design*



LIGHTNING PROTECTION  
ANALYSIS

- Second Paper published in Utility Automation (now Electric: Light and power)

The screenshot shows the homepage of the Electric Light & Power website. The header includes the site's name, navigation links (Home, Generation, T & D, Metering, Policy & Regulation, Renewable Energy, Energy Efficiency/DR, Utility Products, Customer Service, Smart), and a search bar. The main content area features an article titled "Advances in 3-D Substation Design at Hydro-Québec" by S. Lamothe and P. Graveline. The article discusses the use of 3-D CAD technology for substation design, highlighting cost savings and improved efficiency. A sidebar on the right contains a large advertisement for "Optmze." and a "MOST RECOMMENDED" section listing various articles.

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**Advances in 3-D Substation Design at Hydro-Québec**

By S. Lamothe and P. Graveline, Hydro-Québec

Engineering projects are being carried out at an increasingly rapid pace in our day. Invariably, the goal is to reduce engineering time and costs, and this is true of all enterprises, not just energy providers. To do so, Hydro-Québec has turned to three-dimensional computer-aided design (3-D CAD) technology, which the utility now uses to design substations.

Hydro-Québec now has 30 substations (from 25 kV to 735 kV) modeled in 3-D—six more than half a year earlier. To further reduce engineering time, our development efforts focused on optimizing and accelerating the production of 2-D drawings. A potential benefits assessment was performed to see if 3-D modeling might be a cost-effective approach. The assessment made us realize that our financial goals could only be met if we improved our use of the software—not only for production of 2-D drawings but also by using the 3-D model for certain engineering tasks.

This article describes the results of the potential benefits assessment. It also looks at some new applications of the 3-D CAD software: the combination of 2-D and 3-D, the "equipment blocks" concept and lightning protection design.

**Potential Benefits Assessment**

At the end of 2007, Hydro-Québec performed a cost analysis to determine the potential benefits of using 3-D CAD technology for substation design. The purpose was to identify promising avenues for development in the next few years.

The analysis involved examining the costs of designing a completely new substation using a 3-D model in 2008. The same substation design was then cost-estimated using design methods projected for 2012—that is, assuming developments projected for 2012.

The cost difference between the 2008 and the 2012 designs were estimated at \$350,000 for this project only. Electrical engineering costs were reduced by around 20 percent and civil engineering costs by about 30 percent. These reductions were due to developments such as completely automated generation of 2-D drawings combined with changes in work methods.

As mentioned, projected benefits were not the only thing evaluated. Developments required to achieve these benefits were also analyzed. Certain redundant tasks are to be automated by 2012. Generation of 2-D drawings will not be required at all or will demand minimal effort. Substation models will be updated in real time with engineering input and will include engineering intelligence; for example, validation of standards and rules will be integrated in the software. The substation builder will also have access to the model. New employees will be familiar with the software and will use it on a larger scale than today.

There are two other potential benefits of these developments. With the reduced engineering time, financing costs will drop, and, with better interdisciplinary coordination, there will be fewer changes during construction of the substation, hence fewer unexpected additional costs.

The potential benefits assessment clearly showed that Hydro-Québec should continue to invest in 3-D CAD as there are still benefits to be derived. (See Figure 1)

**Optmze.**

**pecr**

**Energy for Change**

**MOST RECOMMENDED**

**FREE Transmission Poster**

**LFW Article Display - OptIQ**

**Harris Poll finds public has little awareness**

**2008: October**

- Paper presentation at Cigré Canada Conference on Power Systems 2008 in Winnipeg, MB.
- Paper #508 – Advances in 3D Substation Design at Hydro-Québec



21, rue d'Artois, F-75008 PARIS  
<http://www.cigre.org>

Paper #508

CIGRÉ Canada  
Conference on Power Systems  
Winnipeg, October 19-21, 2008

### Advances in 3D Substation Design at Hydro-Québec

S. LAMOTHE, ENG.<sup>1</sup>, P. GRAVELINE, JR. ENG.<sup>2</sup>  
Hydro-Québec<sup>1</sup>(CAN), Hydro-Québec<sup>2</sup>(CAN)

#### SUMMARY

Engineering projects are being carried out at an increasingly rapid pace in our day. Invariably, the goal is to reduce engineering time and costs, and this is true of all enterprises, not just energy providers. To do so, Hydro-Québec has turned to three-dimensional computer-aided design (3D CAD) technology, which the utility now uses to design substations.

Hydro-Québec now (March 2008) has 30 substations (from 25 kV to 735 kV) modeled in 3D, six more than half a year earlier. To further reduce engineering time, our development efforts were still focused on optimizing and accelerating the production of 2D drawings. A potential benefits assessment was performed to see if 3D modeling might be a cost-effective approach. The assessment made us realize that our financial goals could only be met if we improved our use of the software—not only for production of 2D drawings but also by using the 3D model for certain engineering tasks.

This paper is describing the results of the potential benefits assessment. It also looks at some new applications of the 3D CAD software: the combination of 2D and 3D, the "equipment blocks" concept and lightning protection design. The last part is a discussion of possible future developments.

#### KEYWORDS

3D CAD, substation, design, cost, teaching, lightning protection, future developments

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Graveline.philippe@hydro.qc.ca



## 2009: January to March

- Decision to design every projects in 3D.
- Paper published in the "Choc" magazine.
- Return to the IGEE for a second time to give the 3D CAD course.

### La conception tridimensionnelle des postes à haute tension chez Hydro-Québec

Sylvain Lamothe, ing.  
et Philippe Graveline, ing. jr

« Réduction des coûts », « réduction des échéanciers », « amélioration de la qualité » : en gestion des projets d'ingénierie, ces expressions font maintenant partie du langage courant, et Hydro-Québec Équipement n'échappe pas à cette réalité. Afin de répondre aux nouvelles attentes liées au rendement, l'entreprise a dû redéfinir sa façon de travailler. Pour y arriver, elle s'est tournée il y a quatre ans vers la technologie de conception assistée tridimensionnelle, qu'elle utilise maintenant pour concevoir ses postes à haute tension. Cette technologie, couramment employée dans les domaines de l'automobile et de l'aéronautique, fait ainsi son entrée dans celui de l'énergie.

En 2005-2006, Hydro-Québec a procédé à l'évaluation du progiciel CATIA<sup>®</sup> et des avantages qu'il serait en mesure d'apporter. Cet exercice a permis de constater que l'entreprise pourrait atteindre ses objectifs financiers en améliorant l'utilisation du progiciel pour la production des plans 2D – seuls livrables aujourd'hui requis par nos clients – et des maquettes 3D. En raison des résultats obtenus et du potentiel énorme décelé, l'entreprise a adopté le progiciel. Jusqu'à maintenant, il a servi à modéliser plus de 30 postes à haute tension.

Le présent article fait état de certains avantages de la CAO 3D. Il présente les résultats de l'évaluation des avantages effectuée par Hydro-Québec et jette un regard sur de nouvelles applications du progiciel de CAO 3D, notamment la combinaison de plans 2D et de modèles 3D, le concept de « blocs fonctionnels » et la modélisation des équipements de protection contre la foudre. Enfin, il aborde des projets en cours.



Figure 1 : Maquette 3D d'un poste à haute tension.


#### Les avantages de la modélisation 3D

L'adoption de la modélisation 3D cible principalement l'amélioration des produits livrables ainsi que de l'efficacité de la conception. De ces deux objectifs découlerait une réduction potentielle des coûts et du temps d'ingénierie. L'utilisation d'une maquette 3D offre les avantages suivants par rapport à celle des plans 2D.

- La CAO 3D facilite la communication et la collaboration entre les différents intervenants (ingénieur, sous-traitant, client, approvisionnement, administration et construction) et elle peut être particulièrement utile au moment d'audiences publiques. Les postes électriques sont souvent situés en zone urbaine, et les populations voisines sont naturellement inquiètes de l'impact que la présence des postes électriques pourrait avoir sur leur qualité de vie. Les modèles 3D permettent aux gens d'apprécier plus facilement comment un projet s'intégrera à leur environnement.

Février 2009 CHOC 45

**2009: April**



**COE 2009 Annual  
PLM Conference & TechniFair**  
April 19-22, 2009 • Seattle, Washington  
Washington State Convention & Trade Center

Celebrating 25 Years  
of COE Community

**CATIA Deployment at  
Hydro-Québec in  
Substation Design**  
*Philippe Graveline – Hydro-Québec*

Bringing Together the Users of Dassault Systèmes PLM Solutions

**COE**  
www.coe.org

**2009: October**

- Paper presentation at Cigré Canada Conference on Power systems 2009, in Toronto, Ont.
- Paper #132: 3D Substation Design: Better, Easier, Faster

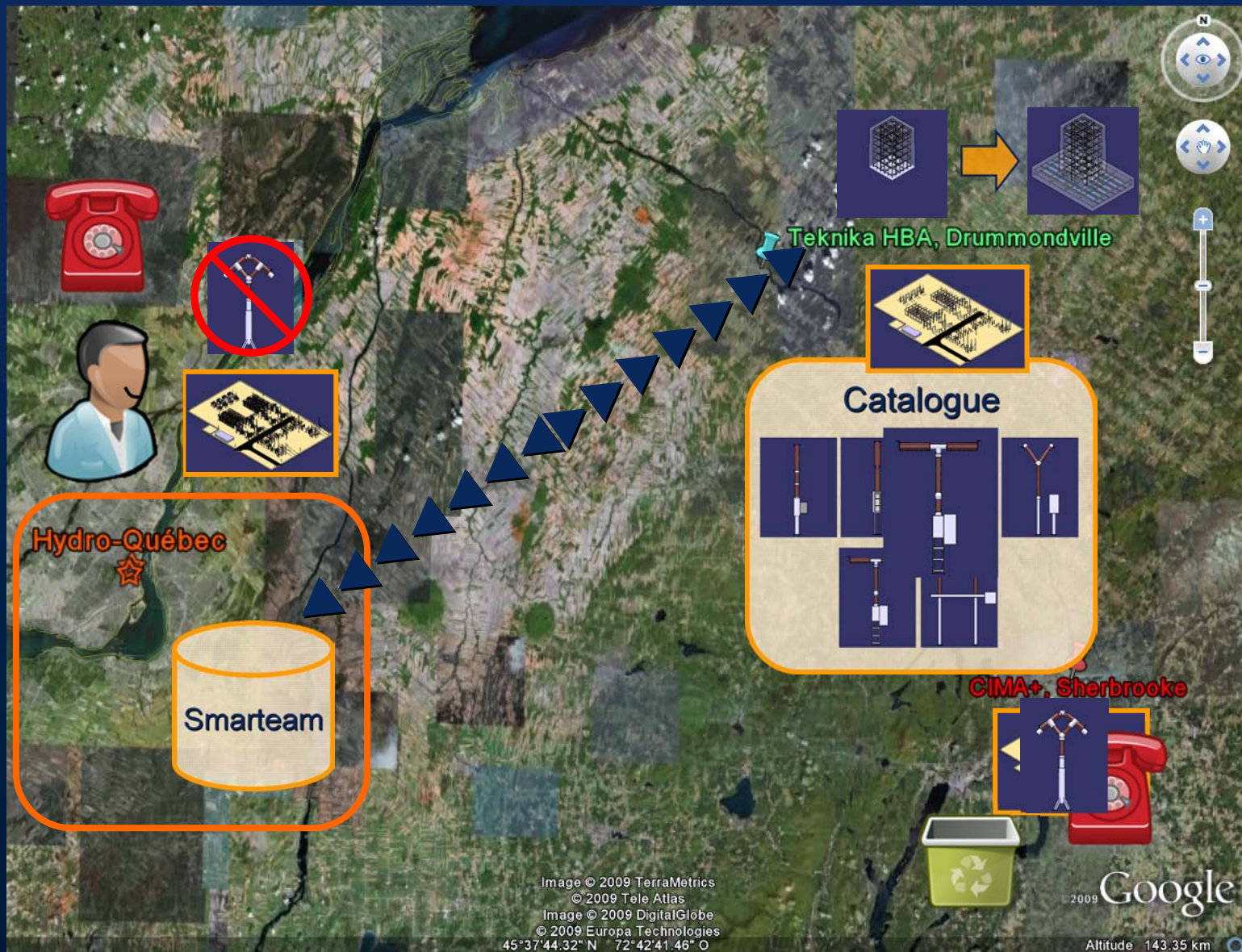




## ***2009: PDM testing – Connections with eng. Consultants***

- **Integrating the PDM in-house was a relative success, enough to make a prototype project with a consultant.**
- **The prototype project ended in last December.**
- **It was a success too, so all our 7 consultants will be connected to our PDM database.**

# Multi-disciplinary Design – Proactive Engineering



2010

- Third time at IGEE for the 3D CAD course.
- COE 2010

Bringing together the users of Dassault Systèmes PLM solutions — CATIA®, ENOVIA®, DELMIA®, SIMULIA® and 3DVIA®

Users • Technology • COE Community

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energy market**

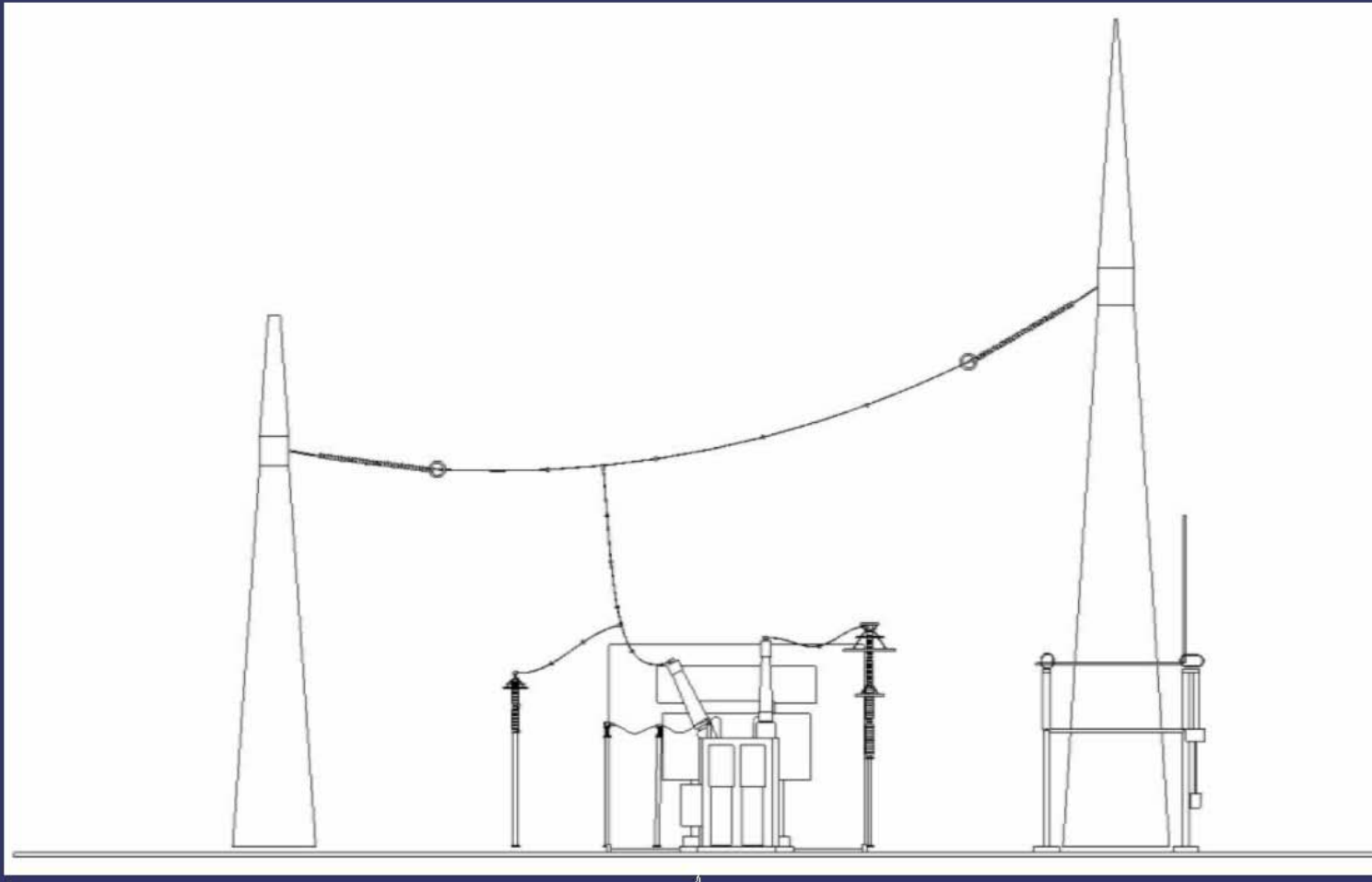
*Philippe Graveline, Hydro-Québec  
Julie Betit, Cima+*

COE 2010 ANNUAL  
**PLM CONFERENCE**  
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April 18-21, 2010 • The Rio All-Suite Hotel • Las Vegas, Nevada

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## ***Substation model – Design in 3D***



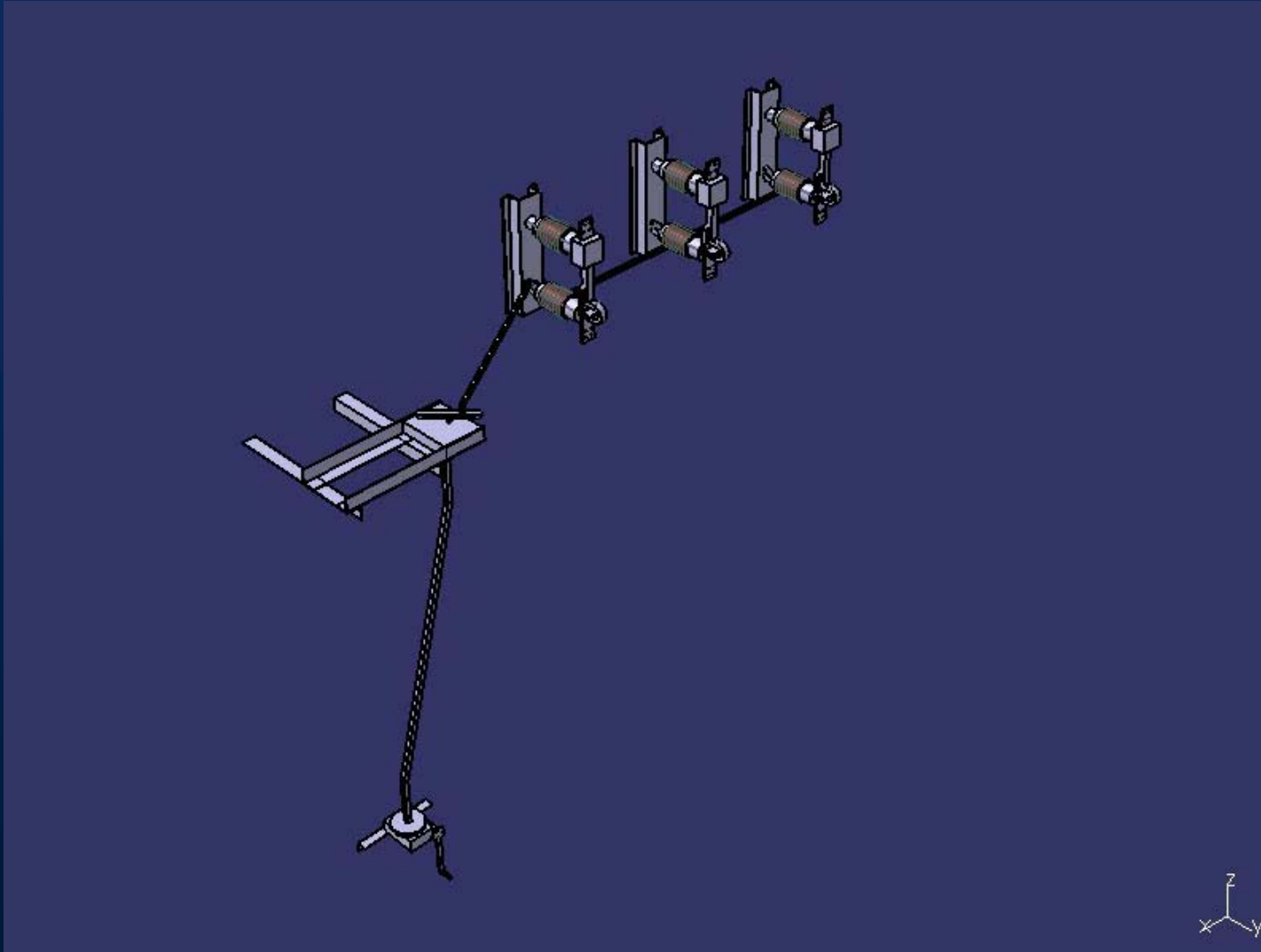
***Define  
equipments***

***Auto-adapting and intelligent models***

**DE**

Version 0.1  
2010-05-20

## *Easy-to-modify Electrical equipments*

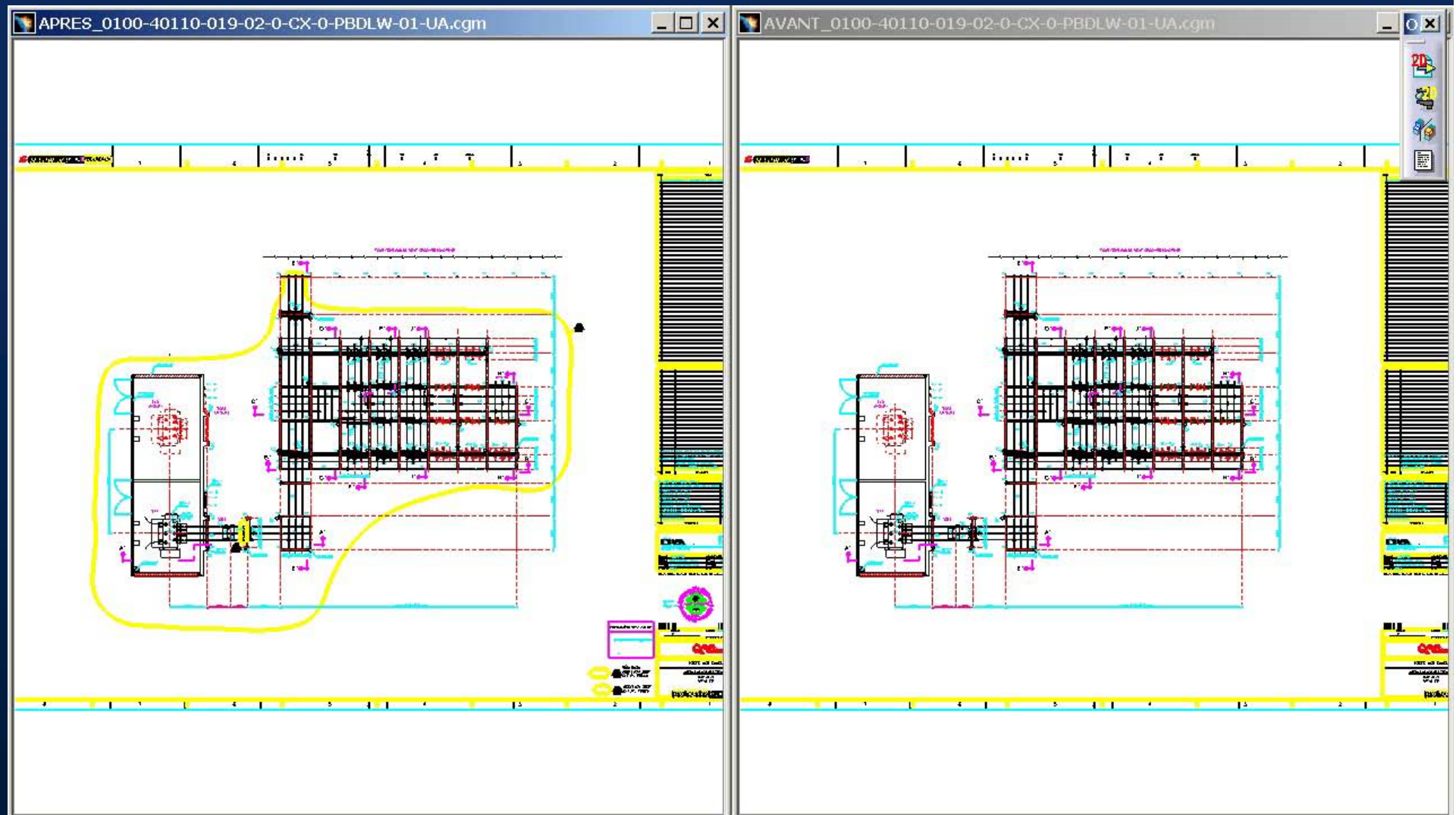


## Intelligent copper bars

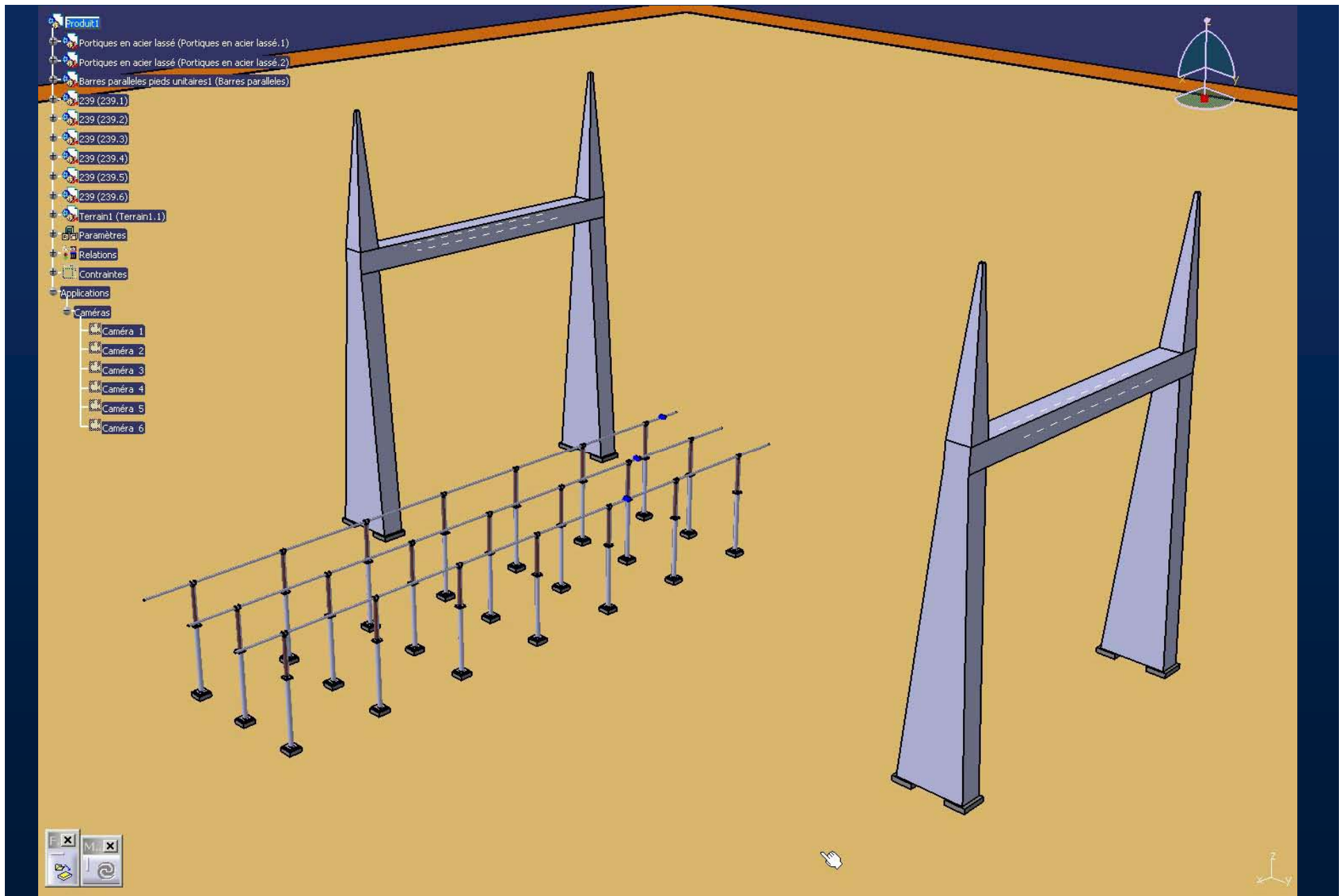




## 2D comparison: Easier and faster



# *Suspended bus bars design*





***That's what concludes my presentation.  
Any questions?***