

Beyond System Modeling: Extending SysML for Goal-driven Generative Design

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Autodesk

GLOBAL PRODUCT DATA INTEROPERABILITY **SUMMIT** 2015



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DESIGN

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Create a specification of an object or a system, intended to accomplish goals in a particular environment, using a set of primitive components, satisfying a set of requirements and subject to constraints.

-Wikipedia

DESIGN

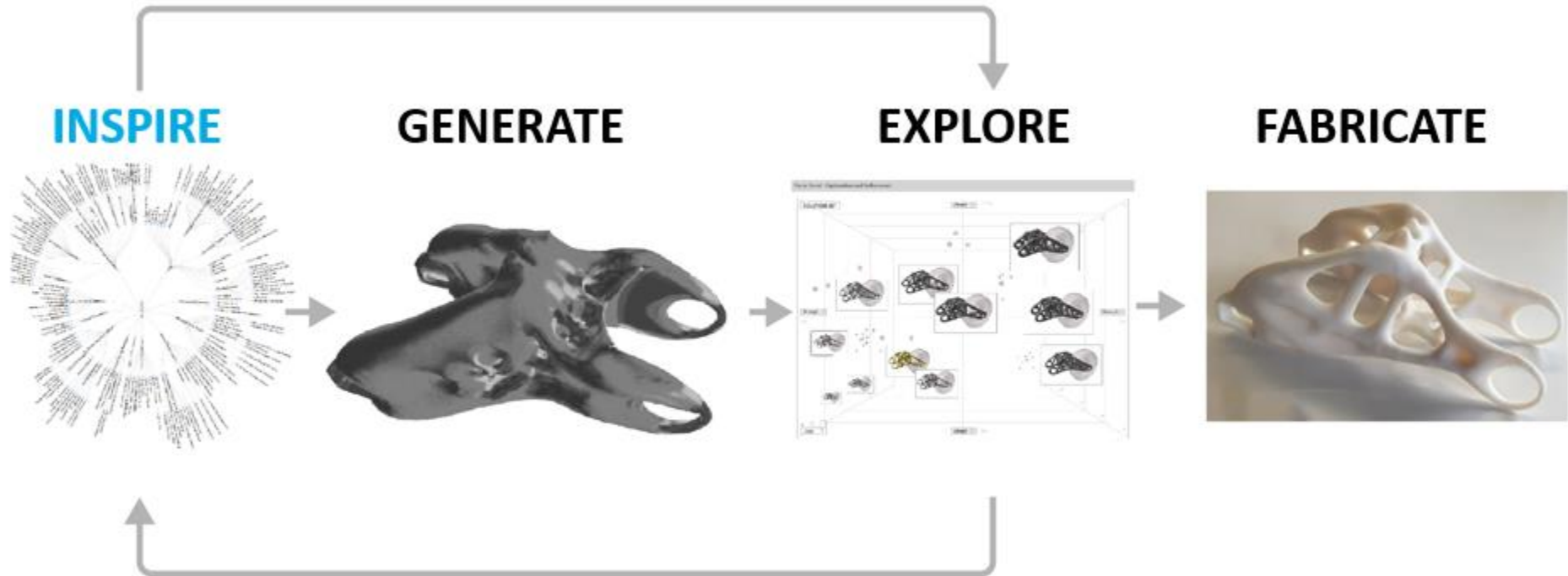
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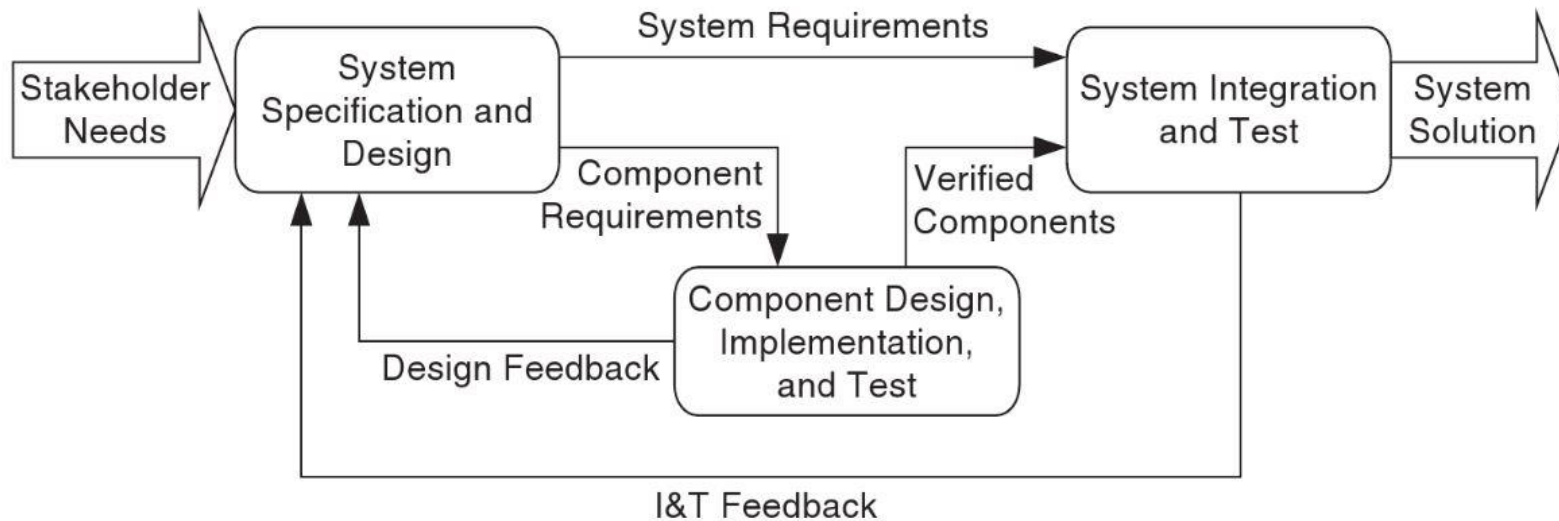
Unlocking Generative Design

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Systems Engineering Process

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Representation of Design Knowledge

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Natural language?



- Colored a light off-white (Fog) or light gray (Platinum)
- Inlaid three-dimensional Apple logo, diamond cut to the exact shape
- Zero-draft enclosures, with no variances in case thickness and perpendicular walls
- Recessed international port identification icons and silk-screened product name badging
- Shallow horizontal and vertical lines, 2 mm wide, 2 mm deep, spaced 10 mm apart on center, which run along any and all of the surfaces of the product, some of which act as vents and setback 30 mm from the front and 4 mm from the back.

...

Representation of Design Knowledge

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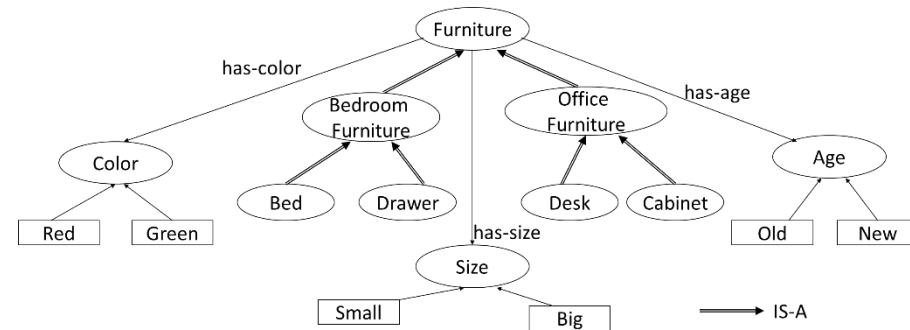
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...

Description Logic?



```
=(defconcept furniture)
|c| FURNITURE
```

```
=(defconcept office-furniture (?f furniture))
|c| OFFICE-FURNITURE
```

```
=(defconcept desk (?f OFFICE-furniture))
|c| DESK
```

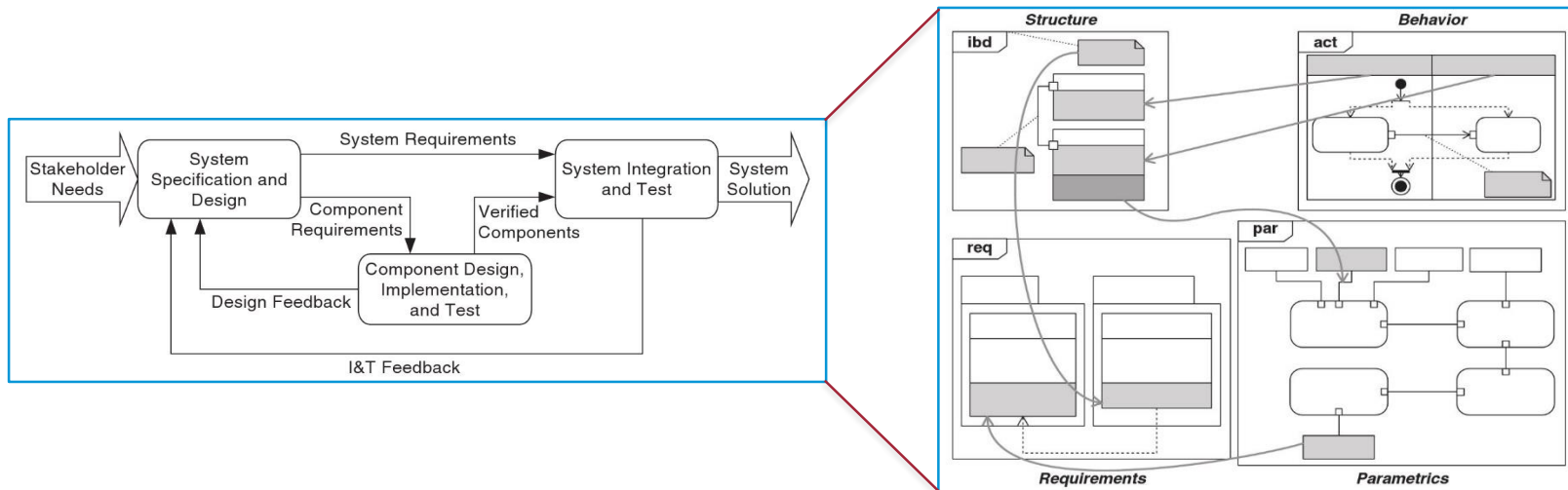
```
=(defconcept color (?c) :<=> (member-of ?c (setof green red blue)))
|c| COLOR
```

...

Model-based Systems Engineering

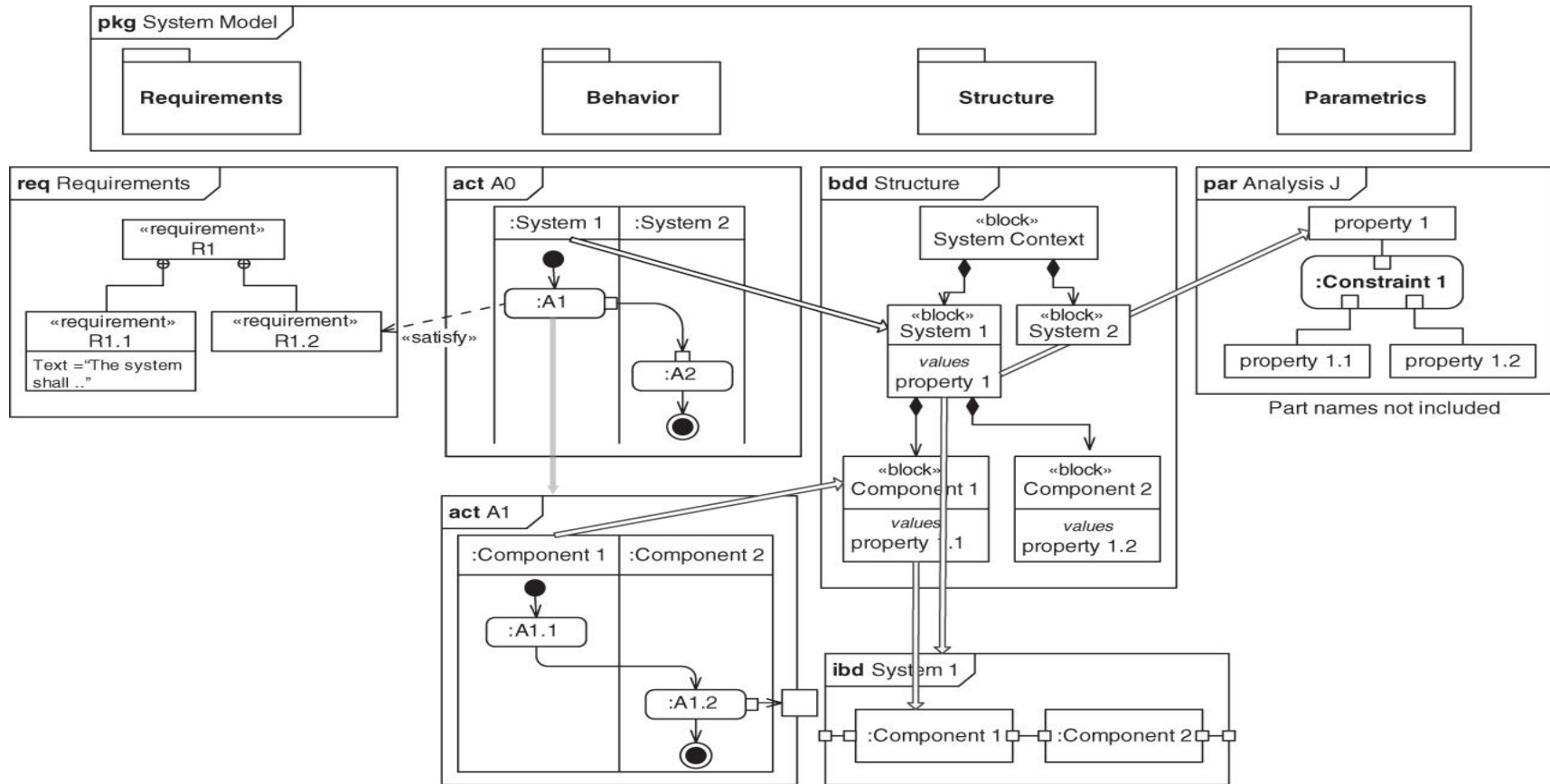
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- **Formalize system modeling for:**
 - Consistency of requirements / specification information
 - Model organization (generalization / specification) and reuse
 - Automated verification and validation



SysML Diagrams

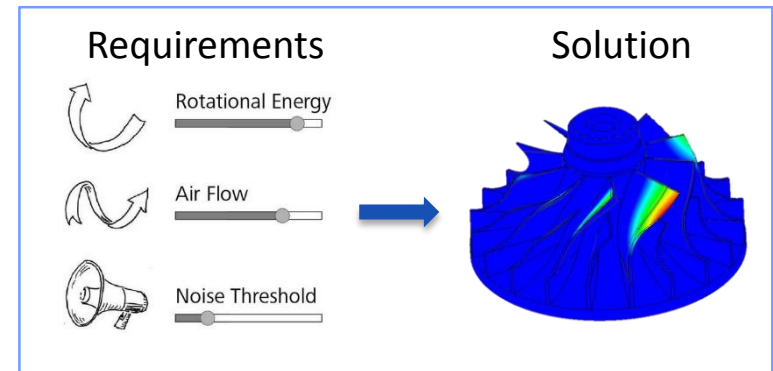
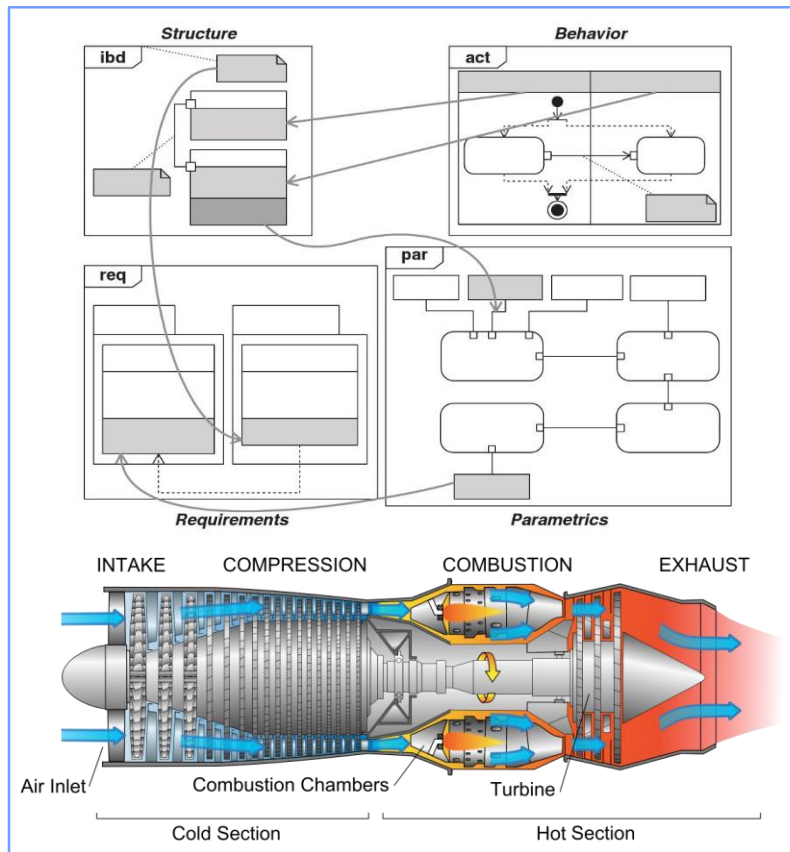
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Application examples

Relevance to Goal-driven Generative Design

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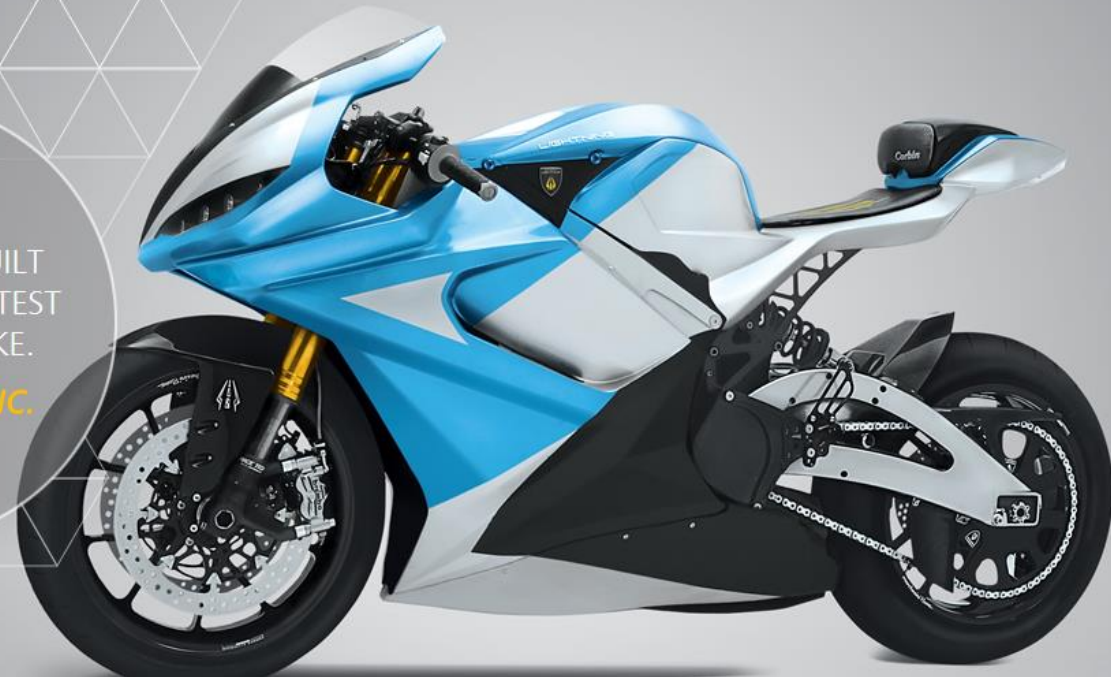
Example1: Modeling Lightning Motorcycle Swingarm

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THE FUTURE OF
MAKING THINGS

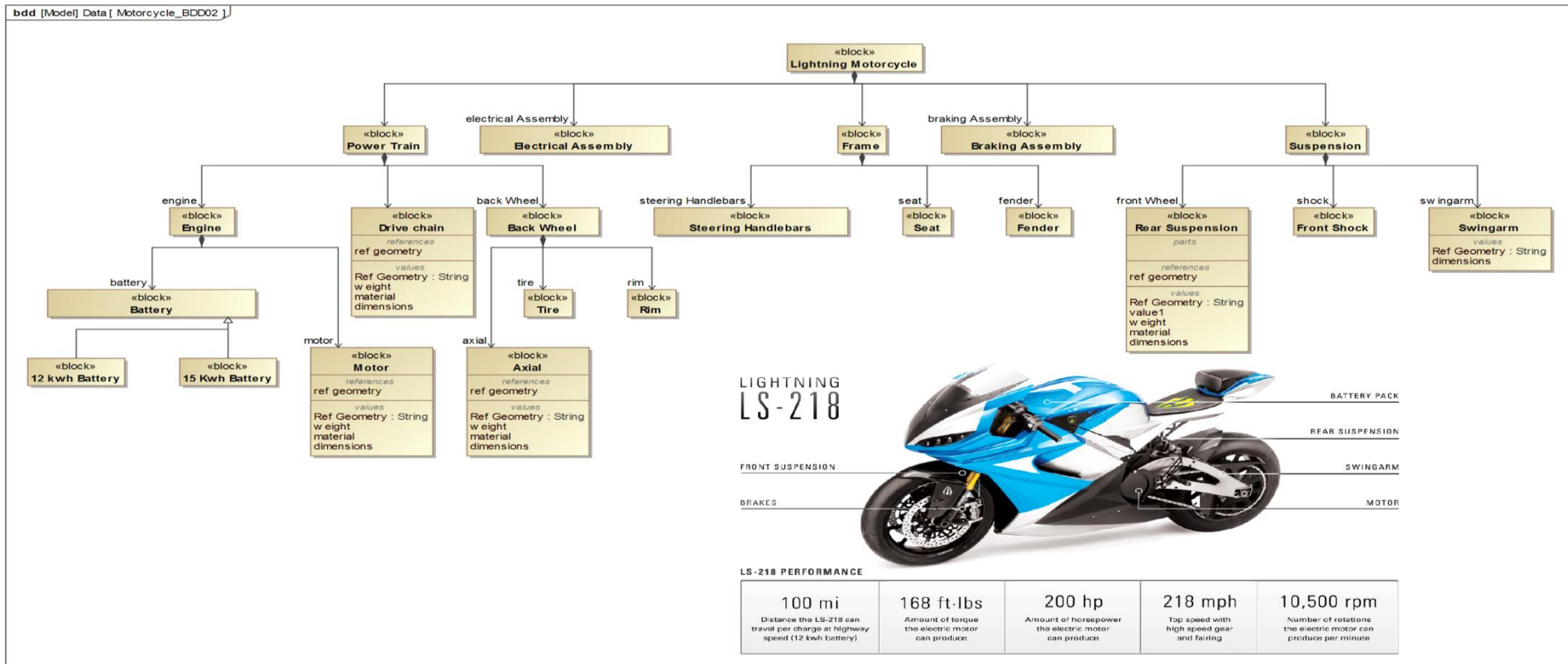
LIGHTNING
MOTORCYCLE BUILT
THE WORLD'S FASTEST
PRODUCTION BIKE.

AND IT'S ELECTRIC.



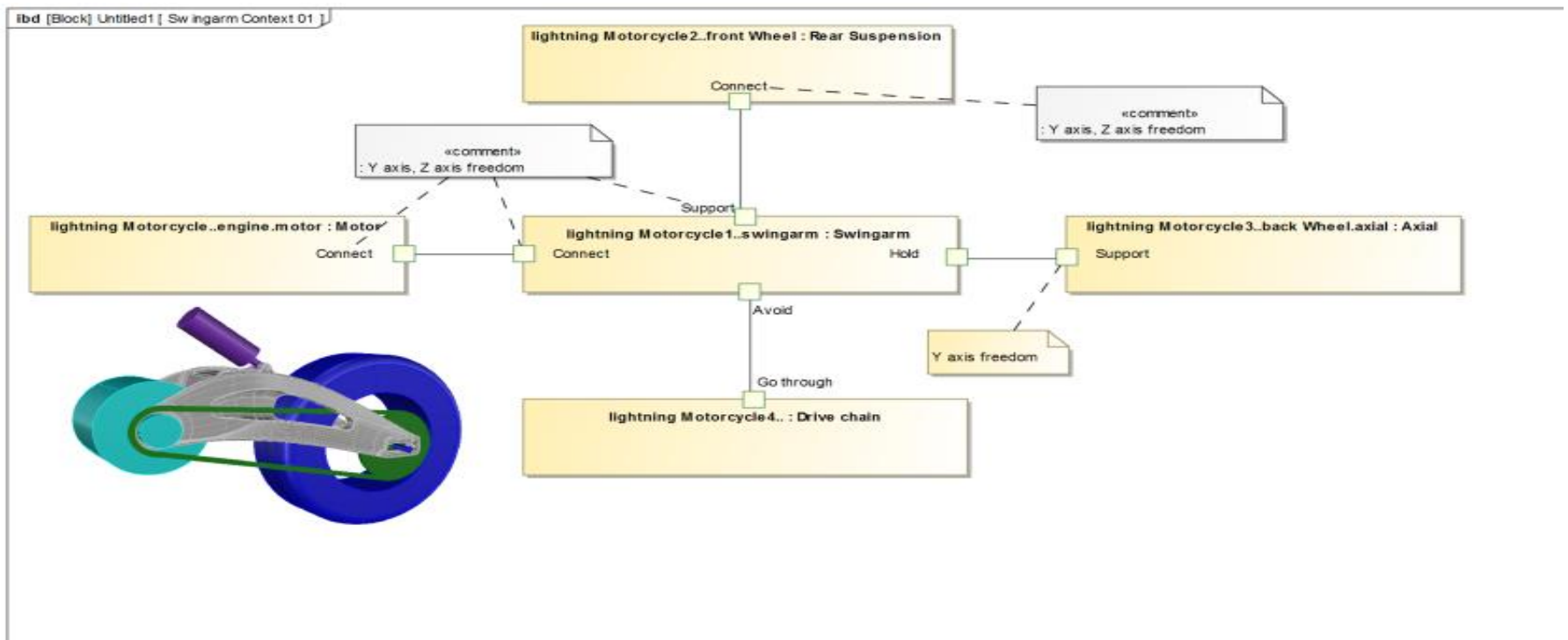
Block Definition Diagram

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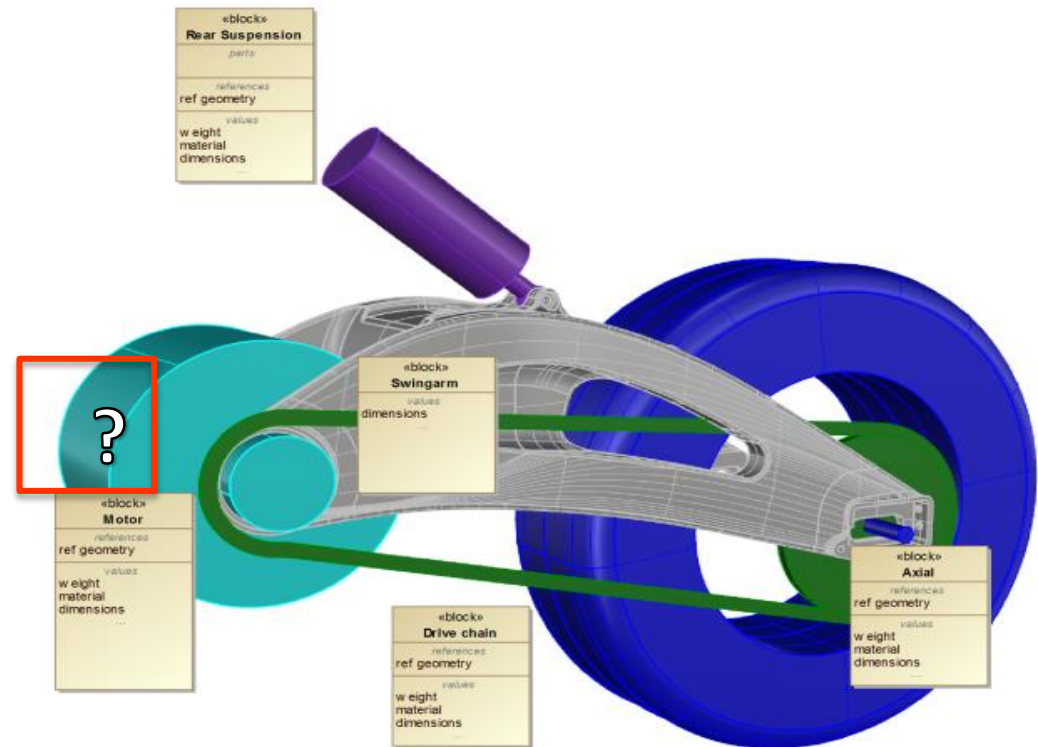
Internal Block Diagram

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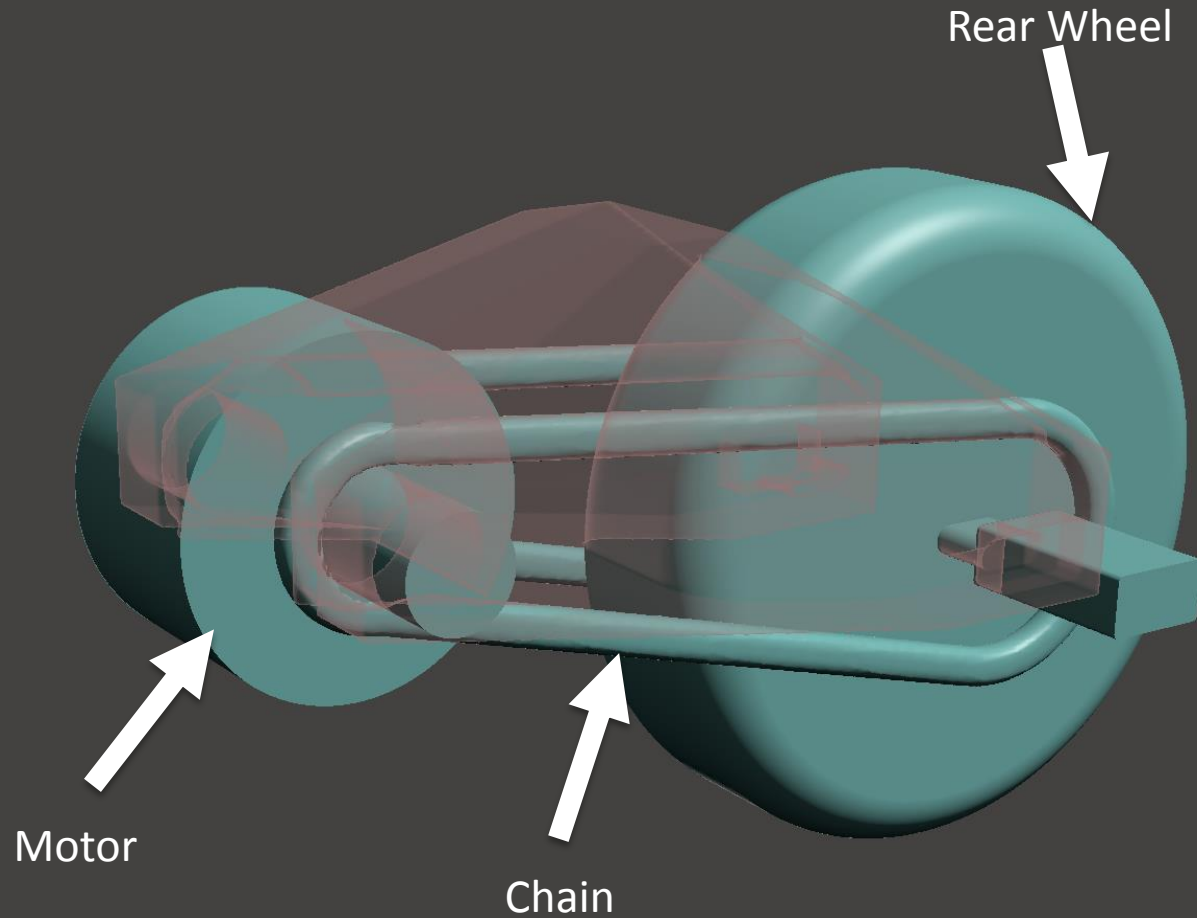
Internal Block Diagram

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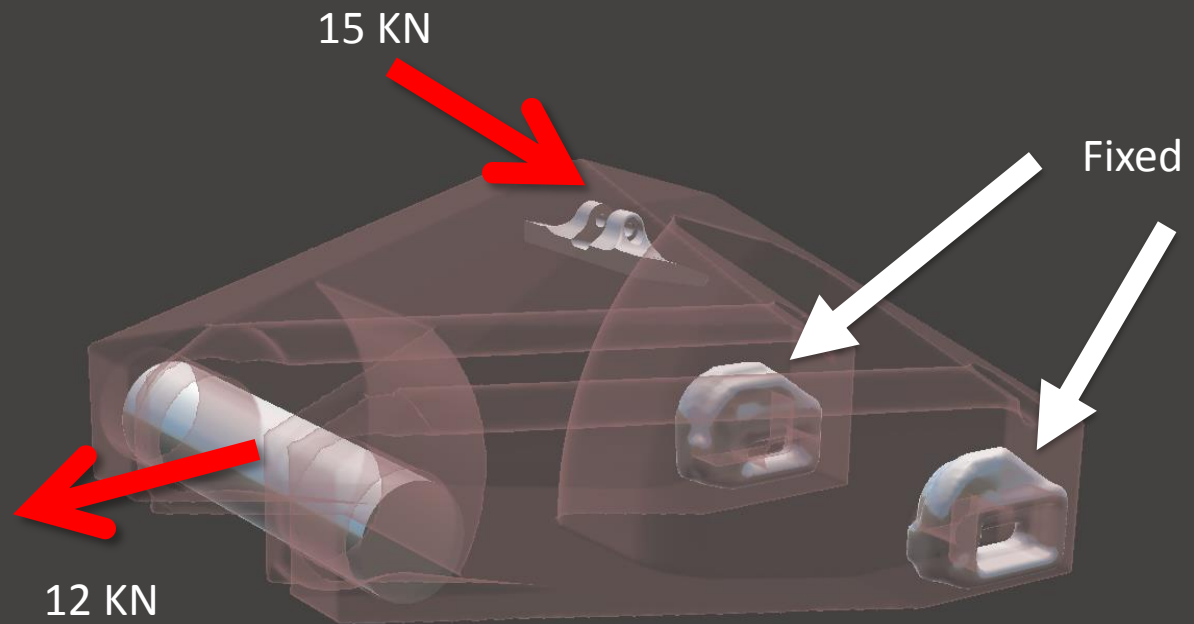
Problem Definition

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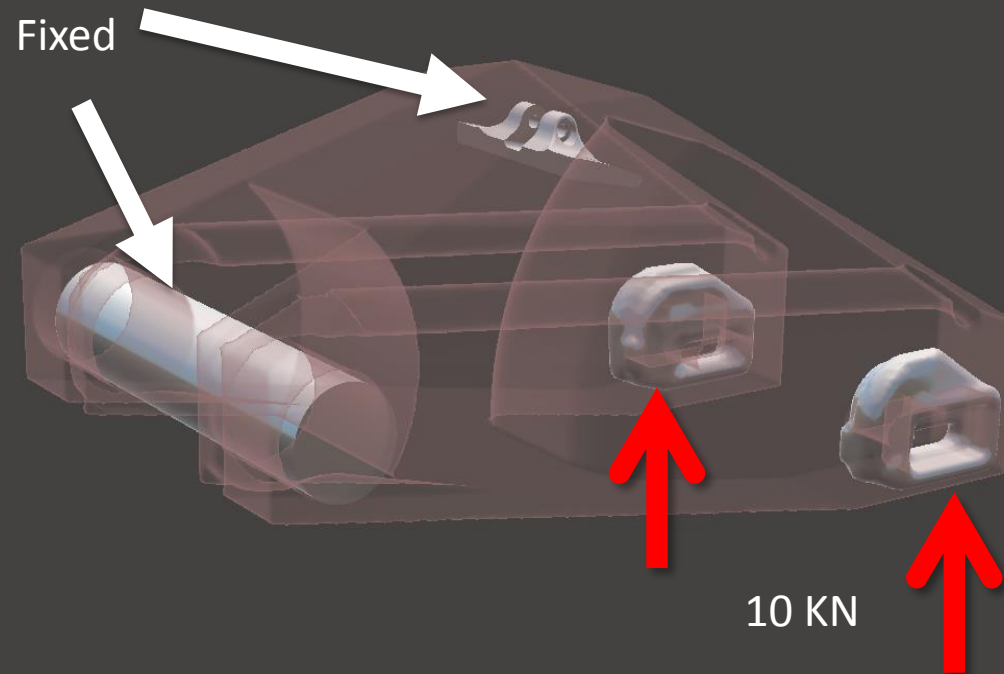
Problem Definition

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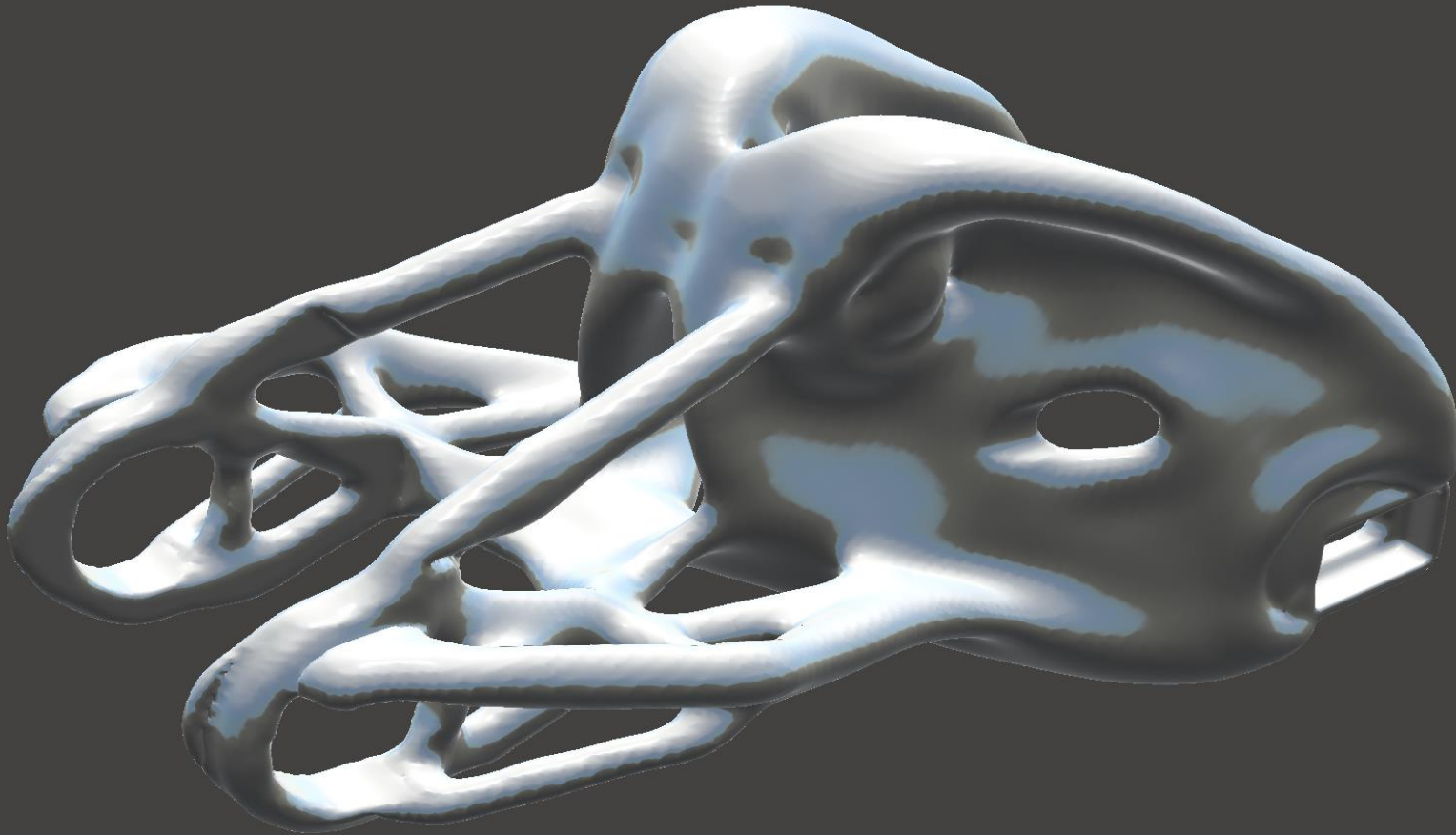
Problem Definition

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Generated Swing Arm

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Example2: Modeling Formula 1 Roll Hoop

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Requirements – F1 regulations

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ARTICLE 15 : CAR CONSTRUCTION

15.2 Roll structures :

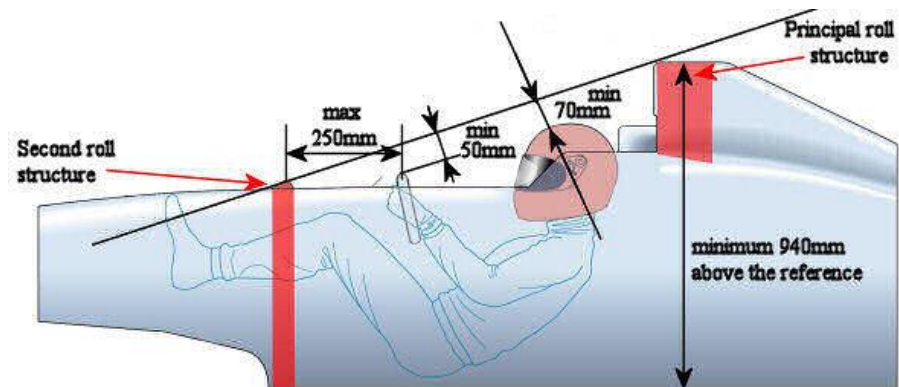
15.2.1 All cars must have two roll structures which are designed to help prevent injury to the driver in the event of the car becoming inverted.

The principal structure must be at least 940mm above the reference plane at a point 30mm behind the cockpit entry template. The second structure must be in front of the steering wheel but no more than 250mm forward of the top of the steering wheel rim in any position. is 1050mm in front of the rear of the cockpit

ARTICLE 17 : ROLL STRUCTURE TESTING

17.2 Principal roll structure test :

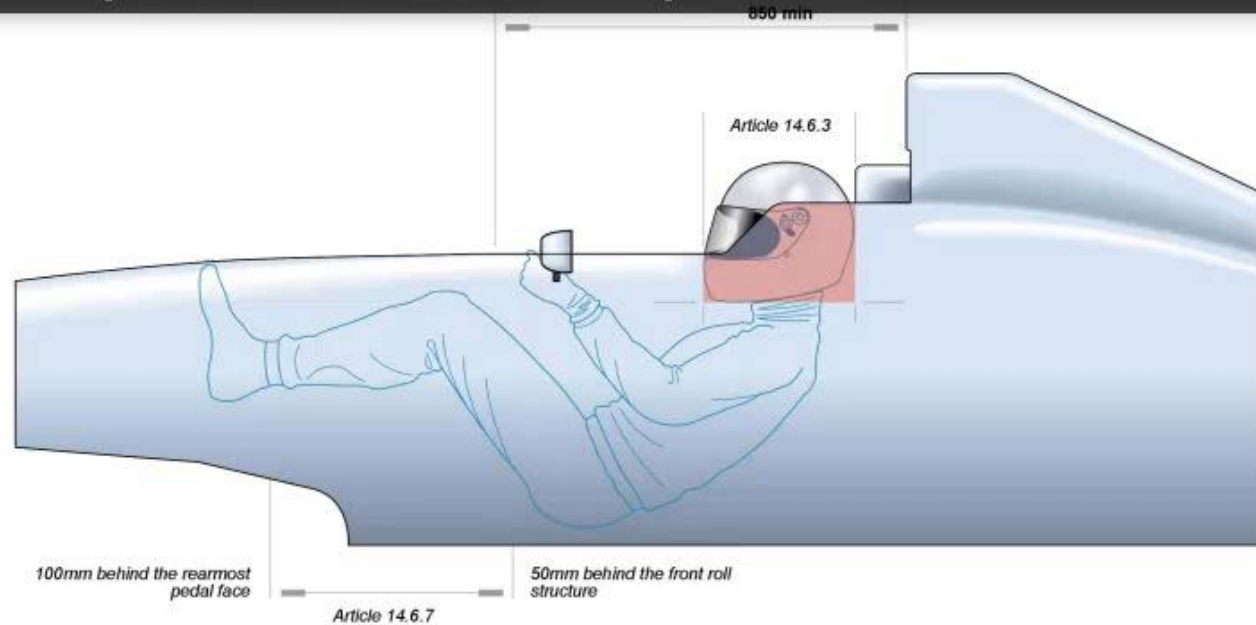
A load equivalent to 50kN laterally, 60kN longitudinally in a rearward direction and 90kN vertically, must be applied to the top of the structure through a rigid flat pad which is 200mm in diameter and perpendicular to the loading axis.



Requirements – F1 regulations

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Step 1: Harvest Requirements



Future Work

Existing SysML Tools

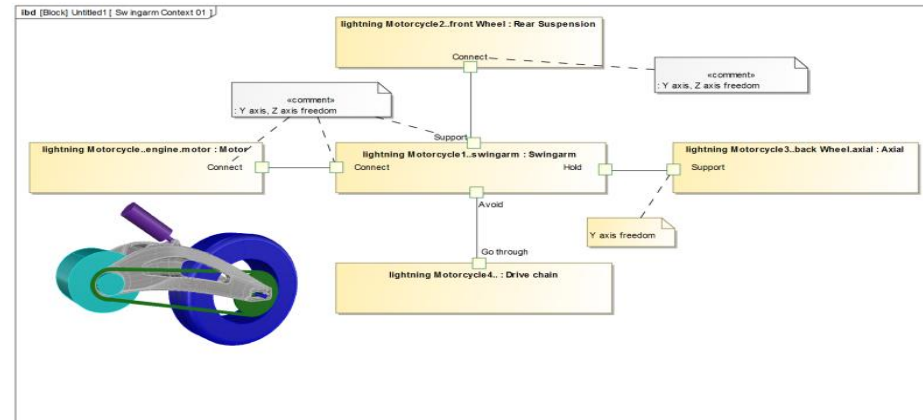
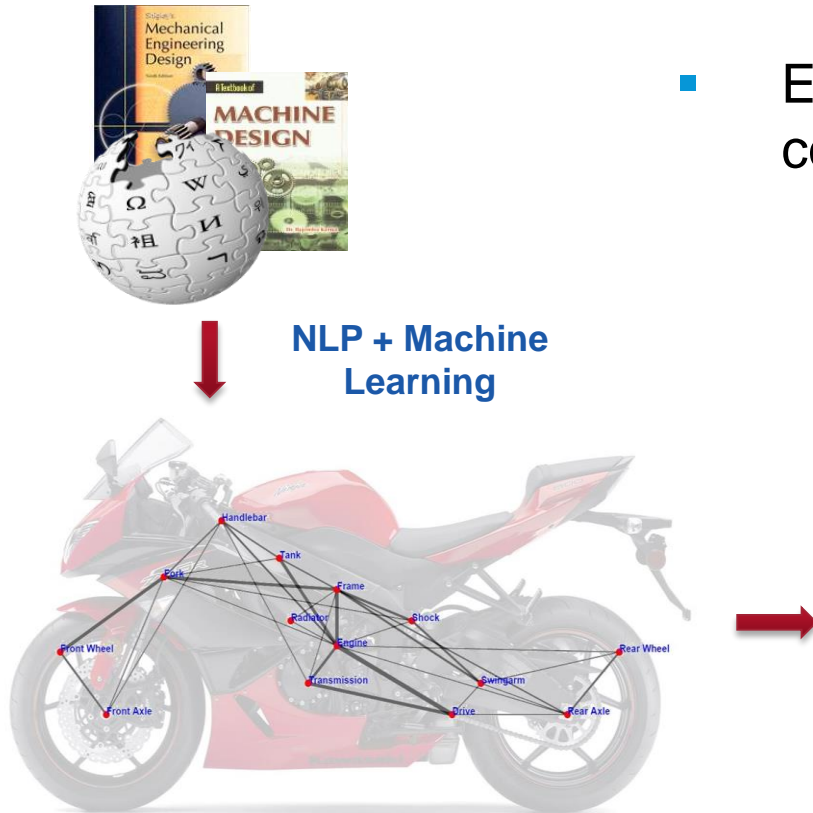
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- **Magic Draw (No Magic)**
- **Rational Rose (IBM)**
- **Enterprise Architect (Sparx Systems)**
- **SCADE (ANSYS)**
- **Papyrus (Eclipse community)**

Automatic Knowledge Extraction

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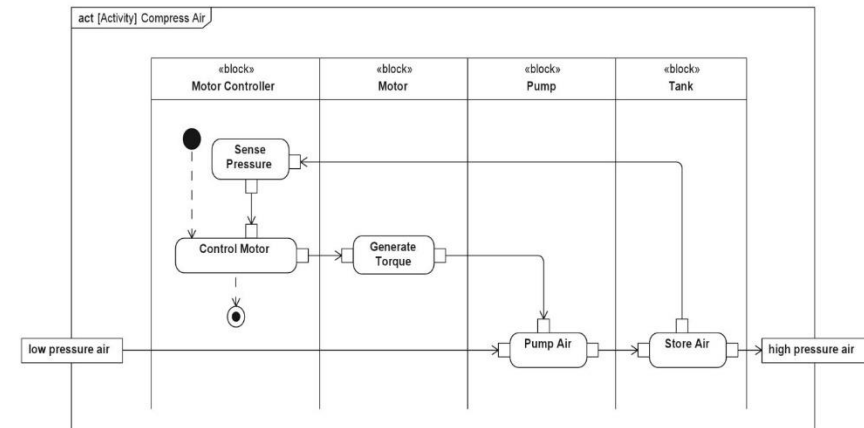
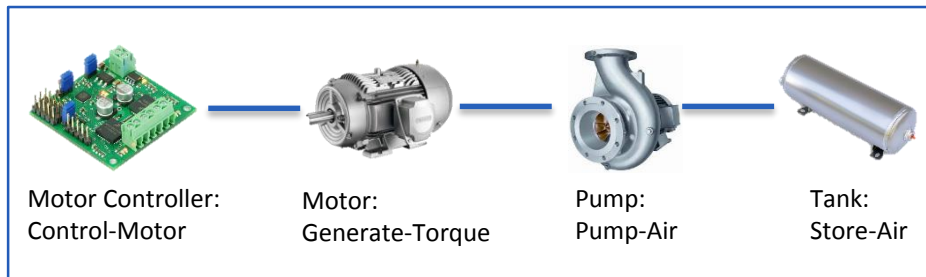
- Extract relationships between components



Automatic Knowledge Extraction

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- **Extract component-function knowledge**



Knowledge extraction - search

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Relation Search Engine

tor2ua0100fd7lx.ads.autodesk.com:5000

RELATION SEARCH ENGINE

Subject Verb Object


You can specify a single field or any combination of two fields for your query.

Example queries:

Subject: *turbocharger*
(what does a *turbocharger* do?)

Subject: *engine* **Object:** *wheel*
(what's the relationship between an *engine* and a *wheel*?)

Verb: *dissipate* **Object:** *heat*
(which object can / how can we *dissipate* *heat*?)

 **AUTODESK.**
RESEARCH

Acknowledgements

Global Product Data Interoperability Summit | 2015

- **Wei Li**
Prin. Research Scientist
- **Francesco Iorio**
Distinguished Research Scientist

Contact Info

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