OPCAT Version 3

Getting Started Guide

March 2009

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1. Intrudction to the OPCAT Guide

The purpose of this Guide is to help the systems engineer who is an OPCAT user to start modeling with OPCAT 3.0. The Guide briefly presents OPM – Object-Process Methodology, which is OPCT's underlying language and modeling approach. OPM also serves as the basis for OPCAT advanced features. After reading the guide the user is encouraged to continue to the advanced lessons which could be obtained by contacting us at consulting@opcat.com.

This Guide is divided into sections. Each section describes another aspect of the OPM language or the OPM-based modeling environment OPCAT software product and contains a summary at the end.

2. Brief Introduction to OPM

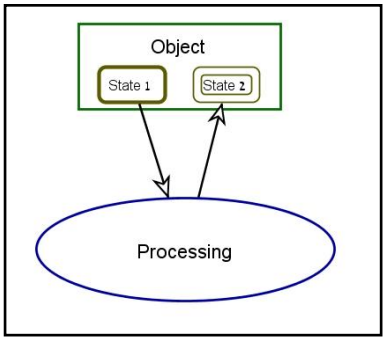


Figure 1: An Object-Process Diagram (OPD) showing the three OPM entities: Object, Process, and State, and the input/output procedural link pair, which expresses that Processing changes Object from State 1 to State 2.

Object Process Methodology (OPM) is a holistic approach for conceptual modeling of complex systems. A complete treatment of OPM can be found in the OPM book. Below is a brief introduction of OPM to get you started.

The OPM model integrates the functional, structural, and behavioral aspects of a system in a single, unified view, expressed bi-modally in equivalent graphics and text with built-in refinement-abstraction mechanism.

Two semantically equivalent modalities, one graphic and the other textual, jointly express the same OPM model. A set of inter-related hierarchically organized Object-Process Diagrams (OPDs), showing portions of the system at various levels of detail, constitute the graphical, visual OPM formalism. The OPM ontology comprises entities and links. Each OPM element (entity or link) is denoted in an OPD by a symbol, and the OPD syntax specifies correct and consistent ways by which entities can be connected via structural and procedural links, such that each legal entity-link-entity combination bears specific, unambiguous semantics (see Figure 1 for example). There are three different types of entities: objects, processes (collectively referred to as "things"), and states. These entities are shown in Figure 1. Objects are the (physical or informatical)

things in the system that exist, and if they are stateful (i.e., have states), then at any point in time they are at some state or in transition between states. Processes are the things in the system that transform objects: they generate and consume objects, or affect stateful objects by changing their state.

Links can be structural or procedural. Structural links express static, time-independent relations between pairs of entities. The four fundamental structural relations are aggregation-participation, generalization-specialization, exhibition-characterization, and classification-instantiation. General tagged structural links provide for creating additional "user-defined" links with specified semantics. Procedural links connect processes with objects or object states to describe the behavior of a system. System behavior is manifested in three ways: (1) a processes can transform (generate, consume, or change the state of) one or more objects; (2) an object can enable one or more processes without being transformed by them, in which case it acts as an agent (if it is human) or an instrument; and (3) an object can trigger an event that invokes a process if some conditions are met. Accordingly, a procedural link can be a transformation link, an enabling link, or an event link. A transformation link expresses object transformation, i.e., object consumption, generation, or state change. Figure 1 shows a pair of transformation links, the input/output link. It expresses in OPL that Processing changes Object from State 1 to State 2. An enabling (agent or instrument) link expresses the need for a (possibly state-specified) object to be present in order for the enabled process to occur. The enabled process does not transform the enabling object. An event link connects a triggering entity (object, process, or state) with a process that it invokes.

The System Diagram, SD, is the topmost diagram in a model. It presents the most abstract view of the system, typically showing a single process as the main function of the system, along with the most significant objects that enable it and the ones that are transformed by it. The further from the root the OPD is, the more detailed it is. Each OPD, except for the SD, is obtained by refinement—in-zooming or unfolding—of a thing (object or process) in its ancestor OPD. This refined thing is described with additional details. The abstraction-refinement mechanism ensures that the context of a thing at any detail level is never lost and the "big picture" is maintained at all times.

A new thing (object or process) can be presented in any OPD as a refineable (part, specialization, feature, or instance) of a thing at a higher abstraction level (a more abstract OPD). It is sufficient for some detail to appear once in some OPD for it to be true for the system in general even though it is not shown in any other OPD. Accordingly, copies of a

thing can appear in other diagrams, where some or all the details (such as object states or thing relations) that are unimportant in the context of a particular diagram need not be shown.

The Object-Process Language (OPL) is the textual counterpart modality of the graphical OPD set. OPL is a dual-purpose language, oriented towards humans as well as machines. Catering to human needs, OPL is designed as a subset of English, which serves domain experts and system architects, jointly engaged in modeling a complex system. Every OPD construct is expressed by a semantically equivalent OPL sentence or phrase that is generated automatically by OPCAT in response to the user's input. According to the modality principle of the cognitive theory of multimodal learning, this dual graphic/text representation of the OPM model increases the human processing capability. It has indeed been our experience that humans enhance their understanding of the model as they conveniently draw upon the graphic and/or the textual model representation to complement what they missed in the other modality.

A major problem with most graphic modeling approaches is their scalability: As the system complexity increases, the graphic model becomes cluttered with symbols and links that connect them. The limited channel capacity is a cognitive principle which states that there is an upper limit on the amount of detail a human can process before being overwhelmed. This principle is addressed by OPM and implemented in OPCAT with three abstraction/refinement mechanisms. These enable complexity management by providing for the creation of a set of interrelated OPDs (along with their corresponding OPL paragraphs) that are limited in size, thereby avoiding information overload and enabling comfortable human cognitive processing. The three refinement/abstraction mechanisms are: (1) unfolding/folding, which is used for refining/abstracting the structural hierarchy of a thing and is applied by default to objects; (2) in-zooming/out-zooming, which exposes/hides the inner details of a thing within its frame and is applied primarily to processes; and (3) state expressing/suppressing, which exposes/hides the states of an object.

The software environment embodied in the OPCAT 3 product supports OPM-based system development, evolution, lifecycle engineering, and lifecycle management. This software package implements the bimodal expression of the OPM model along with many new model-based capabilities. In addition to OPM-based systems modeling, the OPCAT platform supports such features as requirements engineering, information layers management, model repository, simulation and validation of the model, and automatic document generation and management.

OPM Basics: A Quick Summary

- OPM is a modeling language based on the paradigm that views processes and objects as equally important in the system model.
- OPM uses **Objects** and **Processes** in order to model the structural and behavioral aspects of a system.
- **Objects** are things that exist over time. Object can be **stateful** (i.e., have states).
- **Processes** are things that transform **Objects** by creating them, destroying them, or changing their states.
- **Procedural links** connect processes to objects to express these transformations.
- **Structural relations** connect objects to express static, long-term between them.

3. Starting to Model with OPCAT

The OnStar System, specified in Annex A in free text, is used as a running example throughout this guide.

A detailed, step-by-step OPM-based model construction of the OnStar System is used to explain how to do the modeling with OPCAT by describing almost each mouse-click, so you, as a new user, can closely follow each step and reproduce the model as you proceed with following the model while it is being constructed in the pages below.

Install OPCAT

OPCAT 3 is standalone Java based software. A **trial** and **academic only** version is available.

Note that Java 6JRE is required before installing OPCAT. Press Setup file and install OPCAT. Note that you are required to select directory in which OPCAT models will be saved. You are also required to restart your computer after installation.

Open a New System

Double clicking the green OPCAT icon application, a blank screen is opened, as shown in Figure 2.

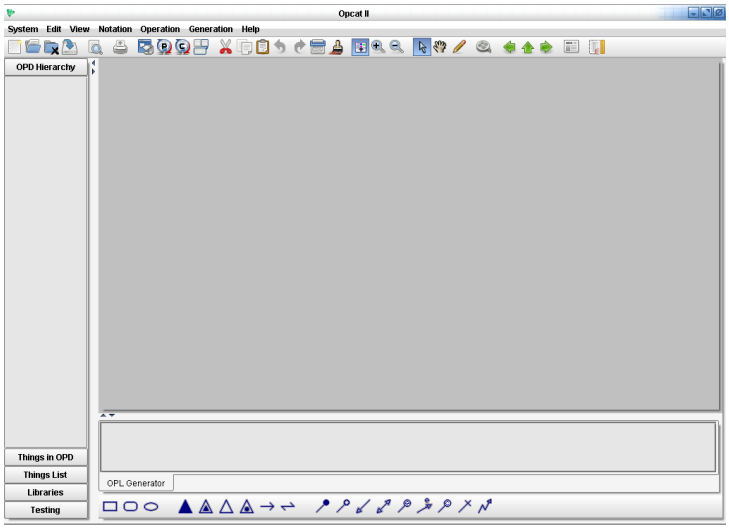


Figure 2. A blank OPCAT opening screen

Clicking **System -> New** we get the **New System Properties** dialog box shown in Figure 3.

Fill in the details and click **OK**. At this point you may also want to save the system in a designated folder.

Next we start modeling the system in the *System Diagram*.

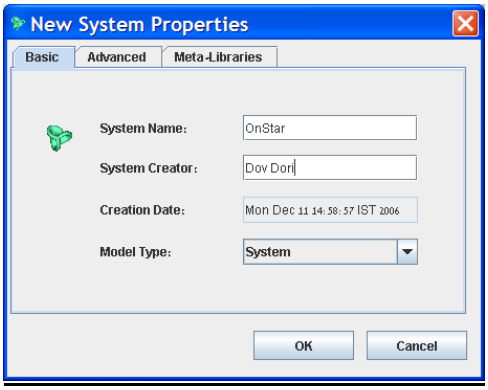


Figure 3. The New System Properties dialog box

The System Diagram (SD)

The ***System Diagram*** (SD) is the first, top-level Object-Process Diagram (OPD) of our system. SD needs to contain one central process – an ellipse (oval) which expresses clearly the main system's function – what it is designed to do. The name of this process is a 2-3 word phrase such as "Laundry Washing", "Border Securing", or "Space Exploring".

In addition, SD shall contain the beneficiary – the entity that benefits from the system, such as "Household", "Citizens Group", or "Scientists Group". SD shall include in addition also the main, top-level objects that are consumed (inputs), created (outputs), and/or affected (those whose state changed) by the main process – the system's top-level function. Additional possible objects include the main human and non-human enablers of the system, and the objects which interact with our system (called environmental, as opposed to systemic).

Define the System's Main Function

We now start to actually model the OnStar system. We do this by drawing model elements – processes, objects, and links – on the graphic screen, the top right pane marked as *SD*, the *System Diagram*. OPL is the textual equivalent of the OPD. As we model, we inspect the translation in real-time of our graphic editing into OPL – Object-Process Language – to make sure we have done the right thing.

The first thing we need to do when modeling a new system is to **define the system's major function**. This is going to be the central process which we will draw in the center of the SD. Contemplating about the main function of OnStar we conclude that the major function of the OnStar system is **Driver Rescuing**.

The OPM element symbols are depicted in the OPM symbols bar at the bottom of the screen. Although the number of elements in OPM is very small, there is no need to memorize them since OPCAT spells them out for you (see Figure 4). The symbol set is divided into three groups:

1. On the left: The three OPM entities
    a. Object
    b. State (which is always inside an object)
    c. Process
2. In the middle: The group of structural relations – relations between pairs of objects
3. On the right: The group of procedural links – links between a process and an object or a state inside that object.

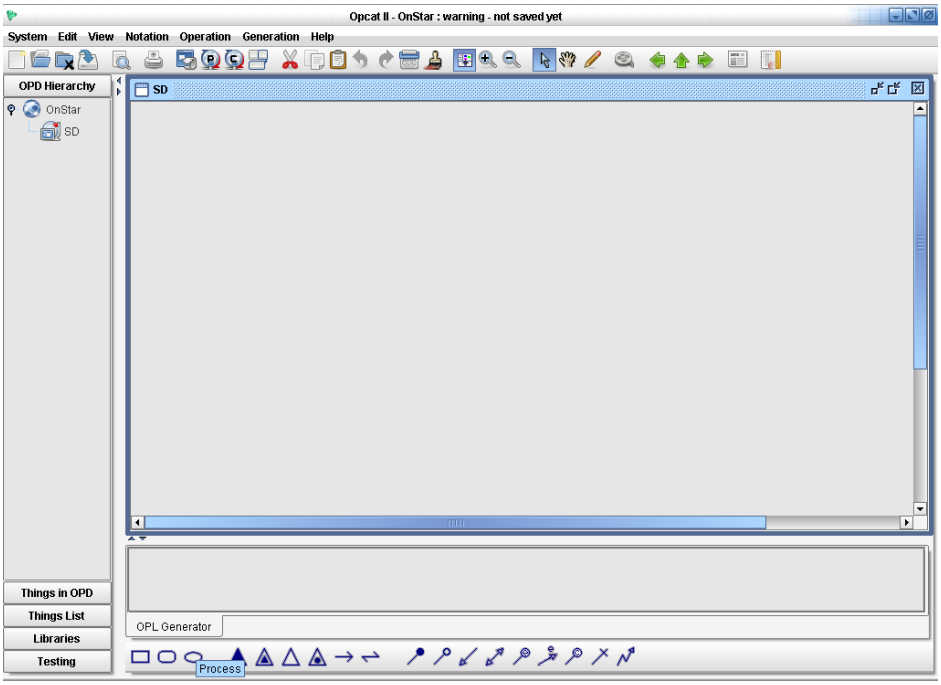


Figure 4. OPCAT Screen after opening the new OnStar System model

Sliding the mouse over the OPM symbols bar presented in the bottom toolbox shows their name. In Figure 4 the mouse is over the ellipse and we see that the ellipse is the symbol for a process.

Click on the process icon. You will get the dialog window shown in Figure 5. Type the process name. Since this process is physical, click on the **physical essence** radio button and click OK.

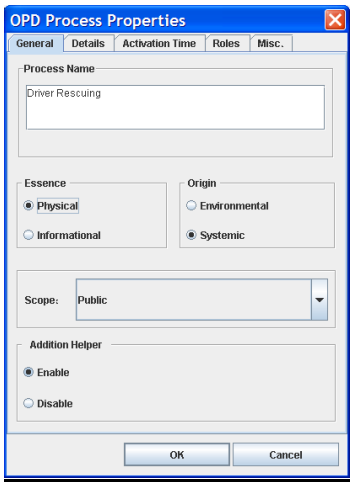


Figure 5. The Process Properties dialog box

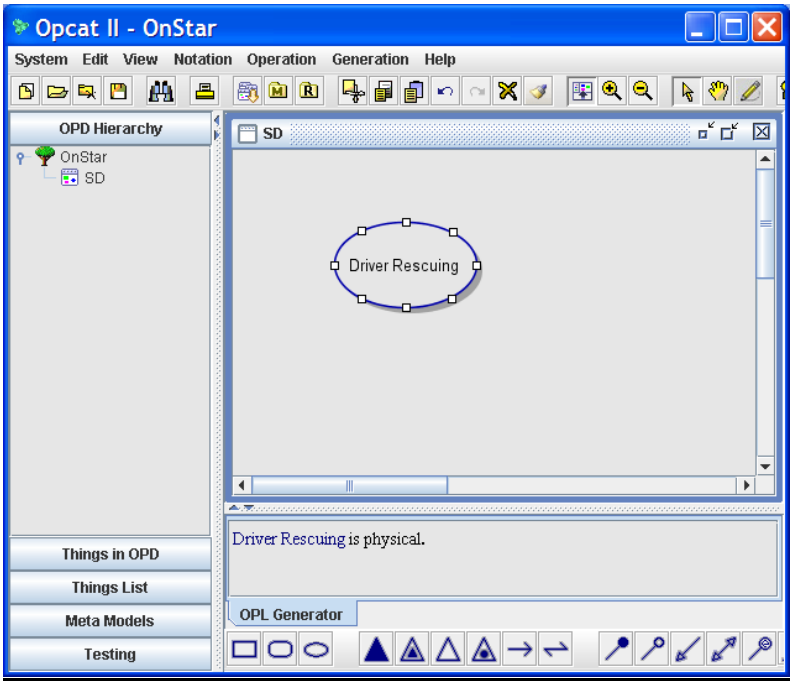


Figure 6. Driver Rescuing, the main function of the system, has been inserted as a physical process. First OPL sentence shows up.

You should get the process as shown in Figure 6. Note that the process is shaded to denote that its **essence** attribute is **physical** (the default essence of OPM things – processes as well as objects – is **informatical**).

Note also that the following OPL sentence appeared in the bottom right pane:

Driver Rescuing is physical.

To help distinguishing between objects and processes, the process name in the text is in blue, as it is in the OPD. Analogously, objects will be green in both the OPD and the OPL. OPL reserved words are in black.

Defining and linking the system's main objects

Having defined the major system function, we now turn to depicting the main objects in the system. We need to think first about who is the beneficiary of the system, i.e., who is the person (or group or people) who gets value from using the OnStar system. Obviously, it is the driver, so we insert **Driver** as a physical object. Since the driver is not part of the system, but interacts with it, its **affiliation** is **environment** rather than **system**, so we mark both radio buttons and the OPL sentence gets automatically updated as follows:

Driver is environmental and physical.

Another vital object in the mode is, of course, the **OnStar System**, which we also add as a physical object. Figure 7 shows SD, the System Diagram, after the objects **Driver** and **OnStar System** were added.

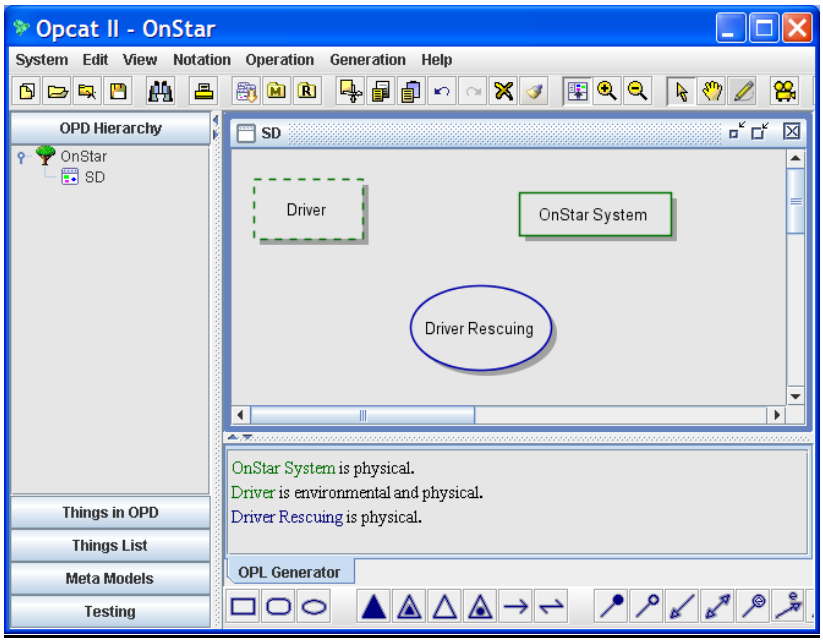


Figure 7. SD after adding the two objects

As the beneficiary, **Driver** is affected by the **Driver Rescuing** process. In OPM, when an object is affected it means that the state of that object (**Driver** in our case) is changed as a result of **Driver Rescuing** acting on it from some state (the input state, i.e., the state of **Driver** at the beginning of the **Driver Rescuing** process) to another state (the output state).

In order to express this, we shall use the effect link. Recall that since this link is between an object and a process, it belongs to the group of procedural links. Indeed, it is the bidirectional arrow depicted fourth from the left within the group.

To create the effect link, clink on it first. Then click on the process and drag it from the process to the object. The result, shown in Figure 8 is expressed in a new OPL sentence:

Driver Rescuing affects Driver.

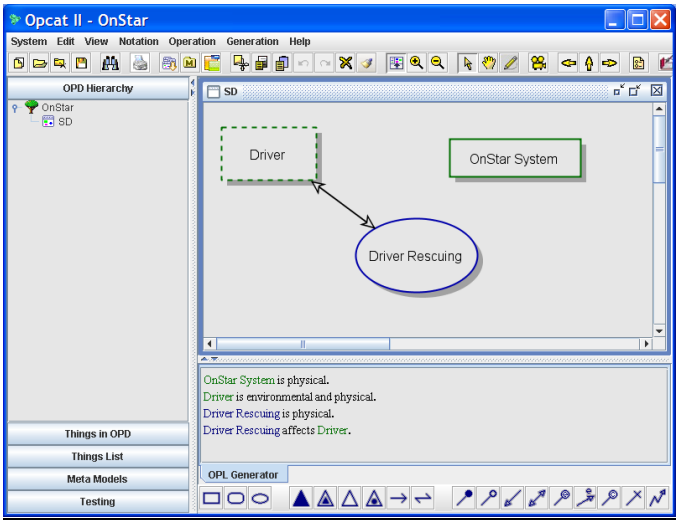


Figure 8. SD after linking Driver and Driver Rescuing with an effect link

The semantics of this OPL sentence is that the **Driver**'s state is changed by the **Driver Rescuing** process, but at this abstract level of detail, the states themselves are not specified, so the effect link abstracts this expression – it is a generalization of the detailed description. At a later stage we will describe the relationship between the **Driver** and **Driver Rescuing** process in more details to show the input and output states of **Driver**.

Next, in Figure 9, the **OnStar System** is added as an *instrument* to the **Driver Rescuing** process. This is done by clicking on the instrument link button – the line with the white circle (white lollipop) – and dragging it from the **OnStar System** – the instrument – to the **Driver Rescuing** process. The sentence added as a result is:

Driver Rescuing requires OnStar System.

Reading the OnStar description we find that

> "*At its most basic, OnStar consists of four different systems: cellular phone, voice recognition, GPS and vehicle telemetry.*"

We now wish to model this sentence, which describes the four main parts of the OnStar System. Adding these four parts is shown in Figure 9.

The parts are added one by one. We first click on the Object symbol button, then on the spot on the screen where we want it to be located. The location of each object is determined by where we click on the screen after selecting the Object button. Naturally, the objects are therefore not quite aligned, and we may wish to align them.

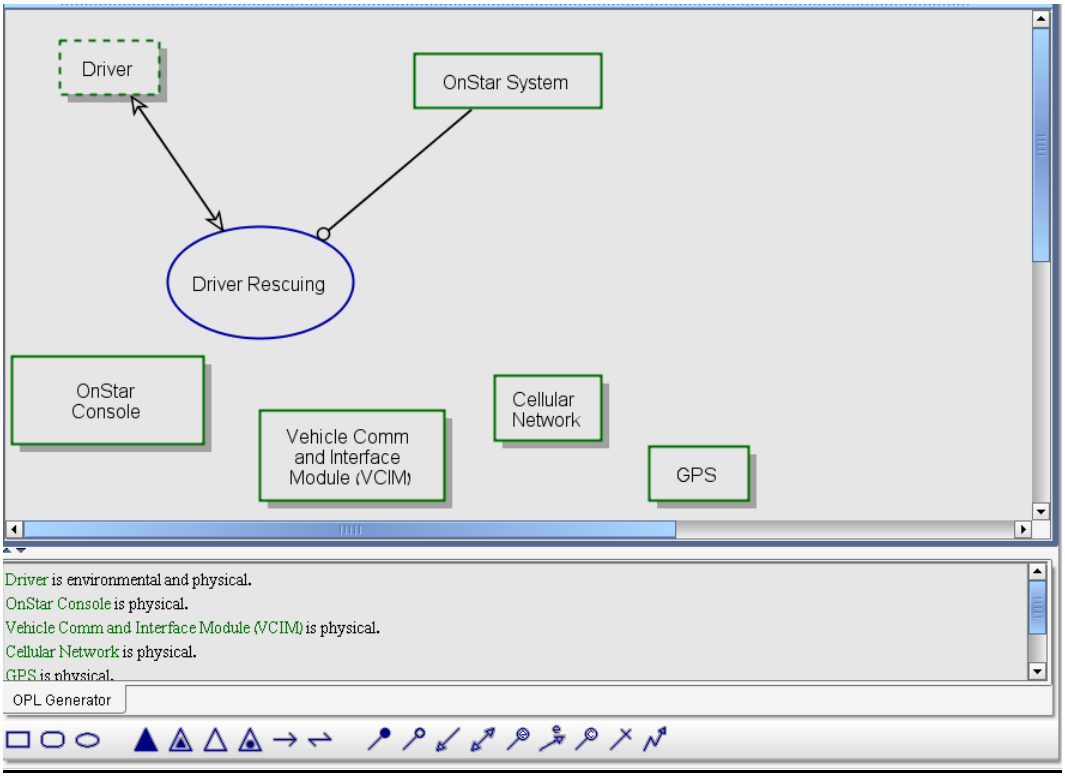


Figure 9. Adding the four parts of OnStar System

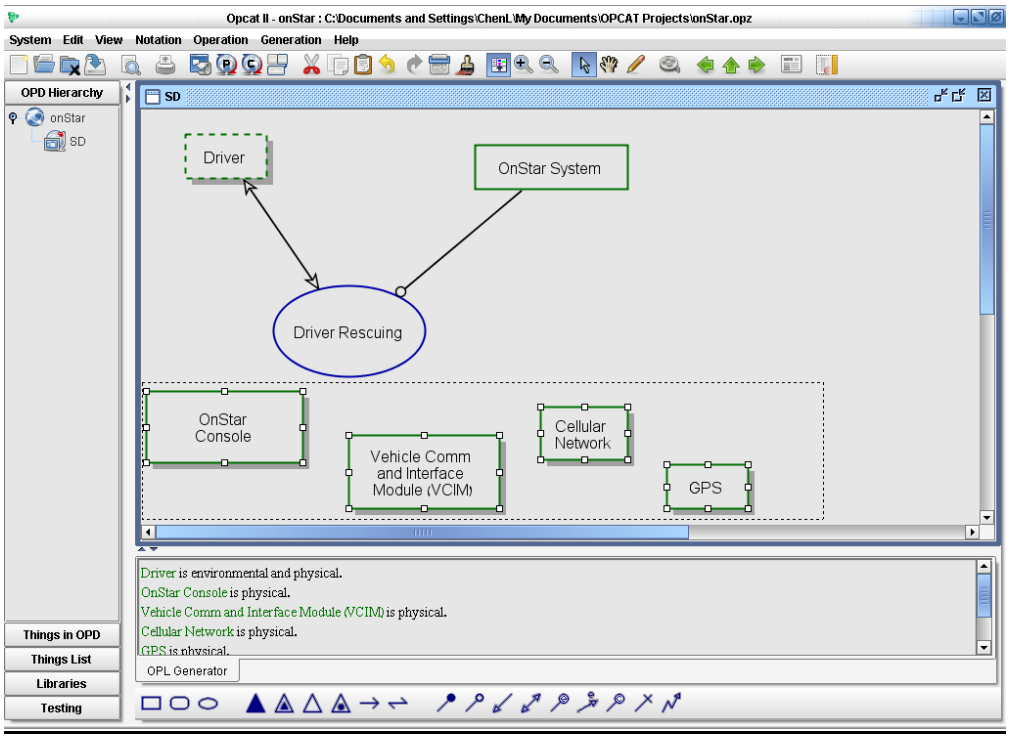


Figure 10. Marking the four parts of OnStar System for horizontal alignment

Marking the four parts of OnStar System for horizontal alignment is shown in Figure 9. We mark all at once by clicking and dragging the mouse to include all the things we wish to mark within the dotted area. The marking is shown by small white squares on each object.

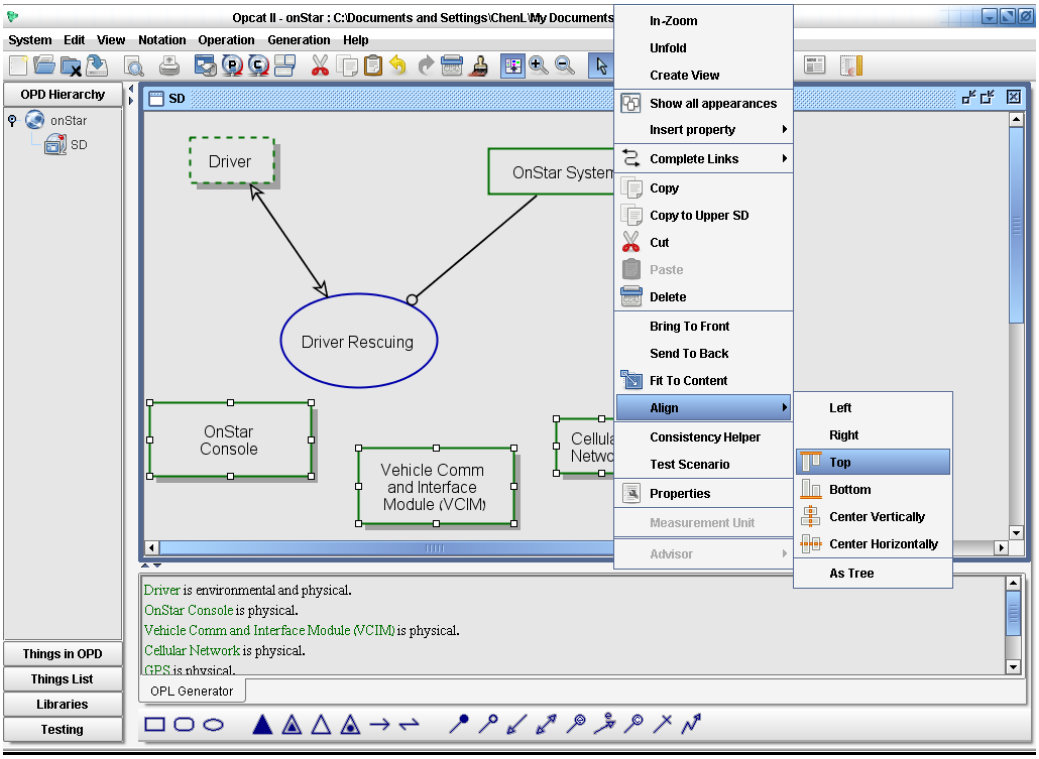


Figure 11. Top alignment of the four parts of OnStar System

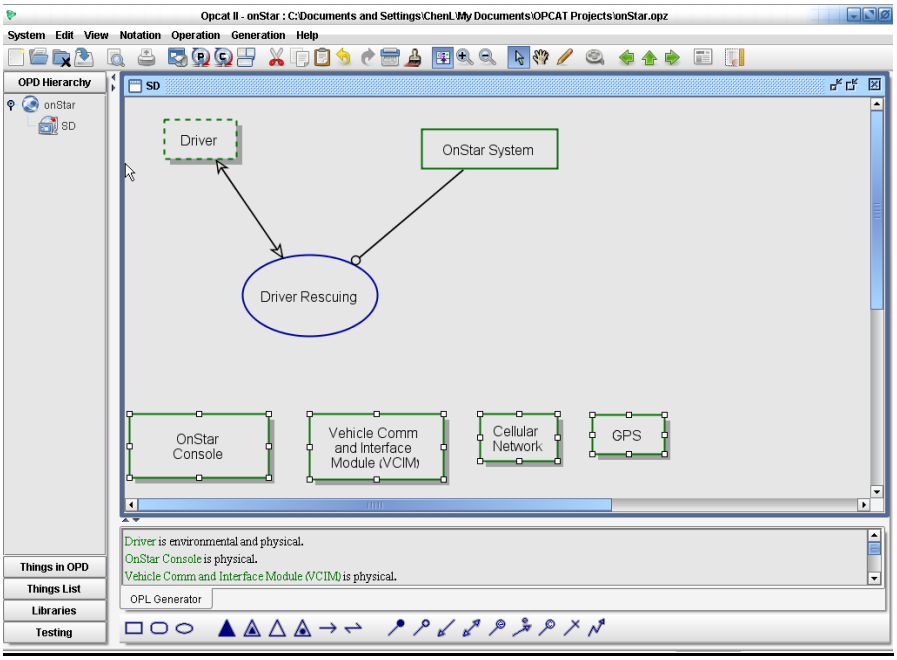


Figure 12. The four parts of OnStar System after top alignment

Right Clicking on one of the four marked objects brings the pop-up menu shown in Figure 11, and clicking "Align" brings a sub-menu, from which we select "Top". The result of the aligned objects is shown in Figure 12.

At this point, we wish to denote the fact that all these four objects are part of the OnStar System. This is an opportunity to introduce in the next section the set of OPM symbols which appear at the bottom of the screen.

Quick Summary

- Using a top-down approach, we start off by modeling the main function of the system as the central process in **SD** - the **S**ystem **D**iagram, which is the first **OPD** in our model.
- In SD we establish the main function of the system and the objects involved in this process.
- **Things** – **Objects** or **Processes** – have an **Essence** attribute and an **Affiliation** attribute.
- The default **Essence** is **informatical** and the default **Affiliation** is **systemic**.
- Informatical **things** are for example file, command, message, and algorithm. **Things** which are not Informatical shall be marked as **physical**.

- **Things** which are not **systemic** – not part of the system (but interact with it) – shall be marked as **environmental.**
- Environmental objects interact with our system but we, as system architects and designers, have no influence on their design.
- The system can affect environmental objects but it is not responsible for creating them.
- We add the main objects in the system, denoting, if needed, their **Essence** as **physical** and their **Affiliation** as **environmental**.
- Each part of the system which will be modeled later in more detailed OPDs is some refinement (specification of parts, specializations, or features) of the Things in the **SD**.

4. The OPM symbols

The OPM symbol buttons at the bottom of the screen are divided into three groups. The next three figures present in tabular form each one of the three symbol groups.

Entities

The group on the left is the group of the entities: Object, state, and process.

Symbol		Name: Definition	OPL	Allowed Source-to-Destination connections	Semantics/ Effect on the system flow/ Comments
Things		Object **A**: A thing that exists	**A** is physical [and environmental].		**A** is informatical and systemic by default.
		Process **B**: A thing that transforms (generates, consumes, or changes the state of an) object.	**B** is physical [and environmental].		**B** is informatical and systemic by default.
		State: A situation of an object.	**A** is s1. **A** can be s1 or s2. **A** can be s1, s2, or s3.		Always within an object.

Figure 13. The OPM entities

Structural Links

In the middle is the group of the structural links: four triangles and two arrows with open heads.

The structural links denote static, long-term relations that have no relation to the time dimension and hold true throughout the system's existence between an object and other objects or between a process and other processes.

Symbol	Name: Definition	OPL	Allowed Source-to-Destination connections	Semantics/ Effect on the system flow/ Comments
▲	Aggregation-Participation	**A** consist of **B**.	Object-Object Process- Process	Whole -Part
△	Exhibition-Characterization	**A** exhibits **B**.	Object-Object Object-Process Process-Object Process- Process	
△	Generalization-Specialization	**B** is an **A**. (objects) **B** is **A**. (processes)	Object-Object Process- Process	
△	Classification-Instantiation	**B** is an instance of **A**.	Object-Object Process- Process	
→ ⇄	Tagged structural links: Unidirectional Bidirectional	According to text added by user	Object-Object Process- Process	Describes structural information.

Figure 14. The structural links

Procedural Links

The OPM symbols grouped on the left are the procedural links: four triangles and two arrows with open heads.

The procedural links denote dynamic, transient relations that have everything to do with the time dimension. Opposite to the structural links, they connect an object and a process but not an object to another object.

Symbol	Name: Definition	OPL	Allowed Source-to-Destination connections	Semantics/ Effect on the system flow/ Comments
	Agent Link	**A** handles **B**.	Object (A) to Process (B)	Denotes a human operator. Activating the link triggers the process B.
	Instrument Link	**B** requires **A**.	Object (A) to Process (B)	Wait until A is generated and exists. Wait until A is at state s1.
		B requires s1 **A**.	State (s1) to Process (B)	
	Condition Link	**B** occurs if **A** exists.	Object (A) to Process (B)	Execute if object A exists, and if not then skip process B and continue the regular system flow. Execute if object A is at state s1, and if not then skip process B and continue the regular system flow.
		B occurs if **A** is s1.	State (s1) to Process (B)	
	Effect Link	**B** affects **A**.	Object (A) to Process (B)	Used when details of the effect are not necessary or will be add at a lower level (also created when states lined to a process with an input-output pair are hidden-suppressed) Affect at an high level signifies at lower levels – • State changes • Consumption and later generation

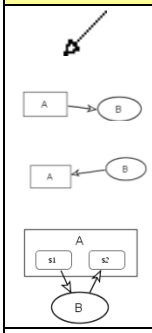
Symbol	Name: Definition	OPL	Allowed Source-to-Destination connections	Semantics/ Effect on the system flow/ Comments
	Consumption Link Result Link Input-Output Link Pair	**B** consumes **A.** **B** yields **A**. **B** consumes s1 **A.** **B** yields s1 **A**. **B** changes **A** from s1 to s2.	Object to Process Process to Object State to Process Process to State Process – State s1 to Process and Process to s2.	Process consumes the object. Process creates the object. Process changes the state of object.
	Invocation Link	**B** invokes **C**.	Process-Process	Execution will proceed if the triggering failed (due to failure to fulfill one or more of the conditions in the precondition set).
	Instrument Event Link	**A** triggers **B**. s1 **A** triggers **B**.	Object (A) to Process (B) State (s1) to Process (B)	Execution will proceed if the triggering failed (due to failure to fulfill one or more of the conditions in the precondition set). For normal, non-triggered execution, the object or state linked is not required for the process to take place.
	Consumption Event Link	**A** triggers **B**, which, if occurs, consumes **A**. s1 **A** triggers **B**, which, if occurs, consumes **A**.	Object (A) to Process (B) State (s1) to Process (B)	Execution will proceed if the triggering failed (due to failure to fulfill one or more of the conditions in the precondition set). For normal, non-triggered execution, the object or state linked is not required for the process to take place.

Figure 15. The procedural links

5. Using Structural Relations

Structural relations are used to model the structure of the system. The most prevalent structural relation is the Whole-Part relation, denoted as solid, filled-in triangle whose tip is connected to the whole and whose base—to the parts.

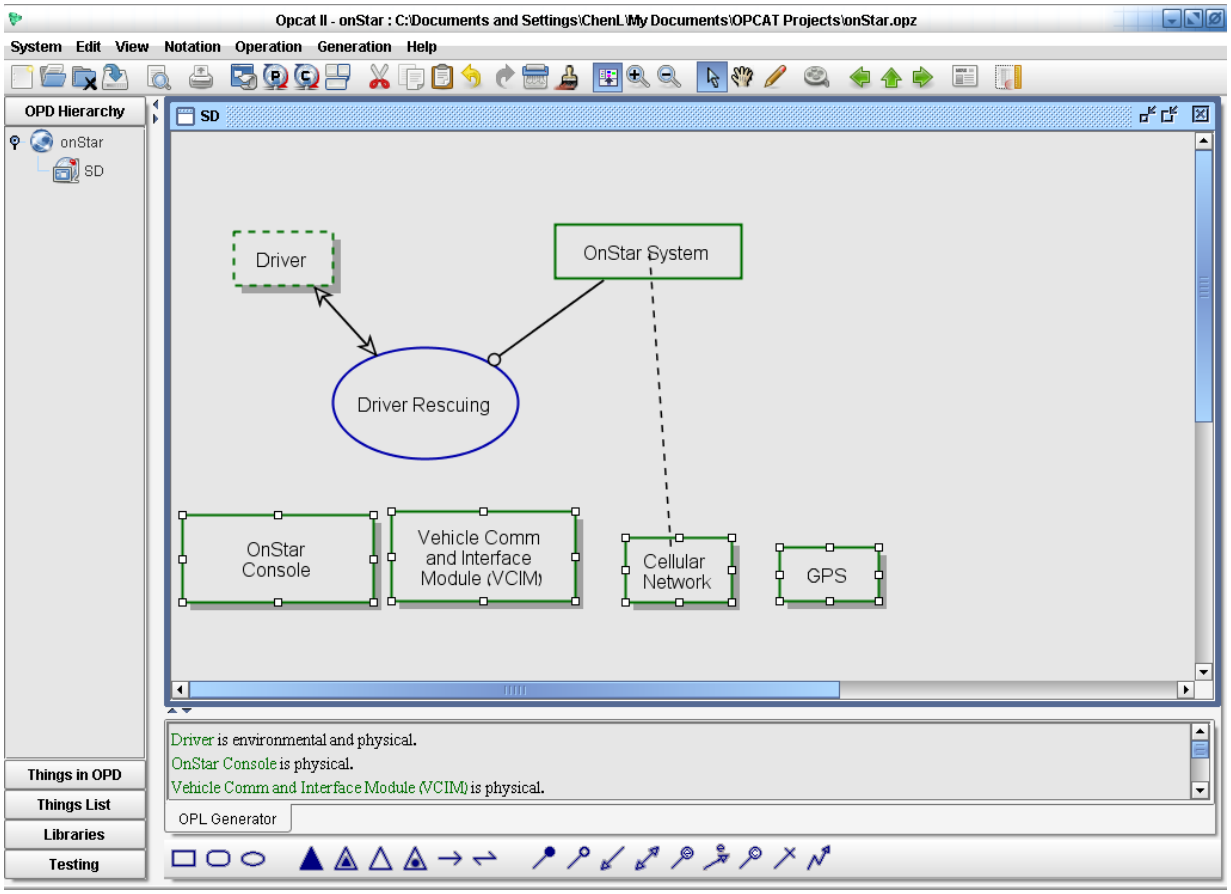


Figure 16. Linking the Cellular Network part of OnStar System to the whole OnStar System

Continuing with our example, to denote the fact that the four marked objects in Figure 16 are parts of OnStar System, click on the solid (black or blue) triangle and then click the mouse on the whole – the OnStar System – and drag it to one of the parts, e.g., Cellular Network.

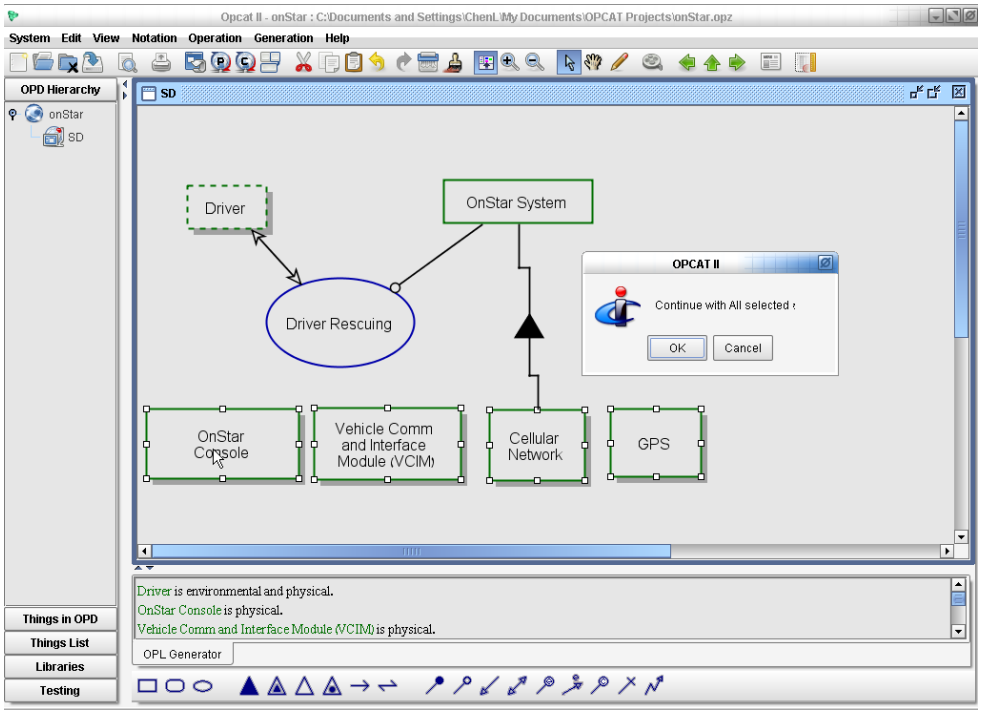


Figure 17. The question asked after linking Cellular Network to the whole OnStar System

Since several objects are marked, a question shown in Figure 17 appears, asking whether we wish to continue with all the selected objects, i.e., are they too parts of the whole.

Clicking OK will generate the four links in Figure 18. The resulting OPL sentence, shown in the second line of the OPL pane, is:

OnStar System consists of OnStar Console, Vehicle Comm and Interface Module (VCIM), Cellular Network, and GPS.

In order to specify that **Driver** communicates via **OnStar Console**, we click on the unidirectional tagged structural link, the fifth button in the middle in the structural links group, and drag it from **Driver** to **OnStar Console**. The result (without the label along the link) is shown in Figure 19. Inspecting the newly generated OPL sentence we see that it reads as follows:

Driver relates to OnStar Console.

Since we wish to be more specific, we double click the link we just drew and get the dialog box in Figure 20. We type "**communicates via**" in the Tag box, click OK, and the OPL sentence now changes to: Driver communicates via OnStar Console. This OPL sentence appears at the last line in Figure 19.

Tagged Structural Links are user-defined and they provide additional information about the system that cannot be expressed via the OPM predefined structural links.

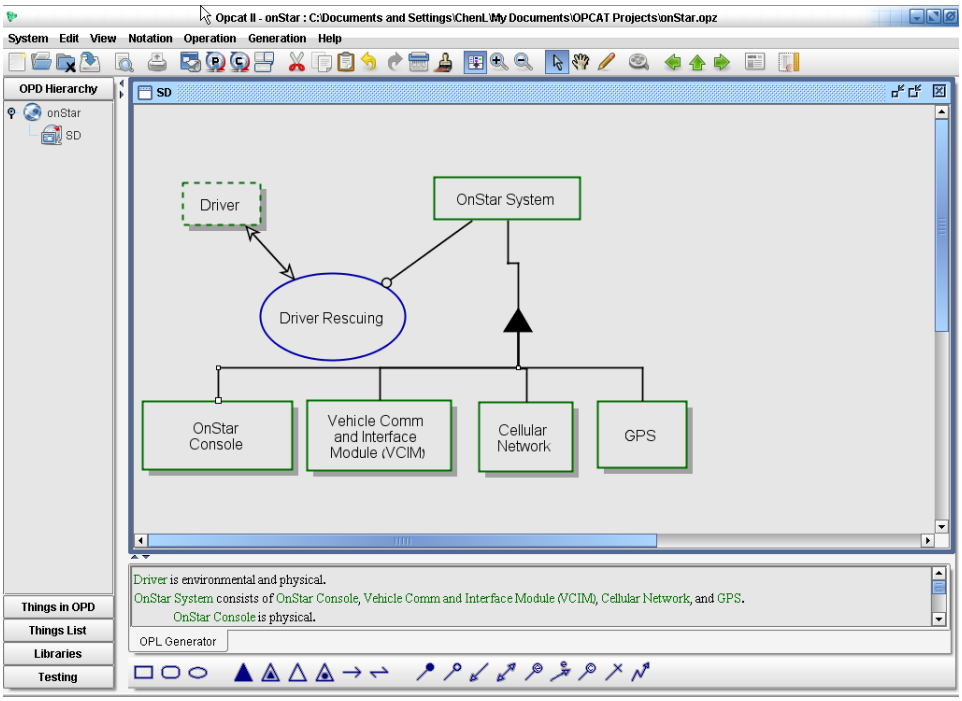


Figure 18. The four parts of Cellular Network are now linked to the whole OnStar System

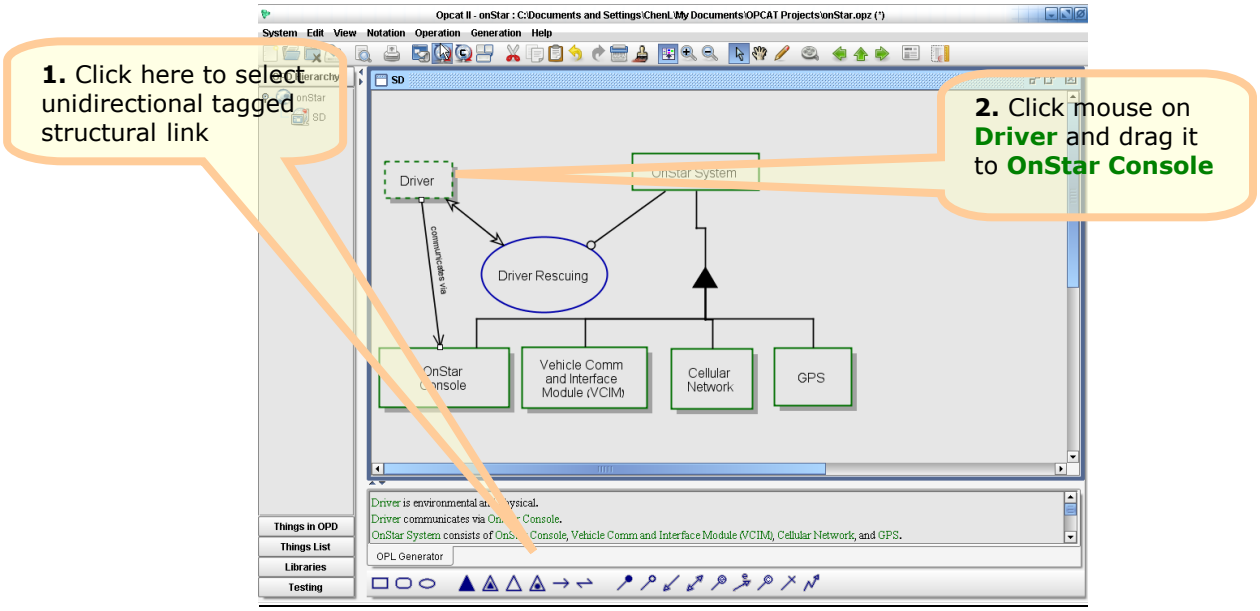


Figure 19. Specifying that Driver communicates via OnStar Console

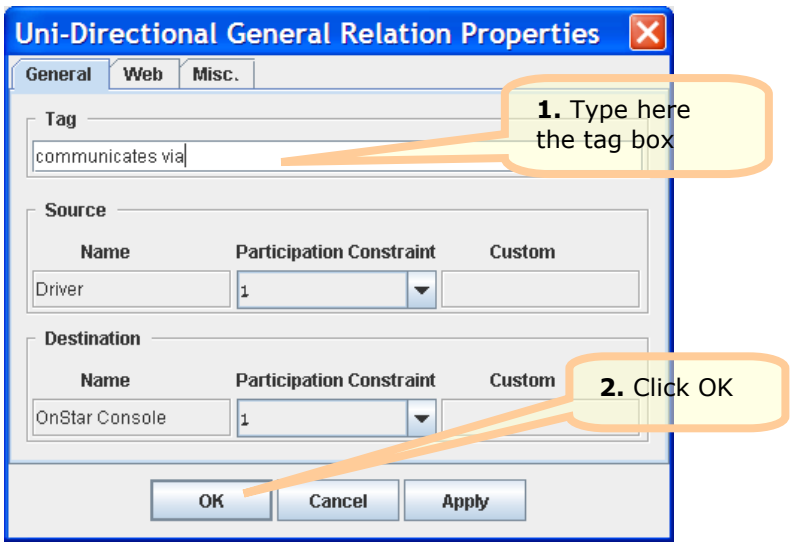


Figure 20. Inserting the tag "communicates via" in the unidirectional general structural relation

6. Zooming into the main process

At this point the System Diagram, SD, is already quite crowded, but we barely scratched the surface of specifying the **OnStar System**. How are we going to keep on modeling while maintaining the OPD clear and readable?

To the rescue comes the OPM built-in in-zooming mechanism. In-zooming is a refinement mechanism. It enables starting a new Object-Process Diagram (OPD), in which a thing (process or object) is copied from the ancestor OPD, and it is blown-up (in-zoomed) in order to enable specifying its sub-processes within it. To maintain the consistency across the entire OPD set, while you zoom into a thing and create a new OPD, things that were attached to that thing directly or indirectly via more abstract in-zooming levels are brought along to the newly-created OPD.

As Figure 21 shows, we select the main function of our system, the **Driver Rescuing** process, and continue refining the specification of the system using SD as the root of the OPD tree.

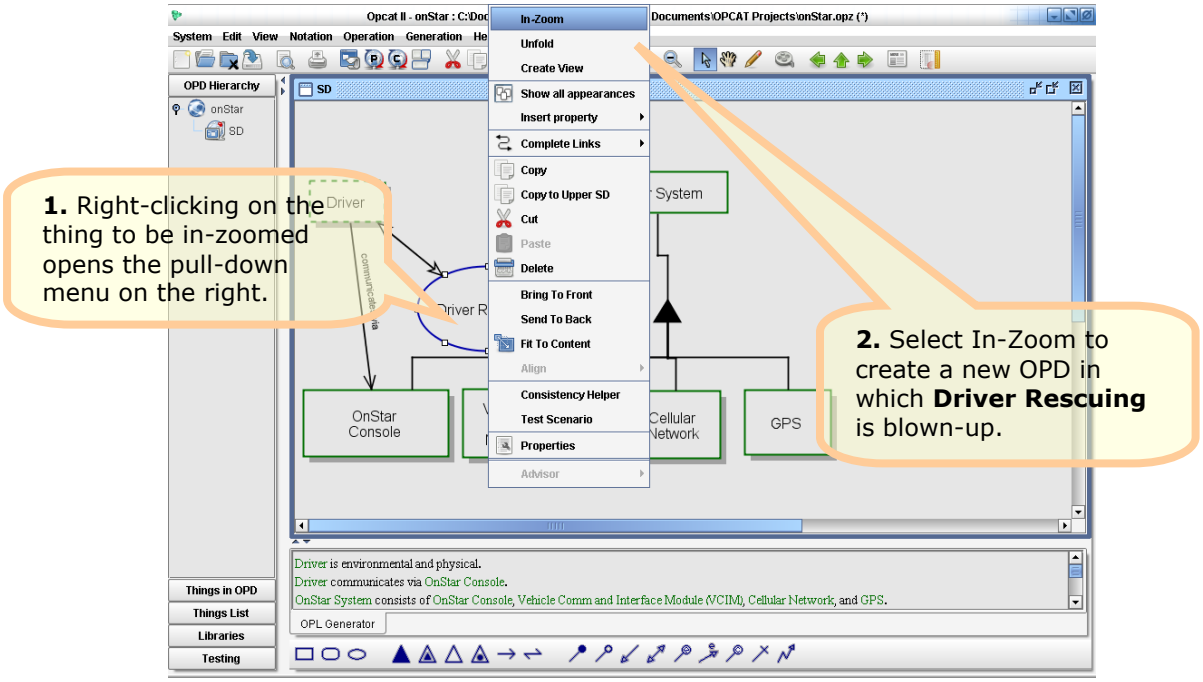


Figure 21. Zooming into the Driver Rescuing process

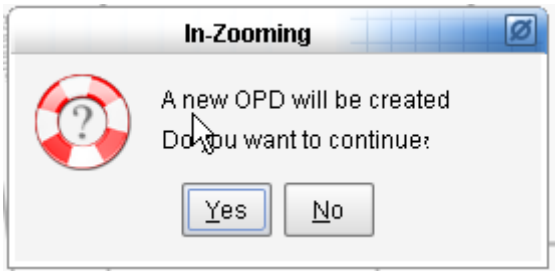


Figure 22. Zooming into the Driver Rescuing process

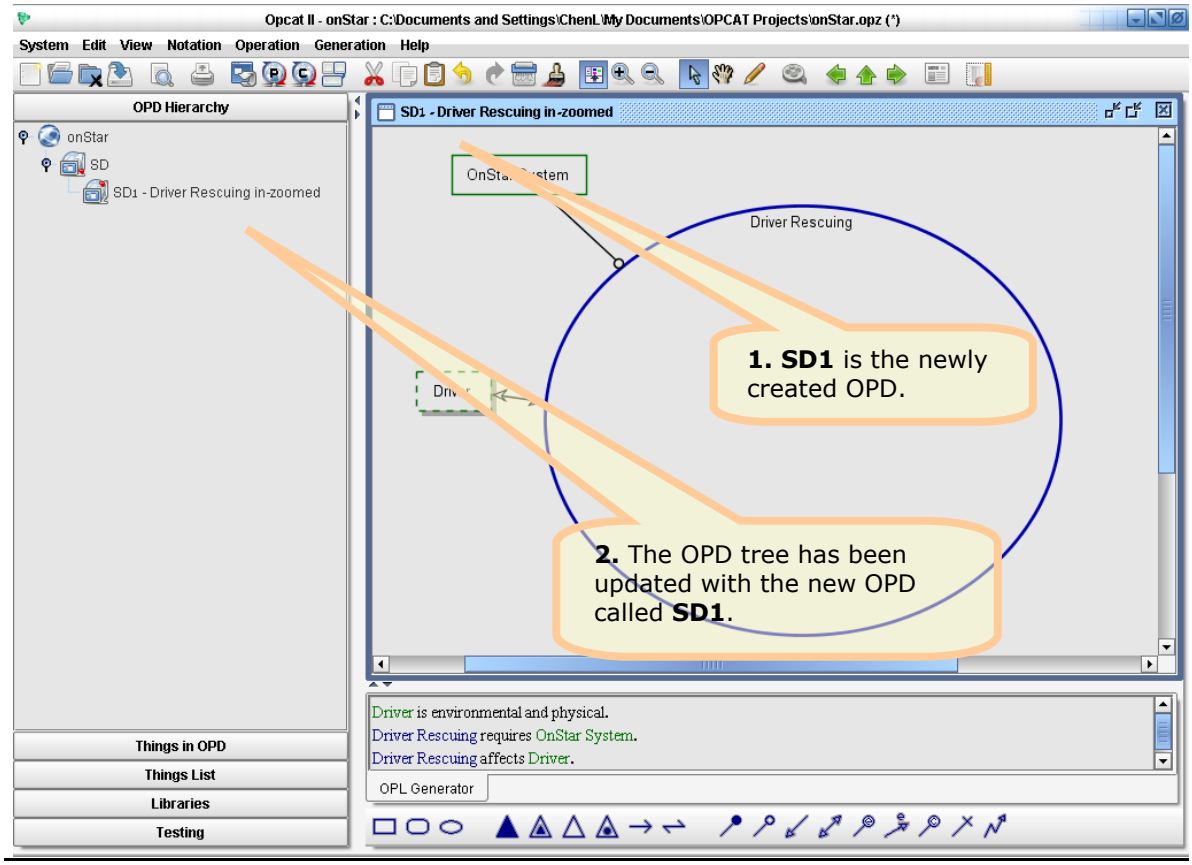


Figure 23. The new OPD titled SD1 – Driver Rescuing in-zoomed, created after zooming into the Driver Rescuing process

Following the "five plus or minus two" rule related to humans' limited channel capacity, we continue refining the system's specification by depicting 3 to 6 subprocesses nested inside the in-zoomed process, which, in turn can be further in-zoomed into new 3 to 6 subprocesses, and so on, until the level of detail is sufficient for the task at hand.

SD1 should hence describe the 3 to 6 main subprocesses comprising the **Driver Rescuing** process by the **OnStar** system.

For each process we will describe the preconditions and the postconditions of that process. Both preconditions and postconditions are expressed in terms of the (possibly stateful) objects that are linked to the process. More details about these additional objects can possibly be added when we zoom into the sub-subprocesses of each subprocess.

OPDs at lower levels are merely detailed descriptions of OPDs in upper levels. No object can be depicted in a lower-level OPD unless it or its ancestor (parent in some generation). Consistency must be maintained between any two OPDs related by a father-son relationship,

so that overall the entire OPD set is consistent. Additional explanation about this topic is provided in the Advanced Course Package.

To make a call in the **OnStar** system, the driver says out-loud a phone number or a previously stored name associated with a phone number. Modeling this statement presents us with an opportunity to recommend an effective OPCAT design facility called ***Insert Property***.

The first subprocess of **Driver Rescuing** is **Call Making**. In Figure 24 we add this subprocess within and at the top of the enclosing **Driver Rescuing** process.

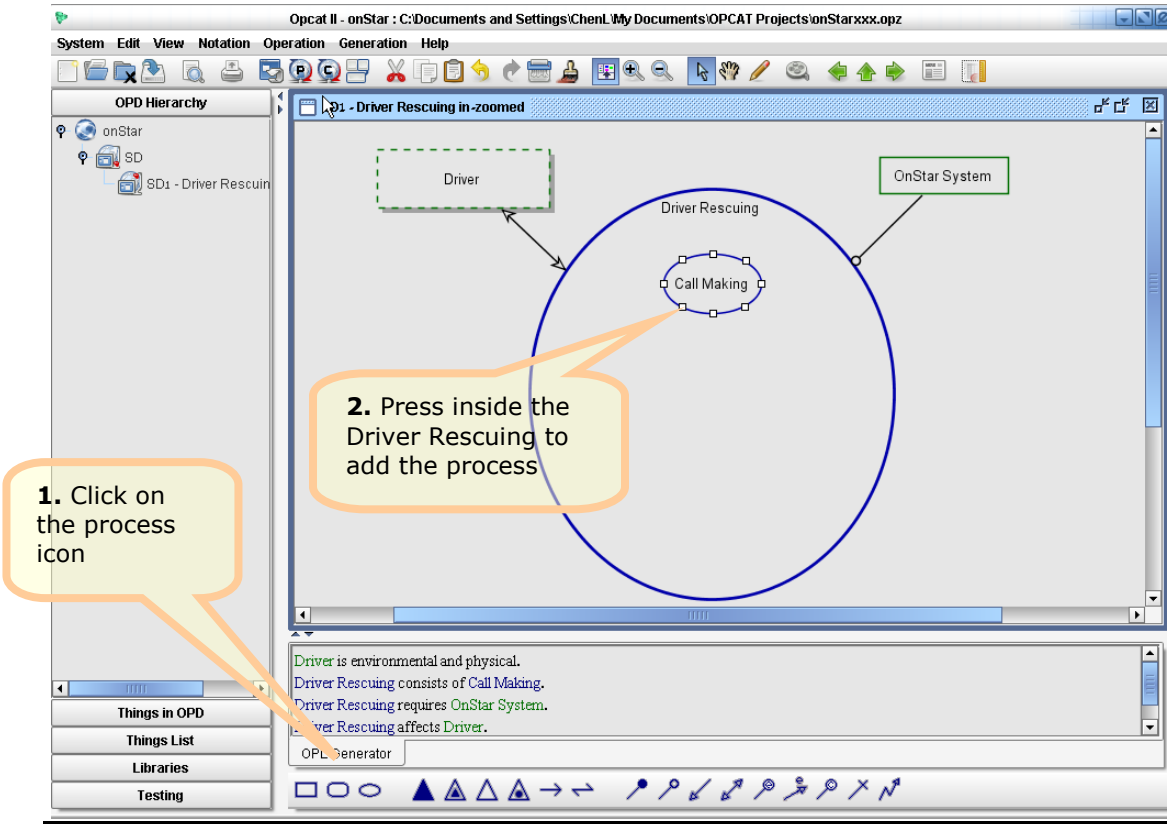


Figure 24. Call Making is inserted as the first subprocess within the in-zoomed Driver Rescuing process.

Call making requires the **Driver** and the **OnStar Console**. In order to express this we need to bring **OnStar Console** to this OPD. Since **OnStar Console** is already connected to the **OnStar System** elsewhere, in another OPD, we can use ***Insert Property*** to facilitate this action.

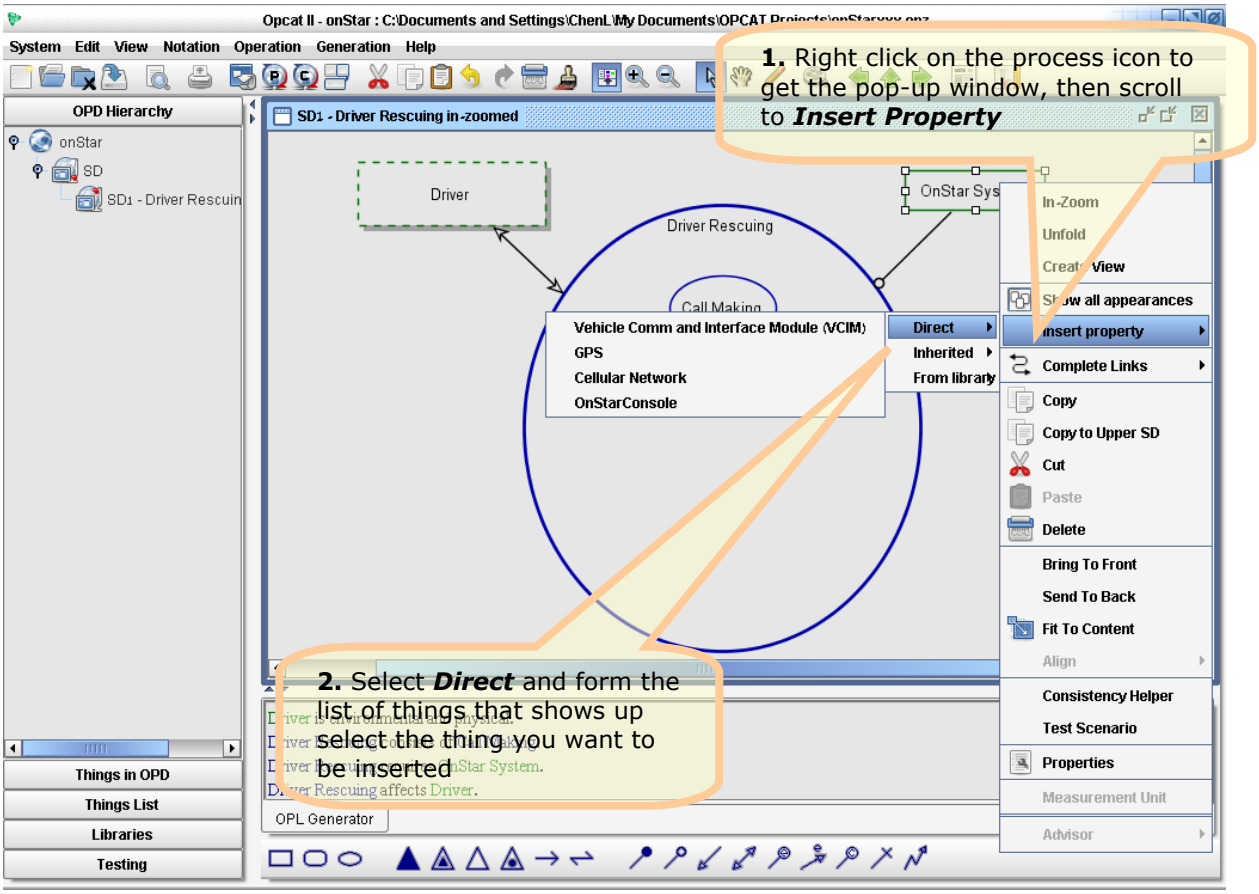


Figure 25. Adding OnStar Console by using the Insert Property feature

*The **Insert Property*** feature is available if the relationship is defined in other OPD or is inherited. Figure 25 shows how **Driver** and **OnStar System** are brought into **SD1**. It is also possible to insert a structural relationship which is stated in the model repository. To learn more about this option please refer to the Advanced Course Package.

Having placed **Call Making** inside **Driver Rescuing**, we now wish to indicate that **Driver** and **OnStar Console** are both enablers of the **Call Making** process. **Driver** is a human enabler—an ***agent***, while **OnStar Console** is a non-human enabler—an ***instrument***. To denote this, we link **Driver** to **Call Making** using an agent link—the solid lollipop—the first link in the procedural links group. We select it, then click on **Driver** and drag it to **Call Making**. Similarly, we link **OnStar Console** to **Call Making** using an instrument link—the hollow white lollipop—the second link in the procedural links group. We select it, then click on **OnStar Console** and drag it to **Call Making**.

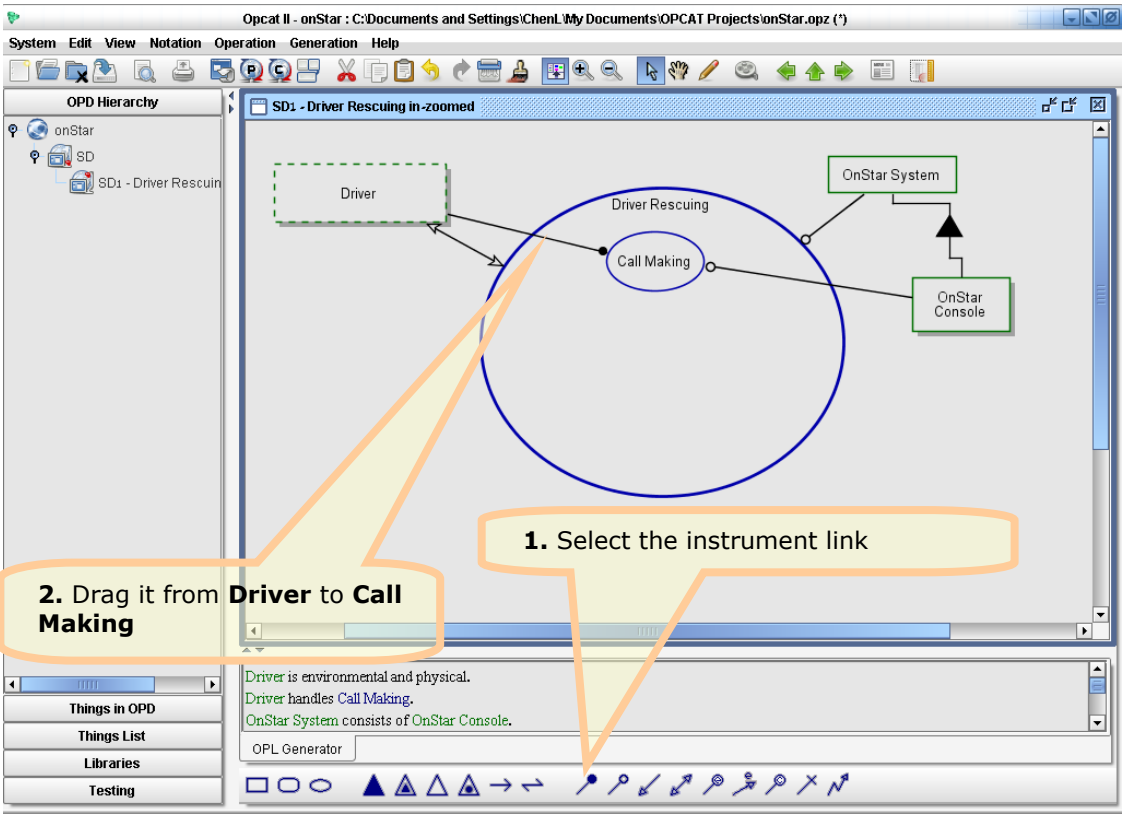


Figure 26. Connecting Call Making to the agent Driver and the instrument OnStar Console

The **Driver** and **OnStar System** linked to **Call Making** are the preconditions set for **Call Making** to occur. To define the postcondition set for **Call Making**, we ask ourselves what is the result or effect of **Call Making**. The result of **Call Making** is a **Call**, so we add it in Figure 27.

Once **Call** is created by **Call Making**, it needs to be transmitted, so the next process is **Call Transmitting**.

Important: Processes in OPCAT within an in-zoomed process happen top down—the time line is vertical starting from the top of the in-zoomed process ellipse and ending at the bottom of the ellipse.

Since **Call Transmitting** occurs after **Call Making**, in Figure 28 we place the latter before the former.

If processes happen in parallel, they are positioned such that their corresponding ellipse tops are at the same height. To design asynchronous processes that are triggered without a

predetermined time order, we use whole-part relation between processes. For more details, please refer to the Advanced Course Package.

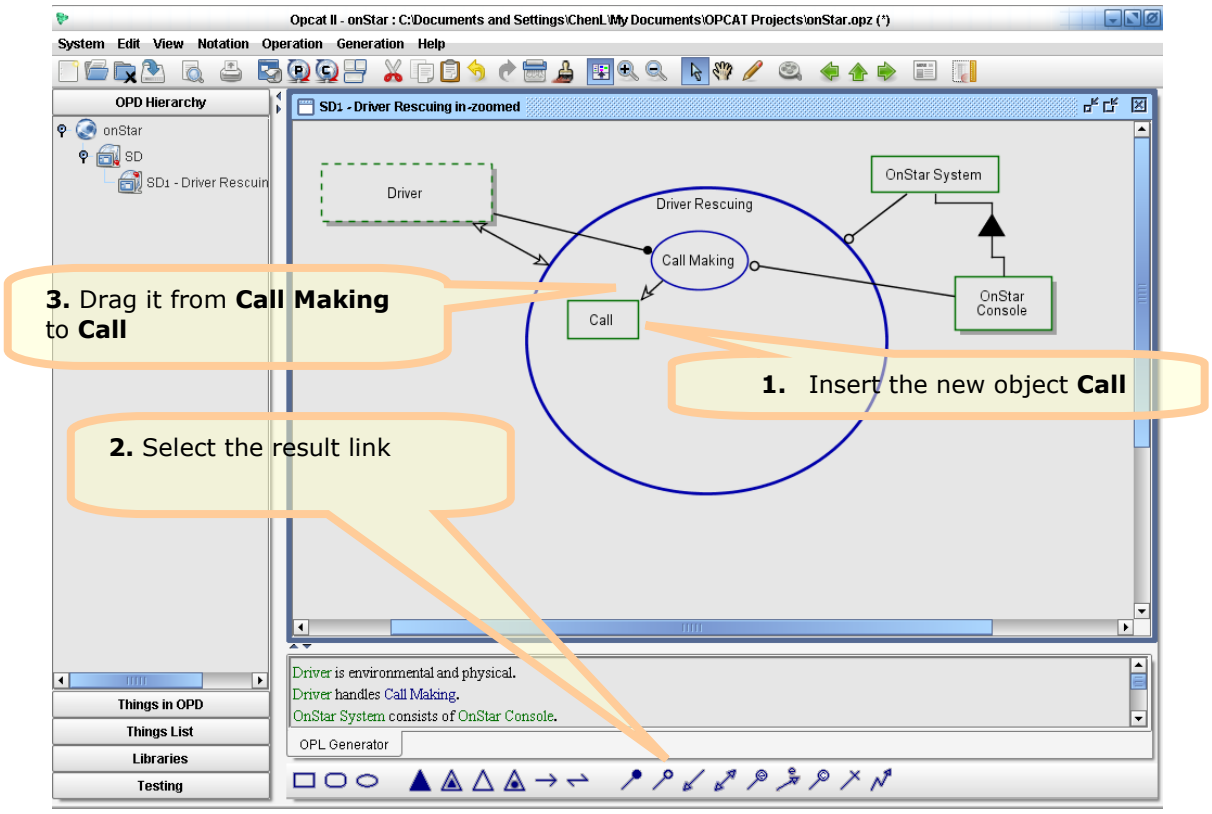


Figure 27. Call is generated as a result of Call Making.

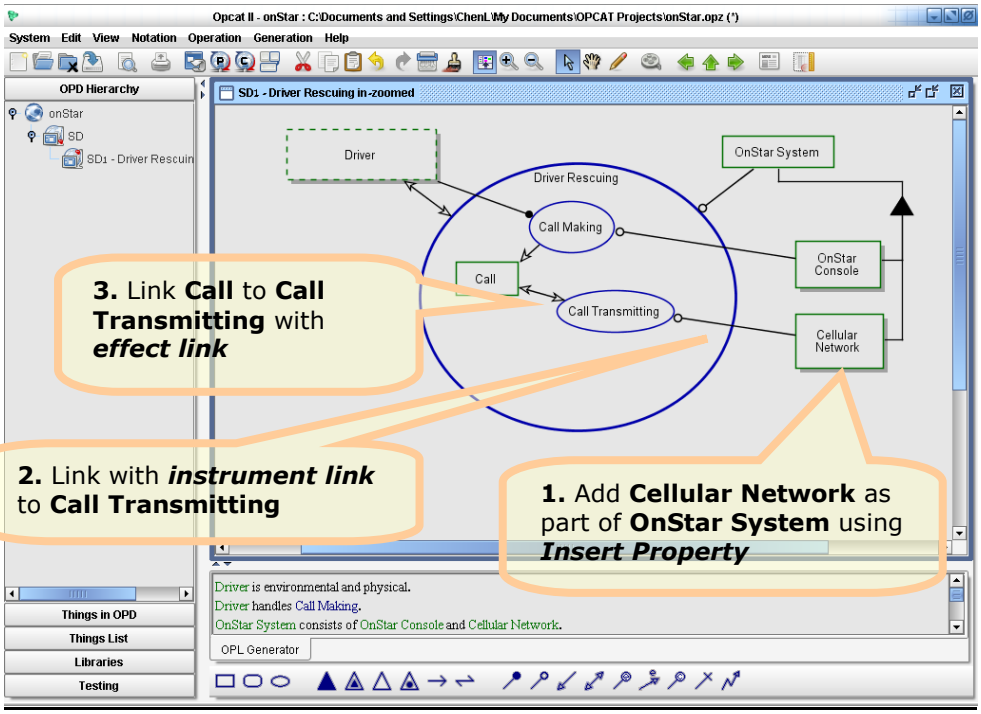


Figure 28. Call Transmitting preconditions

Call Transmitting requires the **Cellular Network** and affects the **Call**. We add **Cellular Network** to **SD1** using the ***Insert Property*** feature. Alternatively we could copy **Cellular Network** from **SD** and paste it to **SD1**.

Vehicle Location Calculating is a process that is done in parallel to **Call Transmitting** using the **GPS** to produce the **Vehicle Location**. These new objects and processes and the links between them are shown in Figure 29.

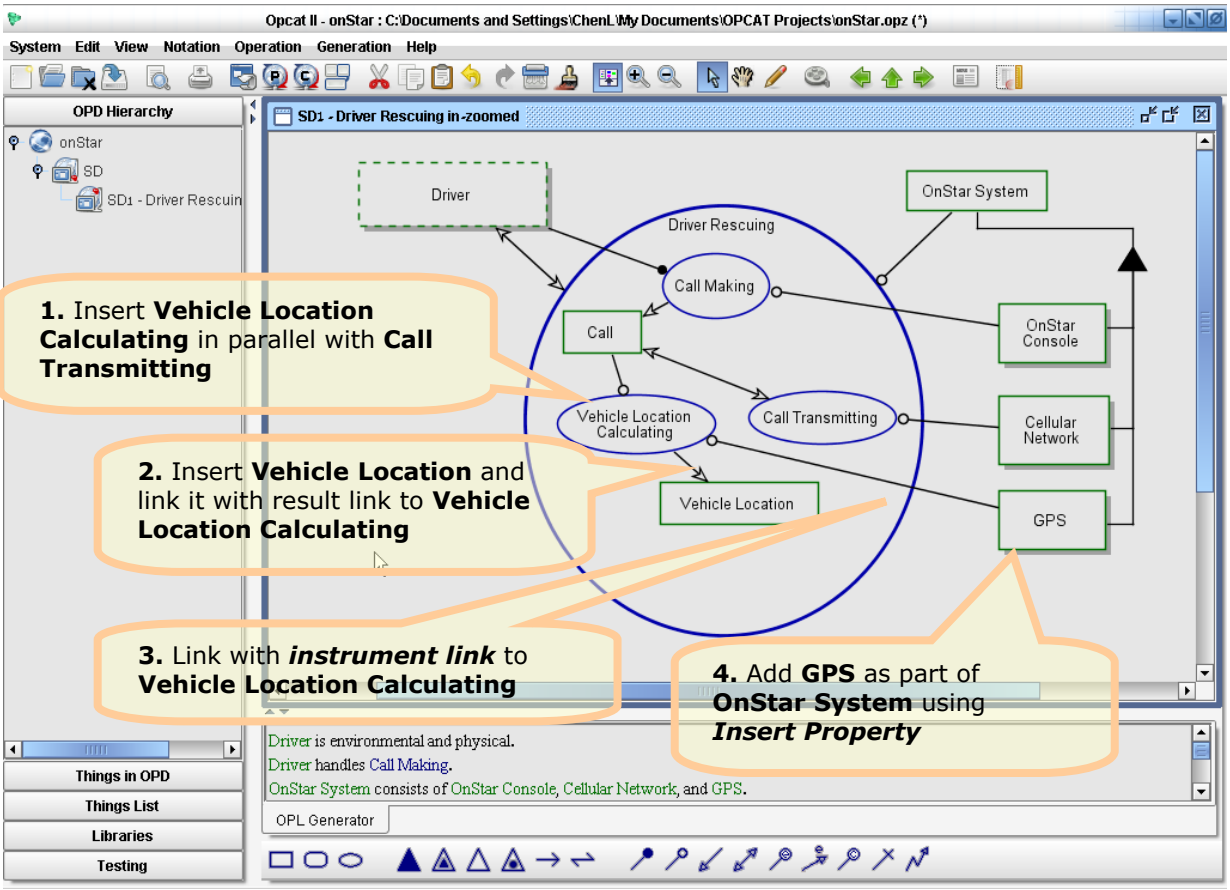


Figure 29. Adding Vehicle Location Calculating

Quick Summary

- We zoom into the main process and then describe the different subprocesses within it.
- The process activation order is from the top of the in-zoomed process ellipse to its bottom. Parallel subprocesses are positioned at the same height.
- Processes that are asynchronous (i.e., without a predetermined time line) are positioned outside the super-process and are linked to it with aggregation relation. For more information about this please refer to the OPCAT Advanced Course lessons.
- In parallel to specifying the subprocesses we describe the details (parts) of the surrounding objects.
- Each process will be connected to the relevant object with the appropriate procedural link.
- An object that is linked to all the subprocesses with the same link type (for example, an object is an instrument to all the subprocesses) can and should be connected with just one link to the in-zoomed process, which acts as "parenthesis", similar to parenthesis in an algebraic expression.

7. States and Basic Control Flow

As noted, the ***effect link*** between **Call Transmitting** and **Call**, shown in Figure 29, can be replaced in a lower level OPD by a set of more detailed links showing the actual change of states of **Call**. In Figure 30 we add to **Call** the two states **requested** and **online**.

Once these two states are established, we replace the ***effect link*** between **Call** and **Call Transmitting** with a pair of links called ***input-output links pair***. This pair consists of an ***input link***—from the state **requested** to **Call Transmitting** and an ***output link***—from **Call Transmitting** to the state **online**. This fact is also represented by the OPL sentence:

Call Transmitting changes **Call** from **requested** to **online**.

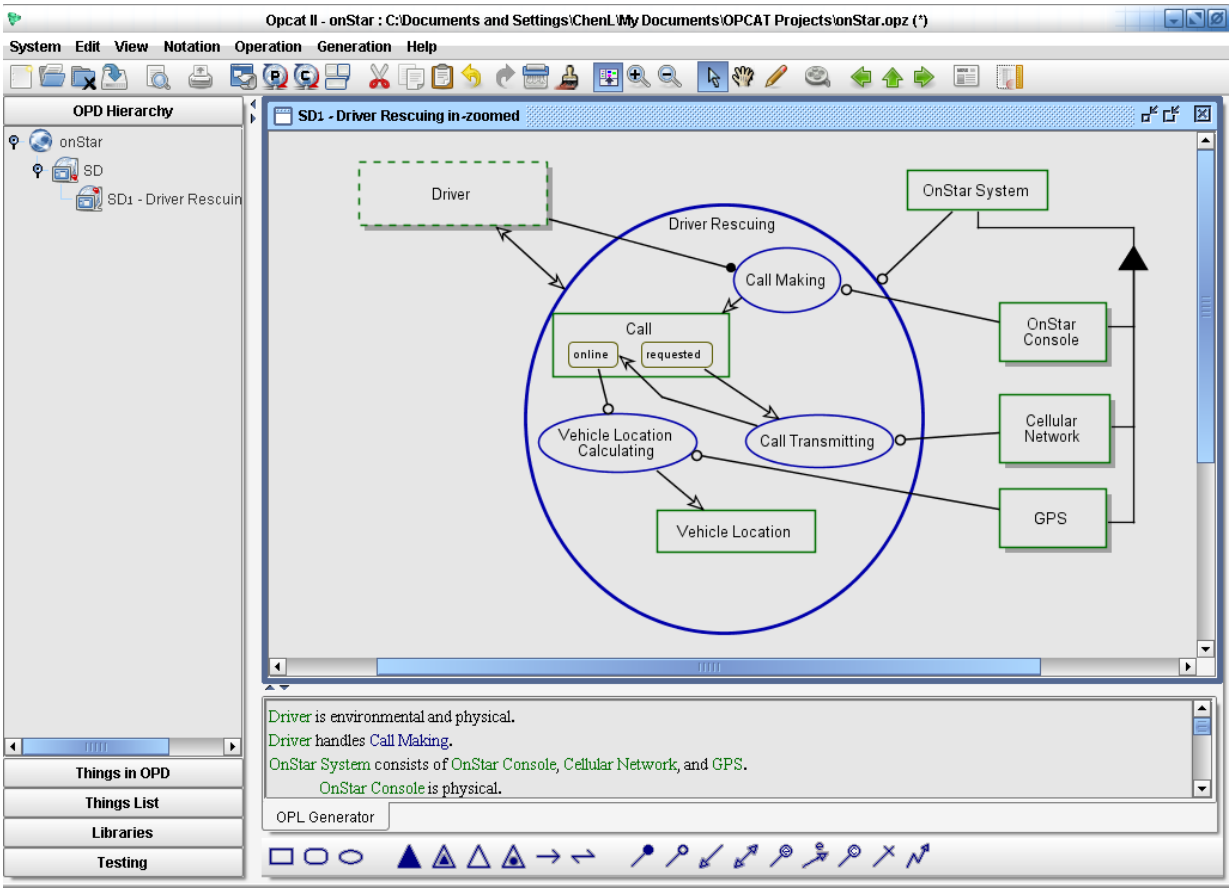


Figure 30. States added to Call Conditional flow

Additional information about conditional flow can be found in the Advance Course Package.

8. Consistency

We now add the final subprocess of **Driver Rescuing**, which is **Call Handling**. According to the **OnStar System** description, the OnStar advisor handles the received call. In Figure 31 we therefore add **OnStar Advisor** to the OPM model.

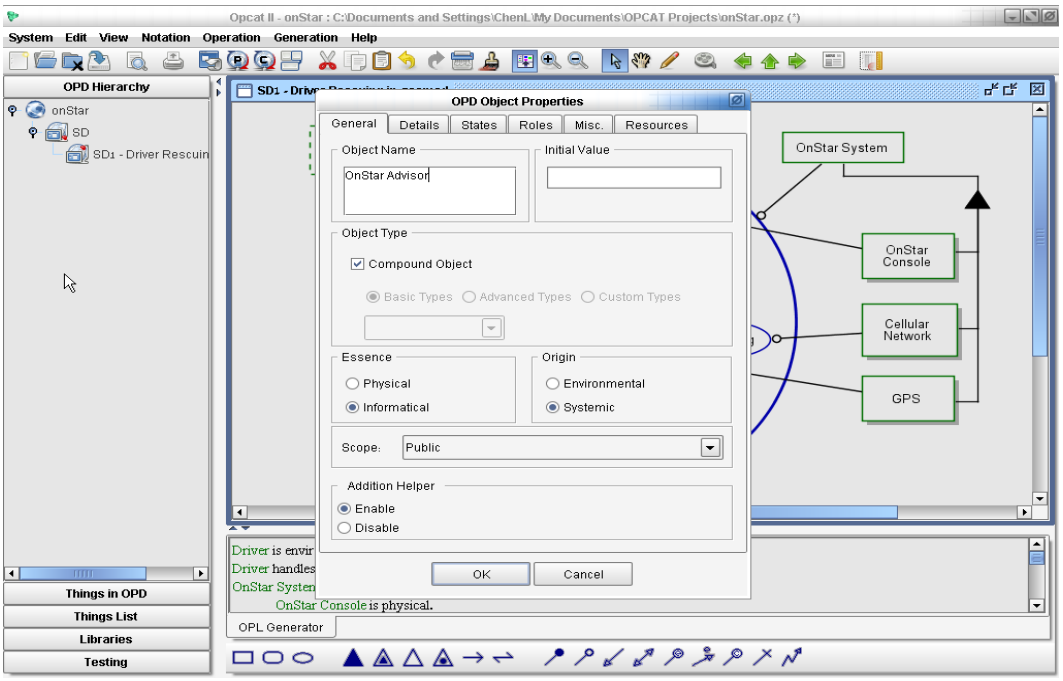


Figure 31. Adding the OnStar Advisor

OnStar Advisor is added outside the process, while **Call** was previously added inside the processes. Why is that so? The answer is that **Call** is an object which "lives" only as long as **Driver Rescuing** is active. In general, an object that is required only by one or more subprocesses and does not exist when the process is not active will be positioned inside the process. Otherwise the object must be positioned outside the process.

However, as noted, adding a thing at a lower OPD mandates that it or its ancestor already exists in at least one OPD at an upper level. In our case, is the **OnStar Advisor** part of the **OnStar System** or is it a stand-alone object at the upper, SD level? In any case, OPCAT draws our attention to the need for consistency by asking the question shown in Figure 32.

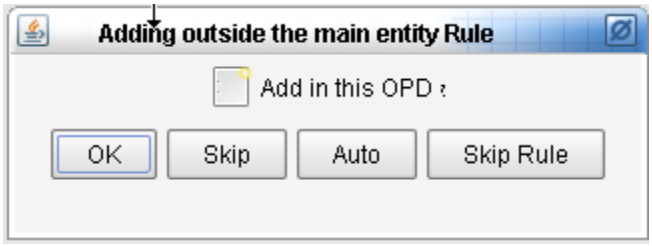


Figure 32. Application of OPCAT's consistency checker

Selecting OK will add **OnStar Advisor** as an object to the top-level OPD. Another question is whether the **OnStar Advisor** is part of the system. If not, we will mark the **OnStar Advisor** as Environmental. This is done in Figure 33.

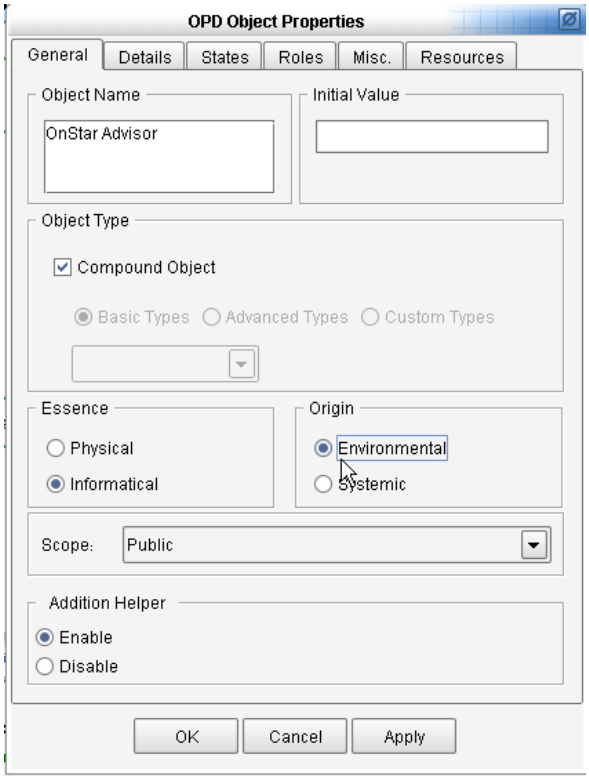


Figure 33. OnStar Advisor is marked as Environmental

We will now connect the **OnStar Advisor** with an ***agent link***. At **SD**, the **OnStar Advisor** will be connected with an ***agent link*** to the **Driver Rescuing Process**. At **SD1** we can and should be more specific and link the **OnStar Advisor** to the subprocess for which **OnStar Advisor** is required. We therefore connect the agent link to the **Call Handling** process.

In order for **Call Handling** to happen we need also the **Driver** and the **Vehicle Location**.

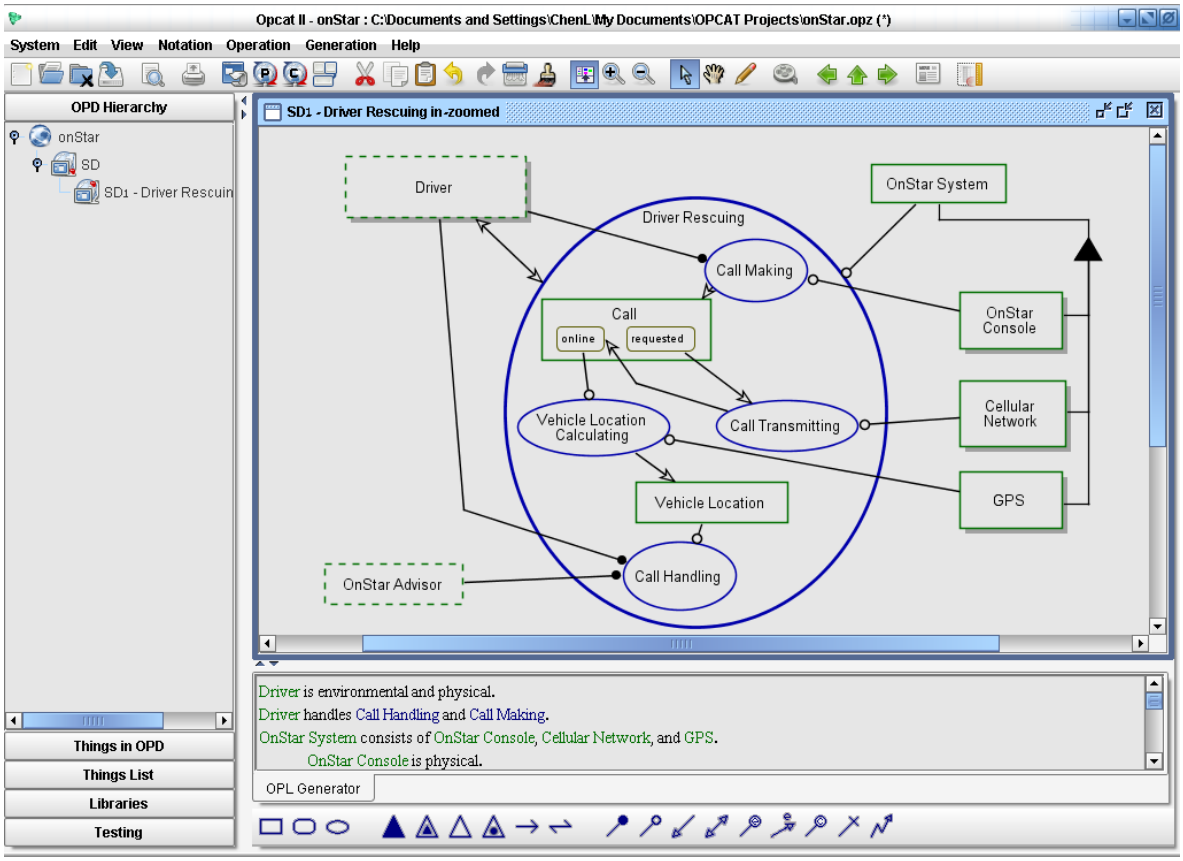


Figure 34. Call Handling Preconditions

Eventually, the **Call Handling** process changes the **Driver**'s **Danger Status**, an attribute of **Driver**, from **endangered** to **safe**.

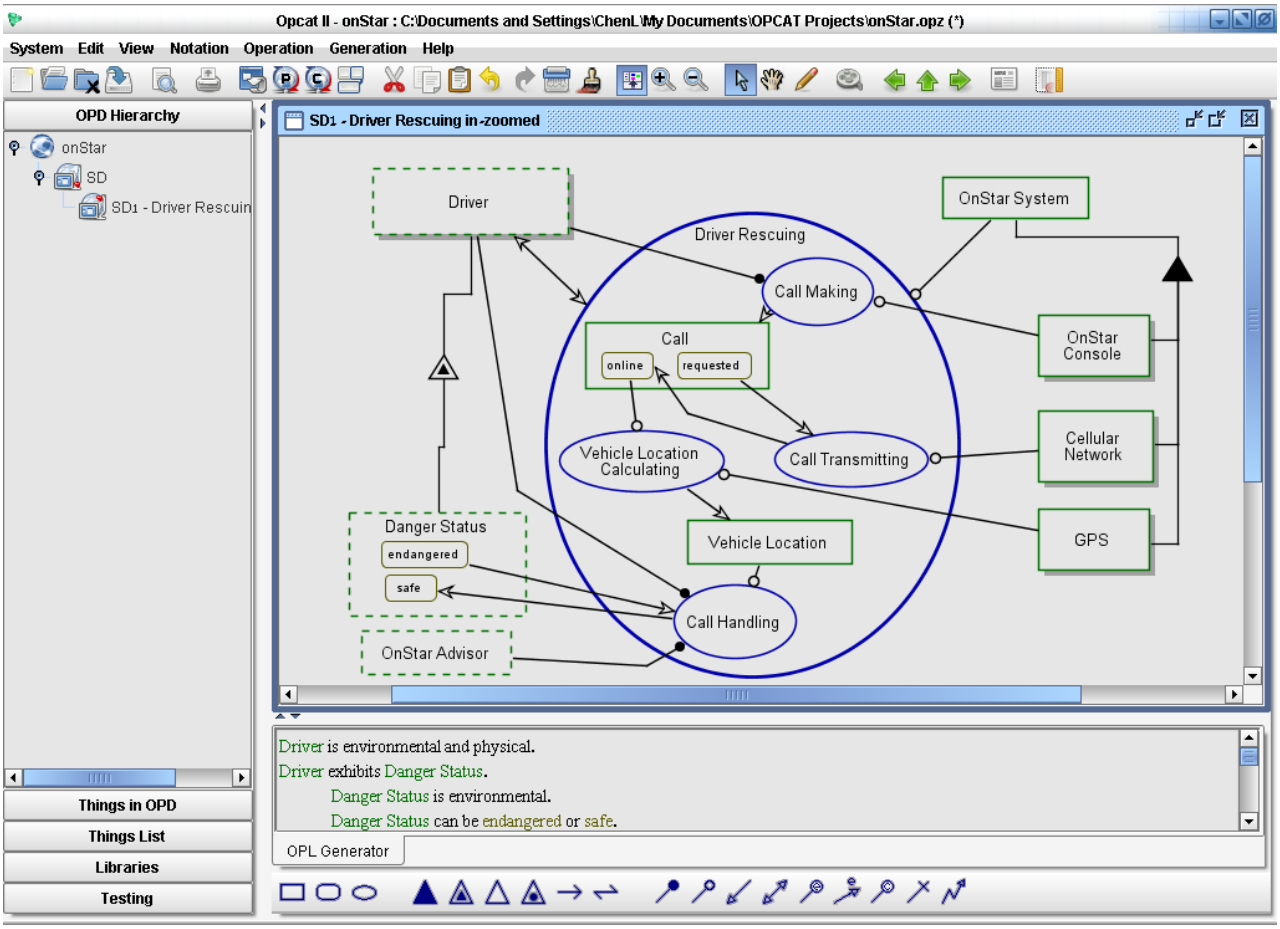


Figure 35. Call Handling results

Marking Initial States

At this stage we may want to emphasize the fact that when the system starts to operate, the **Danger Status** of **Driver** is in the **endangered** state. We may also want to say that the object **Call** is created by the process **Call Making** in the **requested** state. We can do this by marking those states as "initial". This is shown in Figure 36. In a similar manner we can mark another state of an object as final.

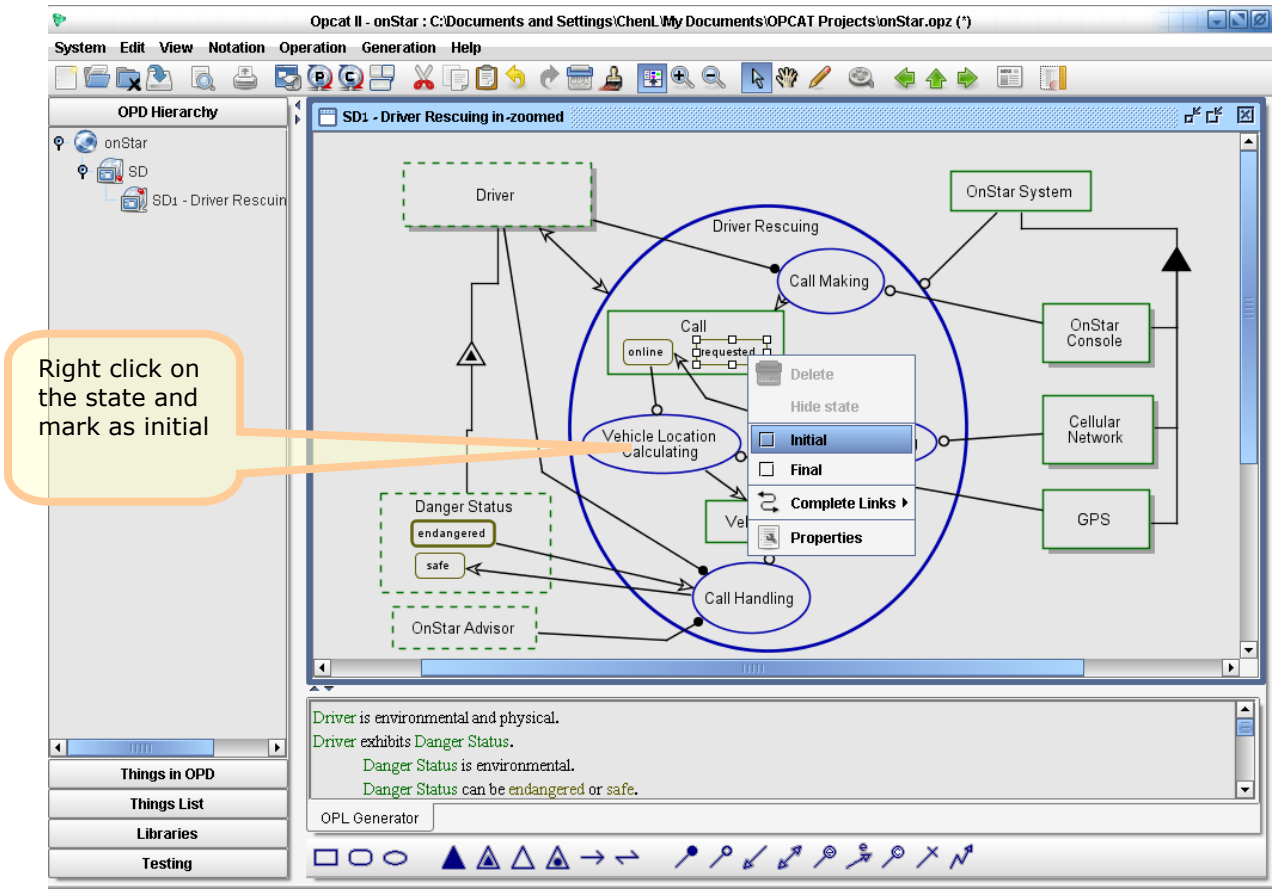


Figure 36. Marking initial states

9. In-zooming into the next level

At this stage when our Driver is finally safe we can continue and go into the details of each of the sub-processes.

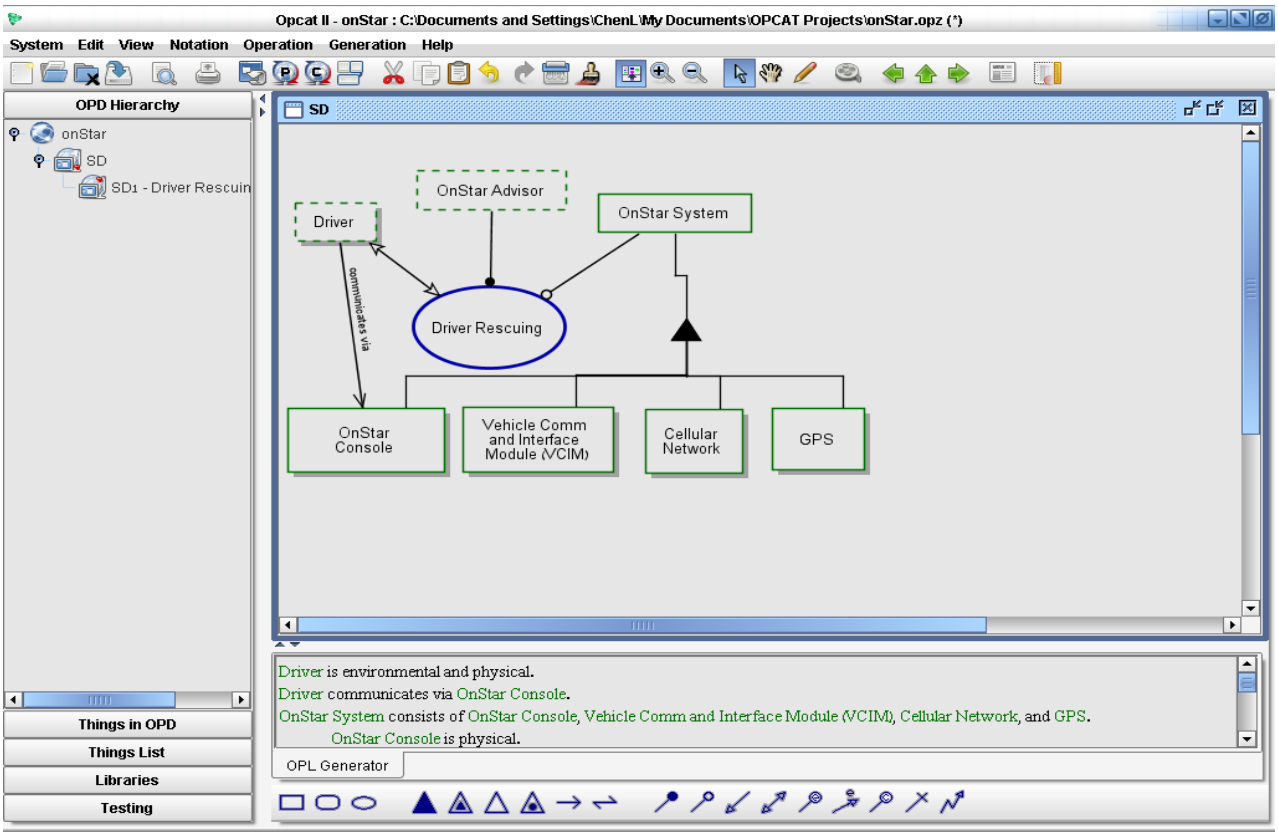


Figure 37. returning to top level OPD

While in-zooming to create a more detailed OPD we should bear in mind that the parent OPD defines the borders for its lower-level OPDs. For instance, **Call Making** uses **OnStar Console** and the **Driver**, and it yields **Call**. At the next level, we might describe the different parts of the **OnStar Console**, user interface, authentication processes and so on. Nevertheless, it will all be details of the **Driver**, **Call Making** or **OnStar Console**. If, while modeling in an OPD at a low level we find that something is missing, then it should be added to the upper-level OPDs as well all the way to **SD**, as demonstrated above with regard to the **OnStar Advisor**. The consistency checker of OPCAT helps you do this properly.

The requirements of the **OnStar System**, described in Appendix 1, specify a possibility of automatic **Call Making** by using a "small panel located in the rearview mirror". This **Panel** is instrument to **Call Making**. If this **Panel** is part of the **OnStar Console**, it will be described as such in **SD1**. If not, it needs to be added in **SD** as a direct part of **OnStar System**.

It may be also a good time to revisit SD and decide whether we need this level of details at the top level. We may decide that the parts of the **OnStar System** will be described only at the lower levels to avoid clutter of **SD** and leave it simple and clear.

10. Summary

This guide provides basic concepts of OPM-based design with OPCAT. To gain more experience, you are encouraged to complete the design of the **OnStar System** according to the requirements in Appendix A.

In order to learn how to use the simulation, tagging, views creation, model repository and additional advanced topics you are invited to obtain the OPCAT Advanced Course Package by contacting us at consulting@opcat.com.

List of Diagrams

Appendix A

OnStar System Specification

Being in a car accident, you push a button on a console and are instantly connected with an OnStar advisor. The advisor can pinpoint your exact location and relay your problem to emergency services. If you're in an accident, your car can "tell" OnStar without you having to do a thing.

Source: http://auto.howstuffworks.com/onstar.htm/printable

Cars equipped with OnStar have a small panel located in the rearview mirror, the dashboard or an overhead console, depending on the model. The blue OnStar button allows you to contact a live or virtual advisor. The red button with the cross on it is for emergencies, and the phone or "white dot" button allows you to make phone calls just as if you were using a cell phone.

At its most basic, OnStar consists of four different systems: cellular phone, voice recognition, GPS and vehicle telemetry. All of the services that OnStar provides are a result of one or more of these systems working together, making it a ""System of Systems".

OnStar's cellular service is voice-activated and hands-free. The console contains a built-in microphone and uses the car speakers. To make a call, you speak a phone number or a previously stored name associated with a phone number. The console is connected to a Vehicle Comm and Interface Module (VCIM), which uses a cellular antenna on top of the car to transmit signals to OnStar's cellular network.

For calls to the advisor, OnStar uses voice recognition software. OnStar can "surf the Web" using the Virtual Advisor automated system. For this service, OnStar uses text-to-voice technology called VoiceXML. When you ask for information, such as "weather," the software translates your request into XML (Extensible Markup Language) and matches it to settings in your OnStar profile. Then it translates the information into VoiceXML and reads it to you.

The GPS receiver is called OnCore, and it is part of the VCIM. A GPS receiver in the vehicle picks up signals form GPS satellites and calculates the location of the vehicle. The OnStar Call Center uses four different satellites to pinpoint the car's location when either the driver or the car itself asks to be located. That location is stored in the vehicle's OnStar hardware. The GPS uses the amount of time that it takes for a radio signal to get from satellites to a specific location to calculate distance.

When the driver pushes the blue OnStar button or red emergency button or an airbag deploys, OnStar places an embedded cellular call the OnStar Center with the vehicle location data. An OnStar advisor handles the call.

To give a vehicle the ability to call when it is in an accident, OnStar uses an event data recorder (also known as a crash data recorder). GM calls the entire process the Advanced Automatic Crash Notification System (AACN). The AACN system comprises four components: sensors, the Sensing Diagnostic Module (which includes the event data recorder), the VCIM and the cellular antenna. When the car is in a crash, sensors transmit information to the Sensing Diagnostic Module (SDM). The SDM also includes an accelerometer, which measures the severity of the crash based on gravitational force. The SDM sends this information to the VCIM, which uses the cellular antenna to send a message to the OnStar Call Center. When an advisor receives the call, he uses the GPS to find the vehicle's location and calls the car to check with the driver. Even if there's not a measurable impact, the VCIM also sends a message when the air bag goes off, prompting the advisor to call the car's driver.