
2019 NATO MODELLING AND SIMULATION GROUP SYMPOSIUM

Development of an Air Operation eXtension with the (Future) C2SIM Standard



■ ■ Bruno Gautreau

■ ■ Magdalena Dechand

Lukas Sikorski

■ ■ Eric Bouvier

■ ■ Lionel Khimeche

Irmtrud Trautwein

 **Fraunhofer**
FKIE



AIRBUS

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Overview

- **COMELEC**
- **The C2SIM Context**
 - The Role of Ontologies
 - From Ontologies to Schemata
- **Air Operations in C2SIM**
 - Specifics of Air Operations
 - Ontological Representations
 - Exchanging TDL Messages
- **Lessons Learned**
- **Conclusion**



Development of an Air Operation eXtension with the (Future) C2SIM Standard

Project COMELEC

COMELEC

(Commission Electronique)

is

- a) the abbreviation for a German-French C2SIM working group;
- b) the short term for the current project of that group.

Members are

DGA, Airbus, DigiNext

iABG, FKIE



Systems

C2-Systems
(or Demonstrators)

Orders & Reports

C2LG-
GUI

Orders & Reports

Starlinx

Messages
e.g. Orders

Messages
e.g. Reports

Simulation Systems

JOINT



AIR

Direct
CGF

LAND



Development of an Air Operation eXtension with the (Future) C2SIM Standard

preliminary remarks

- This is work in progress. However, we already can present experience with the forthcoming C2SIM standard we judged as important.
- We plan to present an updated version of our work at the next SIW (10-14 February, Orlando, Florida).
- This presentation has a focus on the work done by FKIE.
- The scenario, however, had been developed by DigiNext. Therefore pictures show mostly French platforms.
- In the current COMELEC project, we also discuss a second scenario, developed by iABG, but as that scenario is about ground operations. Thus, it is not topic of this presentation.

Development of an Air Operation eXtension with the (Future) C2SIM Standard

The C2SIM Context

SISO C2SIM PDG is developing a C2SIM standard.

The SISO C2-Simulation interoperation has always been supported by NATO activities, currently by NATO MSG-145.

Existing standards are

- the MSDL standard (SISO-STD-007-2008) for initialization and
- the C-BML standard (SISO-STD-011-2014) for the exchange of military communication (reports, requests, orders) during simulation runs.

Development of an Air Operation eXtension with the (Future) C2SIM Standard

The C2SIM Context – the Role of Ontologies

Currently, SISO develops a new C2SIM standard since

- the cooperation of MSDL and C-BML turned out to be difficult and the goal is an integrated solution;
- the new standard is supposed to be extensible.

To these ends, an ontology will serve as the C2SIM main representation.

Extensibility is granted by the development of a core ontology to be supplemented by extensions. This talk is about the air operation extension.

Development of an Air Operation eXtension with the (Future) C2SIM Standard

The C2SIM Context – from Ontologies to Schemata

Ontologies represent knowledge; schemata allow the exchange of messages.

Good ontologies represent the knowledge correctly. → Semantics

Good schemata transmit their messages in a correct form. → Syntax

Nevertheless, the receiver of a message should understand the message's meaning as intended by the sender.

Therefore, in the C2SIM case, schemata need to refer back to ontologies: We generate the schemata automatically out of the ontology, as is explained in Blais et al. (2018).

Evaluation criterion: can the schema generated out of the ontology (core plus air operation extension) handle the message exchange as intended?

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Air Operations in C2SIM – Specifics

Airborne entities move fast. → Automated position updates are generated by an airborne radar picket system, like an AWACS. These data form tracks. → Units are referred to by track numbers.

Messages are exchanged as TDL messages. (TDL = tactical data link, e.g. link 16).

A secure data network allows the exchange of TDL messages.



Development of an Air Operation eXtension with the (Future) C2SIM Standard

Air Operations in C2SIM – Ontological Representations

The screenshot displays a web-based ontology editor interface. On the left, a class hierarchy tree is shown under 'owl:Thing'. The hierarchy includes: C2SIMContent, AbstractObject, Action, Code, Entity, EntityDescriptor, EntityState, EntityType, APP6-SIDC, and DISEntityType (highlighted in blue). Other classes in the hierarchy include Observation, PhysicalConcept, PlanPhase, PlanPhaseTrigger, Resource, InitializationConcept, and MessageConcept. The main area on the right shows the details for the selected class, DISEntityType. It includes a 'Class Annotations' tab, an 'Annotations: DISEntityType' section, a 'Description: DISEntityType' section, and a 'SubClass Of' section. The 'SubClass Of' section lists the following properties and their cardinalities: Entity Type, hasDISCategory exactly 1 xsd:byte, hasDISCountryCode exactly 1 DISCountryCode, hasDISDomainCode exactly 1 DISDomainCode, hasDISExtra exactly 1 xsd:byte, hasDISKindCode exactly 1 DISKindCode, hasDISSpecific exactly 1 xsd:byte, and hasDISSubCategory exactly 1 xsd:byte. Each property has a set of control icons (question mark, at-sign, cross, circle) to its right. There are also sections for 'Equivalent To', 'General class axioms', and 'Class Usage'.

Initialization: define airborne entities

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Air Operations in C2SIM – Ontological Representations

The screenshot displays an ontology editor interface. On the left, a class hierarchy tree is shown under the heading 'Class hierarchy: TDLNetworkParticipantDefinition'. The tree structure is as follows:

- owl:Thing
 - C2SIMContent
 - InitializationConcept
 - InitializationDataFile
 - ObjectDefinitions
 - ScenarioSetting
 - SystemEntityList
 - TDLNetworkParticipantDefinition** (highlighted)
 - MessageConcept

On the right side of the editor, the 'Class Annotations' and 'Class Usage' tabs are visible. The 'Class Annotations' tab is active, showing the following information for the selected class:

- Annotations: TDLNetworkParticipantDefinition
- Annotations (+)
- Description: TDLNetworkParticipantDefinition
- Equivalent To (+)
- SubClass Of (+)
 - hasCommunicationNetworkUUID exactly 1 UUIDBase
 - hasSubjectEntity exactly 1 UUIDBase
 - hasTDLTrackNumber exactly 1 xsd:string
 - InitializationConcept
- General class axioms (+)

Initialization: define the secure data network and its participants

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Air Operations in C2SIM – Ontological Representations

The screenshot displays an ontology editor interface. On the left, a class hierarchy tree is shown under the heading 'Class hierarchy: TDLPPLIReportContent'. The tree starts with 'owl:Thing' at the root, followed by 'C2SIMContent', 'InitializationConcept', and 'MessageConcept'. Under 'MessageConcept', there is a 'ReportContent' class, which is further divided into several subclasses: 'ObservationReportContent', 'PositionReportContent', 'StandardPositionReportContent', 'TDLPPLIReportContent' (highlighted in blue), 'TDLBattleDamageStatusReportContent', 'TDLDropReportContent', 'TDLEmergencyPointReportContent', 'TDLInternalDetectionReportContent', 'TDLPointerReportContent', 'TDLReferencePointReportContent', 'TDLRemoteTransmissionReportContent', 'TDLResourceStateReportContent', 'TDLThreatWarningReportContent', and 'TDLTrackControlReportContent'. Below these are 'C2SIMHeader', 'Message', 'MessageBody', and 'MessageCode'. On the right, the 'Description: TDLPPLIReportContent' panel is visible. It shows 'Equivalent To' (empty), 'SubClass Of' (with a '+' icon), and 'General class axioms' (with a '+' icon). The 'SubClass Of' list includes: 'hasSpeed max 1 xsd:double', 'hasTDLDirectionOfMovement max 1 Azimuth', 'hasTDLEnvironment exactly 1 TDLEnvironmentCode', 'hasTDLLeaderTN max 1 xsd:string', 'hasTDLPlatformType exactly 1 xsd:string', 'hasTDLVoiceCallSign exactly 1 xsd:string', 'isC2 exactly 1 xsd:boolean', and 'PositionReportContent'. The 'General class axioms' section includes: 'hasTimeOfObservation exactly 1 DateTime', 'hasSubjectEntity exactly 1 UUIDBase', 'hasLocation exactly 1 Coordinate', 'hasStrength max 1 Strength', and 'hasOperationalStatus max 1 OperationalStatus'.

Message Exchange: define TDL messages (example PPLI)

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Air Operations in C2SIM – Exchanging TDL Messages

The SISO PDG found that representing information in an ontology and also exchanging that information in a standard way with a schema requires compromise. They agreed to constrain C2SIM ontology features somewhat in order to

- allow the schema resulting out of a transformation (ontology into schema) rendered possible by the tool developed by Curt Blais,
- achieve a workable standard in a reasonable time.

```
<?xml version="1.0" encoding="UTF-8"?>
<Message xmlns="http://www.sisostds.org/schemas/C2SIM/1.1" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.sisostds.org/schemas/C2SIM/1.1 file:///C:/C2SIM/Comelec/Airbus/C2SIM_SMX_LOX_TDL.xsd">
  <C2SIMHeader>
    <StandardC2SIMHeader>
      <CommunicativeActTypeCode>Inform</CommunicativeActTypeCode>
      <MessageID>cd1d895f-ea3e-4858-906d-6abc93907a5d</MessageID>
      <Protocol>C2SIM</Protocol>
      <ProtocolVersion>1.1</ProtocolVersion>
      <SendingTime>2019-07-30T13:36:30:Z</SendingTime>
      <FromSendingSystem>C2LG</FromSendingSystem>
      <ToReceivingSystem>DirectCGF</ToReceivingSystem>
      <ConversationID>d10f9a43-e4ea-4edc-9ede-ebde7d5e1b2</ConversationID>
    </StandardC2SIMHeader>
  </C2SIMHeader>
  <MessageBody>
    <DomainMessageBody>
      <OrderBody>
        <FromSender>00000000-0001-0001-1000-000000000000</FromSender>
        <ToReceiver>00000000-0000-0001-2000-000000000000</ToReceiver>
        <Task>
          <TDLTask>
            <TDLMissionTask>
              <TaskNameCode>ATTACK</TaskNameCode>
              <PerformingEntity>00000000-0000-0001-2000-000000000000</PerformingEntity>
              <UUID>cd1d895f-ea3e-4858-906d-6abc93907a5e</UUID>
              <Name>TDLMissionTask_1</Name>
              <TDLMissionType>ATTACK</TDLMissionType>
              <TDLTargetType>AIR_DEFENSES</TDLTargetType>
              <TDLAttackAxis>
                <Angle>90</Angle>
              </TDLAttackAxis>
              <TDLClearanceAxis>LEFT</TDLClearanceAxis>
              <TDLTargetPosition>
                <Latitude>50.397138</Latitude>
                <Longitude>9.862633</Longitude>
              </TDLTargetPosition>
              <TDLArmament>missiles</TDLArmament>
              <TDLTargetTN>501</TDLTargetTN>
            </TDLMissionTask>
          </TDLTask>
        </Task>
        <IssuedTime>
          <DateTime>
            <IsoDateTime>2019-07-30T13:36:30:Z</IsoDateTime>
          </DateTime>
        </IssuedTime>
        <OrderID>cd1d895f-ea3e-4858-906d-6abc93907a5f</OrderID>
      </OrderBody>
    </DomainMessageBody>
  </MessageBody>
</Message>
```

TDL mission order as completed schema

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Lessons Learned

Since this is a project in which different members have different expertise, we learned from each other. We also learned a lot from other colleagues from the SISO C2SIM PDG and the NATO MSG-145.

Our FKIE group, for example, learned a lot about air operations, TDLs, tracks, and how to represent all this ontologically.

We also learned some specifics on ontologies and how to build an extension to an already existing core. Here is an example:

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Lessons Learned – Example

If a class inherits a property from its superclass, it might happen that the range for that property is restricted more closely in comparison to the property's range in the superclass.

For example, class “Task” has the property “hasTaskNameCode”. Its range is an enumeration of the codes for all assumed tasks.

“Task” has the subclass “TDLTask”.

“TDLTask” inherits “hasTaskNameCode” but is supposed only to use codes that are codes for TDL tasks.

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Lessons Learned – Example

Adding a (“new”) restriction to the subclass results in two lines in the schema (after transformation).

In order to achieve a working prototype, we currently have not added restricted restrictions to respective subclasses.

Instead, we trust the users to only generate messages that are meaningful.

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Conclusion

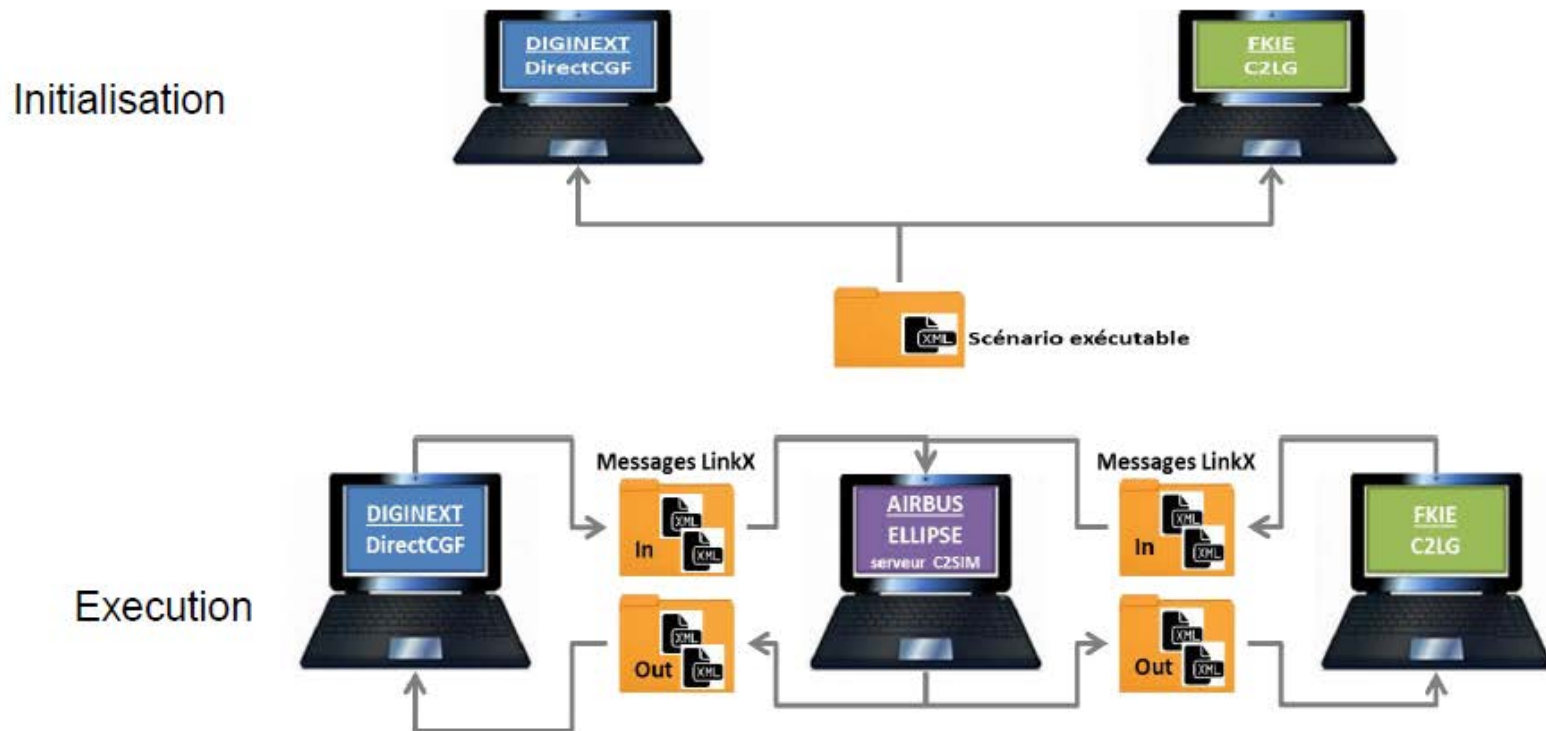
Guided by a scenario, an Air Operation extension of the C2SIM core ontology had been fleshed out. After that the transformation tool provided by SISO's C2SIM PDG had been applied to the ontology (core plus extension) to generate the corresponding schema.

The schema is valid for initialization and message exchange during C2SIM demonstrations that include air operations.

The validity has successfully been evaluated in the French German demonstration.

Development of an Air Operation eXtension with the (Future) C2SIM Standard

Conclusion – The Demonstration's Architecture





Thanks for Your attention!

Questions are appreciated.