Modelling 2012 – Project Assignment

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https://fenix.ist.utl.pt/disciplinas/mod236/2011-2012/2-semestre

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Version: 1.2

1. Context

The Foundation for the Measurement of the Environment (FME) issued a request for proposals for the specification of requirements and the analysis and design of a system of systems, conceptually made of one logical system and one physical system. You team works for the company BestModel Inc. which replied to the call and secured the contract. The execution of this project is now your assignment.

After the conclusion of the project developed by Best Model Inc., FME will start two new projects. One of them will be contracted to LogicInc and entails the development, deployment and maintenance of the logical system. The other project will be contracted to PhysicalInc and is concerned about the development, deployment and maintenance of the physical system. These two new projects will be entirely based on the analysis and design reported by BestModel Inc.

2. Universe of Discourse

An **automatic weather station** (AWS)[1] is a system with instruments for observing, logging and communicating the measurements of atmospheric conditions to another system, a **base weather station** (BWS). These measurements are used by the BWS to produce weather forecasts and to provide access to historical data about the weather and climate. An AWS can be configured to take different measurements including temperature, barometric pressure, humidity, wind speed, wind direction, precipitation amounts, and ultraviolet radiation.

A **weather network** (WN) is a system of systems consisting of multiple AWS that report to a common BWS. A BWS contains specialized software to handle and integrate the measurements from the different AWS within the same WN.

The remainder of this section describes in detail the universe of discourse of this project, namely the concepts of AWS (section 2.1) and BWS (section 2.2), the component suppliers (section 2.4) and the operational processes (section 2.5). Section 3 describes the project assignment, the artefacts to be produced and the report format. Finally, section 4 describes the evaluation and submission rules. Additional information related to the project will be updated on the web page of the Modelling course.

2.1 Automatic Weather Station

Each **automatic weather station** (AWS) is installed on land at a location with WGS-84[2] coordinates measured by a GPS device. Each AWS monitors, logs and communicates the data it collects to a single BWS. An AWS operates autonomously according to a predefined configuration. The communication between the AWS and BWS is unidirectional, i.e. the BWS does not send any kind of commands to the autonomous AWS. Each AWS can be reconfigured at any time. A reconfiguration implies a visit to the location of the AWS and entails removing or adding sensors to it or changing the frequency of communication to the BWS. An AWS includes:

- A unique identifier (AWS ID) that identifies the AWS within the WN.
- A set of meteorological sensors.
- A weather-proof enclosure containing
  – a power supply that provides the station's components with electrical power,
  – an optional data logger that records the data measured by the sensors, and
  – a communication device that sends messages to the BWS.
- A mast that elevates and secures the enclosure above the observation point.

[1] Check http://en.wikipedia.org/wiki/Automatic_weather_station for further background information. Important note: this link provides one example of a system similar to the one we are considering. Please be aware that nothing in this web page should be taken in consideration for the problem to be solved. For this project assignment only the information in this document should be considered.

[2] http://en.wikipedia.org/wiki/WGS84

2.1.1 Mast

A mast is a hollow reinforced stainless steel tube with a wall thickness of at least 5mm and a diameter of 10cm. On top of the mast sits the station platform.

The platform is a square 80x80cm stainless plate 5mm thick. The underside of the platform has a circular hollow socket with a height of 30cm and a diameter of 10cm that fits on the mast. The platform's socket is secured to the mast using six 40 x 10mm bolts forming an angle of 60º between them.

The platform is the place where all the remaining components of the AWS are mounted on, including the sensors and the enclosure.

The overall structure is secured through the installation of tension cables:

- Tension cables shall be installed in groups of three with an angle of 120º between them.
- The tension cables shall be attached to the mast tube.

The standard mast heights are 3, 10, and 30 meters:

- The 3 meter mast is used for the measurement of weather parameters at ground level. All weather parameters can be measured at this height.
- The 10 and 30 meter masts are used for the measurement of weather parameters without interference from objects such as trees or buildings. Usually, wind speed and direction are measured at 10 or 30 meter heights.
- The 3 meter mast doesn't need tension cables and at most one group of cables can be installed if required.
- The 10 meter masts shall have one group of tension cables.
- The 30 meter masts shall have a minimum of two groups of tension cables.

2.1.2 Enclosure

The weather-proof enclosure contains the power supply components, the digital hub, the data loggers and the communication device. The enclosure is attached to the platform with four 40 x 10mm bolts.

The enclosure has two circular cable routing openings, each 20mm in diameter. The routing openings are covered with a weather-proof insulator that shields the contents of the enclosure. One of the openings is used to route all connector cables to and from the sensors. The other opening is where all power supply cables are routed. Power cables and sensor cables can never be routed though the same routing opening.

The enclosure shall be made of weather-proof fiberglass or stainless steel according to the to the IP65 standard[3]. The following conditions apply:

- The condition of a fiberglass enclosure shall be inspected every year and replaced as needed. The maximum lifespan of a fiberglass enclosure is 5 years.
- The condition of a stainless steel enclosure shall be inspected every two years and replaced as needed. The maximum lifespan of a stainless steel enclosure is 15 years.
- Whenever the enclosure is inspected the mast, tension cables, sensors and all other components must also be inspected and repaired or replaced if needed.

2.1.3 Sensors

Each AWS can be equipped with a combination of sensors that take different weather measurements. Table 1 outlines the main characteristics of the available sensors that can be installed on an AWS.

Each sensor is connected to one analogue-to-digital converter (ADC), making a sensor pack. The sensor packs are always located outside of the enclosure.

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[3] http://en.wikipedia.org/wiki/IP_Code

Each sensor is continuously performing readings, producing an electrical signal that is fed to the ADC, which converts the analogue measurement to a discrete digital representation.

All sensors are powered by 12V DC current provided by the power supply.

Sensor ID	Sensor	Measurement	Unit
1 or 9	Thermistor	Temperature	C
2 or 10	Resistive humidity sensor	Humidity	%
3 or 11	Anemometer	Wind speed	Km/h
4 or 12	Wind vane	Wind direction	Degrees
5 or 13	Barometer	Barometric pressure	Mb
6 or 14	Rain gauge	Precipitation	mm/time unit
7	Photometric UV sensor	Ultraviolet radiation	W/m2
8	GPS	Location (latitude, longitude, altitude)	(degrees, degrees, m)

Table 1: Sensors that can be installed on a AWS.

The GPS sensor directly outputs a digital value and therefore is the only sensor pack that is all provided by the same supplier as a unique component.

The output of each ADC is a 5 byte (40 bit) digital value:

- The 4 LSB (32 lsb) represent the measurement data of the sensor.
- The 1 MSB (8 msb) represent a status code, where:
  – A value of zero means that the sensor is operating normally.
  – A non-zero value represents an error code.

The output of each ADC is connected through a weather-proof coated cable to the digital hub.

All sensors operate continuously but each AWS samples its sensors periodically according to a defined *SendFrequency* value whose period is measured in seconds. This value can range from zero to a maximum of 86.400 seconds (the number of seconds in 24 hours).

There is one global electronic timer which is connected to each ADC to signal when to sample the sensor. When the ADC receives the signal it samples the corresponding sensor and converts the electrical signal to a digital value. The electronic timer is housed inside the enclosure and connects to each ADC through a weather-proof coated digital connector cable routed outside through the same opening used for the sensor cables.

An AWS must always include sensors for temperature and humidity. The remaining sensors can be installed optionally.

An AWS can be equipped with a maximum of three redundant sensors for measuring temperature, humidity, barometric pressure, precipitation, wind direction and wind speed. All other sensors cannot be made redundant.

The anemometer is integrated with the wind vane. Therefore, these two sensors cannot be divided or installed separately.

Stations that measure precipitation must also measure barometric pressure.

All sensors shall be housed outside the enclosure.

2.1.4 Sensor Hub

Within the enclosure there is one sensor hub with 16 input ports and 1 output port. Each input port accepts the digital output of the ADC of a sensor pack.

Each input port has 4 switches that set 4 bits to define the sensor identifier of the sensor connected to the port. The value of each identifier is defined in the Table 1 (column Sensor ID).

The output hub port outputs 6 byte values, where:

- 5 bytes (40 bits) are the reading from the sensor (comprising 1 byte of status code plus 4 bytes of measurement data)
- 1 byte (8 bits) from the sensor hub, comprising 4 bits for the sensor ID plus 4 unused bits.

The output port of the sensor hub can be connected to data loggers and to the communication device using a digital 48 bit long parallel cable bus.

2.1.5 Data Logger

The data logger is a persistent digital recording device that stores measurements made by the sensors. The data logger is optional in the AWS. A maximum of three data loggers can be installed for redundancy.

A data logger has one input port that is connected to the output port of the sensor hub. The data logger has a USB port for reading the data stored on the logger.

The measurements of each sensor are logged on independent data streams, i.e. there is an independent data stream for each sensor that is installed on the AWS.

The data logger has a finite capacity but shall be designed in such a way as to hold at least 180 days of measurement data captured with the highest possible sampling rate when the AWS is equipped with all possible sensors.

Whenever the capacity is exhausted, the data logger starts to overwrite the older data first (i.e. the new data from one sensor overwrites its recorded oldest data first).

The data logger is powered by 12 V DC power.

2.1.6 Communication Device

An AWS communicates with a BWS through packet-data over a GPRS[4] mobile network. This is accomplished through a packaged communication device that handles all the GPRS connection, authentication, encryption and message interchange between the AWS and the BWS.

The communication device has one input port connected to the output port of the sensor hub.

The communication device of the AWS is configured upon installation.

The digital data that is provided as input to the communication device is transparently transmitted as data packets to the BWS.

The communication device ensures it only communicates with the configured BWS.

2.1.7 Power Supply

Each AWS has a power supply component comprising a battery producing stable 12V DC, a regulator and an external power source depending of the configuration of the AWS.

All the components of an AWS requiring energy are powered directly by the battery.

The battery is recharged by a regulator that provides it with a stable tension of 12V.

The regulator gets its power from at least one of the following external sources:

- One photovoltaic cell array,
- A wind turbine,
- A DC rectifier connected to a 12V transformer connected to an AC power grid.

The photovoltaic cell array and wind turbine are installed on the station's platform, i.e. outside the enclosure.

The battery, regulator, rectifier and transformer are installed inside the enclosure.

The battery has built-in a charge analyser that measures the remaining battery level. Whenever the charge analyser detects that the battery reached 5% of its capacity it cuts power to all the AWS components. When this happens the AWS is said to be on "standby mode". When the battery is recharged to 10% it resumes power to all the AWS components.

[4] http://en.wikipedia.org/wiki/General_Packet_Radio_Service

2.2 Base Weather Station and MeteoNet Software

One **Base Weather Station** (BWS) manages exactly one WN. Such management is accomplished through the **MeteoNet** software system running on a computational server with the Linux operating system. This server has one communication board that handles all the connection, authentication and communication details with all the AWS that are part of the WN. The communication board receives the data from each AWS and makes them available to the MeteoNet software through a pre-defined port available to operating system, which is read by using a specific AWS Driver. One AWS is always associated with a single BWS (i.e. it belongs to only one WN).

MeteoNet is always prepared to receive the data packets sent by all the registered AWS within the WN. These packets are sent autonomously by each station. In case a data packet identifies an error code (cf. sections 2.1.3, 2.1.6) the software sends a preconfigured email message to the OperationalManager that includes the AWS ID and the Sensor ID that reported the error and the timestamp of the data packet. Each email only reports a single error, therefore a different email is sent for every error that occurs.

The MeteoNet software maintains a record of all the AWS within the WN along with the following properties:

- Identifier (AWS Id)
- List of all sensors installed on the AWS along with its type, serial number, provider, date of installation, and corresponding sampling period.
- List of all problems related to a sensor, along with the timestamp, sensor identifier and error type.
- Records of all readings, comprising the timestamp of each message and corresponding content (structured in a proper logical information structure).
- Configuration of the AWS (such as masts, power sources, etc.).
- The geographical location of the station.
- ~~A record of all changes or repairs, comprising the timestamp of the operation, the responsible for the operation and the details of the actions performed.~~

2.3 MeteoNet as a Service

The MeteoNet system will be used by these external information systems, operated by third-party entities:

- DALI - Current Weather Observation System.
- PICASSO - Weather Forecast System.
- MATISSE - WN Management and General Data Processing System.

MeteoNet software will provide the functional interface described on the next table. This interface will be used to interoperate with all external information systems. The aspects of physical interoperation between MeteoNet and these external systems will be managed by PhysicalInc.

Service	Input	Output	Description
AddStation	aws_id	error code	adds a new station AWS to the WN.
RemoveStation	aws_id	error code	removes a station AWS from the WN.
GetStations	-	list of (aws_id, attributes)	lists all the AWS along with all their attributes.
GetStationReading	aws_id, sensor_id	measurement	provides the most recent measurement of a sensor for a given station.
GetWNReadings	sensor_id, t1, t2	list of (aws_id, measurement)	provides the list of measurements of all sensors of a given type across the entire weather network on a time interval [t1, t2]. The response includes a list of all measurements for all the AWS with that sensor.
GetAreaReadings	sensor_id, t1, t2, latitude, longitude, radius	list of (aws_id, measurement)	similar to GetWNReadings but the stations are inside the circle given by (latitude, longitude, radius). The centre of the circle is measured in degrees and the radius is measured in meters.
GetSilentStations	t1, t2	list of aws_id	lists the stations that did not communicate with the base station during the time interval [t1, t2].
GetSensorErrors	t1, t2	list of (timestamp, aws_id, sensor_id, error code)	lists the sensor errors reported during the time interval [t1, t2].

Table 2: Functional interface of MeteoNet.

2.4 Components Suppliers

All the physical components of the AWS described in 2.1 and 2.2 are provided by external certified suppliers.

The AWS Driver used in the BWS is developed by an external provider.

Each sensor pack is provided by the same external supplier, but these suppliers can change over time. In a specific moment a provider is certified to provide zero or more types of sensors and the respective ADC. The provider of the sensor is always the provider of the respective ADC, but in case of replacement, a sensor or an ADC can be replaced separately (but the same pair always has to be provided by the same supplier, which means that if one component needs to be replaced but that supplier is not certified anymore, then both components must be replaced).

2.5 Operational Processes

A WN is coordinated by the WNCoordinator who works for the FME. The operations are managed by the OperationalManager who works for PhysicalInc and is responsible for the process that manages the **Daily Work Plan** (DWP), which is executed by the maintenance team (MTeam) and the construction team (CTeam). The workers of the MTeam and the CTeam are employed by the PhysicalInc.

The operational processes observe the following rules:

- The OperationalManager is responsible for creating the DWP daily between 08:00 and 10:00.
- The OperationalManager sends the DWP to the teams no later than 10:00. In case there are no operations to be performed, the teams receive a DWP that states that "no action is required". The DWP is a document structured according to a template which is sent via email to its recipients.
- The OperationalManager defines the operations to be performed according to multiple sources of information:
  - The requests for *installation*, *reconfiguration* or *removal* of an AWS. These requests are stated by the WNCoordinator who sends them by email to the OperationalManager. One email is sent for each request.
  - The email error messages sent from the MeteoNet software. The software sends one email to the OperationalManage for each error or problem related to the AWS. These requests may entail *repairing* an AWS.
  - The problems reported by the teams are sent by email to the OperationalManager. The teams send only one email that describes all problems of the same AWS.
  - The requests for *data collection* which can be stated by any valid requester. These actors are called Data Requesters. All data collection requests for data must be first *authorized* by the WNCoordinator who can accept or decline the request. In case the WNCoordinator accepts the request he sends an email to the OperationalManager for each request.
  - All the business rules that are described on this document (e.g. lines 70-75).
- Based on this information, the OperationalManager specifies the DWP that schedules the order of visit of the concerned AWS, the teams that are required, and the corresponding operations that need to be performed.

There are six core operations that may apply to the DWP, described as follows.

(1) Installation – configuring a new AWS and deploying it on a given location.

- The initial configuration of the station is decided by a WNCoordinator and the request is sent by email to the OperationalManager. The configuration setup involves deciding on the sensors and power supply options of the AWS.
- The installation is performed by the CTeam and the MTeam.
- After installation the AWS becomes *operational*.

(2) Reconfiguration – removing or adding sensors to an operational AWS or changing its frequency of communication ("*SendFrequency* ").

- The reconfiguration operation is performed by the MTeam.
- Whenever there is a reconfiguration the team also performs an *inspection* to the overall AWS.

(3) Data Collection – collect data from the data loggers installed on the AWS. This operation only applies to AWS with data loggers installed.

- The data collection is performed by the MTeam.
- Whenever there is a data collection operation the MTeam also performs an *inspection* to the AWS.
- Even if there are no explicit requests for data collection, the data of an AWS with a data logger is collected every 3 months.

(4) Inspection – inspecting and maintaining all component of an operational AWS.

- The MTeam inspects an AWS.
- In case any problems are detected then the teams log the problems and send them via email to the OperationalManager after the inspection is concluded.

(5) Repair – correcting problems on an installed AWS.

- Any component of an AWS may be repaired after a problem is detected.
- In case any problems are reported by the sensors, the OperationalManager checks if there are any sensors in the inventory that can replace the faulty sensor at the AWS.
- If there are no replacement sensors in inventory, the OperationalManager orders a new sensor from the sensor provider if the available budget allows for it. If the sensor provider has available sensors it will send a new sensor within the next 24 hours after the request is placed. In case they have no available sensors they reply with the expected delivery date. Based on the delivery date, the OperationalManager decides whether to keep the order or to cancel it. All communication between the OperationalManager and providers is done via email.
- While the MTeam checks the AWS it will replace all faulty sensors that can be replaced. If they have no replacement the team will remove the faulty sensor from the AWS and its replacement will be scheduled later by the OperationalManager. Meanwhile, the station will be reconfigured to operate without that sensor.
- All sensors that are removed from the AWS are returned to the OperationalManager who decides whether the sensor can be repaired. This decision is made after the MTeam tests the sensor according to a standard procedure manual. If the tests judge the sensor unsalvageable (cannot be repaired) the OperationalManager decides whether to order a new sensor from the provider depending on the current number of replacements on inventory and on the budget.
- After receiving a sensor, the provider will perform additional tests and repair it or deem it unsalvageable. In case the sensor is unsalvageable but is still under warranty, the provider sends the OperationalManager a new sensor. Otherwise, it will repair the sensor and send it to the OperationalManager.
- The inventory is where all the sensors that are not in use are stored. Each sensor stored in inventory has a colour tag that identifies its status.
  - A *white* tag attached to the sensor states the date when the sensor first arrived.
  - A *green* tag is attached to a sensor that was never repaired. This tag is removed if the sensor is repaired.
  - A *yellow* tag identifies the sensors that were repaired. There is one yellow tag for each repair operation with the repair date written on it.
  - A *blue* tag identifies sensors that were installed on an AWS. The installation and removal date is written on each blue tag. There is one blue tag for each installation.
  - A *red* tag identifies unsalvageable sensors. This tag states the date when the sensor stopped working.
- All the changes to the inventory and all inventory operations, such as repairs and new sensor orders, are registered on a paper based Inventory Log by the OperationalManager and the MTeam.

(6) Removal – removing an installed AWS from its location..

- The removal is performed by the CTeam and the MTeam.
- The station is removed and all of its sensors and returned to the inventory.
- The AWS ceases to be operational after removal.

Additional notes regarding the Operational Processes:

- All communication between the CTeam, MTeam, WNCoordinator and OperationalManager are done via email.
- The MTeam is composed by Certified Technicians.
- The CTeam is composed by Certified Constructors.
- All problems detected by the MTeam or the CTeam are reported to the OperationalManager via email.
- The soundness of each AWS mast shall be checked every year and repaired whenever needed by the CTeam. This should be considered when preparing the DWP.
- The enclosure of the AWS can be checked by the MTeam or CTeam but only the CTeam can replace it in case of need.
- The lifecycle of each sensor is fully recorded on paper by the OperationalManager. The lifecycle of a sensor starts from requesting a new sensor from a provider and ends when the sensor becomes un-salvageable and cannot be further repaired.
- The same sensor can be re-installed multiple times on any AWS during its lifecycle.
- A sensor can be removed from a station for repair or because the AWS was reconfigured. Each type of sensor is identified by a unique serial number.
- All the emails exchanged in the context of these business processes pass through an existing email server owned by the FME. This server supports the protocols SMTP and POP and keeps copy of all emails.

2.6 List of Acronyms

AC	Alternate Current
ADC	Analogue-to-Digital Converter
AWS	Automatic Weather Station
DC	Direct Current
BWS	Base Weather Station
CTeam	Construction Team
DWP	Daily Work Plan
FME	Foundation for the Measurement of the Environment
GPS	Global Positioning System
OperationalManager	Weather Network Operational Manager
MTeam	Maintenance team
USB	Universal Serial Bus
WN	Weather Network
WNCoordinator	Weather Network Coordinator

3. Project Assignment

The table describes the 29 artefacts to be included in the report. The colours indicate different domains.

ID	Artefact	Technique	Description
1	Effort and work-breakdown	table	Two tables: (1) effort per student per phase; (2 work-breakdown per artefact per student.
2	AWS context	concept map	Specification of the system context described with a concept map. Identify all interactions between the system, its stakeholders and enabling systems.
3	AWS requirements	text	Well-formed list of SMART requirements. The specification of each requirement includes a hierarchical identifier (e.g. 2.3.1), a description and its source.
4	AWS use cases	SysML (uc)	One use case diagram showing all the use cases of the system. ~~The diagram shall be accompanied by a table that maps requirements to use cases~~
5	AWS use cases scenarios	table	One table for each use case with the description of all the relevant scenarios.
6	BWS context	concept map	Specification of the system context described with a concept map. Identify all interactions between the system, its stakeholders and enabling systems.
7	MeteoNet context	concept map	Specification of the system context described with a concept map. Identify all interactions between the system, its stakeholders and enabling systems.
8	MeteoNet requirements	text	Well-formed list of the SMART requirements. Each requirement shall have a hierarchical identifier (e.g. 1.3.2), a description and a link to its source.
9	MeteoNet use cases	UML (uc)	One use case diagram showing all the use cases of the system. ~~The diagram shall be accompanied by a table that maps requirements to use cases.~~
10	MeteoNet use case scenarios	table	One table for each use case with the description of its primary and alternative scenarios.
11	AWS structure	SysML (bdd, ibd)	Block diagram (or diagrams) and internal block diagrams to specify all structural blocks, ports, data types and flows of the system. Relevant parametric information may be represented in parametric diagrams (par) or pragmatically modelled in the bdd, ibd diagrams.
12	MeteoNet classes	UML (class)	One class diagram with the detailed specification of all classes of the MeteoNet system. All types, properties and operations must be specified.
13	MeteoNet components	UML (component)	One component diagram with all components related to the MeteoNet system.
14	MeteoNet deployment	UML (deployment)	One deployment diagram showing the mapping between the components and logical and physical devices.
15	AWS behaviour	SysML (seq)	One sequence diagram for the primary scenario of each use case. The alternative scenarios can be embedded on the same diagram, represented on different sequence diagrams or left out if considered irrelevant. All the content of the sequence diagrams must be fully traceable to the other models.
16	AWS states	SysML (stm)	One state machine specifying the states that describe the full lifecycle of an AWS.
17	MeteoNet behaviour	UML (seq)	One sequence diagram for the primary scenario of each use case. The alternative scenarios can be embedded on the same diagram, represented on different sequence diagrams or left out if considered irrelevant. All the content of the sequence diagrams must be fully traceable to the other models.
18	MeteoNet states	UML (stm)	(1) One state machine specifying the states related to the lifecycle of each sensor as required by the services provided by the MeteoNet software (cf. section 1.2) (2) One state machine specifying the states required to manage the network of AWS by the MeteoNet software (cf. section 1.2).
19	DWP management process	BPMN (process diagram)	A BPMN 2.0 process diagram for each process 19-25. Each process diagram specifies: (1) processes/ activities/tasks, (2) events, (3) business/data objects, (4) actors/roles, (5) control flow relationships, (6) data flow relationships. Artefacts 19-25 must be fully aligned (i.e. share concepts and observe traceability).
20	Installation process		
21	Reconfiguration process		
22	Data collection process		
23	Inspection process		
24	Repair process		
25	Removal process		
26	AWS traceability matrix	table	Matrix showing the realization of all requirements on all system models.
27	MeteoNet traceability matrix	table	Matrix showing the realization of all requirements on all system models.
28	Architectural description	text	Explanation of the relationship between each artefact 1-29 and the concepts specified in the standard ISO-IEC-IEEE 42010:2011 (maximum 200 words per artefact).
29	Change log	text	Log of changes between each version (phase) of the report.

A **report** is delivered on each phase. The report is delivered as an electronic PDF document as well as a printed paper document. A **report template** is provided which defines the following mandatory parts.

3.1 Cover

The cover identifies the phase of the project, the group (campus and number) and of all the students (name and number).

3.2 Tables of Contents

There are three tables of contents:

1. A table that summarizes all the document **sections** and corresponding page numbers.
2. A table that summarizes all the document **figures** and corresponding page numbers.
3. A table that summarizes all the document **tables** and corresponding page numbers.

Note that all pages in the report (except the cover and tables of contents) must be sequentially numbered at the bottom of each page.

3.3 Introduction

The one-page introduction describes the main decisions, assumptions and all relevant issues the group had to address.

3.4 Artefacts

The report describes artefacts 1-29 as required (cf. section 2.1). The artefacts shall be presented exactly in the same order as described in section 2.1 and each artefact shall be described within exactly one section.

Note that the same artefact may be described using multiple techniques. Therefore the same artefact may imply producing several diagrams or textual explanations. Other explanations considered important may be included inside the diagrams (as a note) or as text along the corresponding diagram.

All the diagrams and tables in the report shall have a sequentially numbered caption. The caption of the report shall include the name of the artefact (as described earlier on section 2.1).

All diagrams shall be designed for readability and ease of communication. This implies that the layout of a diagram, which includes the placement of all graphical elements and connectors, must be clear and well organized. A correct and consistent use of colours and other adornments that facilitate reading the diagram and communicating a clear message will be valued. Diagrams that display an unsuitable design will be penalized even if the content is satisfactory.

3.5 Work-breakdown Table and Artefact Description Table

Artefact #1 includes two tables. The first table is the **work-breakdown table** where each cell states the number of hours a specific student spent working directly on the respective phase of the project. The last row is the sum of the effort of all the students for each phase and the final column the sum for each student along the project.

Number	Name	Phase 1	Phase 2	Phase 3	Phase 4	Total per student
Student #1	Name 1					Sum(row#1)
Student #2	Name 2					Sum(row#2)
Student #3	Name 3					Sum(row#3)
Student #4	Name 4					Sum(row#4)
Total per phase		Sum(column)	Sum(column)	Sum(column)	Sum(column)	

Table 3. Work-breakdown table structure.

The second table to be presented is the **artefact description table** as exemplified next.

Artefact	Page	Student #1	Student #2	Student #3	Student #4
1	10	**O, M**	**D, M**		
2	11	**M**	**O**		
3	12-14	**d**	**M**	**O**	**m**
…	…				
29	23-25			**O**	

Table 4. Artefact description table structure.

This table indicates:

- The page number where the models that describe the artefact are (note that some artefacts will produce more than one diagram).
- A column for each member of the group with the student number as header. Each *cell student x artefact* identifies the *roles* played by each student during the development of the project regarding each artefact. Each student may combine more than one role. The contribution effort is proportional to the number of hours a specific student spent working directly on an artefact.
- The roles that can be played are the following:
  - **Owner (O)** of the artefact. Each artefact shall have one and only one owner. The owner is ultimately responsible for all the design decisions, the quality of the conceptual design and the quality of its structure, including its graphical layout. The owner of the artefact must be a major designer meaning that it has contributed at least 50% to the *conceptual design decisions* of the artefact.
  - **Major designer (D)**. Indicates contributions of at least 40% to the *conceptual design decisions* of the artefact. At most one major designer can be assigned to the same artefact (the other major designer is always the Owner).
  - **Major modeller (M)**. Indicates contributions of at least 40% to the *modelling effort* of the artefact. At most two major modellers can be assigned to the same artefact. Modelling effort encompasses using tools to transform the conceptual design of the artefact into a suitable format (e.g. graphic, text) and including the result into the report.
  - **Minor designer (d)**. Indicates contributions of 20-40% to the *conceptual design* of the artefact.
  - **Minor modeller (m)**. Indicates contributions of 20-40% to the *modelling effort* of the artefact.
  - **Empty cell**. A cell is empty if the design and/or modelling contributions are less than 20%.

4. Project Evaluation

The project has four phases. For each phase each group delivers a report according the rules detailed below.

Phase	Delivery	Weight	Evaluation
1	Report with artefacts **1-10 and 26-28**	15%	**Grade = (8% for artefacts 1-10) + (5% for artefacts 26, 27) + (10% for artefact 28)** **0-25% grade penalty based on the overall report quality** Important remarks: (1) traceability between *requirements* and *use cases* must be explicitly specified.
2	Revised phase 1 report plus artefacts **11-14** and **26-29**	15%	**Grade = (20% for artefacts 11-14) + (5% for artefacts 26, 27, 28)** **0-25% grade penalty based on the overall report quality** (including artefact 29) Important remarks: (1) quality of SysML structural diagrams will be assessed; blocks, associations, flows, ports and types must be fully specified; (2) quality of UML class diagrams will be assessed; classes, associations, properties and types must be fully specified; (3) traceability between *requirements* and *structure* must be explicitly specified.
3	Revised phase 2 report plus artefacts **15-18** and **26-29**	15%	**Grade = (20% for artefacts 15-18) + (5% for artefacts 26, 27, 28)** **0-50% penalty based on the overall report quality** (including artefact 29) Important remarks: (1) traceability between *behavioural diagrams*, *use cases*, *use case scenarios* and *structural diagrams* must be fully observed.
4	Final report with **artefacts 1-29**	55%	**Grade = (100% question & answers session)** **2 grade point penalty for each missing artefact 19-25** **0-100% penalty based on the overall report quality**

4.1 Evaluation

- The grading of phases 1-3 will be based on the contents of the report. As a general rule, all members of the group will be graded similarly during these three intermediate phases. However, members of the same team may receive different grades if the relative quality of the artefacts varies significantly. Therefore, the accuracy of the work-breakdown table and the artefact description table plays an important role in grading.
- During phases 1-3 each group will get feedback for further improvements. The feedback will be provided to the students on the classes the week following the due date of each phase.
- The maximum grade of phase 4 will depend on overall quality of the final report. The grades will then be assigned individually to each member of the group based on:
  - The performance of each student during the question & answers session,
  - The contributions breakdown and the judged quality of these contributions as reported on the work breakdown table and on the artefact description table.
- Phase 4 entails a question and answer session where all the members of the group are expected answer individually to questions which can deal with any subject directly related of the project. All members of the group need to be able to explain the overall project and not only the artefacts that they worked on. The owner of an artefact is ultimately responsible for its quality and must be able to defend all of its design and modelling decisions.
- The question & answers session of phase 4 may be conducted with the whole group or with individual members of the group. This will be decided on a case by case basis. At the end, all members of the group will be evaluated. Students that do not attend this session will be graded zero.
- Groups must carefully plan this project. The ownership of artefacts should be planned in advance and the task allocation revised continuously.
- Important remark: phases 1-3 aim providing feedback and guidance to the groups during the development of the project. Their goal is to highlight major deviations to the problem or solution, identify major flaws and to suggest areas of improvement. The evaluation of these phases has not the goal of assessing in detail the conceptual quality of all artefacts or identifying all modelling errors. Thus, projects that are on the right track and show a satisfactory use of the modelling techniques despite having some omissions and flaws will be constructively rewarded. The overall quality of the project will only be assessed in detail on phase 4. This means the grade of phase 4 may not correlate directly with the grades of phases 1-3.

4.2 Submission

- Each phase of the project is concluded with an electronic submission on Fénix until the posted due date.
- Students must submit a single ZIP archive with the name **MOD2012-C-NN.zip**, where **C** is the campus where the group is enrolled (**A** for Alameda, **T** for Taguspark) and **NN** is the group identifier, with two digits (therefore, group 1 of Alameda submits as "MOD2012-A-01.zip" and group 10 of Taguspark as "MOD2012-T-10.zip"). The ZIP archive contains the following files:
  - One PDF document report MOD2012-C-NN.pdf.
  - All files with the source models, such as Enterprise Architect files and Visio files. Please use the same file name as the archive name (e.g. a Visio should be named MOD2012-C-NN.vsd and an Excel file MOD2012-C-NN.xlsx).
- The document report in PDF of each submission must also be printed in duplex (printed on both sides of the sheet) and handed over during the lecture ("aula teórica") immediately after the project's due date. Printed reports that are not handed over in due time will not have any feedback.
- If a group is unable to meet the due date, the submission must be delivered by email to mod.dei.ist@gmail.com. Late submissions will be penalized with one grade point for each hour or fraction thereof that they are late (minimum penalty is one grade point). A late submission must be emailed with the subject "Phase **X** Group **C-NN**" where **C** is the campus where the group is enrolled (**A** for Alameda, **T** for Taguspark) and **NN** is the group identifier.

5. Modelling Tools

- **UML diagrams**
  - Any modelling tool compliant with UML 2.x
  - Suggestion: Enterprise Architect 7.5
- **SysML diagrams**
  - Any modelling tool compliant with SysML 1.x
  - Suggestion: Visio with SysML stencil (better than EA with most diagrams, especially structural diagrams) or Enterprise Architect 7.5 (slightly better than Visio with sequence diagrams)
- **BPMN diagrams**
  - Any tool compliant with BPMN 2.0
  - Suggestion: Visio with BPMN 2.0 stencil
- **Context diagrams**
  - Any drawing tool (e.g. Visio, Cmap Tools)
  - Suggestion: Cmap Tools
- **Requirements**
  - Suggestion: spread sheet editor (e.g. Excel)

6. Notes and Change Log

- V1.2 (08/03/2012)
  - Artefacts 4 and 9 wrongly ask to include a table that maps requirements to use cases. These traceability tables should be specified only on artefacts 26 and 27.
  - Note: Groups may opt to use more than one table (matrix) to specify artefacts 26 and 27. The goal is to convey information as clearly and effectively as possible.
  - Lines 180, 181: are incorrect and are not to be considered.
  - Line 382: Minor modeller ~~designer~~ (m).
  - Lines 13-21: An automatic weather station (AWS) is a~~n~~ ~~entity~~ system (...) measurements of atmospheric conditions to another system, a base weather station (...) A weather network (WN) is a system of systems consisting of multiple AWS ~~entities~~ that (...)

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