Global Airlines Support Team delivers all the necessary data to the company.

We are continually improving the quality of our service and tend to create world-class database support systems specialized in aero transport.

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Problem statement

- It is completely obvious that weather conditions have a strong impact on airline companies and their business. Nature knows many ways to disturb normal flight execution. Sometimes in very unexpected and even never seen ways yet. That is confirmed with the case of broken engines and airplane accident all caused by ash from the nearby active volcano.
- The company is aware of the weather influence but does not have a possibility to analyze this influence and make the appropriate decisions that help better business. Due to the fact that people are showing more and more fear of flying under bad weather, management made a decision and granted resources for solution that will help company solve this problem.
- There is a need for a database that will increase company knowledge about weather circumstances. Company already has a database which supports basic company efforts and activities in the area of aero transport.
- Company needs weather forecasts to enable prediction of danger flight zones. Company has a goal to be the first one on the market that offers to its' customers special arrangements that guarantee nice weather on the whole flight. Analyses of possible demand for this service showed that customers like the idea of flights performed under perfect weather circumstances.
- Company does not own resources to build the whole network of meteorological stations. The solution is to use meteorological services that are present and available on the Internet. These services take location coordinates and date as input parameters and return a whole set of meteorological parameters predicted for that location and date.

Our vision and goals

- Our vision is, as always, to create a database that will completely suite business needs and exceed the placed expectations.
- Our primary goal is to cover all relevant meteorological data that are considered important for the safety of flights.
- Due to relatively small amount of company knowledge about weather influence, additional research will be needed to eliminate missing requirements and ensure that all important aspects of the problem are taken into consideration.
- Our actual goals are to:
  - ensure presence of demanded meteorological data
  - completely track changes and historical data
  - enable user notification in case of any possible problem
  - enable storage for data that may be different for each service
  - create flexible model that allows different configurations
  - enable different types of data manipulation
  - deliver really useful reports

Business needs – Meteorological data

- One of the basic demands is to model the database so that it can memorize important meteorological data for any possible location, date and time.
- This data should be automatically delivered in predefined time intervals or on demand. Data may present forecast for a single day or even a period of day.
- Recent forecast is often more accurate than the older one. Easy navigation through different versions of the same forecast should be enabled.
- For each location, collection of meteorological parameters at least must include:
  - Minimal and maximal temperature
  - Current temperature
  - Wind speed and direction
  - Fog indicator
  - Rain and snow indicator
  - Visibility and sky
  - Surface look
  - Lightning indicator
- Some of related reports are listed bellow:
  - Predicted parameter value for each location in the route
  - Maximum parameter value for the given location

Business needs – Disasters and accidents

- There is a need for history data about certain nature disasters and events that could cause accidents on flights. Company is specially interested in wind data.
- For each disaster there should be data that points to location, corrupted area and exact time of the disaster.
- One disaster may start another one and this chain of events has to be researched in the future. That is the reason why this situations has to be memorized inside of the database.
- Different users should be alerted each time any of the parameters reaches extreme value. For each alert there should be data about delivery date and time, and data that identifies meteorological service that published the extreme value.
- When an accident happens, all accident data should be saved into the database. Each accident should be linked with location of the accident. Accident can happen only during one of the flight phases.
- Accidents don’t happen without reason. In this case, reason can be parameter value or disaster event. The accident data also involves number of injured and number of passed passengers.
- Realization of the risk-reduction strategy is depended on these two reports:
  - Most common cause of accident for entered route and time period
  - Number of accidents by each phase of flight

Business needs – User activities

- Simple users are responsible for insertion of data. Basic rule is that each change must be tracked with a username of user who made that change and exact date and time of the change.
- For each service the quality should be tracked. The final quality of the service depends on marks that are placed by authorized users. These marks are entered on a monthly basis and have values between 1 and 10. Each mark must be backed up with some form of explanation why is the given mark most appropriate in that case.
- These marks can be entered only by an analysts.
- Analysts place marks for each route based on the weather that is predicted or captured for locations in that route. These marks are needed so that all routes can be classified into one of three categories. These categories describe what will the weather be like for all the given routes.
- When supplied with that data, analysts will be able to analyze the weather on the company routes and reorganize them so that they can be executed under much safer circumstances. This directly increases the quality of the service and higher passenger satisfaction.
- Here are the two additional reports that can be useful for decision making:
  - Year final mark for quality and accuracy of published meteorological services
  - Number of routes inside of each weather group for entered year.

Business needs – Interviews

Bratislav Radojević, activity director of JAT School center:

Mr. Radojevic shared with us his experience with weather conditions that can cause problems and accidents.

Before the interview we did not think about the different phases of flights, so this conversation really helped us understand the way flights are executed. The interview was completed with a description of one of the defined procedures for emergency situations that are applied in JAT which gave us the idea to define alert notifications in our database.

We used this given time to inform our selves about good books and articles that could be found on this subject. We did not get any books, but after the interview, we were familiar with the world major meteorological organizations and other keywords that made our access to information much simpler.

Djordje Arandjelović, ICT sector at airport Nikola Tesla:

Mr. Arandjelovic explained us how the weather can disorder the normal flow of the activities on the airport. The interview with Mr. Arandjelovic was very useful because we had a chance to speak with someone who has experience in our problem domain.

Mr. Arandjelovic saw the first version of the database model and quickly spotted that we didn't consider the altitude of location, different wind speed on different altitudes and that we made a few more other mistakes that could become problems in the later design.

Mr. Arandjelovic showed us a part of the active airport database which helped us to identify data that already exists and should be copied into the new database.

Assumptions

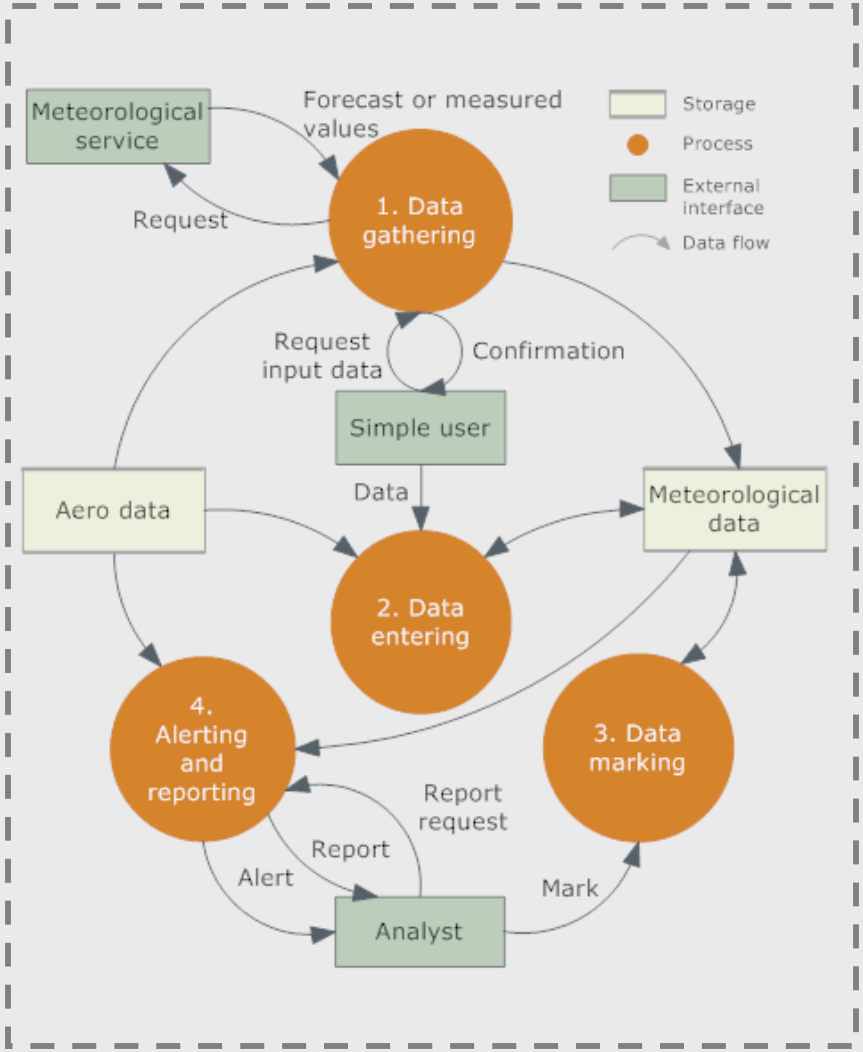
In order to be able to concentrate on main business needs, we made a list of assumptions. These assumptions place boundaries on our problem scope and keep us away from out-of-scope tasks. We assumed that:

- it is easy to find enough meteorological services on the Internet from which it is possible to get forecasts. We also assumed that we can get this data really quickly.
- the mechanism for service call exists and it can be used together with existing location data to gain needed forecast for that location
- there is an existing database in the company with flight schedules and data about users, locations, routes and flight phases and that we can gain access to this data. We also assumed that all the data is valid.
- there is a mechanism which will activate an alert when all conditions are needed.
- there is no need to transfer the historical data and that there are no restrictions for maximum size of the database.
- there is no need for any kind of security considerations.

On the other hand, we didn’t assume that:

- data is received from only one meteorological service
- meteorological services deliver perfectly accurate forecasts

Data flow diagram (DFD)



On this diagram we tried to explain our idea on how the company problem could be solved. With the assumption that all the basic data already exist in database, the data has approximately next flow:

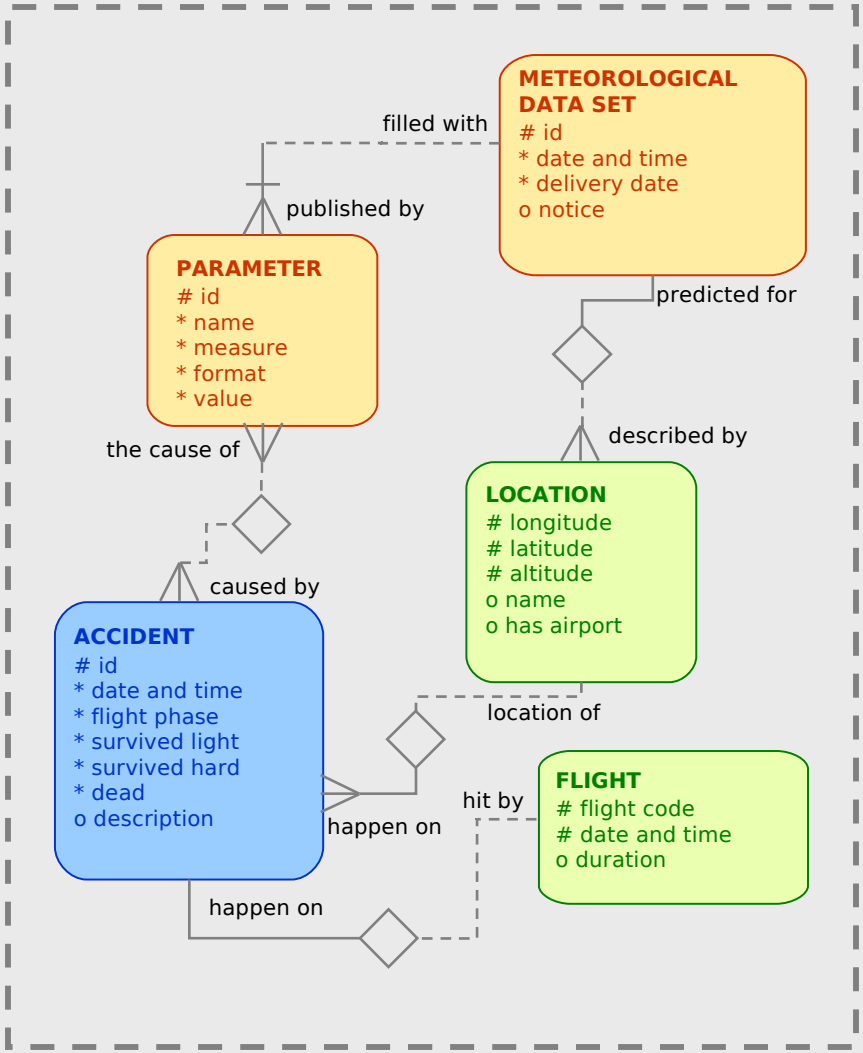
1. Simple user enters request input parameters based on the location data. This request is sent to the selected meteorological service. Depending on the request, the forecast or measured meteorological parameters are saved into the database.

2. Simple user executes insert into the database each time some disaster or accident happens. This process is using the existing data from the database to create more complex objects.

3. Analysts are responsible for placing the marks about different objects and their attributes using forecasts from database.

4. Automatic alerting raises an alert each time the predefined conditions are met. On the other hand, reporting uses all defined data in the database, combines them and presents them to the analyst in a form that helps making better decision.

Preliminary ERD



Preliminary ERD represents core entities and most important relationships in the model. Creation of preliminary ERD was the first step in modeling phase which helped us to ensure the most important functionalities.

Diagram shows the way in which meteorological data are connected to the primary activities of the company.

Starting from this preliminary model, we created the final model that represents the real structure of the future database by:

- adding additional entities and attributes
- normalizing the diagram
- removing duplicate definitions
- solving historical data problems

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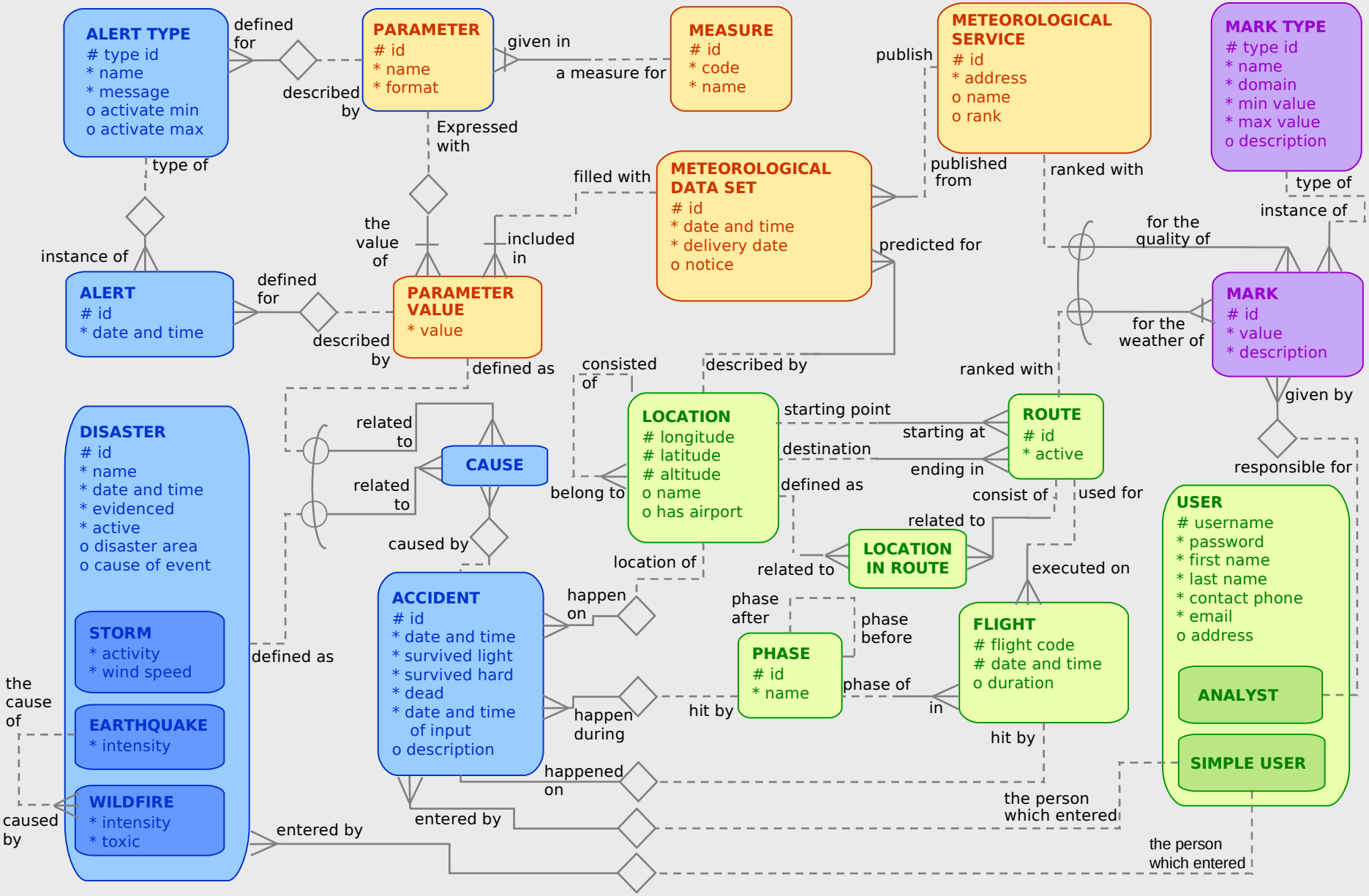
Final ERD


ALERT TYPE
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MARK TYPE
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the person which entered

ERD explanation

Bright green color is used for entities that already exist in the company database. This data is initially taken from the active database and updated on a need basis or in an exactly planned moment. The data about planned and executed flights are transferred in the moment of creation in the company database. All changes during the day are tracked.

Dark green color is used for entities that represents a subclass of the user entity. In our case, these subclasses define user privileges on the database operations.

Orange color is used for objects which are involved in the process of information gathering.

Blue color is used for the part of the database that is used for maintenance of dangerous events and alert signals. Main responsibility of this part is to save historical data about these events and link these events to accidents that can happen on the company flights. Collected data will enable statistical reports and form a solid base for the future research of weather influence.

Dark blue color is used for entities that represents a subclass of the disaster entity. All of these entities describe disaster type with more detail.

Purple color is used to for entities which are responsible classification and ranking of different elements in the database.

ERD explanation - Entities

LOCATION

The Location can be any location with defined longitude, latitude and altitude. The location may be a city or some smaller place, it may have an airport, and can be named by the name of a city or a place and can include other smaller locations.

ROUTE

The Route is a collection of the locations ordered from a starting point to a destination location. It can be changed over time and be disabled in a case of bad weather experiences.

FLIGHT

Company organizes and performs many flights each day. It may have many flights with the same flight code during the day, but they must be scheduled for a different time.

PHASE

Each flight has to pass all of the standard flight phases unless an accident happens. The phase may be a flight preparation phase, taxi on the airport to reach the runaway, other phases during flight and the final landing phase.

USER

Database users are performing different actions on the database based on their roles.

METEOROLOGICAL SERVICE

These services present the source of meteorological data. They are almost always available, publishing meteorological data for the input coordinates.

ERD explanation - Entities

METEOROLOGICAL DATA SET

Data set presents a set which is received based on a single service request. It contains a collection of different weather parameters values. Delivery time should be known for each set so that one could know how old the data is.

PARAMETER

Single parameter may be any of the meteorological factors, such as wind speed, temperature, presence of lighting and similar. Universal parameter code is used for parameter identification.

PARAMETER VALUE

Presents the value of a weather parameter for the input location, date and time.

MEASURE

This can be any measure in which parameter values are presented.

ALERT TYPE

Alert type defines lower and upper bound for a parameter value along with a message that displays a description about the alert.

ALERT

If a parameter reaches a value which is not inside of the bounds defined by its' type, an instance of that alert type is created.

ERD explanation - Entities

DISASTER

It could be any elementary disaster that can be dangerous for flight performing. Each disaster can corrupt certain surface area and be caused by some other event. For each disaster users tracks status changes and waits for completion.

STORM

Is a disaster which manifests in a form of extremely strong winds. This can be any type of storm such as Hurricane, Tornado, Cyclone and others.

EARTHQUAKE

Is a disaster which manifests in a form of ground shake. The danger of this disaster is presented by its' intensity.

WILD FIRE

Is also a type of disaster. It can have a different level of intensity and can be extremely toxic.

ACCIDNET

It represents an accident that happened on a flight. It consists of basic identification information and statistic data about the accident.

MARK TYPE

It defines characteristics of each mark that belongs to this type.

MARK

Marks are given by a user for the quality of route weather and accuracy of the received information from the meteorological services.

ERD explanation - Relationships

MEASURE – PARAMETER

Each parameter must be measured in an appropriate measure.

PARAMETER – PARAMETER_VALUE

Each parameter may have many different values.

METEOROLOGICAL SERVICE – METEOROLOGICAL DATA SET

Meteorological services are publishing their forecasts in a form of meteorological data set which represents a collection of meteorological parameter values.

METEOROLOGICAL DATA SET– PARAMETER_VALUE

Meteorological data set presents a list with values of the certain meteorological parameters. Each parameter value must belong to just one data set.

METEOROLOGICAL DATA SET– LOCATION

Forecast is always given for an exact location. Usually, each day locations get described by many different forecasts from different sources.

ROUTE - LOCATION

Each route must have exactly one starting point, exactly one destination and any number of locations between the starting and ending point.

FLIGHT - ROUTE

Each flight is executed on exactly one route. On each route there can be many flights.

ERD explanation - Relationships

FLIGHT - PHASE

In a single moment, each flight must be in one phase. There can be many flights in the same phase.

PHASE – PHASE

Each phase may have one and only one previous phase. Also, each phase may have one and only one next phase.

LOCATION – ACCIDENT

An accident must happen on some location. If the accident coordinates do not suite any location, then the accident is related to a location that is nearest to the given coordinates.

FLIGHT – ACCIDENT

Accidents happen on company flights. Each flight may have only one accident.

PARAMETER VALUE – ACCIDNET

Extreme value of some meteorological parameter often presents the main cause of an airplane accident.

DANGEROUS EVENT – ACCIDENT

Nature disasters may also cause airplane accidents.

ACCIDENT - PHASE

Each accident must happen on one flight phase.

ERD explanation – Other constraints

Constants

- Value of quality mark must be between 1 and 5.
- Intensity of fire may be between 1 and 10.
- Attribute <has airport> of entity LOCATION may have value ‘YES’ or ‘NO’
- Attribute <active> of entity DISASTER may have value ‘YES’ or ‘NO’

Time constraints

- Time of some accident on the flight must be after the scheduled start of that flight
- Accident on the flight can not happen during a phase of the flight, if the flight was not already in that phase.

Value constraints

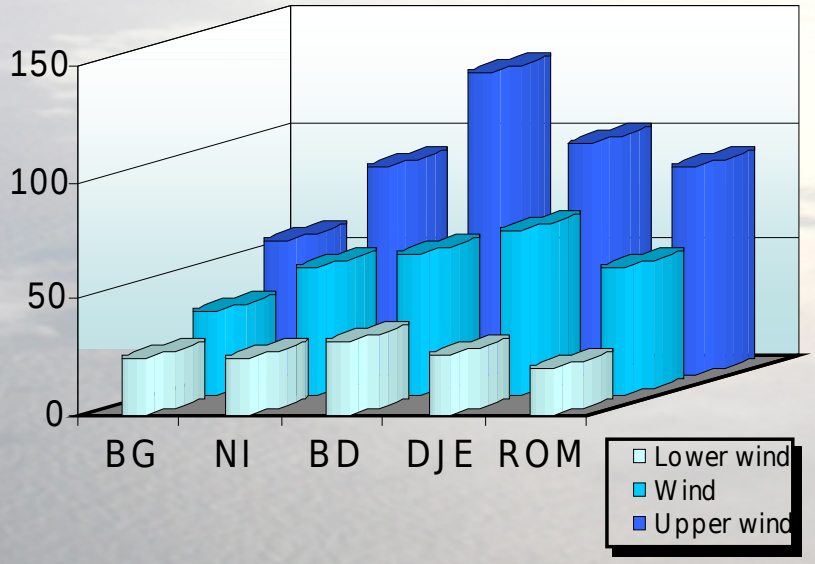
- Parameter value in each moment must be from its’ domain.
- Service address must be a valid Internet address
- Corrupted area is measured in square kilometers.
- Number of injured and dead people is entered in the form of rate and their sum must be 100.

Other

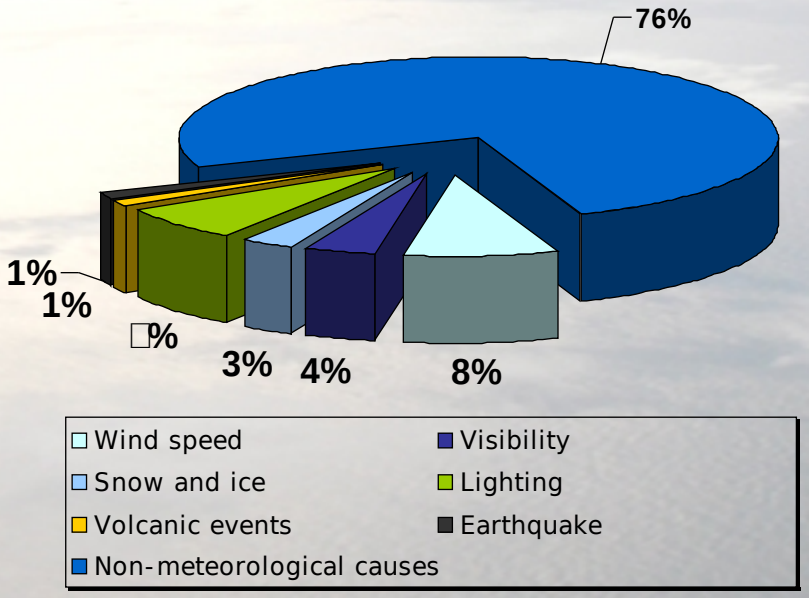
- Fields <activate min> and <activate max> are optional for the entity ALERT TYPE. If someone defines that type of alert and the received data set contains parameter for which this type of alert is defined, appropriate alert will be created no matter what is the value of that parameter.

Reports

This report represents the predicted wind speed in meters per second for all places in the route Belgrade – Rome for time period between 12:00 and 14:00 on March, 21st 2007. Report shows that the strongest wind in the route Belgrade – Rome has been predicted for Budva, location in Montenegro.

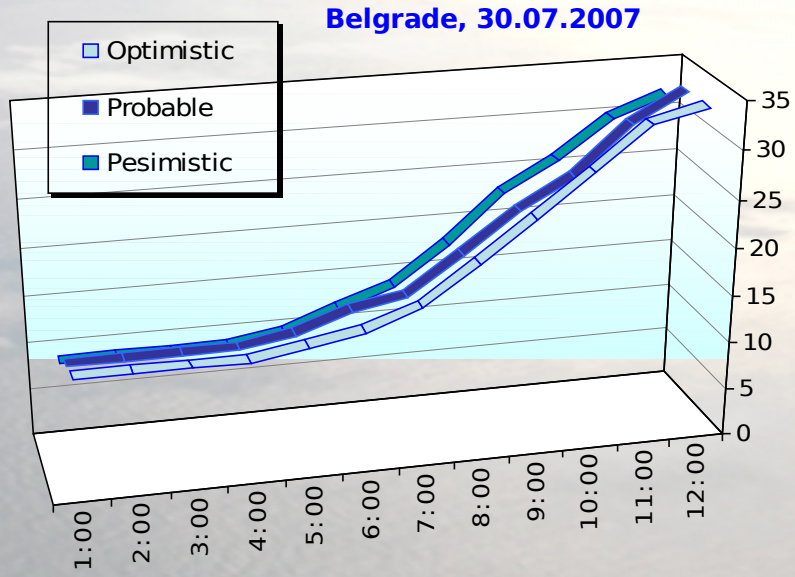


This report represents the number of accidents in 21th century caused by extreme values of meteorological parameters. For each parameter or nature disaster the report presents a percentage of all accidents caused by extreme values of the parameter or disaster event. Report shows that extreme wind speed and lightings presence is the most common cause of all accidents.



Reports

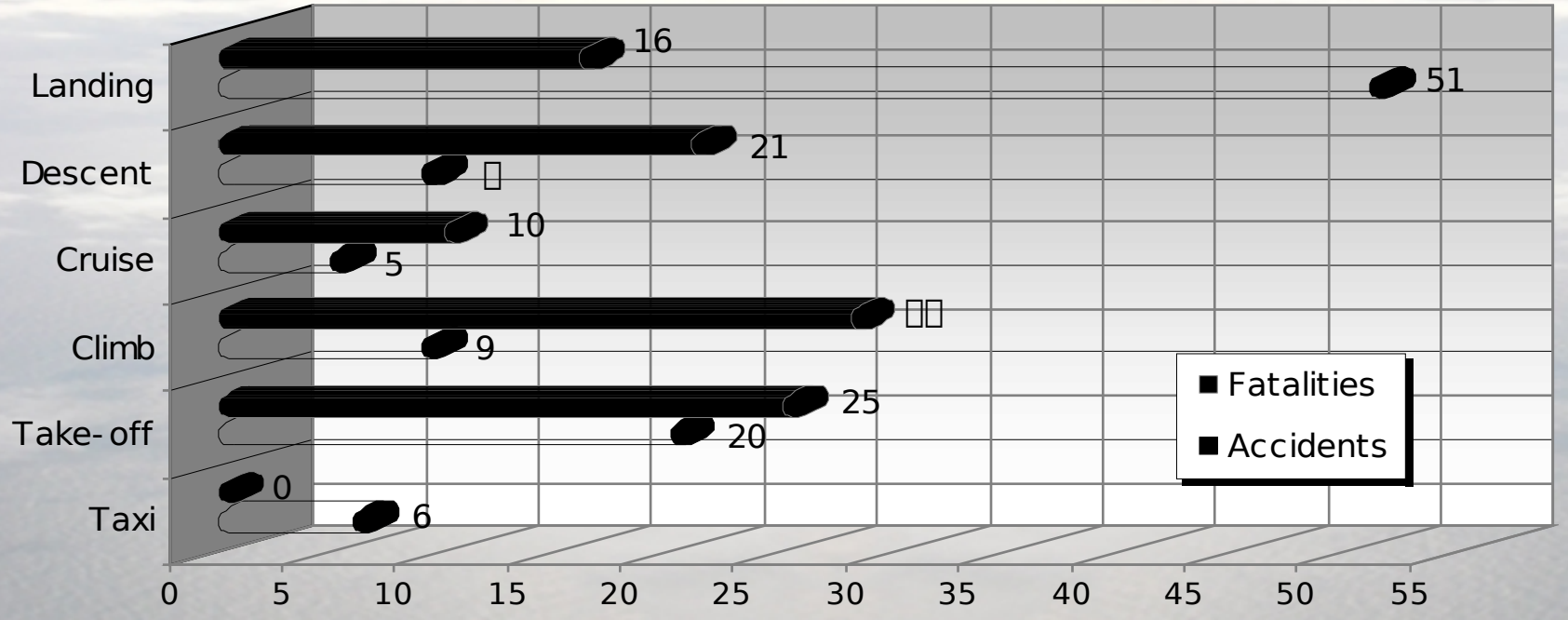
This report represents the predicted temperature for the first 12 hours in Belgrade on 30. 07.2007. There is an option to group forecasts received from different services into optimistic, probable and pessimistic. Thirty percent of all forecasts with the highest values are optimistic, thirty percent of all forecasts with the lowest values are pessimistic while others are probable.



This report represents a number of routes within each weather group. A route is placed into a group by an analyst using procedure for marks. Analyst makes a decision about a mark value based on the different statistical parameters, such as: number of accidents, number of not first landed, number of canceled flights and similar.

Reports

This report presents the number of accidents and fatalities in year 2007. grouped by flight phase in which the accident happened. The most dangerous parts of flight are take-off and landing phase. Accidents during the landing are as frequent as all of the accidents in all of the other phases together. They are reaching astonishing 51%, which means, if accident is going to happen, there is 50% chance that it will happen during the landing.



Conclusion

- The whole project team is completely satisfied with the produced solution and quality and the amount of information given to the database users and other employees in the company. We think that we successfully fulfilled all of our expectations.
- We helped the company to gain access to such important data for the business. The company is now able to predict danger situations and efficiently manage emergency situations relaying on the automatic alert notification system.
- Gathered data will enable route classification so that low rank routes can be easily noticed and transformed into successful ones.
- We are specially pleased how we managed to:
  - Ensure model flexibility and easy extension with new types of information.
  - Create complete and organized collection of historical data.
  - Execute integration with existing database and copy all necessary data into the new database.
  - Enable quality marks for received forecasts and define the method for selection of the representative sample.
  - Create strong basis for the future researches and upgrades
- Only the time can tell how useful the produced solution is. In any case, our team is more then satisfied with the gained experience and knowledge about users, their needs and the way how to analyze a problem and build a solution that will fit those needs.

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