Simulating surface to air missile defence: Creating an interface between Excel and the 3D Simulation Tool STK

STUDENT PROJECT

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Motivation

CC SBAMD

This project was a collaboration with the *Competence Center - Surface Based Air and Missile Defence* (CC SBAMD). The German-Dutch cooperation aims at constantly developing and improving the air defence capabilities of the two sponsoring nations. 2D planning tools have already been used to calculate coverage from possible aerial attacks and to assess the safety of individual targets. In order to realise more precise and visually comprehensible plans, the transition to the 3D mission planning tool *Systems Tool Kit* (STK) of Analytical Graphics, Inc. is now intended to be carried out.

Creating an interface between Microsoft Excel and STK

STK is a very powerful simulation platform for aerospace and defence technology that additionally allows the integration of external applications. In order to improve and accelerate the use of STK, we have created an interface with Microsoft Excel based on the requirements of CC SBAMD. This enables a mostly automated process for efficiently creating air defence layouts. Furthermore, it is straightforward enough for untrained users to handle. Further features of STK are its analysis tools. The interface additionally allows directly printing the data of those tools in an Excel sheet.

Create objects in STK

Objects in air defence scenarios

The CC SBAMD categorises three different types of objects in a scenario. **Assets**, **Resources** and **Threats**. To create those objects in STK, a name and their defining properties must be entered in Excel tables. A Microsoft Visual Basic script is executed, that creates all objects from the specific table, by clicking a button.

Assets

Assets represent infrastructure that should be protected. They are defined by their coordinates.

| Update Assets	Assets		
	AssetName	Latitude	Longitude
	POL-KAINJI-Hydro_Power_Plant	10.500	04.800
	SOF-LAME_BURRA-HQ	10.700	07.200
	ACC-MAKURDI_AB	07.900	09.400
	JFC-TUDUN_WADA	07.200	03.600
	ACC-GOMBE-RRP2	07.300	10.800
	LCC-ZAKARA-BRIDGE	09.080	03.020
	ACC-PORT_HARCOURT	04.800	07.800

Resources

Resources depict the defence systems. Each of them is equipped with a sensor, whose main property is its range.

Update Resources	Resources				
	Resource Name	Sensor Name	Latitude	Longitude	Range [km]
	Patriot1	ANMPQ-65	11.700	06.000	200
	SAMPT1	Arabel	10.200	07.400	100
	Patriot2	ANMPQ-65	07.050	08.730	200
	SAMPT2	Arabel	07.620	03.330	100
	Patriot3	ANMPQ-65	07.680	10.170	200
	Patriot4	ANMPQ-65	10.030	03.760	200
	SAMPT3	Arabel	05.460	07.840	100

Further properties can optionally be determined in order to create different types of sensors. It is possible to differentiate between either simple or rectangular conic and either static or rotating sensors.
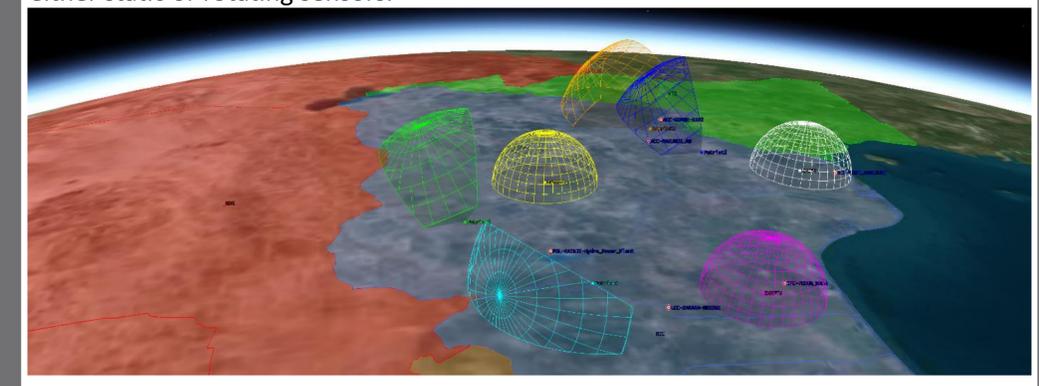

Threats

Threats are the opponent's weapon systems which can penetrate the airspace and destroy assets on the ground. The two types of threats are missiles and aircrafts.

Update Missiles	Missile	Launch		Impact		Apogee
	MissileName	Latitude	Longitude	Latitude	Longitude	Altitude (km)
	Missile1	19.100	10.600	10.500	04.800	200.0
	Missile2	19.100	10.600	10.700	07.200	150.0
	Missile3	13.000	03.080	07.200	03.600	300.0
	Missile4	17.500	12.500	07.900	09.400	280.0
	Missile5	17.500	12.500	07.300	10.800	320.0
	Missile6	08.370	16.180	04.800	07.800	120.0
	Missile7	08.370	16.180	07.300	10.800	180.0
	Missile8	12.120	16.720	11.810	12.210	150.0

Set Aircraft	New Aircraft			
	Aircraft Name	Aircraft1		
	Color	red		
	Waypoints	Latitude	Longitude	Altitude (m)	Speed (m/s)
		12.2700	03.380	11000	300
		09.080	03.020	11000	300

Missiles need launch and impact coordinates and an apogee height to be defined.

The flightpath of an aircraft is described by a list of coordinates, altitude and speed.
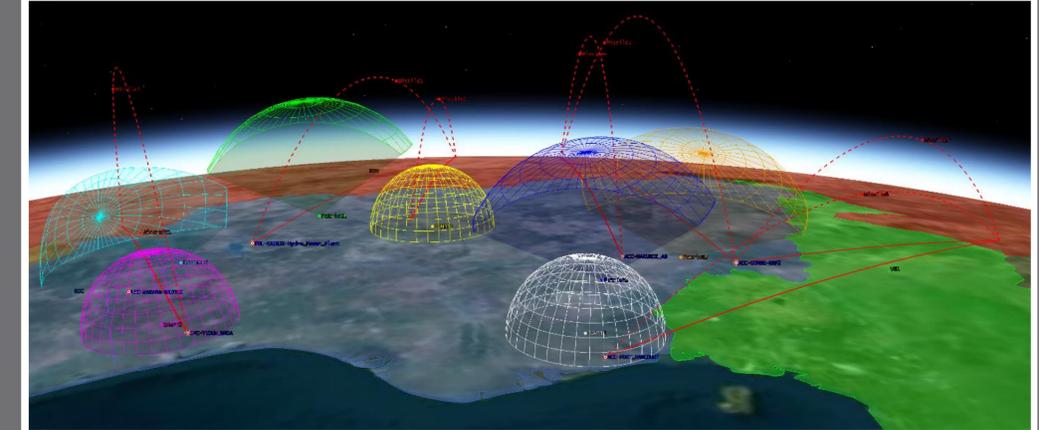
Analysis

Access Report

STK has a wide range of analysis options. This project focused on the access report. An access describes the time a threat is in observation range of a sensor. Every access is listed in tabular form in the report. To create an access report, it is necessary to select the threat and the resource between which a supposed access occurs.

Access Report	New Access Report				
	Threat Type:	Threat Name:	Resource Type:	Resource Name:	Sensor Name:
	Missile	Missile1	Facility	Patriot4	ANMPQ-65

By pressing the button, the access is calculated by STK and the report is automatically transferred to the Excel document.

Report:			
Access Number	Start Time	Stop Time	Duration [sec]
1	18.09.2020 10:06:49	18.09.2020 10:06:50	1.709439
2	18.09.2020 10:06:54	18.09.2020 10:06:55	1.698487
3	18.09.2020 10:06:59	18.09.2020 10:07:00	1.685063
4	18.09.2020 10:07:03	18.09.2020 10:07:05	1.670793
5	18.09.2020 10:07:08	18.09.2020 10:07:10	1.649470
6	18.09.2020 10:07:13	18.09.2020 10:07:15	1.625292

Check for Accesses

Check for Accesses	Threat Type:	Threat Name:		Resource Type:	Resource Name:	Sensor Name:
	Missile	Missile1	is detected by	Facility	Patriot1	ANMPQ-65
			is detected by	Facility	Patriot4	ANMPQ-65
	Missile	Missile2	is detected by	Facility	SAMPT1	Arabel
	Missile	Missile3	is detected by	Facility	SAMPT2	Arabel
	Missile	Missile4	is detected by	Facility	Patriot2	ANMPQ-65
			is detected by	Facility	Patriot3	ANMPQ-65
	Missile	Missile5	is detected by	Facility	Patriot3	ANMPQ-65
	Missile	Missile6	is detected by	Facility	SAMPT3	Arabel
	Missile	Missile7	is detected by	Facility	Patriot3	ANMPQ-65
	Missile	Missile8	is not detected!			
	Aircraft	Aircraft1	is detected by	Facility	Patriot4	ANMPQ-65

To examine the defence system, a check for accesses option has been integrated. It analyses every threat object with every resource for accesses. Then each actual access is listed in the Excel sheet. If a threat is not detected by a single sensor, a warning will appear.

In addition, all accesses are now displayed on the 2D map in STK in the colour of the respective resource. The map allows to get a first overview of the existing accesses. For a more detailed examination of a specific access, an access report can be created.
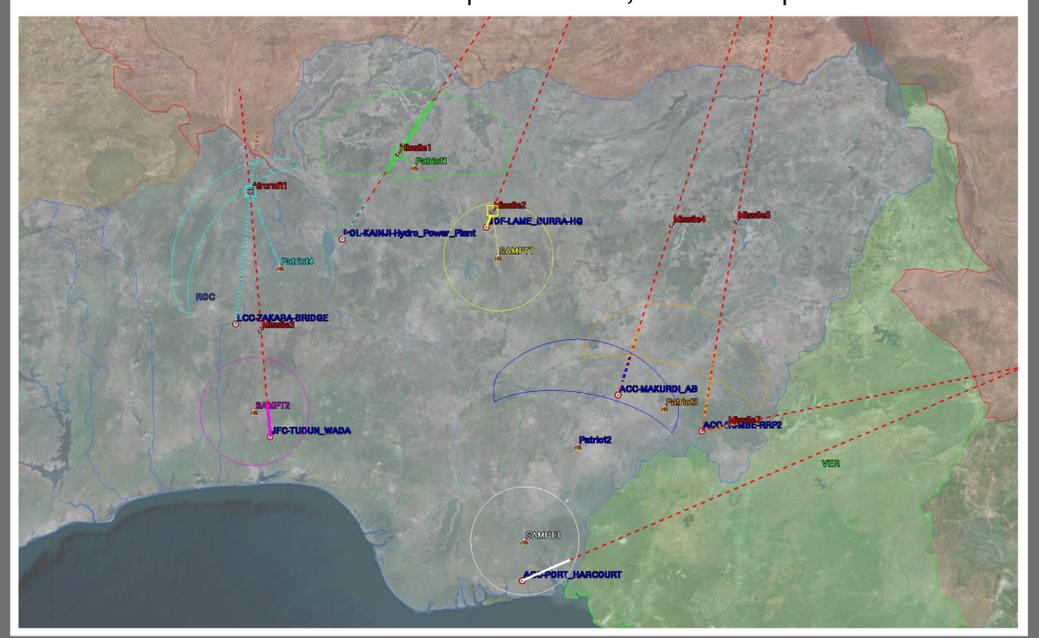
Conclusion

This work resulted not only in a practical implementation, but also demonstrated the capabilities of operating STK with Excel. Through this project, a comparably easy operability was achieved. This enables the use of STK without a long training period and convinced CC SBAMD to use the file for interactive teaching methods in training courses as well. The insight into STK's capabilities gathered by implementing numerous features lead the project partners to continue using STK in the future and to expand their competences in this area.