

Evidence-based planning of a fossile-free emergency response fleet

Energimyndigheten project P2023-01441
Joint work of LiU, RTÖG, VTI

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Emergency response

Overall logic of a mission

1. Receive call to SOS & start mission.
2. Repeat until mission complete:
 - 2.1 Dispatch required vehicles:
 - 2.1.1 Identify required vehicle types.
 - 2.1.2 Find / wait for available vehicles.
 - 2.1.3 Send vehicles to mission.
 - 2.2 Recall no longer needed vehicles.
 - 2.3 Monitor mission progress.

↑

We aim to realistically simulate this.

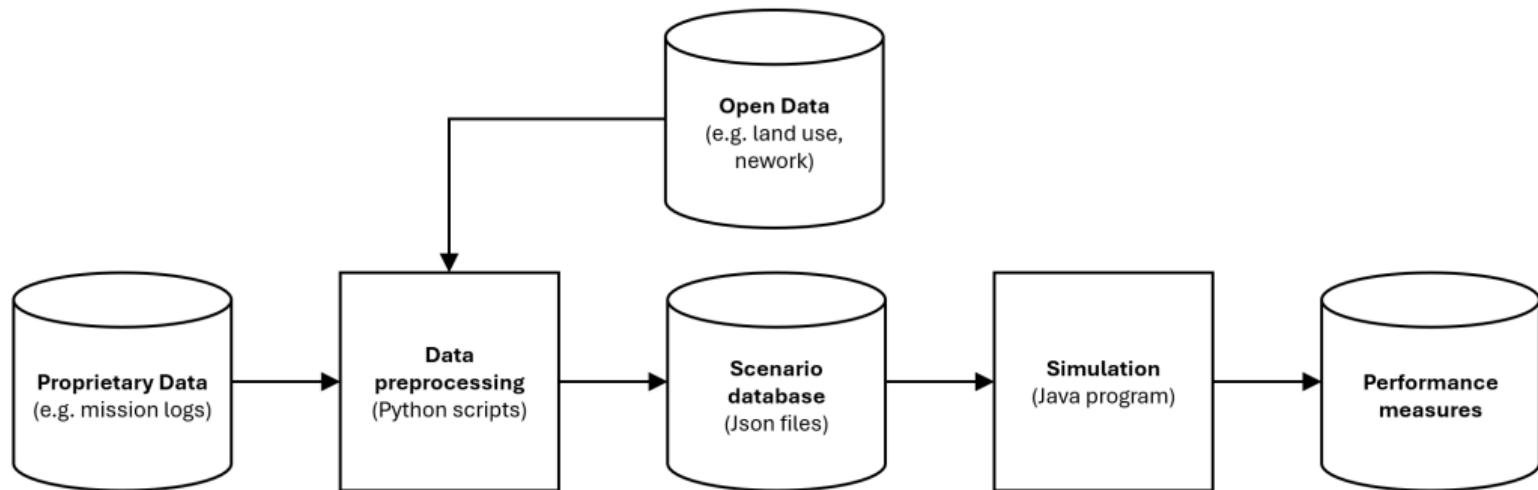
Electrified fleet

- Limited charging speed, battery capacity.
- Driving and mission consume energy.
- Vehicles recharge at dedicated stations.
- Vehicle availability depends on SOC.

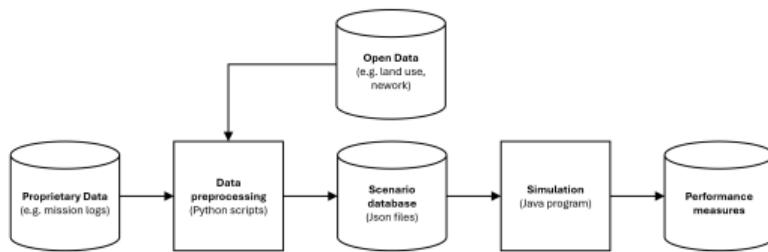
Simplifications

- No limitations on available staff.
- No vehicle failures.
- No en-route obstacles (congestion etc.).

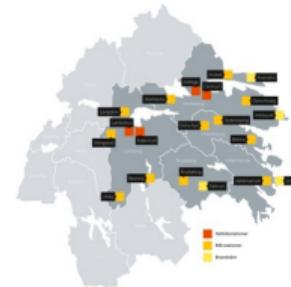
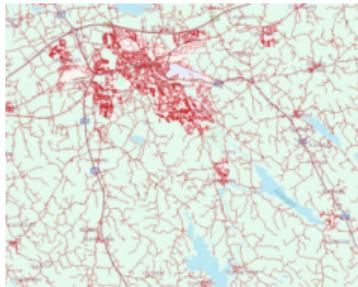
Evidence-based simulation needs data



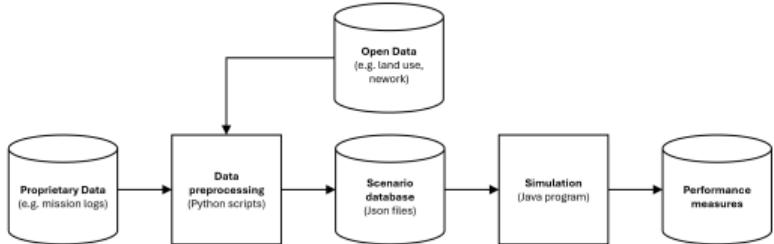
Open data



- Road network from NVDB.
- Land use from Lantmäteriet.
- Stations/fleet from RTÖG.
- Electrified fleet – vendor specifications.



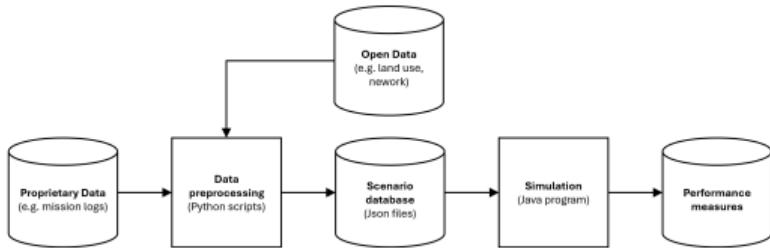
Proprietary data



- Daedalos mission logs (from RTÖG).
- Emergency location, time, type, ...
- Resource logs (vehicles, persons).

Ärende, årsr	Händelse, typ	Resurs, station	Geo, nord	Resurs, tid klar	Resurs, tid framme	Geo, ost	Resurs, enhet
G2024.129679	Hjärtstop	242-1000		1900-01-00 00:00	2024-11-06 07:44		242-1065
G2024.129600	Annan bärhjälp till ambulans	242-2200		2024-11-05 21:36	2024-11-05 21:26		242-2210
G2024.129728	Trafikolycka (vög, terräng, spår, flyg, sjö)	242-2000		2024-11-05 17:54	2024-11-05 17:43		242-2010
G2024.129728	Trafikolycka (vög, terräng, spår, flyg, sjö)	242-2000		2024-11-05 17:54	2024-11-05 17:43		242-2040
G2024.129718	Brand eller brandtillstånd i fordon eller fartyg utomhus	242-1000		2024-11-05 17:07	1900-01-00 00:00		242-1010
G2024.129718	Brand eller brandtillstånd i fordon eller fartyg utomhus	242-1200		2024-11-05 17:18	2024-11-05 17:18		242-1210
G2024.129708	Trafikolycka (vög, terräng, spår, flyg, sjö)	242-1000		2024-11-05 16:37	1900-01-00 00:00		242-1040
G2024.129708	Trafikolycka (vög, terräng, spår, flyg, sjö)	242-1200		1900-01-00 00:00	1900-01-00 00:00		242-1210
G2024.129707	Hjärtstop	242-1000		1900-01-00 00:00	1900-01-00 00:00		242-1065
G2024.129697	Trafikolycka (vög, terräng, spår, flyg, sjö)	242-2000		2024-11-05 16:13	1900-01-00 00:00		242-2008
G2024.129697	Trafikolycka (vög, terräng, spår, flyg, sjö)	242-2000		2024-11-05 16:18	2024-11-05 16:17		242-2010
G2024.129647	Automatarm utan brandtillstånd	242-1900		2024-11-05 14:20	2024-11-05 14:16		242-1910
G2024.129569	Automatarm utan brandtillstånd	242-2700		2024-11-05 11:24	2024-11-05 11:08		242-2760
G2024.129569	Automatarm utan brandtillstånd	242-2700		1900-01-00 00:00	2024-11-05 11:11		242-2770
G2024.129569	Automatarm utan brandtillstånd	242-2700		1900-01-00 00:00	2024-11-05 11:19		242-2710
G2024.129472	Annan krosta hjälpen eller sjukvård	242-3500		2024-11-05 04:51	2024-11-05 04:28		242-3560
G2024.129472	Annan krosta hjälpen eller sjukvård	242-3500		2024-11-05 04:51	2024-11-05 04:27		242-3570
G2024.129469	Lytthjälp (intåg till ambulans)	242-3000		2024-11-05 03:13	1900-01-00 00:00		242-3010
G2024.129469	Suicid eller suicidförörelse (inte brand, trafikolycka, utsläpp eller drunkning)	242-7000		1900-01-00 00:00	2024-11-05 01:57		242-7010
G2024.129469	Suicid eller suicidförörelse (inte brand, trafikolycka, utsläpp eller drunkning)	242-7000		1900-01-00 00:00	2024-11-05 01:57		242-7070
G2024.129469	Suicid eller suicidförörelse (inte brand, trafikolycka, utsläpp eller drunkning)	242-7000		1900-01-00 00:00	2024-11-05 01:57		242-7060
G2024.129469	Suicid eller suicidförörelse (inte brand, trafikolycka, utsläpp eller drunkning)	242-1000		2024-11-05 02:30	2024-11-05 02:22		242-1080
G2024.129441	Automatarm utan brandtillstånd	242-1000		2024-11-04 23:57	2024-11-04 23:57		242-1010
G2024.129441	Automatarm utan brandtillstånd	242-1000		1900-01-00 00:00	2024-11-04 23:58		242-1080

Scenario database



Processed data

- vehicleTypes.json, vehicles.json, stations.json
- distanceTypes.json, distances.json

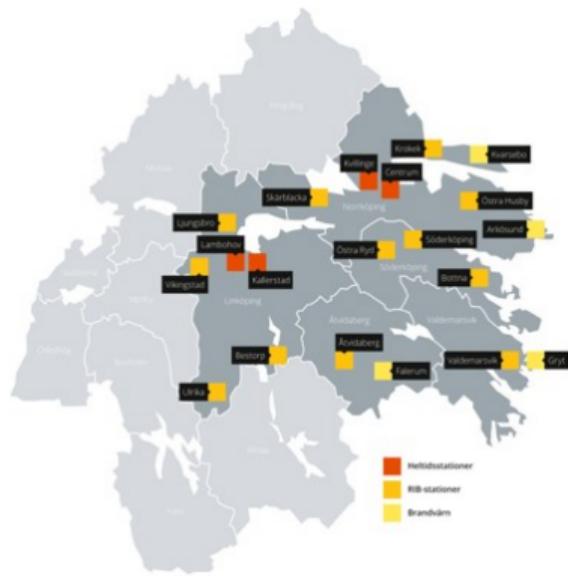
Statistical models

- incidentTypes.json, zones.json, missions.json

```
[ {  
    "id" : "EV_Car",  
    "batteryCapacity_kWh" : 75.0,  
    "energyNeed_kWh_per_km" : 0.15,  
    "chargingRate_kw" : 50.0,  
    "energyNeedDuringMission_kWh" : 0.5,  
    "maxSpeed_km_h" : 130.0  
}, {  
    "id" : "EV_Truck",  
    "batteryCapacity_kWh" : 300.0,  
    "energyNeed_kWh_per_km" : 0.8,  
    "chargingRate_kw" : 150.0,  
    "energyNeedDuringMission_kWh" : 1.5,  
    "maxSpeed_km_h" : 90.0  
} ]
```

```
[ {  
    "id" : "BuildingFire",  
    "season2Weight" : {  
        "SUMMER" : 1.0,  
        "WINTER" : 1.0,  
        "AUTUMN" : 1.0,  
        "SPRING" : 1.0  
    },  
    "incidentType2Intensity_1_yr" : {  
        "CarCrash" : 10.0,  
        "BuildingFire" : 10.0  
    },  
    "typeOfDay2Weight" : {  
        "HOLIDAY" : 1.0,  
        "WORKDAY" : 1.0  
    },  
    "incidentType2Intensity_1_yr" : {  
        "CarCrash" : 1.0,  
        "BuildingFire" : 10.0  
    },  
    "timeOfDay2Weight" : {  
        "NIGHT" : 1.0,  
        "DAY" : 2.0  
    },  
    "id" : "NorthernAmal",  
    "zoneId" : "NorthernAmal"  
}, {  
    "id" : "SouthernAmal",  
    "incidentType2Intensity_1_yr" : {  
        "CarCrash" : 1.0,  
        "BuildingFire" : 10.0  
    },  
    "typeOfDay2Weight" : {  
        "NIGHT" : 1.0,  
        "DAY" : 2.0  
    },  
    "id" : "SouthernStation",  
    "zoneId" : "SouthernAmal"  
}, {  
    "id" : "WesternAmal",  
    "zoneId" : "WesternAmal"  
}]
```

Östra Götaland case study



→ Results are not yet validated. ←

Baseline

- 90 consecutive autumn days.
- Anticipated market standard electrification.
- Ca. 1400 missions in total.

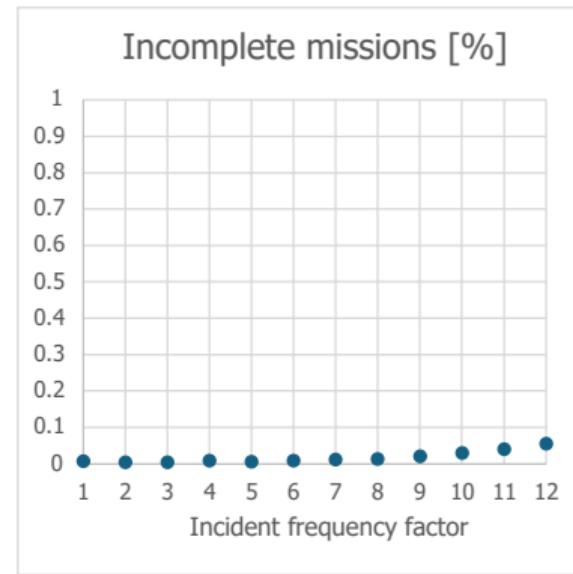
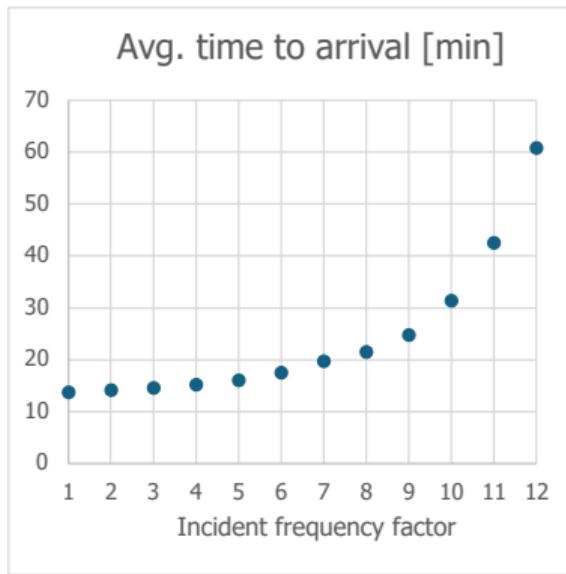
Simulation

- 100 replications of each scenario.
- consider only system-wide statistics.
- limit statistical analysis to mean values.

Considered scenarios

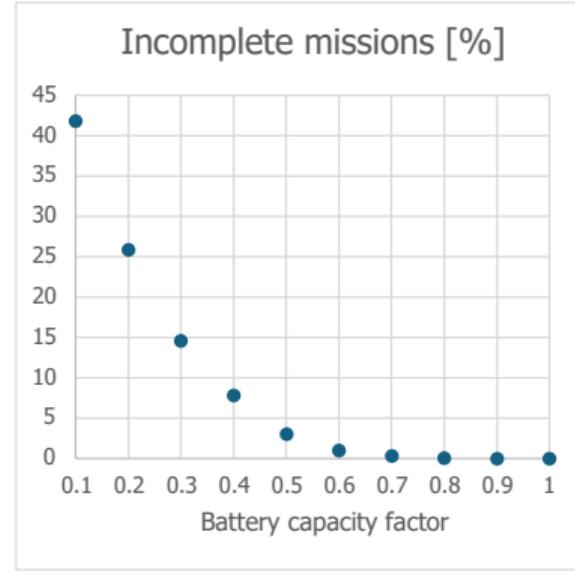
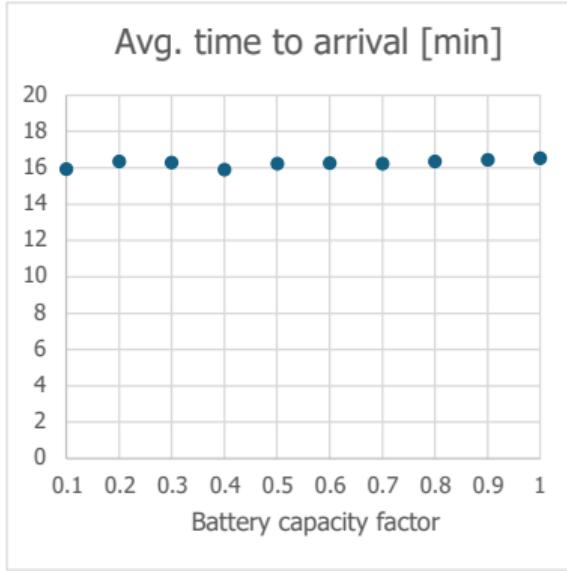
1. Stress-test: incident frequency.
2. Battery capacity.
3. Charging speed.
4. Minimal SOC for mission-readiness.

1. Incident frequency



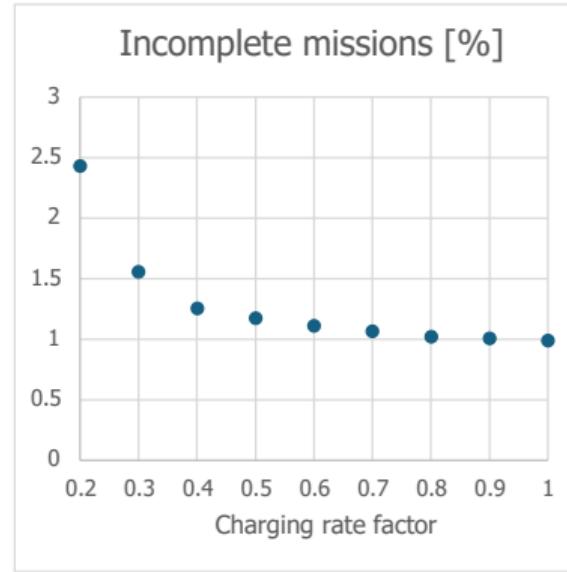
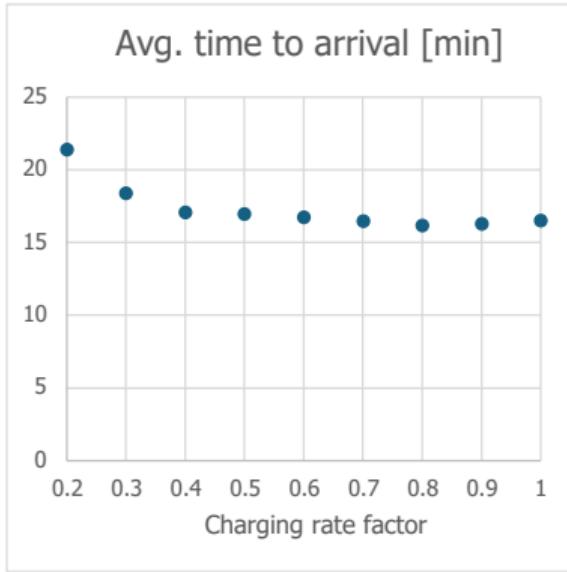
- Battery parameters (capacity, charging rate) at anticipated market standard.
- Vehicles need to be fully charged before entering a mission.
- **Sufficient performance at 500% incident increase.**

2. Battery capacity



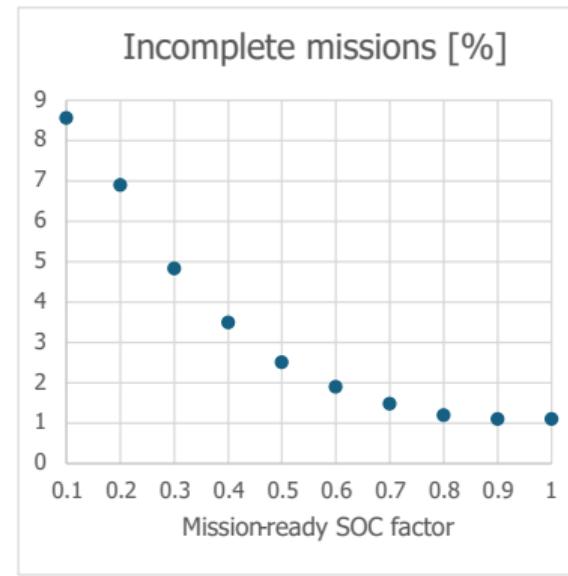
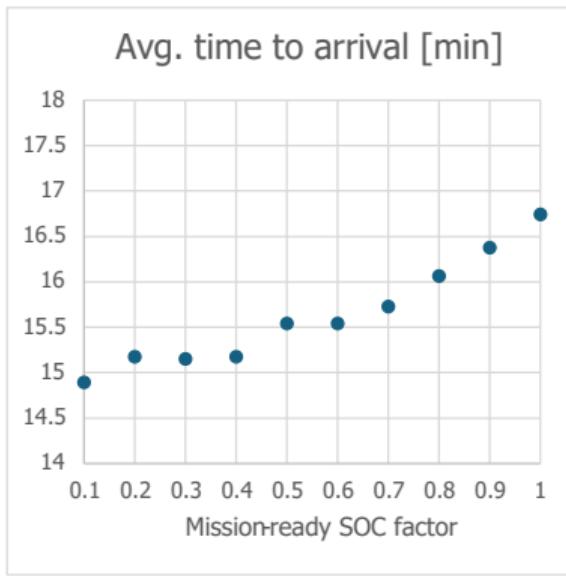
- Stress test: 500% incident increase.
- Charging rate at anticipated market standard.
- Vehicles need to be fully charged before entering a mission.
- **Sufficient performance with 60% battery size.**

3. Charging rate



- Stress test: 500% incident increase.
- Battery capacity at anticipated market standard.
- **Sufficient performance with 60% charging speed.**

4. Minimal SOC for mission-readiness



- Stress test: 500% incident increase.
- Battery capacity and charging rate at 60% of anticipated market standard.
- **Sufficient performance when dispatching vehicles at 80% SOC.**

Next steps: case studies!

The screenshot shows a GitHub repository page for 'vtisweden/java-projects/certain'. The repository has 1 star and 0 forks. It contains 13 files and 12 commits. The commits are listed as follows:

Name	Last commit message	Last commit date
...		
docs	updated example	2 months ago
minimal/input	adding minimal (test) scenario	last month
src/main/java/se/vti/certain	noted eon scenario specs	4 days ago
COPYING	publishing certain	3 months ago
DESCRIPTION	publishing certain	3 months ago
LICENSE	publishing certain	3 months ago
WARRANTY	publishing certain	3 months ago
pom.xml	running replications + analysis profile...	last month

README.md

CERTAIN repository

This java program allows to simulate emergency service activities, in particular with respect to the energy needs of a future electrified emergency vehicle fleet. It synthesizes a sequence of incidents based on historical data and land use information, triggers corresponding missions (vehicles being dispatched to handle the incidents), and tracks vehicle availability and state of charge. The program allows to study the effect of changed emergency patterns (e.g. because of land use development or increased frequency of certain incident types), vehicle technologies (overall fleet composition, charging durations, battery capacities), and of energy availability.

"CERTAIN" is an acronym for "Evidence-based fossil free emergency service fleet planning", which is the name of the project in which this computer problem is developed. The project is funded by the Swedish Energy Agency.

Code:



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