

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.

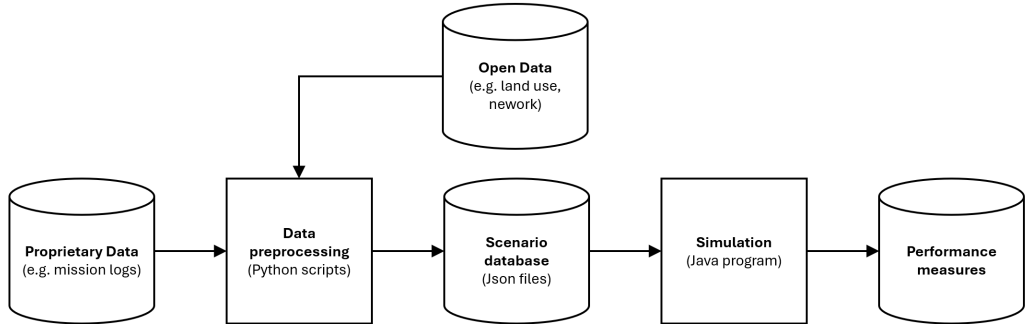
Electrified fleet

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

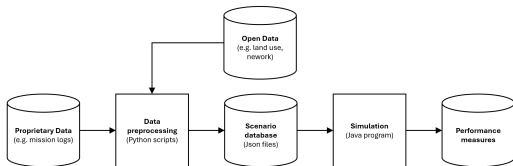
Simplifications

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

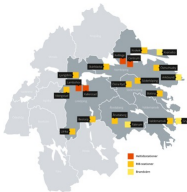
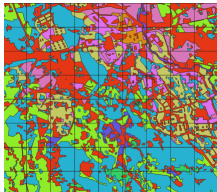
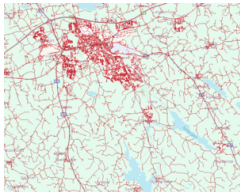
Evidence-based simulation needs data



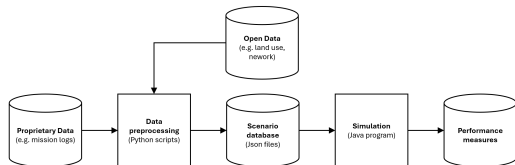
Open data



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



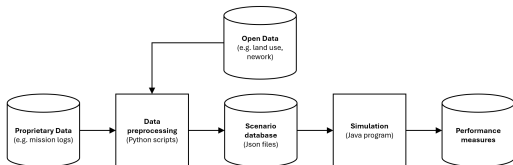
Proprietary data



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

| Ärende, årsnr | Händelse, typ | Resurs, station | Geo, nord | Resurs, tid klar | Resurs, tid framme | Geo, ost | Resurs, enhet |
|---------------|---|-----------------|-----------|------------------|--------------------|----------|---------------|
| G2024.129679 | Hjärtstopp | 242-1000 | | 1900-01-00 00:00 | 2024-11-06 07:44 | | 242-1065 |
| G2024.129690 | Annan bärhjälp till ambulans | 242-2200 | | 2024-11-05 21:36 | 2024-11-05 21:26 | | 242-2210 |
| G2024.129728 | Trafikolycka (väg, terräng, spår, flyg, sjö) | 242-2000 | | 2024-11-05 17:54 | 2024-11-05 17:43 | | 242-2010 |
| G2024.129728 | Trafikolycka (väg, terräng, spår, flyg, sjö) | 242-2000 | | 2024-11-05 17:54 | 2024-11-05 17:43 | | 242-2040 |
| G2024.129718 | Brand eller brandtillbud i fordon eller fartyg utomhus | 242-1000 | | 2024-11-05 17:07 | 1900-01-00 00:00 | | 242-1010 |
| G2024.129718 | Brand eller brandtillbud i fordon eller fartyg utomhus | 242-1200 | | 2024-11-05 17:18 | 2024-11-05 17:18 | | 242-1210 |
| G2024.129708 | Trafikolycka (väg, terräng, spår, flyg, sjö) | 242-1000 | | 2024-11-05 16:37 | 1900-01-00 00:00 | | 242-1040 |
| G2024.129708 | Trafikolycka (väg, terräng, spår, flyg, sjö) | 242-1200 | | 1900-01-00 00:00 | 1900-01-00 00:00 | | 242-1210 |
| G2024.129707 | Hjärtstopp | 242-1000 | | 1900-01-00 00:00 | 1900-01-00 00:00 | | 242-1065 |
| G2024.129697 | Trafikolycka (väg, terräng, spår, flyg, sjö) | 242-2000 | | 2024-11-05 16:13 | 1900-01-00 00:00 | | 242-2009 |
| G2024.129697 | Trafikolycka (väg, terräng, spår, flyg, sjö) | 242-2000 | | 2024-11-05 16:18 | 2024-11-05 16:17 | | 242-2010 |
| G2024.129647 | Automatarm utan brandtillbud | 242-1900 | | 2024-11-05 14:30 | 2024-11-05 14:16 | | 242-1910 |
| G2024.129569 | Automatarm utan brandtillbud | 242-2700 | | 2024-11-05 11:24 | 2024-11-05 11:08 | | 242-2760 |
| G2024.129569 | Automatarm utan brandtillbud | 242-2700 | | 1900-01-00 00:00 | 2024-11-05 11:11 | | 242-2770 |
| G2024.129569 | Automatarm utan brandtillbud | 242-2700 | | 1900-01-00 00:00 | 2024-11-05 11:10 | | 242-2730 |
| G2024.129472 | Annan första hjälpen eller sjukvård | 242-3500 | | 2024-11-05 04:51 | 2024-11-05 04:28 | | 242-3560 |
| G2024.129472 | Annan första hjälpen eller sjukvård | 242-3500 | | 2024-11-05 04:51 | 2024-11-05 04:27 | | 242-3570 |
| G2024.129469 | lyttjälp (inte åt ambulans) | 242-3000 | | 2024-11-05 03:13 | 1900-01-00 00:00 | | 242-3010 |
| G2024.129460 | Suicid eller suicidförsök (inte brand, trafikolycka, utsläpp eller drunkning) | 242-7000 | | 1900-01-00 00:00 | 2024-11-05 01:57 | | 242-7010 |
| G2024.129460 | Suicid eller suicidförsök (inte brand, trafikolycka, utsläpp eller drunkning) | 242-7000 | | 1900-01-00 00:00 | 2024-11-05 01:57 | | 242-7070 |
| G2024.129460 | Suicid eller suicidförsök (inte brand, trafikolycka, utsläpp eller drunkning) | 242-7000 | | 1900-01-00 00:00 | 2024-11-05 01:57 | | 242-7060 |
| G2024.129460 | Suicid eller suicidförsök (inte brand, trafikolycka, utsläpp eller drunkning) | 242-1000 | | 2024-11-05 02:30 | 2024-11-05 02:22 | | 242-1080 |
| G2024.129441 | Automatarm utan brandtillbud | 242-1000 | | 2024-11-04 23:57 | 2024-11-04 23:57 | | 242-1010 |
| G2024.129441 | Automatarm utan brandtillbud | 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
} ]
```

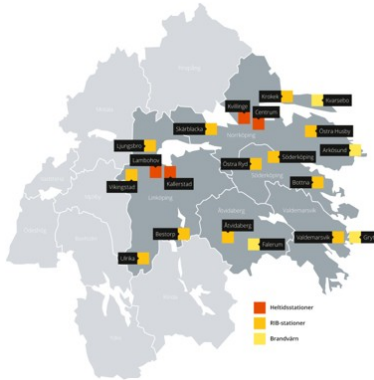
```
[ {
  "id" : "Car_001",
  "typeId" : "EV_Car",
  "stationId" : "NorthernStation"
}, {
  "id" : "Truck_001",
  "typeId" : "EV_Truck",
  "stationId" : "NorthernStation"
}, {
  "id" : "Car_002",
  "typeId" : "EV_Car",
  "stationId" : "SouthernStation"
} ]
```

```
[ {
  "id" : "NorthernStation",
  "zoneId" : "NorthernAmal"
}, {
  "id" : "SouthernStation",
  "zoneId" : "SouthernAmal"
} ]
```

```
[ {
  "id" : "NorthernAmal",
  "incidentTypeId2Intensity_1_yr" : {
    "CarCrash" : 10.0,
    "BuildingFire" : 10.0
  }
}, {
  "id" : "SouthernAmal",
  "incidentTypeId2Intensity_1_yr" : {
    "CarCrash" : 1.0,
    "BuildingFire" : 10.0
  }
}, {
  "id" : "WesternAmal",
```

```
[ {
  "id" : "BuildingFire",
  "season2Weight" : {
    "SUMMER" : 1.0,
    "WINTER" : 1.0,
    "AUTUMN" : 1.0,
    "SPRING" : 1.0
  },
  "timeOfDay2Weight" : {
    "HOLIDAY" : 1.0,
    "WORKDAY" : 1.0
  },
  "timeOfDay2Weight" : {
    "NIGHT" : 1.0,
    "DAY" : 2.0
  }
}, {
```

Östra Götaland case study



→ Results are not yet validated. ←

Baseline

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

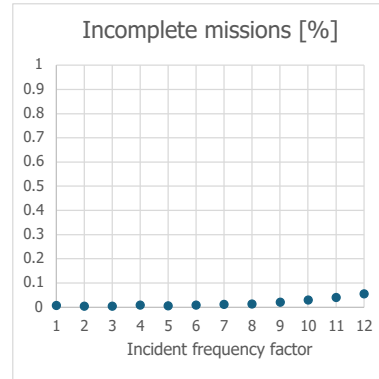
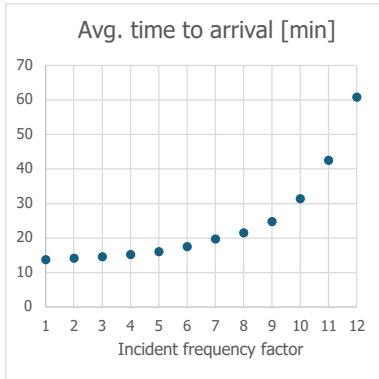
Simulation

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

Considered scenarios

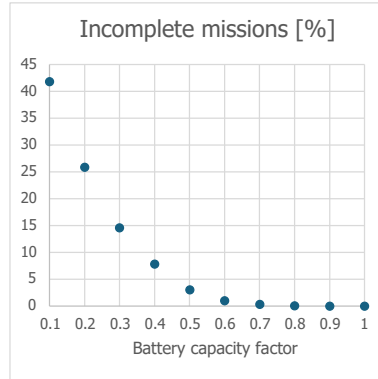
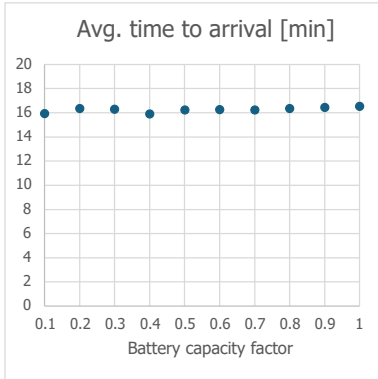
1. Stress-test: incident frequency.
2. Battery capacity.
3. Charging speed.
4. Minimal SOC for mission-readiness.

1. Incident frequency



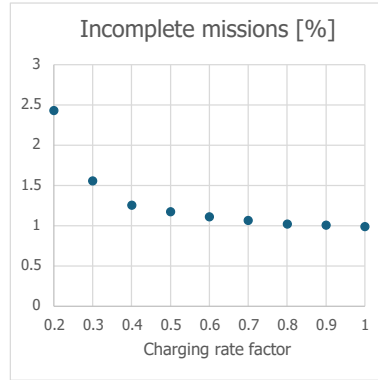
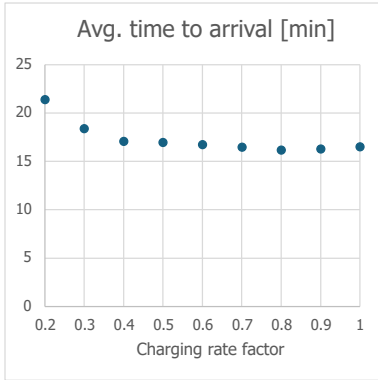
- Battery parameters (capacity, charging rate) at anticipated market standard.
- Vehicles need to be fully charged before entering a mission.
- **Sufficient performance at 500% incident increase.**

2. Battery capacity



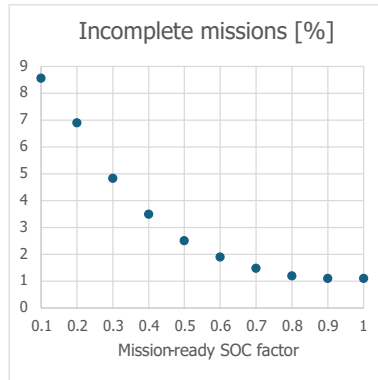
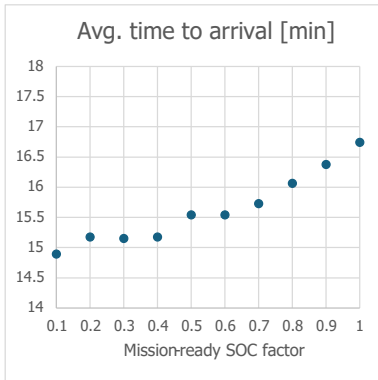
- Stress test: 500% incident increase.
- Charging rate at anticipated market standard.
- Vehicles need to be fully charged before entering a mission.
- **Sufficient performance with 60% battery size.**

3. Charging rate



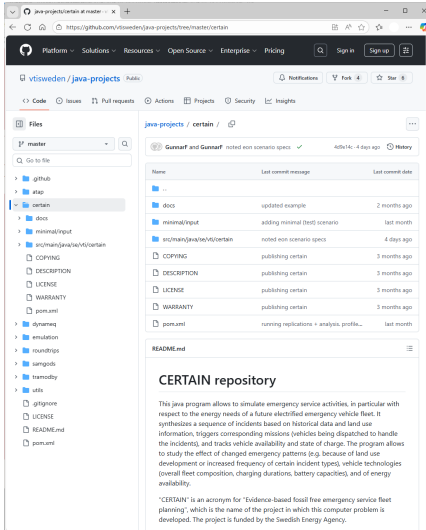
- Stress test: 500% incident increase.
- Battery capacity at anticipated market standard.
- **Sufficient performance with 60% charging speed.**

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 displays the GitHub repository for `vtisweden/java-projects/certain`. The repository is public and has a commit history table with the following data:

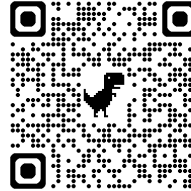
| Name | Last commit message | Last commit date |
|------------------------------|---|------------------|
| .. | | |
| docs | updated example | 2 months ago |
| minimal/input | adding minimal (test) scenario | last month |
| src/main/java/se/vti/certain | noted eon scenario specs | 4 days ago |
| COPYING | 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 |

The README file is titled "CERTAIN repository" and contains the following text:

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:



Contact:

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