

¹ pyMassEvac: A Python package for simulating multi-domain mass evacuation scenarios

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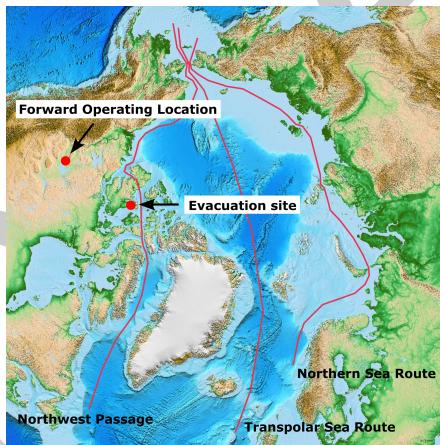
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⁵ Summary

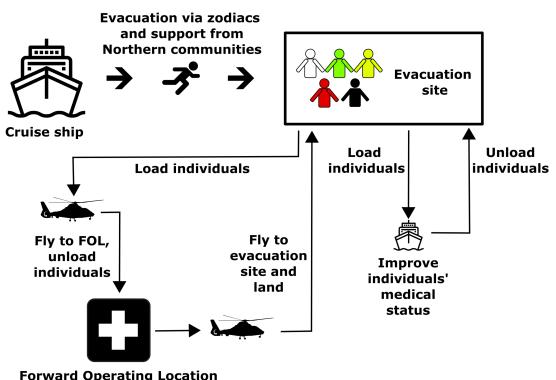
⁶ pyMassEvac is a Python package whose aim is to study mass evacuation scenarios. In particular, it is designed to simulate single- and multi-domain mass evacuation operations in which:

- ⁷ ▪ the individuals to be evacuated are at a remote location, such as in the Arctic, where access to immediate medical care is limited or non-existent;
- each individual's medical condition may change over time, perhaps due to environmental conditions, injury, or care being provided; and
- the individuals must be transported from the evacuation site to a Forward Operating Location (FOL).

An example of a multi-domain mass evacuation operation, where the objective is to maximize the number of lives saved by transporting them to the FOL, that may be modelled using pyMassEvac is described in Rempel (2024) and is depicted in ??.



¹⁷ width = 50% }



¹⁹ Within this context, pyMassEvac may be used to provide decision support to defence and security planners in two ways. First, through exploring the impact of the policies to make the three decisions depicted in ??:

- ²² ▪ **Decision policy 1:** the policy that determines which individuals are loaded onto a vehicle, such as a helicopter, for transport to the FOL;
- ²⁴ ▪ **Decision policy 2:** the policy that determines which individuals receive medical care (if available) at the evacuation site, such as onboard a nearby ship; and
- ²⁶ ▪ **Decision policy 3:** the policy that determines which individuals are removed from the group receiving medical care, for reasons such as limited capacity or that the individuals' medical condition has been sufficiently improved, and returned to the group ready to be transported to the FOL.

³⁰ Second, given a set three decision policies, decision support may be provided by using
³¹ pyMassEvac to explore their robustness by modifying a scenario's parameters. For example,
³² pyMassEvac may be used to explore how robust a set of decision policies is in terms of the
³³ number of lives saved with respect to:

- ³⁴ ▪ the arrival time of the initial transport vehicle after the individuals have arrived at the
³⁵ evacuation site;
- ³⁶ ▪ the distance, and thus travel time, between the evacuation site and the FOL; and
- ³⁷ ▪ the rate at which an individual's medical condition becomes better (through receiving
³⁸ medical care) or worse (due to injury or exposure to environmental conditions) over time.

³⁹ Changes in such parameters from baseline values may reflect a variety of real-world events,
⁴⁰ such as:

- ⁴¹ ▪ the reduction in the arrival time of the initial transport vehicle may reflect the pre-
⁴² positioning of vehicles during the summer season;
- ⁴³ ▪ the reduction in the distance between the evacuation site and FOL may reflect the
⁴⁴ building a new aerodrome; and
- ⁴⁵ ▪ the decrease in the rate at which an individual's medical condition worsens may reflect
⁴⁶ the use of improved medical kit.

⁴⁷ Thus, pyMassEvac is designed to be primarily used by operational researchers who study
⁴⁸ humanitarian or defence and security operations.

⁴⁹ pyMassEvac is accessible at <https://github.com/mrrempel/pyMassEvac> and is installed via
⁵⁰ a setup.py script. In addition, published evacuation scenarios that have studied using this
⁵¹ package (or its earlier developmental versions) are described in Rempel et al. (2021), Rempel
⁵² (2023), and Rempel (2024).

⁵³ Statement of need

⁵⁴ The significant decrease in Arctic sea ice in recent decades has resulted in increased activity
⁵⁵ in the Arctic across a range of sectors, such as oil and gas, mining, fishing, and tourism. As
⁵⁶ the ability to navigate the Arctic's primary sea routes—the Northwest passage, Northern Sea
⁵⁷ Route, and Transpolar Sea Route (see the left panel of ??)—becomes more commonplace,
⁵⁸ their use for both trade and the transport of individuals will follow. In regard to the transport
⁵⁹ of individuals, for example via cruise ships, Arctic nations are concerned with both the potential
⁶⁰ increase in the number of Search and Rescue (SAR) incidents that may occur, and the increased
⁶¹ size of those incidents in terms of the number of individuals in need of evacuation. This is
⁶² evidenced by recent exercises that have been conducted, such as the SARex series in Norway
⁶³ Solberg et al. (2016); Solberg et al. (2018), a table-top exercise including the United States,
⁶⁴ Canada, and the cruise ship industry McNutt (2016), and NANOOK-TATIGIT 21 by the
⁶⁵ Canadian Armed Forces National Defence (2021).

- ⁶⁶ ▪ “mass evacuation” “software” - review what MassEvac can do and how does it not fit
⁶⁷ this need?
- ⁶⁸ ▪ reference Camur (2021)

⁶⁹ While software exists to support planning for and executing evacuation operations, this software
⁷⁰ either requires a paid license, does not enable a researcher to study the impact of different
⁷¹ decision policies, or ...

⁷² With this in mind, pyMassEvac aims to enable researchers to study the ...

⁷³ Features

⁷⁴ Single dollars (\$) are required for inline mathematics e.g. $f(x) = e^{\pi/x}$

⁷⁵ Double dollars make self-standing equations:

$$\Theta(x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{else} \end{cases}$$

⁷⁶ You can also use plain \LaTeX for equations

$$\hat{f}(\omega) = \int_{-\infty}^{\infty} f(x)e^{i\omega x} dx \quad (1)$$

⁷⁷ and refer to [Equation 1](#) from text.

⁷⁸ Limitations

⁷⁹ Citations

⁸⁰ Citations to entries in paper.bib should be in [rMarkdown](#) format.

⁸¹ If you want to cite a software repository URL (e.g. something on GitHub without a preferred
⁸² citation) then you can do it with the example BibTeX entry below for (?).

⁸³ For a quick reference, the following citation commands can be used: - @author:2001 ->
⁸⁴ "Author et al. (2001)" - [@author:2001] -> "(Author et al., 2001)" - [@author1:2001;
⁸⁵ @author2:2001] -> "(Author1 et al., 2001; Author2 et al., 2002)"

⁸⁶ Acknowledgements

⁸⁷ I acknowledge contributions from Nicholi Shiell and Kaeden Tessier who are co-authors on
⁸⁸ related papers. These collaborations inspired the development of this package.

⁸⁹ References

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