

# <sup>1</sup> pyMassEvac: A Python package for simulating multi-domain mass evacuation scenarios

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## Software

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## <sup>5</sup> Summary

<sup>6</sup> 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:

- <sup>7</sup> ▪ 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 ??.

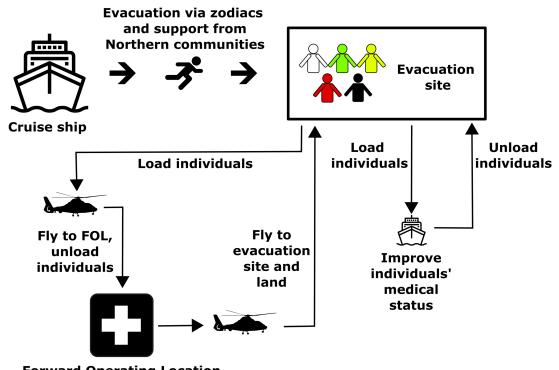
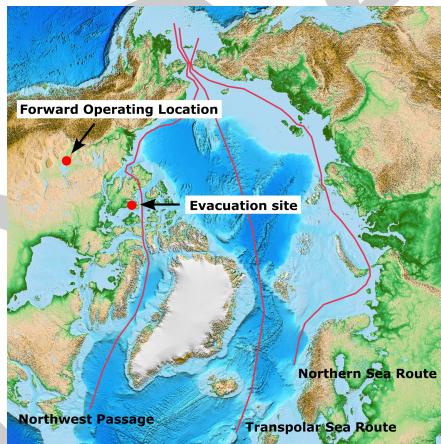


Figure 1: Evacuation plan via air with medical assistance provided via ship

<sup>17</sup> Within this context, pyMassEvac may be used to provide decision support to defence and <sup>18</sup> security planners in two ways. First, through exploring the impact of the policies to make the <sup>19</sup> three decisions depicted in Figure 1:

- <sup>20</sup> ▪ **Decision policy 1:** the policy that determines which individuals are loaded onto a vehicle, such as a helicopter, for transport to the FOL;
- <sup>21</sup> ▪ **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
- <sup>22</sup> ▪ **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'

26 medical condition has been sufficiently improved, and returned to the group ready to be  
27 transported to the FOL.

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

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

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

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

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

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

## 51 Statement of need

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

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

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

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

## 71 Features

- 72 Single dollars (\$) are required for inline mathematics e.g.  $f(x) = e^{\pi/x}$   
 73 Double dollars make self-standing equations:

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

- 74 You can also use plain L<sup>A</sup>T<sub>E</sub>X for equations

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

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

## 76 Limitations

## 77 Citations

- 78 Citations to entries in paper.bib should be in [rMarkdown](#) format.  
 79 If you want to cite a software repository URL (e.g. something on GitHub without a preferred  
 80 citation) then you can do it with the example BibTeX entry below for (?).  
 81 For a quick reference, the following citation commands can be used: - @author:2001 ->  
 82 "Author et al. (2001)" - [@author:2001] -> "(Author et al., 2001)" - [@author1:2001;  
 83 @author2:2001] -> "(Author1 et al., 2001; Author2 et al., 2002)"

## 84 Acknowledgements

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

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