Handling Volunteer Convergence from an OR Perspective: Volunteer Based Team Formation

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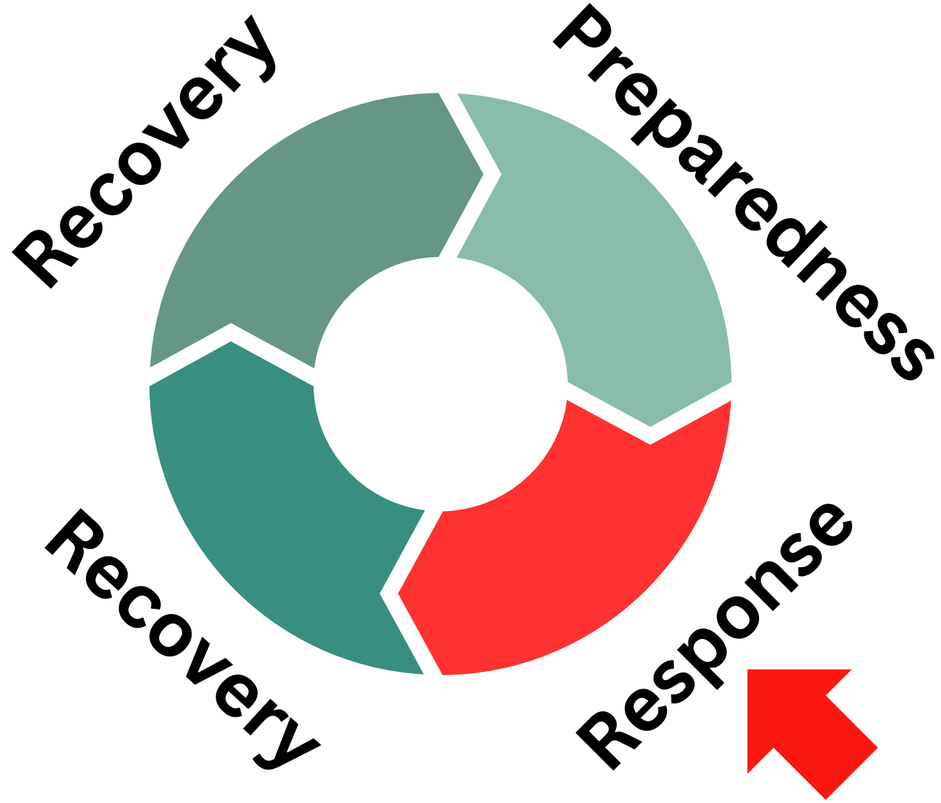
What is SAR?

- Urban SAR
- Mountain SAR
- Coastal SAR
- Avalanche SAR
- Combat SAR

Integrated Disaster Risk Management



Operational Steps of SAR

Arrival → **Appointment** → **Search** → **Rescue** → **Demobilisation**

Sectorization and Debris Marking

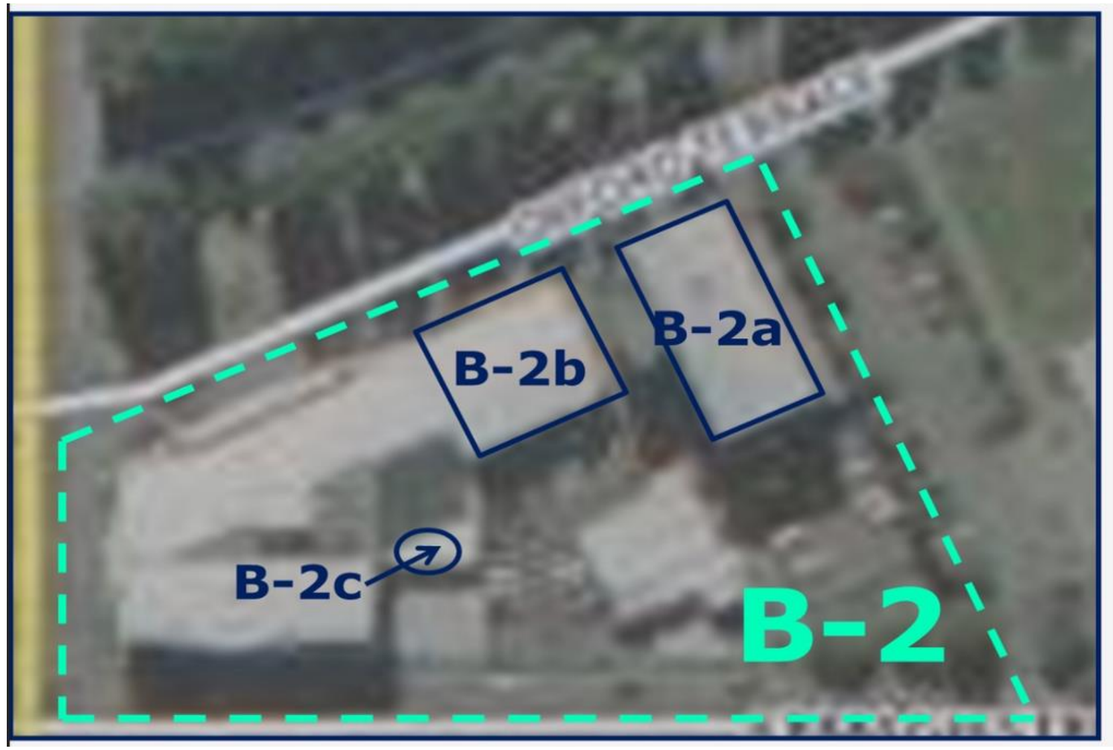


Figure 1: Worksite sectorisation [1]

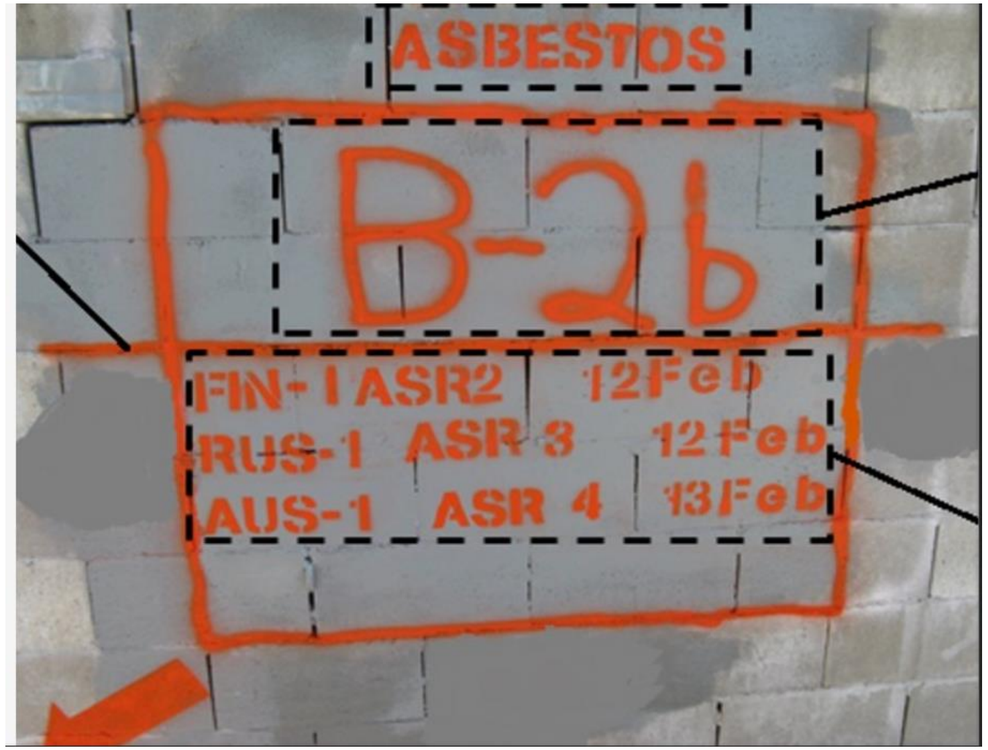
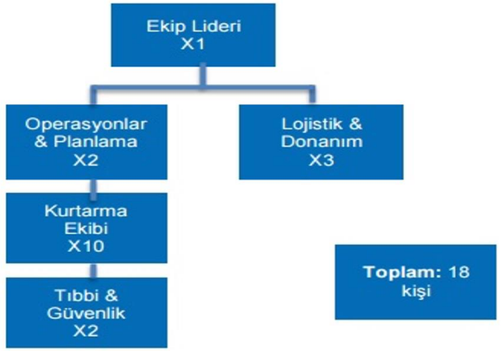


Figure 2: Debris marking [1]

Categorization of SAR Teams



Light SAR Team

USAR Bileşeni	Görevler	Tavsiye Edilen Kadro Tahsisi	Tavsiye Edilen Sayı (Toplam 40)
Yönetim	Komuta	Ekip Lideri	1
	Koordinasyon	Ekip Lideri Yardımcısı	1
	Planlama/Takip	Planlama Yetkilisi	1
	İrtibat/Medya/Raporlama	İrtibat Yetkilisi	1
	Değerlendirme/Analiz	Yapı Mühendisi	1
	Emniyet ve Güvenlik	Güvenlik Yetkilisi	1
	RDC/OSOCC/UCC	Koordinasyon Yetkilisi	2
Arama	Teknik Arama	Teknik Arama Uzmanı	2
	Köpekle Arama	Köpek Eğiticisi	2
	Tehlikeli Madde Değerlendirmesi	Tehlikeli Madde Uzmanı	2
Kurtarma	Kırma ve Geçit Açma; kesme; iksa; teknik halat	Kurtarma Ekibi Yöneticisi ve Kurtarma Teknisyenleri	14 (1 Ekip Lideri ve 6 Kurtarma Görevlisinden oluşan 2 ekip)
	Kaldırma ve Hareket Ettirme	Ağır Sapanla Bağlama Uzmanı	2
Tıbbi	Tıbbi Ekip Yönetimi: Tıbbi ekibin koordinasyon ve idaresi. Yerel sağlık altyapısı ile birleşme Ekibin (köpekler dahil) ve karşılaşılan afetzedelerin tedavisinin yapılması	Tıp Doktoru	1
		Doktor, Sağlık Görevlisi, Hemşire	3
Lojistik	BoO	Lojistik Ekibi Yöneticisi	1
	Su temini	Ulaştırma Uzmanı	1
	Gıda temini	Lojistikçi	1
	Ulaştırma kapasitesi ve yakıt temini	Üs Yöneticisi	2
	Haberleşme	Haberleşme Uzmanı	1

Medium SAR Team

USAR Bileşeni	Görevler	Tavsiye Edilen Kadro Tahsisi	Tavsiye Edilen Sayı (Toplam 59)
Yönetim	Komuta	Ekip Lideri	1
	Koordinasyon	Ekip Lideri Yardımcısı	1
	Planlama	Planlama Yetkilisi	1
	İrtibat/Takip	İrtibat Yetkilisi	1
	Medya/Raporlama	İrtibat Yetkilisi Yardımcısı	1
	Değerlendirme/Analiz	Yapı Mühendisi	1
	Emniyet ve Güvenlik	Güvenlik Yetkilisi	1
	RDC/OSOCC/UCC	Koordinasyon Yetkilisi	2
Arama	Teknik Arama	Teknik Arama Uzmanı	2
	Köpekle Arama	Köpek Eğiticisi	4
	Tehlikeli Madde Değerlendirme	Tehlikeli Madde Uzmanı	2
Kurtarma	Kırma ve Geçit Açma: kesme; iksa; teknik halat	Kurtarma Ekibi Yöneticisi ve Kurtarma Teknisyenleri	28 (1 Ekip Lideri ve 6 Kurtarma Görevlisinden oluşan 4 ekip)
	Kaldırma ve Hareket Ettirme	Ağır Sapanla Bağlama Uzmanı	2
Tıbbi	Ekip Tedavisi (Personel ve Köpekler) Hasta Tedavisi	Tıp Doktoru	2
		Sağlık Görevlisi/Hemşire	4
Lojistik	BoO	Lojistik Ekibi Yöneticisi	1
	Su temini	Ulaştırma Uzmanı	1
	Gıda temini	Lojistikçi	1
	Ulaştırma kapasitesi ve yakıt temini	Üs Yöneticisi	2
	Haberleşme	Haberleşme Uzmanı	1

Heavy SAR Team

Figure 3: AFAD Team Classification

Reasons and Benefits of Sectorization

CODE	OPERATION	Who can conduct?
ASR-1	Disaster Area Exploration	Light, Medium, Heavy SAR teams
ASR-2	Sectoral Review	Light, Medium, Heavy SAR teams
ASR-3	Rapid Search and Rescue	Light, Medium, Heavy SAR teams
ASR-4	Full Search and Rescue	Medium and Heavy SAR teams
ASR-5	Full Search and Rescue and Recovery	Heavy SAR teams

Table 1: ASR Stages and Conducting Teams [2]

Responsible Organizations

International Level

INSARAG
Preparedness Response

OSOCC

Virtual OSOCC
REAL-TIME INTERNATIONAL DISASTER COORDINATION

National Level

AFAD

LEMA

AYDES
AFET YÖNETİM VE KARAR DESTEK SİSTEMİ

SAR Flowcharts

analysis of processes defined by responsible organizations
prepared flowcharts for ideal scenarios

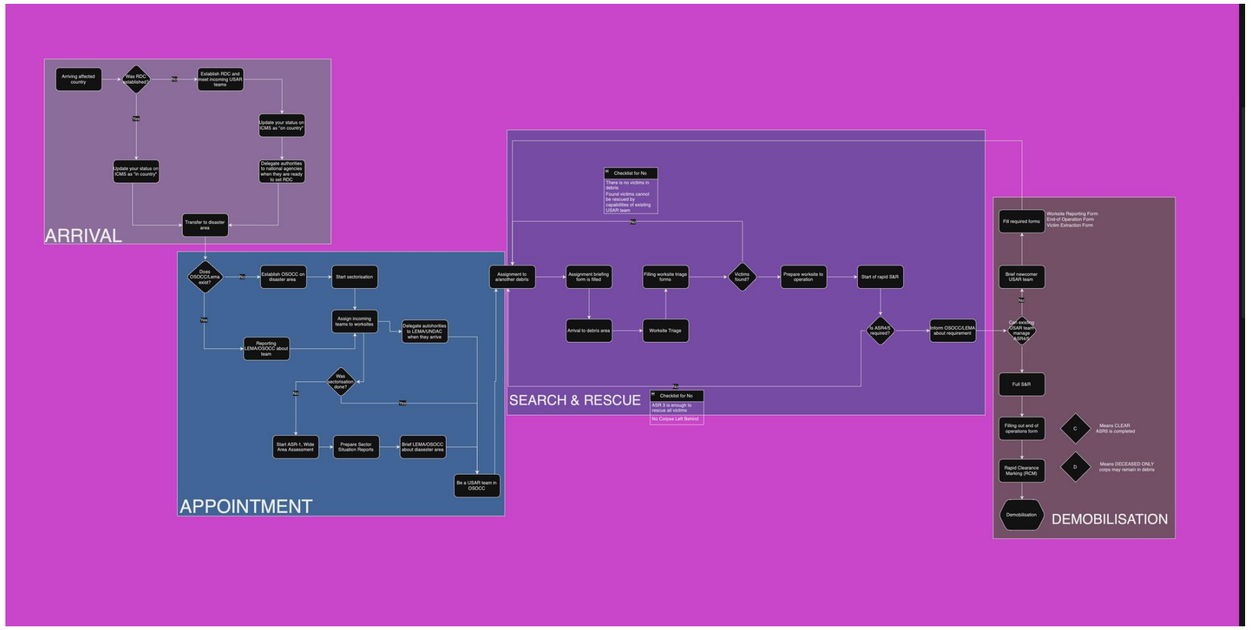


Figure 4: INSARAG SAR Flow

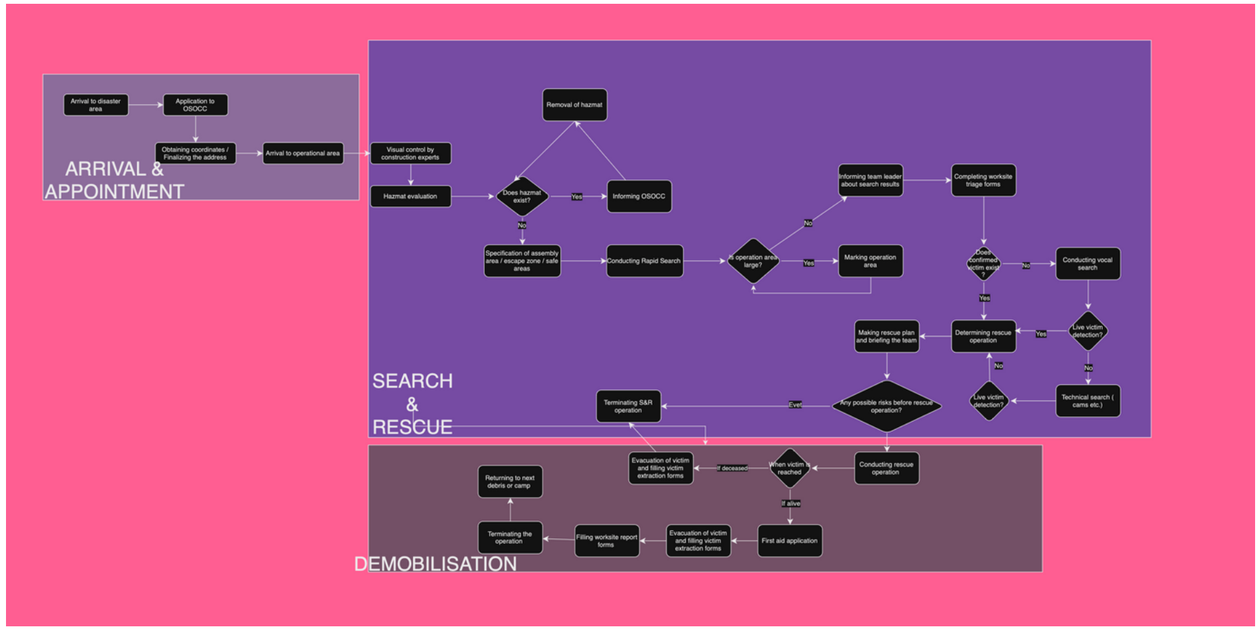


Figure 5: AFAD SAR Flow

SAR Flowcharts

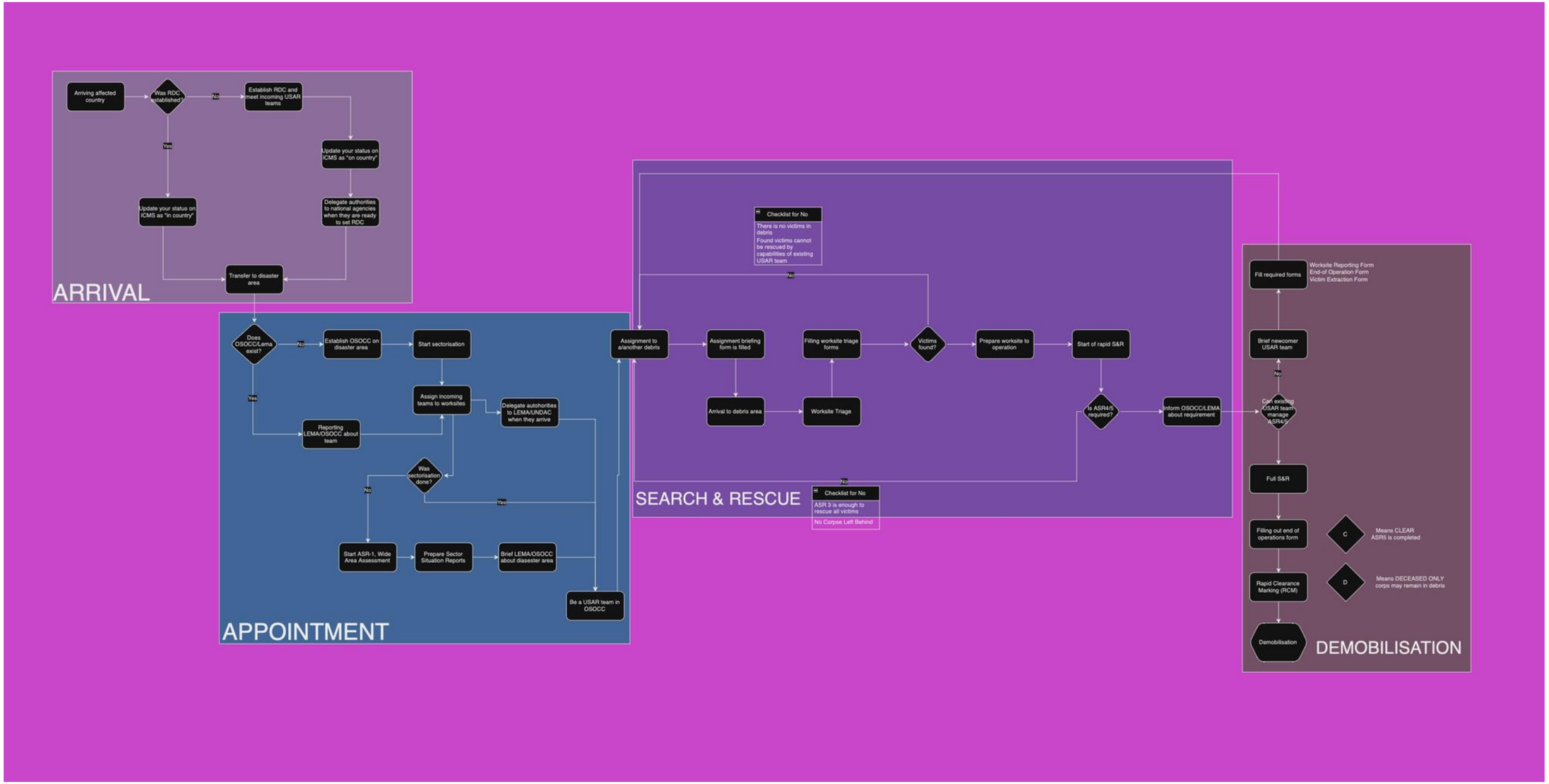


Figure 6: INSARAG SAR Flow

SAR Flowcharts

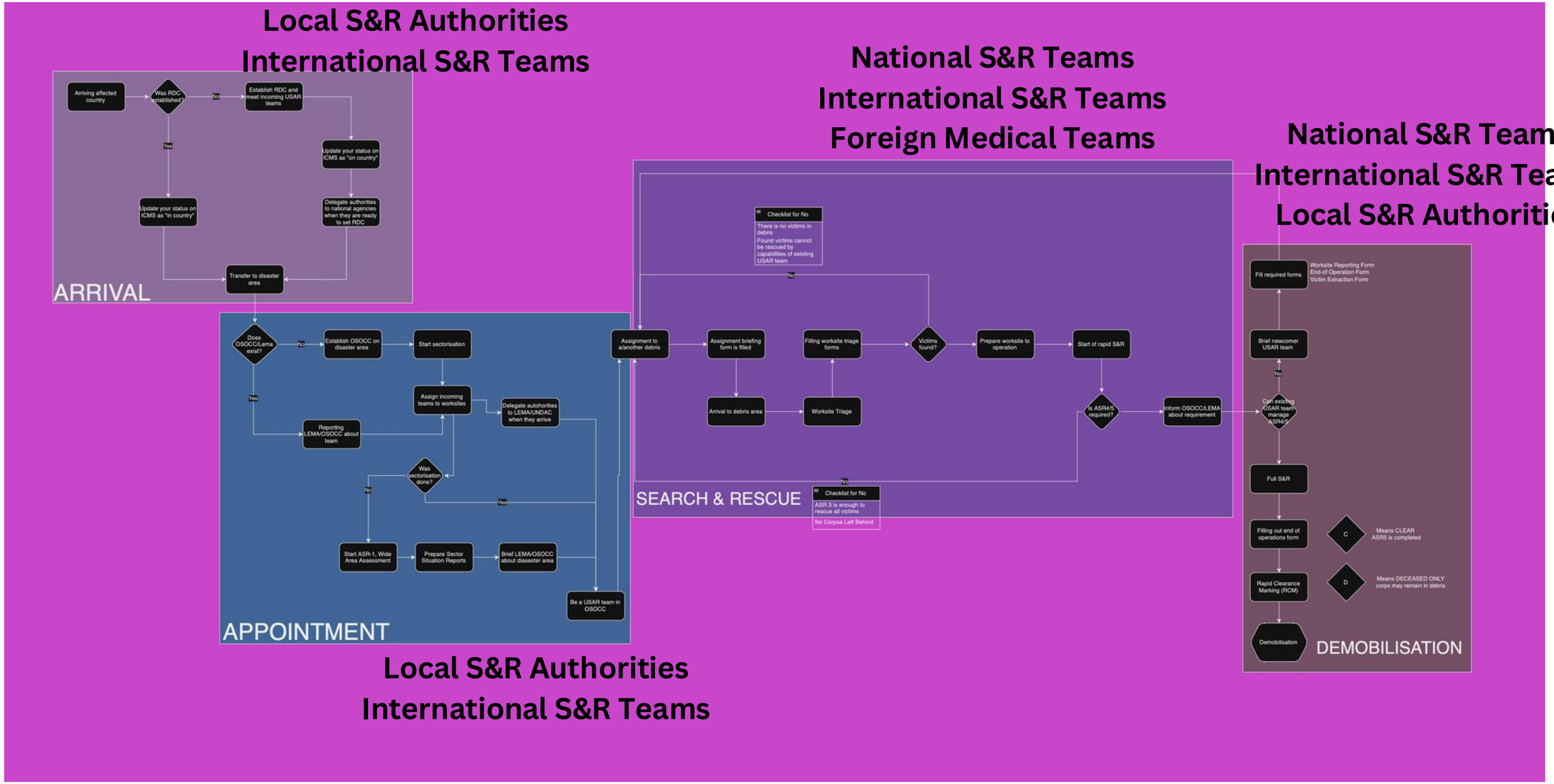


Figure 7: Involved Actors for Steps

SAR Flowcharts

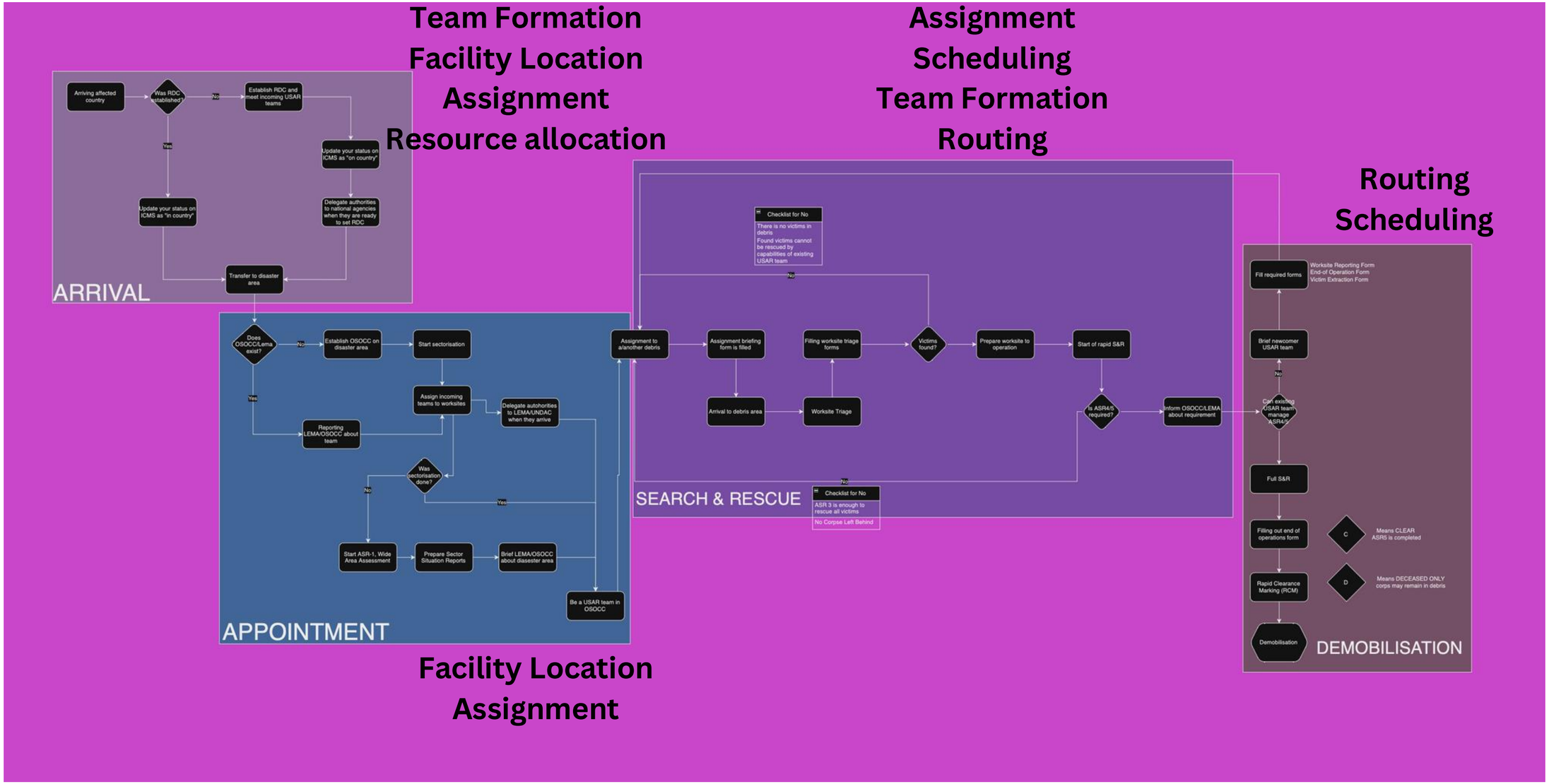


Figure 8: OR Problems

Usual Characteristics of SAR Problems

Decisions

- Facility Location
- Routing
- Clustering and Prioritization
- Assignment
- Scheduling
- Allocation

Service / Item type

- Physical Materials
- Fleet
- Workforce
- Accomodation and Settlement

Objectives

- Arrival Time
- Operational Time
- Coverage
- Survival Rate

Uncertainties

- Demand Locations
- Demand Amounts
- Damage Severity/Type
- Volunteer Competency
- Supply Capacity

Limitations

- Equipment
- Transportation/ Logistics
- Information Gaps
- Coordination Challenges
- Environmental Conditions
- Team Safety
- Time
- Local/Legal Restrictions

Locating critical coordination centers and camp sites

Decisions

- Facility Location
- Routing
- Clustering and Prioritization
- Assignment
- Scheduling
- Allocation

Service / Item type

- Physical Materials
- Fleet
- Workforce
- Accomodation and Settlement

Objectives

- Arrival Time
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- Survival Rate

Uncertainties

- Demand Locations
- Demand Amounts
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- Volunteer Competency
- Supply Capacity

Limitations

- Equipment
- Transportation/ Logistics
- Information Gaps
- Coordination Challenges
- Environmental Conditions
- Team Safety
- Time
- Local/Legal Restrictions

Wide Area Exploration for damage assessment

Decisions

- Facility Location
- Routing
- Clustering and Prioritization
- Assignment
- Scheduling
- Allocation

Service / Item type

- Physical Materials
- Fleet
- Workforce
- Accomodation and Settlement

Objectives

- Arrival Time
- Operational Time
- Coverage
- Survival Rate

Uncertainties

- Demand Locations
- Demand Amounts
- Damage Severity/Type
- Volunteer Competency
- Supply Capacity

Limitations

- Equipment
- Transportation/ Logistics
- Information Gaps
- Coordination Challenges
- Environmental Conditions
- Team Safety
- Time
- Local/Legal Restrictions

Formating SAR teams

Decisions

- Facility Location
- Routing
- Clustering and Prioritization
- Assignment
- Scheduling
- Allocation

Service / Item type

- Physical Materials
- Fleet
- Workforce
- Accomodation and Settlement

Objectives

- Arrival Time
- Operational Time
- Coverage
- Survival Rate
- Number of teams
- Total skill level of teams

Uncertainties

- Demand Locations
- Demand Amounts
- Damage Severity/Type
- Volunteer Competency
- Supply Capacity

Limitations

- Equipment
- Transportation/ Logistics
- Information Gaps
- Coordination Challenges
- Environmental Conditions
- Team Safety
- Time
- Local/Legal Restrictions

Assigning SAR teams to debris

Decisions

- Facility Location
- Routing
- Clustering and Prioritization
- Assignment
- Scheduling
- Allocation

Service / Item type

- Physical Materials
- Fleet
- Workforce
- Accomodation and Settlement

Objectives

- Arrival Time
- Operational Time
- Coverage
- Survival Rate

Uncertainties

- Demand Locations
- Demand Amounts
- Damage Severity/Type
- Volunteer Competency
- Supply Capacity

Limitations

- Equipment
- Transportation/ Logistics
- Information Gaps
- Coordination Challenges
- Environmental Conditions
- Team Safety
- Time
- Local/Legal Restrictions

Team Formation Problem

the allocation of multiple individuals that match a required set of skills as a group must be chosen to maximise one or several objectives [3]

Jones & Barber (2007) [4]	team formation in a large-scale environment
Hashemipour et al. (2018) [5]	analyzing different metrics while formating a first-response team
Okita et.al (2018) [6]	capacity Building of International Search and Rescue Teams
Ge et.al (2021) [7]	building an Interdisciplinary Team for Disaster Response Research
Danışan & Eren (2023) [8]	assignment of 200 search and rescue personnel to medium and heavy teams according to their competencies, volunteers are not considered and the roles that the personnel can perform are determined in advance.

Table 2: Related work with team formation problem in SAR context

Team Formation Problem

USAR Bileşeni	Görevler	Tavsiye Edilen Kadro Tahsisi	Tavsiye Edilen Sayı (Toplam 40)
Yönetim	Komuta	Ekip Lideri	1
	Koordinasyon	Ekip Lideri Yardımcısı	1
	Planlama/Takip	Planlama Yetkilisi	1
	İrtibat/Medya/Raporlama	İrtibat Yetkilisi	1
	Değerlendirme/Analiz	Yapı Mühendisi	1
	Emniyet ve Güvenlik	Güvenlik Yetkilisi	1
	RDC/OSOCC/UCC	Koordinasyon Yetkilisi	2
Arama	Teknik Arama	Teknik Arama Uzmanı	2
	Köpekle Arama	Köpek Eğiticisi	2
	Tehlikeli Madde Değerlendirmesi	Tehlikeli Madde Uzmanı	2
Kurtarma	Kırma ve Geçit Açma; kesme; iksa; teknik halat	Kurtarma Ekibi Yöneticisi ve Kurtarma Teknisyenleri	14 (1 Ekip Lideri ve 6 Kurtarma Görevlisinden oluşan 2 ekip)
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Tıbbi	Tıbbi Ekip Yönetimi: Tıbbi ekibin koordinasyon ve idaresi. Yerel sağlık altyapısı ile birleşme Ekibin (köpekler dahil) ve karşılaşılan afetzedelerin tedavisinin yapılması	Tıp Doktoru	1
		Doktor, Sağlık Görevlisi, Hemşire	3
Lojistik	BoO	Lojistik Ekibi Yöneticisi	1
	Su temini	Ulaştırma Uzmanı	1
	Gıda temini	Lojistikçi	1
	Ulaştırma kapasitesi ve yakıt temini	Üs Yöneticisi	2
	Haberleşme	Haberleşme Uzmanı	1

Figure 9: Medium Team Requirements

- **different qualification requirements**
- **dynamic environment**
- **integration of international teams to national teams**

Team Formation by Volunteers

influx of uncoordinated volunteers to disaster sites

volunteer convergence [9]

Pros	Cons
Accounts for 75 % of search and rescue	Overload transport and communication networks
Source of information to official responders	Use resources (food, shelter, protective equipment)
Source of information to official responders	Safety liability

Table 3: Pros and cons of volunteer convergence [10]

Figure 10: Volunteer Convergence after Kahramanmaraş Earthquakes [11]

Team Formation by Volunteers

major logistical, operational challenges

“the disaster within the disaster” [10]

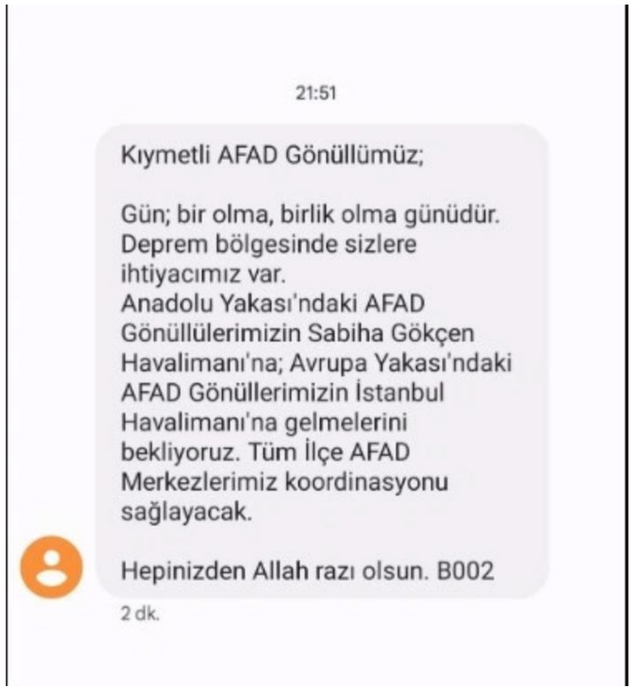

Figure 10: AFAD called volunteers around 10 PM, Feb. 6 [12]

Figure 11: Volunteer crowd in airport [13]

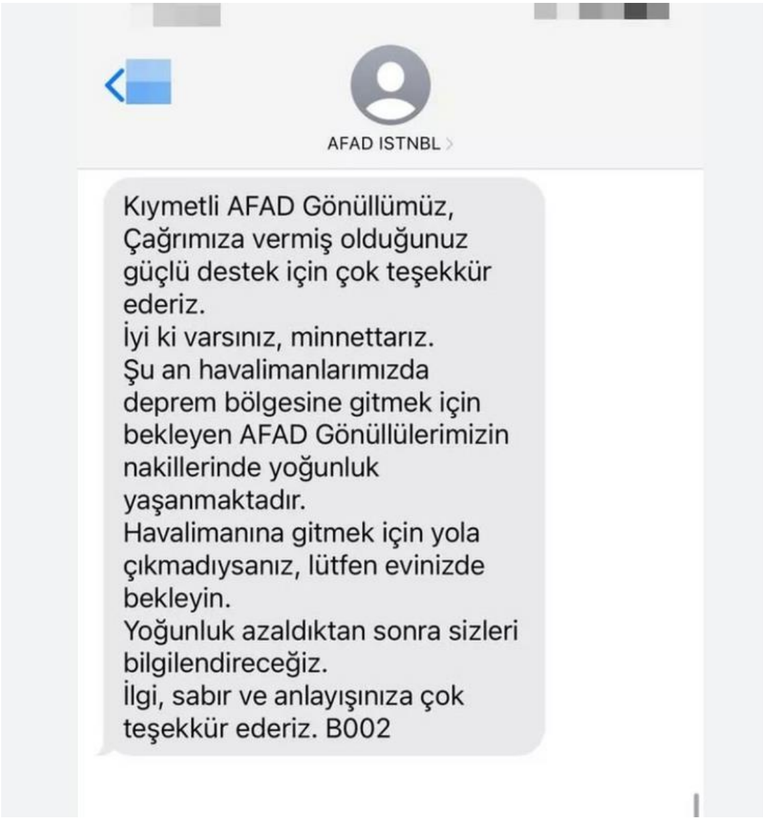

Figure 12: Appeal for volunteers not to come around 2 AM, Feb. 7 [14]

Team Formation by Volunteers

Barsky et al. (2007) [15]	integration of volunteers to FEMA's USAR system
Mayorga et al. (2017) [16]	assignment of volunteers to tasks that do not require any special skills or training.
Abualkhair et al. (2018) [17]	examines the assignment of volunteers to tasks in aid centers, it is assumed that each volunteer can do every job
Paret et al. (2020) [18]	assigning volunteers to tasks in aid distribution centers so the skills or training of the volunteers are not considered.

Table 4: Volunteer convergence literature

assigning volunteers based on their competencies to SAR teams by considering accreditation systems

Problem Setting

Role	Light Team	Medium Team
Medical	1	3
Rescue	10	18
Logistics	4	6
Transmitter	2	6
Canine	0	2
Hazmat	0	2
Doctor	0	1
Total	17	38

Table 5: Number of staff required for teams

Light teams -> ability to move fast
operational capability of ASR3 level

Medium teams -> move slower
operational capability of ASR4 level

Medium⁻ teams

intermediate level teams, have more operational capability then light teams, less capability than medium teams

could be utilized to determine missings while completing medium teams

Mathematical Model

Sets:

- N=Set of volunteers
- R=Set of roles (1:Medical, 2:Rescue, 3: Logistics, 4: Transmitter, 5:Canine, 6:Hazmat, 7:Doctor)
- T=Set of team categories (1=Light, 2=Medium, 3=$Medium^{-}$)
- L=Set of team leaders

Mathematical Model

Sets:

- N=Set of volunteers
- R=Set of roles (1:Medical, 2:Rescue, 3: Logistics, 4: Transmitter, 5:Canine, 6:Hazmat, 7:Doctor)
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Parameters:

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- L=Set of team leaders

Parameters:

- N=number of volunteers
- L=number of leaders
- a_t = Efficiency of team category t

Mathematical Model

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- N=Set of volunteers
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- T=Set of team categories (1=Light, 2=Medium, 3=$Medium^{-}$)
- L=Set of team leaders

Parameters:

- N=number of volunteers
- L=number of leaders
- a_t = Efficiency of team category t
- $b_{ir} = \begin{cases} 1 & \text{if volunteer } i \text{ is suitable for role } r \\ 0 & \text{otherwise} \end{cases}$

Mathematical Model

Sets:

- N=Set of volunteers
- R=Set of roles (1:Medical, 2:Rescue, 3: Logistics, 4: Transmitter, 5:Canine, 6:Hazmat, 7:Doctor)
- T=Set of team categories (1=Light, 2=Medium, 3=$Medium^{-}$)
- L=Set of team leaders

Parameters:

- N=number of volunteers
- L=number of leaders
- a_t = Efficiency of team category t
- $b_{ir} = \begin{cases} 1 & \text{if volunteer } i \text{ is suitable for role } r \\ 0 & \text{otherwise} \end{cases}$
- d_{tr} = Number of role r people team t needs (just for light and medium teams, i.e t $\in \{1, 2\}$)

Mathematical Model

Decision Variables:

Mathematical Model

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- z_{rl}= Number of role r people assigned to team l

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- z_{rl}= Number of role r people assigned to team l
- $x_{ilr}= \begin{cases} 1 & \text{if volunteer } i \text{ is assigned to team } l \text{ in the role } r \\ 0 & \text{otherwise} \end{cases}$

Mathematical Model

Decision Variables:

- z_{rl}= Number of role r people assigned to team l
- $x_{ilr}= \begin{cases} 1 & \text{if volunteer } i \text{ is assigned to team } l \text{ in the role } r \\ 0 & \text{otherwise} \end{cases}$
- $y_{lt} = \begin{cases} 1 & \text{if leader } l \text{ formatted a team with team category } t \\ 0 & \text{otherwise} \end{cases}$

Mathematical Model

Model:

$$\text{maximize} \quad \sum_{l} \sum_{t} a_t y_{lt} \qquad (1)$$

maximizing total efficiency of teams

Mathematical Model

Model:

$$\text{maximize} \quad \sum_{l} \sum_{t} a_t y_{lt} \qquad (1)$$

maximizing total efficiency of teams

$$\text{subject to} \quad y_{lt}\ d_{tr} \leq z_{rl} \qquad \forall r \in R, \forall l \in L \ and \ \forall t \in \{1,2\} \qquad (2)$$

supplying staff demand of light and medium teams

Mathematical Model

Model:

$$\text{maximize} \quad \sum_{l} \sum_{t} a_t y_{lt} \qquad (1)$$

maximizing total efficiency of teams

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supplying staff demand of light and medium teams

$$\sum \sum x_{ilr} \leq 1 \qquad \forall i \in N \qquad (3)$$

a volunteer can be assigned to at most one team

Mathematical Model

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$$\text{maximize} \quad \sum_{l} \sum_{t} a_t y_{lt} \qquad (1)$$

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supplying staff demand of light and medium teams

$$\sum_{l} \sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N \qquad (3)$$

a volunteer can be assigned to at most one team

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L \qquad (4)$$

a leader can be assigned to at most one team

Mathematical Model

Model:

$$\text{maximize} \quad \sum_{l} \sum_{t} a_t y_{lt} \qquad (1)$$

maximizing total efficiency of teams

$$\text{subject to} \quad y_{lt}\ d_{tr} \leq z_{rl} \qquad \forall r \in R, \forall l \in L \ and \ \forall t \in \{1,2\} \qquad (2)$$

supplying staff demand of light and medium teams

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a volunteer can be assigned to at most one team

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L \qquad (4)$$

a leader can be assigned to at most one team

$$z_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R \qquad (5)$$

connecting volunteer, role and team assignments

Mathematical Model

Model:

$$\text{maximize} \quad \sum_{l}\sum_{t} a_t y_{lt} \qquad (1)$$

maximizing total efficiency of teams

$$\text{subject to} \quad y_{lt}\ d_{tr} \leq z_{rl} \qquad \forall r \in R, \forall l \in L \ and \ \forall t \in \{1,2\} \qquad (2)$$

supplying staff demand of light and medium teams

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$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L \qquad (4)$$

a leader can be assigned to at most one team

$$z_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R \qquad (5)$$

connecting volunteer, role and team assignments

$$d_{1r} y_{l3} \leq z_{rl} \qquad \forall r \in R, \forall l \in L \qquad (6)$$

$$z_{rl} \leq d_{2r} \qquad \forall r \in R, \forall l \in L \qquad (7)$$

number of staff assigned to a medium⁻ team should be greater or equal than a light team and less or equal than a medium team

Mathematical Model

Model:

$$\text{maximize} \quad \sum_{l}\sum_{t} a_t y_{lt} \qquad (1)$$

maximizing total efficiency of teams

$$\text{subject to} \quad y_{lt}\ d_{tr} \leq z_{rl} \qquad \forall r \in R, \forall l \in L \ and \ \forall t \in \{1,2\} \qquad (2)$$

supplying staff demand of light and medium teams

$$\sum_{l}\sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N \qquad (3)$$

a volunteer can be assigned to at most one team

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L \qquad (4)$$

a leader can be assigned to at most one team

$$z_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R \qquad (5)$$

connecting volunteer, role and team assignments

$$d_{1r} y_{l3} \leq z_{rl} \qquad \forall r \in R, \forall l \in L \qquad (6)$$

$$z_{rl} \leq d_{2r} \qquad \forall r \in R, \forall l \in L \qquad (7)$$

number of staff assigned to a medium⁻ team should be greater or equal than a light team and less or equal than a medium team

$$\sum_{t} y_{lt} \geq x_{ilr} \qquad \forall i \in N, \forall l \in L, \forall r \in R \qquad (8)$$

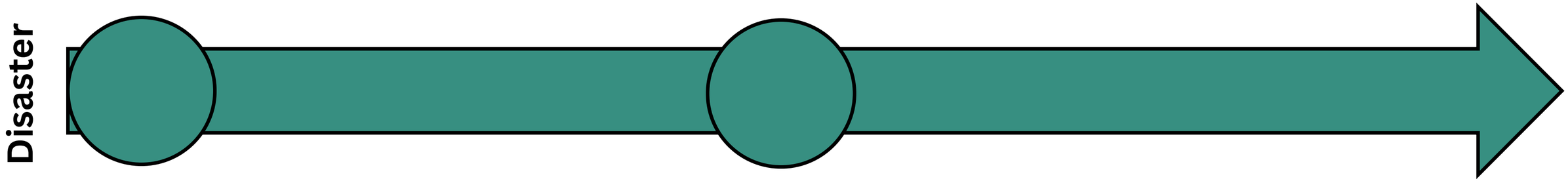
unless a leader is assigned, do not assign any volunteer to that team

Mathematical Model

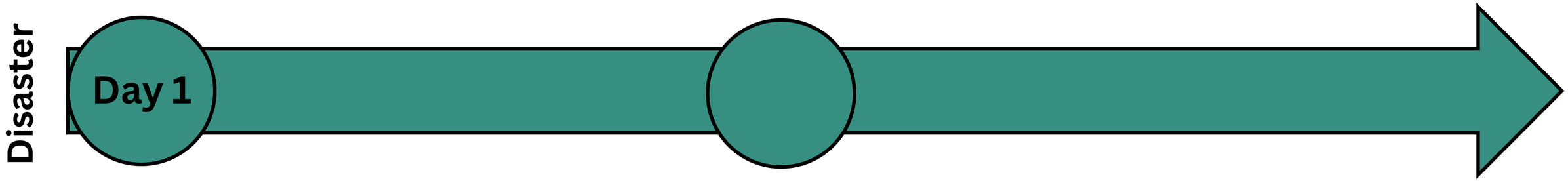
Model:

maximize	$\sum_l \sum_t a_t y_{lt}$		(1)	**maximizing total efficiency of teams**
subject to	$y_{lt}\ d_{tr} \leq z_{rl}$	$\forall r \in R, \forall l \in L\ and\ \forall t \in \{1,2\}$	(2)	**supplying staff demand of light and medium teams**
	$\sum_l \sum_r x_{ilr} \leq 1$	$\forall i \in N$	(3)	**a volunteer can be assigned to at most one team**
	$\sum_t y_{lt} \leq 1$	$\forall l \in L$	(4)	**a leader can be assigned to at most one team**
	$z_{rl} = \sum_i x_{ilr} b_{ir}$	$\forall l \in L, \forall r \in R$	(5)	**connecting volunteer, role and team assignments**
	$d_{1r} y_{l3} \leq z_{rl}$	$\forall r \in R, \forall l \in L$	(6)	**number of staff assigned to a medium⁻ team should be greater or**
	$z_{rl} \leq d_{2r}$	$\forall r \in R, \forall l \in L$	(7)	**equal than a light team and less or equal than a medium team**
	$\sum_t y_{lt} \geq x_{ilr}$	$\forall i \in N, \forall l \in L, \forall r \in R$	(8)	**unless a leader is assigned, do not assign any volunteer to that team**
	$x_{ilr}, y_{lt} \in \{0,1\}$	$\forall i, l, r$	(9)	**domain constraints**
	$z_{rl} \geq 0$	$\forall l, r$	(10)	**domain constraints**

Small Scale Disaster Timeline



Small Scale Disaster Timeline



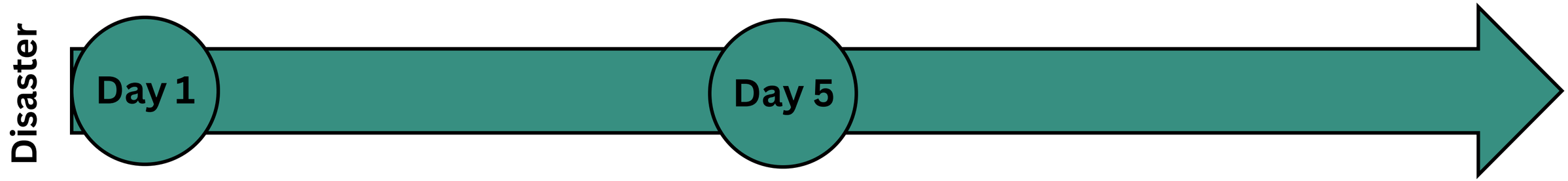
Case 1

few volunteers light teams needed to conduct ASR3 operations

Small Scale Disaster Timeline

Case 2

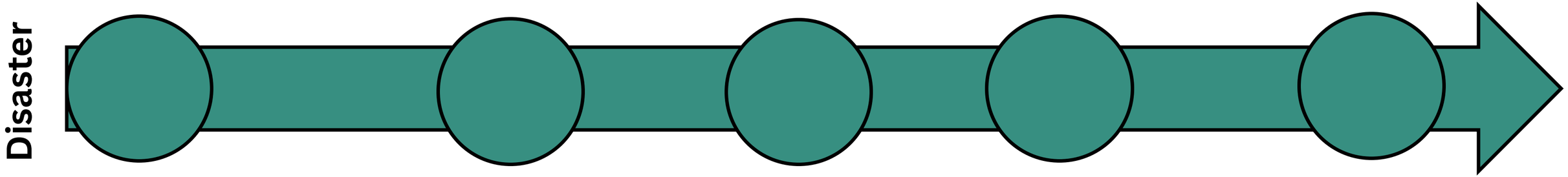
few volunteers
medium teams
needed to conduct
ASR4 operations



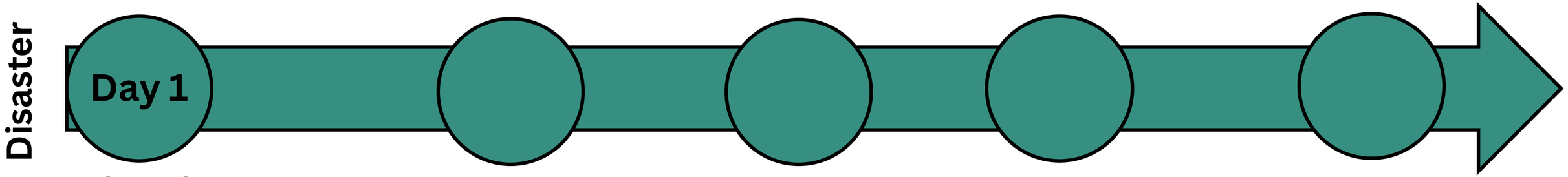
Case 1

few volunteers
light teams needed
to conduct ASR3
operations

Large Scale Disaster Timeline



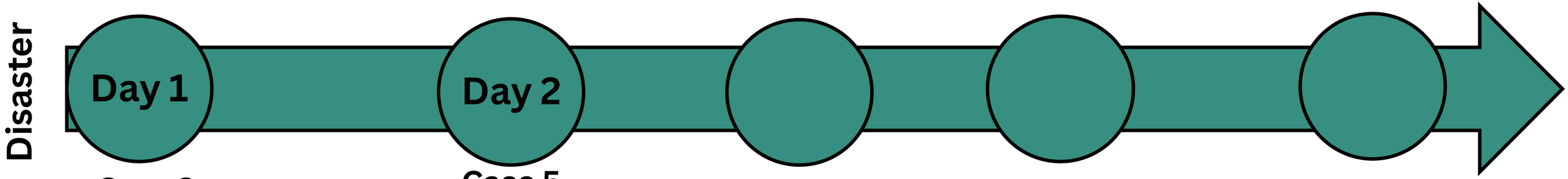
Large Scale Disaster Timeline



Case 3
many volunteers
many leaders
light teams needed

Case 4
many volunteers
few leaders
light teams needed

Large Scale Disaster Timeline



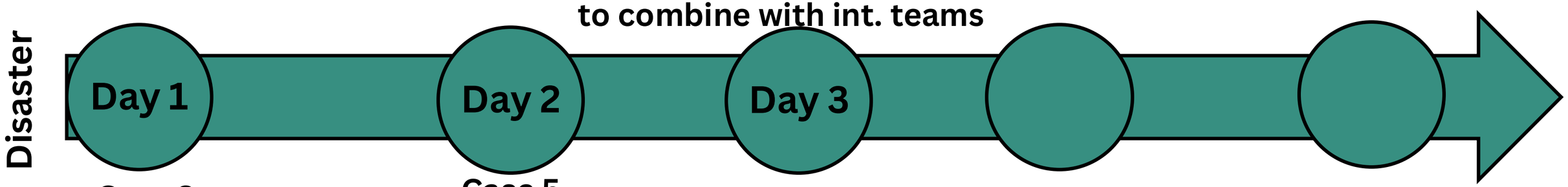
Case 3
many volunteers
many leaders
light teams needed

Case 5
skilled volunteers
many leaders
medium teams needed

Case 4
many volunteers
few leaders
light teams needed

Case 6
skilled volunteers
few leaders
medium teams needed

Large Scale Disaster Timeline



Case 7
more volunteers
medium- teams needed
to combine with int. teams

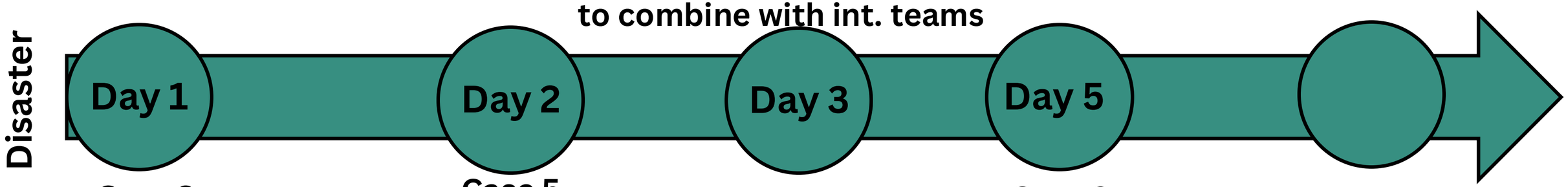
Case 3
many volunteers
many leaders
light teams needed

Case 5
skilled volunteers
many leaders
medium teams needed

Case 4
many volunteers
few leaders
light teams needed

Case 6
skilled volunteers
few leaders
medium teams needed

Large Scale Disaster Timeline



Case 7
more volunteers
medium- teams needed
to combine with int. teams

Case 3
many volunteers
many leaders
light teams needed

Case 5
skilled volunteers
many leaders
medium teams needed

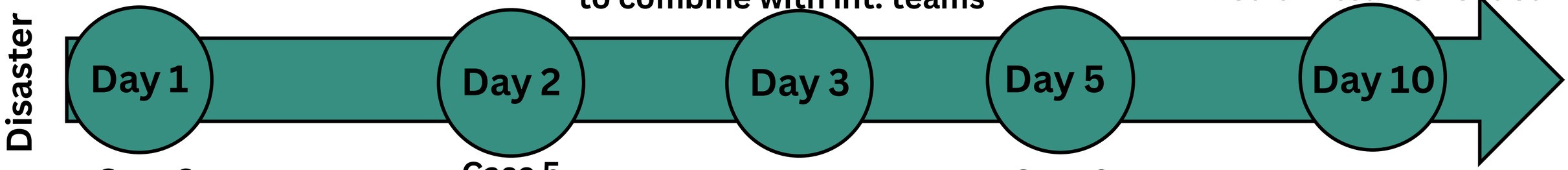
Case 8
many volunteers
many leaders
medium teams needed

Case 4
many volunteers
few leaders
light teams needed

Case 6
skilled volunteers
few leaders
medium teams needed

Case 9
many volunteers
many leaders
light teams needed

Large Scale Disaster Timeline



Case 7
more volunteers
medium- teams needed
to combine with int. teams

Case 10
more volunteers
many leaders
medium teams needed

Case 3
many volunteers
many leaders
light teams needed

Case 5
skilled volunteers
many leaders
medium teams needed

Case 8
many volunteers
many leaders
medium teams needed

Case 4
many volunteers
few leaders
light teams needed

Case 6
skilled volunteers
few leaders
medium teams needed

Case 9
many volunteers
many leaders
light teams needed

Computational Results

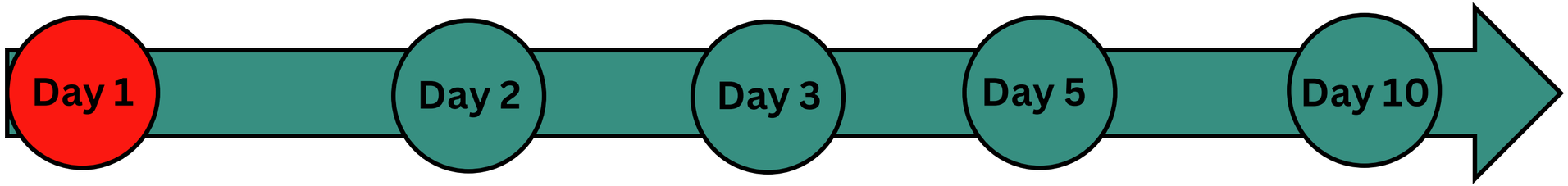
Case Number	PARAMETERS					
	Scale	Time	Number of Volunteers	Number of Leaders	Skill set	Alpha Values
1	Small	First day	100	5	Random	(1000,100,500)
2	Small	Fifth day	100	5	Random	(100,1000,500)
3	Large	First day	1000	40	Most 0's	(1000,100,500)
4	Large	First day	1000	10	Most 0's	(1000,100,500)
5	Large	Second day	1000	40	Most 1's	(100,1000,500)
6	Large	Second day	1000	10	Most 1's	(100,1000,500)
7	Large	Third day	1000	40	Random	(100,500,1000)
8	Large	Fifth day	1000	40	Random	(100,500,1000)
9	Large	Fifth day	1000	40	Random	(1000,100,500)
10	Large	Tenth day	1000	40	Random	(100,1000,500)

Computational Results

	Case Number	Average Number of Teams			Response Time	
		Light	Medium	Medium-	Average	Max
	1	5	0	0	0.04 sec	0.05 sec
	2	0	2	2	0.1 sec	0.14 sec
★	3	20	0	0	2.87 sec	3.47 sec
	4	10	0	0	0.31 sec	0.33 sec
★	5	0	15	25	43.34 sec	44.64 sec
	6	0	10	0	1.38 sec	1.98 sec
★	7	0	0	40	2.54 sec	2.93 sec
	8	0	0	40	2.73 sec	2.99 sec
	9	40	0	0	2.7 sec	3.04 sec
	10	0	19	15	34.63 sec	39.87 sec

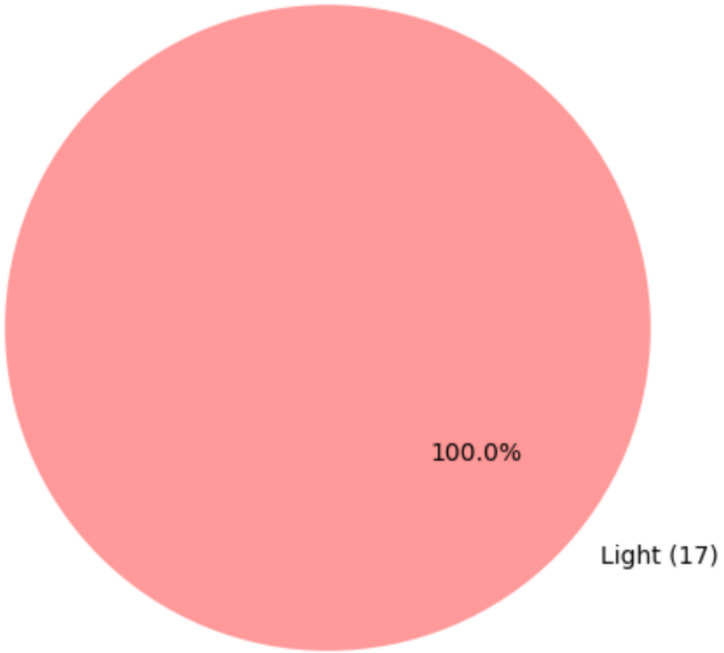
10 instances were solved for each case

Computational Results

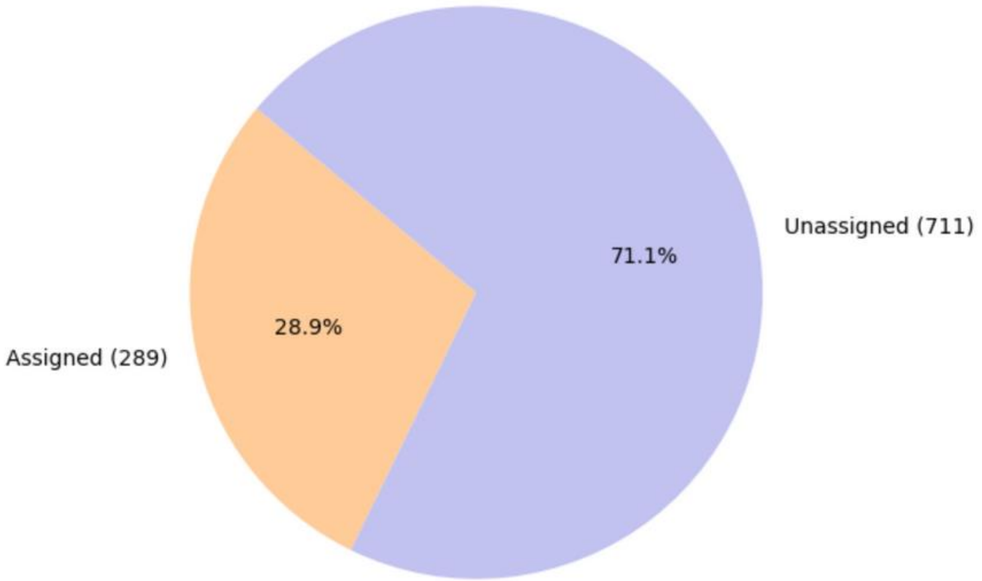


Case 3

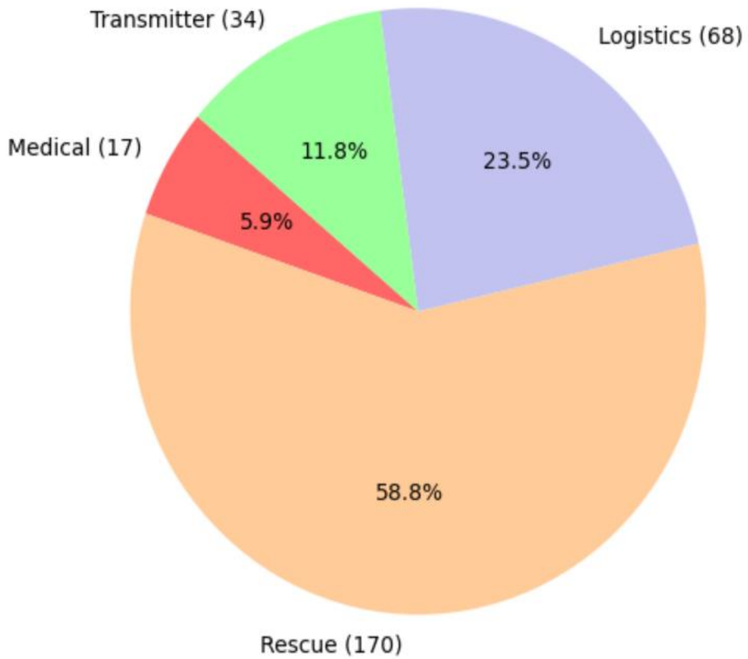
Team Type Distribution



Volunteer Assignment Status

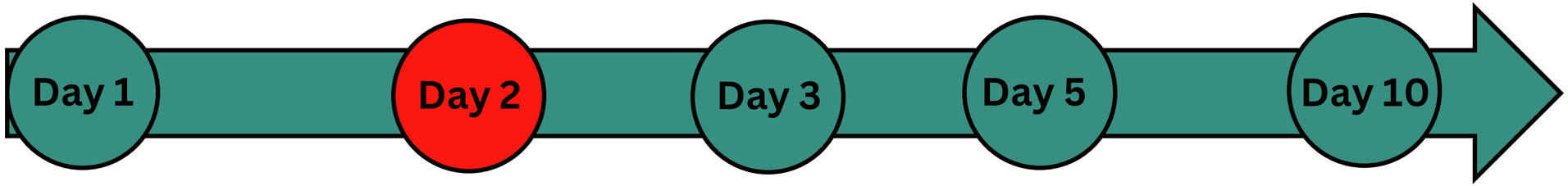


Role Distribution



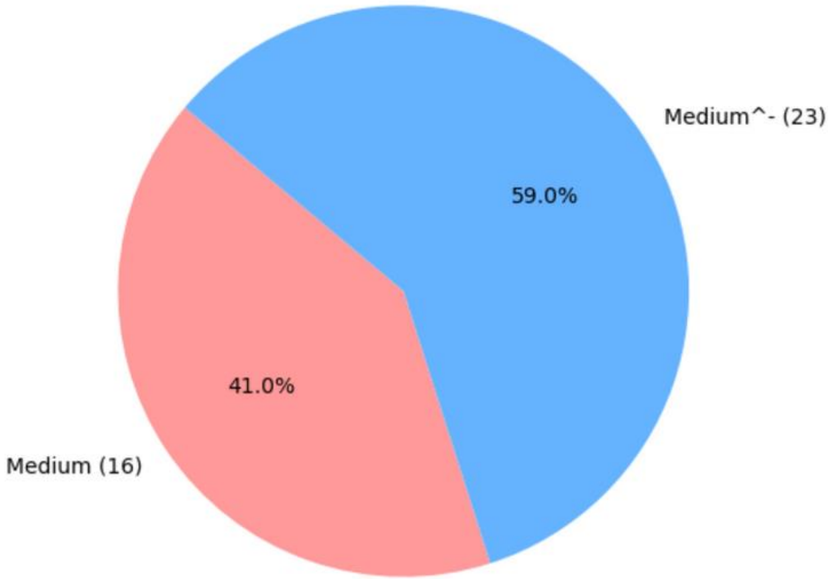
there are many volunteers with little experience
light teams are required to conduct ASR3 level operations

Computational Results

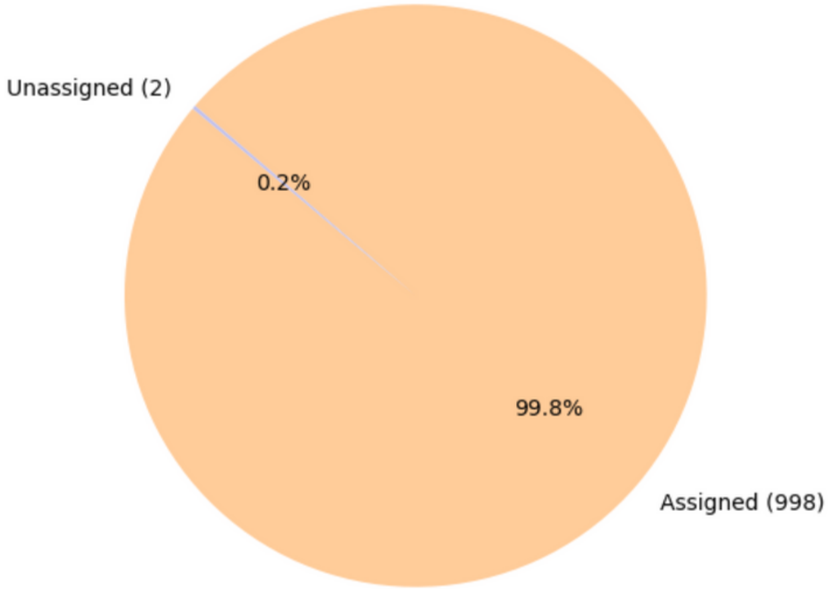


Case 5

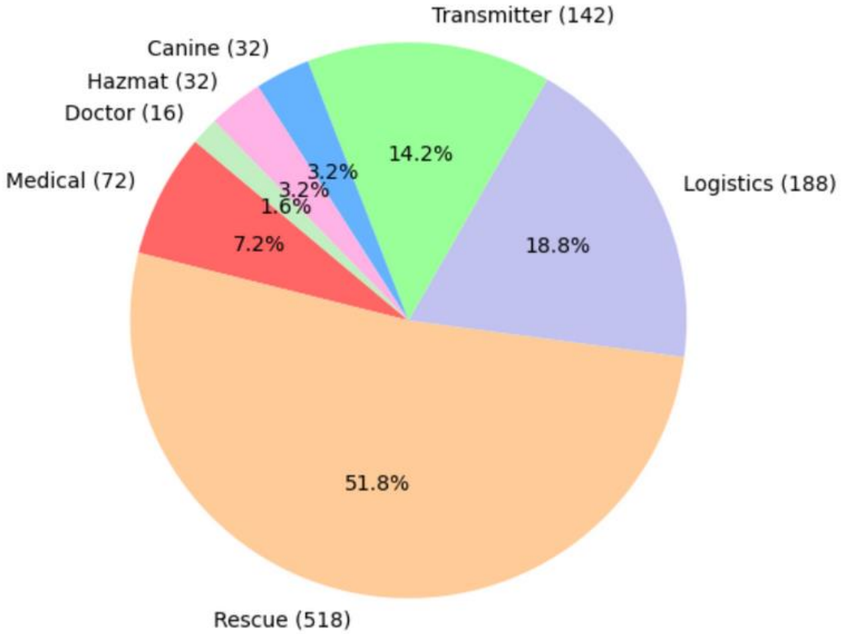
Team Type Distribution



Volunteer Assignment Status

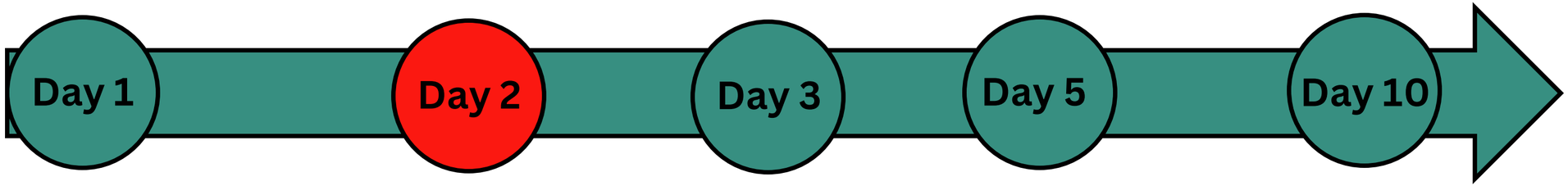


Role Distribution



arrival of experienced (retired) rescuers or SAR teams
medium teams are required to conduct ASR4 level operations

Computational Results



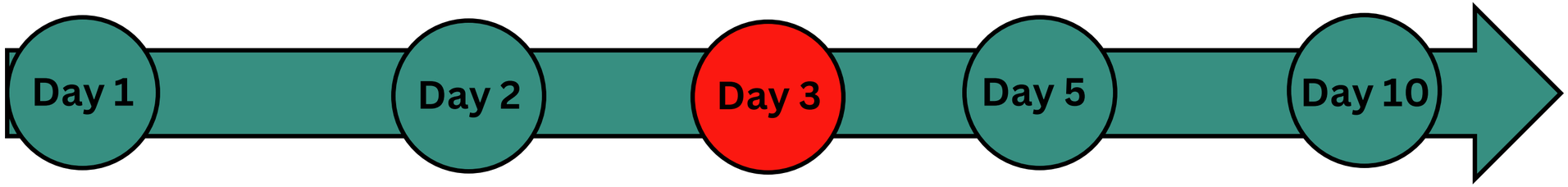
Case 5

Additional Staff Needed:

Role	Existing Staff	Additional Staff Needed
Medical	24	48
Rescue	230	202
Logistics	92	52
Transmitter	46	98
Canine	0	48
Hazmat	0	48
Doctor	0	24

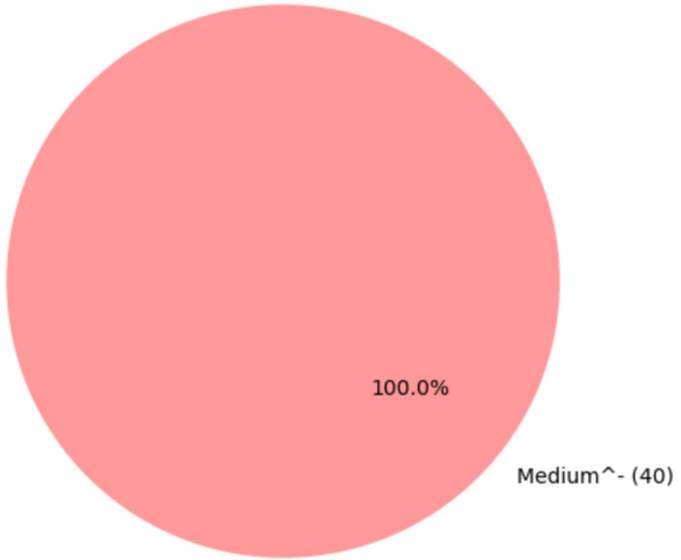
additional staff needed to complete medium⁻ teams to medium teams

Computational Results

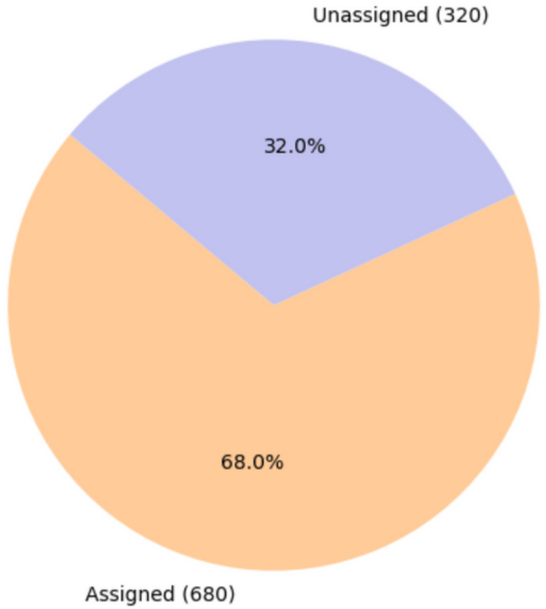


Case 7

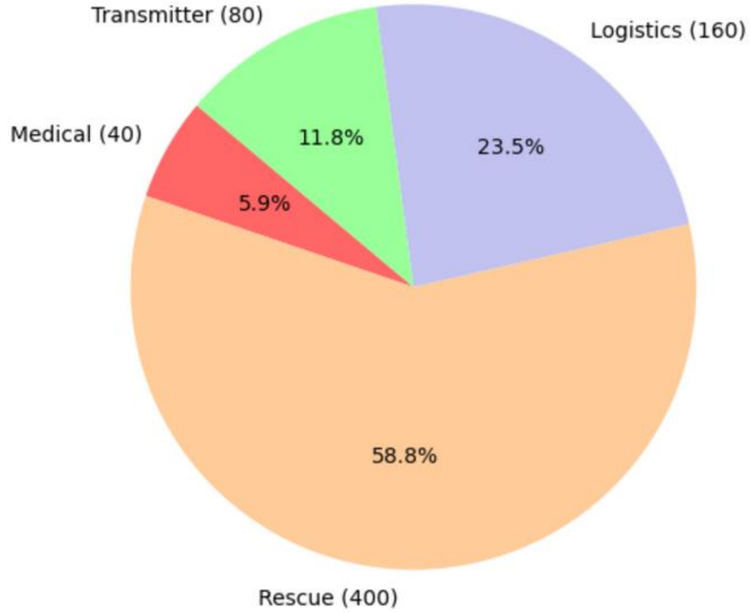
Team Type Distribution



Volunteer Assignment Status

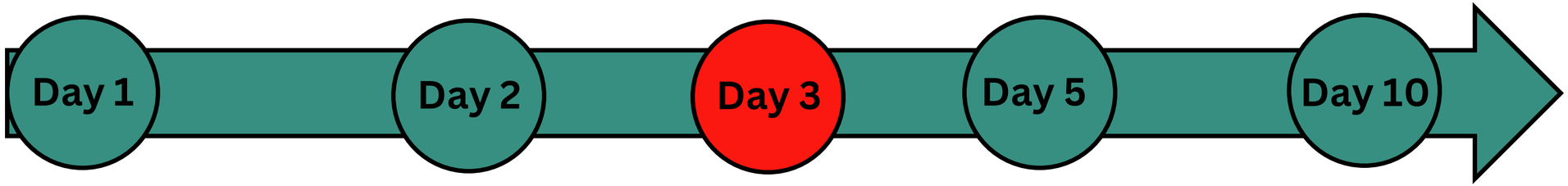


Role Distribution



medium⁻ teams are required to combine them with international teams

Computational Results



Case 7

Additional Staff Needed:

Role	Existing Staff	Additional Staff Needed
Medical	40	80
Rescue	400	320
Logistics	160	80
Transmitter	80	160
Canine	0	80
Hazmat	0	80
Doctor	0	40

additional staff needed to complete medium⁻ teams to medium teams

Model is getting complex

We work with volunteers, but assume that they perform perfectly.
Can do they work as efficient as a professional SAR technician?

Also, let’s assign formed teams to debris sites

Mathematical Model

Sets:

- N = Set of volunteers.
- R = Set of roles, where:

  $R = \{1 : \text{Medical}, 2 : \text{Rescue}, 3 : \text{Logistics}, 4 : \text{Transmitter}, 5 : \text{Canine}, 6 : \text{Hazmat}, 7 : \text{Doctor}\}$
- T = Set of team categories, where:

  $$T = \{1 : \text{Light}, 2 : \text{Medium}, 3 : \text{Medium}^{-}\}$$
- L = Set of team leaders.
- K = Set of team debris.

Mathematical Model

Sets:

- N = Set of volunteers.
- R = Set of roles, where:

  $R = \{1 : \text{Medical}, 2 : \text{Rescue}, 3 : \text{Logistics}, 4 : \text{Transmitter}, 5 : \text{Canine}, 6 : \text{Hazmat}, 7 : \text{Doctor}\}$
- T = Set of team categories, where:

  $$T = \{1 : \text{Light}, 2 : \text{Medium}, 3 : \text{Medium}^{-}\}$$
- L = Set of team leaders.
- K = Set of team debris.

Parameters:

- N=number of volunteers
- L=number of leaders
- a_t = Efficiency of team category t

Mathematical Model

Sets:

- N = Set of volunteers.
- R = Set of roles, where:

  $R = \{1 : \text{Medical}, 2 : \text{Rescue}, 3 : \text{Logistics}, 4 : \text{Transmitter}, 5 : \text{Canine}, 6 : \text{Hazmat}, 7 : \text{Doctor}\}$
- T = Set of team categories, where:

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- L = Set of team leaders.
- K = Set of team debris.

Parameters:

- N=number of volunteers
- L=number of leaders
- a_t = Efficiency of team category t
- b_{ir} is the work unit that volunteer i can meet when assigned to role r (proficiency level of volunteer i at role r) and $b_{ir} \in [0, 1]$.

Mathematical Model

Sets:

- N = Set of volunteers.
- R = Set of roles, where:

  $R = \{1 : \text{Medical}, 2 : \text{Rescue}, 3 : \text{Logistics}, 4 : \text{Transmitter}, 5 : \text{Canine}, 6 : \text{Hazmat}, 7 : \text{Doctor}\}$
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Parameters:

- N=number of volunteers
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- a_t = Efficiency of team category t
- b_{ir} is the work unit that volunteer i can meet when assigned to role r (proficiency level of volunteer i at role r) and $b_{ir} \in [0, 1]$.
- d_{tr} is the needed work unit for role r at team type t.

Mathematical Model

Sets:

- N = Set of volunteers.
- R = Set of roles, where:

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- T = Set of team categories, where:

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Parameters:

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- a_t = Efficiency of team category t
- b_{ir} is the work unit that volunteer i can meet when assigned to role r (proficiency level of volunteer i at role r) and $b_{ir} \in [0, 1]$.
- d_{tr} is the needed work unit for role r at team type t.
- c_r is the criticality of role r and takes values:

$$c_r = \begin{cases} 1 & \text{for roles: Medical, Doctor, Rescue, and Canine} \\ 0 & \text{for roles: Transmitter, Logistics, and Hazmat} \end{cases}$$

Mathematical Model

Sets:

- N = Set of volunteers.
- R = Set of roles, where:

  $R = \{1 : \text{Medical}, 2 : \text{Rescue}, 3 : \text{Logistics}, 4 : \text{Transmitter}, 5 : \text{Canine}, 6 : \text{Hazmat}, 7 : \text{Doctor}\}$
- T = Set of team categories, where:

  $$T = \{1 : \text{Light}, 2 : \text{Medium}, 3 : \text{Medium}^{-}\}$$
- L = Set of team leaders.
- K = Set of team debris.

Parameters:

- N=number of volunteers
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- a_t = Efficiency of team category t
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- c_r is the criticality of role r and takes values:

  $$c_r = \begin{cases} 1 & \text{for roles: Medical, Doctor, Rescue, and Canine} \\ 0 & \text{for roles: Transmitter, Logistics, and Hazmat} \end{cases}$$
- $$e_{kt} = \begin{cases} 1 & \text{if debris k is suitable for team type t} \\ 0 & \text{otherwise} \end{cases}$$

Mathematical Model

Decision Variables:

- t_{rl} = Amount of work unit for role r assigned to team l.

Mathematical Model

Decision Variables:

- t_{rl} = Amount of work unit for role r assigned to team l.
- $$x_{ilr} = \begin{cases} 1 & \text{if volunteer } i \text{ is assigned to team } l \text{ in the role } r \\ 0 & \text{otherwise} \end{cases}$$

Mathematical Model

Decision Variables:

- t_{rl} = Amount of work unit for role r assigned to team l.
- $$x_{ilr} = \begin{cases} 1 & \text{if volunteer } i \text{ is assigned to team } l \text{ in the role } r \\ 0 & \text{otherwise} \end{cases}$$
- $$y_{lt} = \begin{cases} 1 & \text{if leader } l \text{ formed a team with team category } t \\ 0 & \text{otherwise} \end{cases}$$

Mathematical Model

Decision Variables:

- t_{rl} = Amount of work unit for role r assigned to team l.
- $$x_{ilr} = \begin{cases} 1 & \text{if volunteer } i \text{ is assigned to team } l \text{ in the role } r \\ 0 & \text{otherwise} \end{cases}$$
- $$y_{lt} = \begin{cases} 1 & \text{if leader } l \text{ formed a team with team category } t \\ 0 & \text{otherwise} \end{cases}$$
- $$q_{lkt} = \begin{cases} 1 & \text{if team } l \text{ with category } t \text{ and this team is assigned to debris } k \\ 0 & \text{otherwise} \end{cases}$$

Mathematical Model

$$\max \quad \sum_{l} \sum_{t} a_t y_{lt} \tag{1}$$

maximizing total efficiency of teams

Mathematical Model

$$\max \quad \sum_{l} \sum_{t} a_t y_{lt}$$

$$\text{s.t} \quad y_{lt}\, d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \; and \; \forall t \in \{1, 2\}$$

(1) **maximizing total efficiency of teams**

(2) **supplying staff demand of light and medium teams**

Mathematical Model

$$\max \quad \sum_{l} \sum_{t} a_t y_{lt} \qquad (1)$$

maximizing total efficiency of teams

$$\text{s.t} \quad y_{lt}\, d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \; and \; \forall t \in \{1,2\} \qquad (2)$$

supplying staff demand of light and medium teams

$$\sum_{l} \sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N \qquad (3)$$

a volunteer can be assigned to at most one team

Mathematical Model

$$\max \quad \sum_{l} \sum_{t} a_t y_{lt} \qquad (1)$$

maximizing total efficiency of teams

$$\text{s.t} \quad y_{lt}\, d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \; and \; \forall t \in \{1, 2\} \qquad (2)$$

supplying staff demand of light and medium teams

$$\sum_{l} \sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N \qquad (3)$$

a volunteer can be assigned to at most one team

$$\sum y_{lt} \leq 1 \qquad \forall l \in L \qquad (4)$$

a leader can be assigned to at most one team

Mathematical Model

$$\max \quad \sum_{l} \sum_{t} a_t y_{lt}$$

(1) **maximizing total efficiency of teams**

$$\text{s.t} \quad y_{lt}\ d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \ and \ \forall t \in \{1,2\}$$

(2) **supplying staff demand of light and medium teams**

$$\sum_{l} \sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N$$

(3) **a volunteer can be assigned to at most one team**

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L$$

(4) **a leader can be assigned to at most one team**

$$t_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R$$

(5) **connecting volunteer, role and team assignments**

Mathematical Model

$$\max \quad \sum_{l}\sum_{t} a_t y_{lt}$$

(1) **maximizing total efficiency of teams**

$$\text{s.t} \quad y_{lt}\, d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \; and \; \forall t \in \{1,2\}$$

(2) **supplying staff demand of light and medium teams**

$$\sum_{l}\sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N$$

(3) **a volunteer can be assigned to at most one team**

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L$$

(4) **a leader can be assigned to at most one team**

$$t_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R$$

(5) **connecting volunteer, role and team assignments**

$$d_{1r} y_{l3} \leq t_{rl} \qquad \forall r \in R, \forall l \in L$$

(6) **medium- staff assignment**

Mathematical Model

$$\max \quad \sum_{l}\sum_{t} a_t y_{lt} \qquad (1)$$ maximizing total efficiency of teams

$$\text{s.t} \quad y_{lt}\, d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \text{ and } \forall t \in \{1,2\} \qquad (2)$$ supplying staff demand of light and medium teams

$$\sum_{l}\sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N \qquad (3)$$ a volunteer can be assigned to at most one team

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L \qquad (4)$$ a leader can be assigned to at most one team

$$t_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R \qquad (5)$$ connecting volunteer, role and team assignments

$$d_{1r} y_{l3} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \qquad (6)$$ medium- staff assignment

$$\sum_{t} y_{lt} \geq x_{ilr} \qquad \forall i \in N, \forall l \in L, \forall r \in R \qquad (7)$$ unless a leader is assigned, do not assign any volunteer to that team

Mathematical Model

$$\max \quad \sum_{l}\sum_{t} a_t y_{lt}$$ (1) **maximizing total efficiency of teams**

$$\text{s.t} \quad y_{lt}\, d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \text{ and } \forall t \in \{1,2\}$$ (2) **supplying staff demand of light and medium teams**

$$\sum_{l}\sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N$$ (3) **a volunteer can be assigned to at most one team**

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L$$ (4) **a leader can be assigned to at most one team**

$$t_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R$$ (5) **connecting volunteer, role and team assignments**

$$d_{1r} y_{l3} \leq t_{rl} \qquad \forall r \in R, \forall l \in L$$ (6) **medium- staff assignment**

$$\sum_{t} y_{lt} \geq x_{ilr} \qquad \forall i \in N, \forall l \in L, \forall r \in R$$ (7) **unless a leader is assigned, do not assign any volunteer to that team**

$$b_{ir} \geq 0.5 x_{ilr} c_r \qquad \forall i \in N, \forall l \in L, \forall r \in R$$ (8) **ensuring role criticality**

Mathematical Model

$$\max \quad \sum_{l}\sum_{t} a_t y_{lt}$$

(1) **maximizing total efficiency of teams**

$$\text{s.t} \quad y_{lt}\, d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \; and \; \forall t \in \{1,2\}$$

(2) **supplying staff demand of light and medium teams**

$$\sum_{l}\sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N$$

(3) **a volunteer can be assigned to at most one team**

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L$$

(4) **a leader can be assigned to at most one team**

$$t_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R$$

(5) **connecting volunteer, role and team assignments**

$$d_{1r} y_{l3} \leq t_{rl} \qquad \forall r \in R, \forall l \in L$$

(6) **medium- staff assignment**

$$\sum_{t} y_{lt} \geq x_{ilr} \qquad \forall i \in N, \forall l \in L, \forall r \in R$$

(7) **unless a leader is assigned, do not assign any volunteer to that team**

$$b_{ir} \geq 0.5 x_{ilr} c_r \qquad \forall i \in N, \forall l \in L, \forall r \in R$$

(8) **ensuring role criticality**

$$\sum_{i}\sum_{r} x_{ilr} \leq 59 \qquad \forall l \in L$$

(9) **number of staff in a team should be limited**

Mathematical Model

$$\max \quad \sum_{l}\sum_{t} a_t y_{lt}$$

(1) maximizing total efficiency of teams

$$\text{s.t} \quad y_{lt}\, d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \; and \; \forall t \in \{1,2\}$$

(2) supplying staff demand of light and medium teams

$$\sum_{l}\sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N$$

(3) a volunteer can be assigned to at most one team

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L$$

(4) a leader can be assigned to at most one team

$$t_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R$$

(5) connecting volunteer, role and team assignments

$$d_{1r} y_{l3} \leq t_{rl} \qquad \forall r \in R, \forall l \in L$$

(6) medium- staff assignment

$$\sum_{t} y_{lt} \geq x_{ilr} \qquad \forall i \in N, \forall l \in L, \forall r \in R$$

(7) unless a leader is assigned, do not assign any volunteer to that team

$$b_{ir} \geq 0.5 x_{ilr} c_r \qquad \forall i \in N, \forall l \in L, \forall r \in R$$

(8) ensuring role criticality

$$\sum_{i}\sum_{r} x_{ilr} \leq 59 \qquad \forall l \in L$$

(9) number of staff in a team should be limited

$$\sum_{k} q_{lkt} \leq y_{lt} \qquad \forall l \in L, \forall t \in T$$

(10) to assign a team to the debris site, it should be formed

Mathematical Model

$$\max \quad \sum_{l}\sum_{t} a_t y_{lt} \qquad (1)$$

maximizing total efficiency of teams

$$\text{s.t} \quad y_{lt}\, d_{tr} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \text{ and } \forall t \in \{1,2\} \qquad (2)$$

supplying staff demand of light and medium teams

$$\sum_{l}\sum_{r} x_{ilr} \leq 1 \qquad \forall i \in N \qquad (3)$$

a volunteer can be assigned to at most one team

$$\sum_{t} y_{lt} \leq 1 \qquad \forall l \in L \qquad (4)$$

a leader can be assigned to at most one team

$$t_{rl} = \sum_{i} x_{ilr} b_{ir} \qquad \forall l \in L, \forall r \in R \qquad (5)$$

connecting volunteer, role and team assignments

$$d_{1r} y_{l3} \leq t_{rl} \qquad \forall r \in R, \forall l \in L \qquad (6)$$

medium- staff assignment

$$\sum_{t} y_{lt} \geq x_{ilr} \qquad \forall i \in N, \forall l \in L, \forall r \in R \qquad (7)$$

unless a leader is assigned, do not assign any volunteer to that team

$$b_{ir} \geq 0.5 x_{ilr} c_r \qquad \forall i \in N, \forall l \in L, \forall r \in R \qquad (8)$$

ensuring role criticality

$$\sum_{i}\sum_{r} x_{ilr} \leq 59 \qquad \forall l \in L \qquad (9)$$

number of staff in a team should be limited

$$\sum_{k} q_{lkt} \leq y_{lt} \qquad \forall l \in L, \forall t \in T \qquad (10)$$

to assign a team to the debris site, it should be formed

$$\sum_{l}\sum_{t} q_{lkt} \geq 1 \qquad \forall k \in K \qquad (11)$$

each debris site should be covered at least once

Mathematical Model

max	$\sum_{l}\sum_{t} a_t y_{lt}$		(1)	maximizing total efficiency of teams
s.t	$y_{lt}\ d_{tr} \leq t_{rl}$	$\forall r \in R, \forall l \in L\ and\ \forall t \in \{1,2\}$	(2)	supplying staff demand of light and medium teams
	$\sum_{l}\sum_{r} x_{ilr} \leq 1$	$\forall i \in N$	(3)	a volunteer can be assigned to at most one team
	$\sum_{t} y_{lt} \leq 1$	$\forall l \in L$	(4)	a leader can be assigned to at most one team
	$t_{rl} = \sum_{i} x_{ilr} b_{ir}$	$\forall l \in L, \forall r \in R$	(5)	connecting volunteer, role and team assignments
	$d_{1r} y_{l3} \leq t_{rl}$	$\forall r \in R, \forall l \in L$	(6)	medium- staff assignment
	$\sum_{t} y_{lt} \geq x_{ilr}$	$\forall i \in N, \forall l \in L, \forall r \in R$	(7)	unless a leader is assigned, do not assign any volunteer to that team
	$b_{ir} \geq 0.5 x_{ilr} c_r$	$\forall i \in N, \forall l \in L, \forall r \in R$	(8)	ensuring role criticality
	$\sum_{i}\sum_{r} x_{ilr} \leq 59$	$\forall l \in L$	(9)	number of staff in a team should be limited
	$\sum_{k} q_{lkt} \leq y_{lt}$	$\forall l \in L, \forall t \in T$	(10)	to assign a team to the debris site, it should be formed
	$\sum_{l}\sum_{t} q_{lkt} \geq 1$	$\forall k \in K$	(11)	each debris site should be covered at least once
	$q_{lkt} \leq e_{kt}$	$\forall l \in L, \forall t \in T, \forall k \in K$	(12)	team type should be suitable for debris site

Mathematical Model

max	$\sum_{l}\sum_{t} a_t y_{lt}$		(1) maximizing total efficiency of teams
s.t	$y_{lt}\ d_{tr} \leq t_{rl}$	$\forall r \in R, \forall l \in L\ and\ \forall t \in \{1,2\}$	(2) supplying staff demand of light and medium teams
	$\sum_{l}\sum_{r} x_{ilr} \leq 1$	$\forall i \in N$	(3) a volunteer can be assigned to at most one team
	$\sum_{t} y_{lt} \leq 1$	$\forall l \in L$	(4) a leader can be assigned to at most one team
	$t_{rl} = \sum_{i} x_{ilr} b_{ir}$	$\forall l \in L, \forall r \in R$	(5) connecting volunteer, role and team assignments
	$d_{1r} y_{l3} \leq t_{rl}$	$\forall r \in R, \forall l \in L$	(6) medium- staff assignment
	$\sum_{t} y_{lt} \geq x_{ilr}$	$\forall i \in N, \forall l \in L, \forall r \in R$	(7) unless a leader is assigned, do not assign any volunteer to that team
	$b_{ir} \geq 0.5 x_{ilr} c_r$	$\forall i \in N, \forall l \in L, \forall r \in R$	(8) ensuring role criticality
	$\sum_{i}\sum_{r} x_{ilr} \leq 59$	$\forall l \in L$	(9) number of staff in a team should be limited
	$\sum_{k} q_{lkt} \leq y_{lt}$	$\forall l \in L, \forall t \in T$	(10) to assign a team to the debris site, it should be formed
	$\sum_{l}\sum_{t} q_{lkt} \geq 1$	$\forall k \in K$	(11) each debris site should be covered at least once
	$q_{lkt} \leq e_{kt}$	$\forall l \in L, \forall t \in T, \forall k \in K$	(12) team type should be suitable for debris site
	$x_{ilr}, y_{lt}, q_{lkt} \in \{0,1\}$	$\forall l \in L, \forall t \in T, \forall k \in K, \forall i \in N,$	(13) domain constraints
	$t_{rl} \geq 0$	$\forall l \in L, \forall r \in R$	(14) domain constraints

Computational Results

N= 300
(# of volunteers)

Computational Results

N= 300
(# of volunteers)

L=10
(# of leaders)

Computational Results

N= 300
(# of volunteers)

L=10
(# of leaders)

K=5
(# of debris)

Computational Results

N= 300
(# of volunteers)

L=10
(# of leaders)

K=5
(# of debris)

Light

Medium

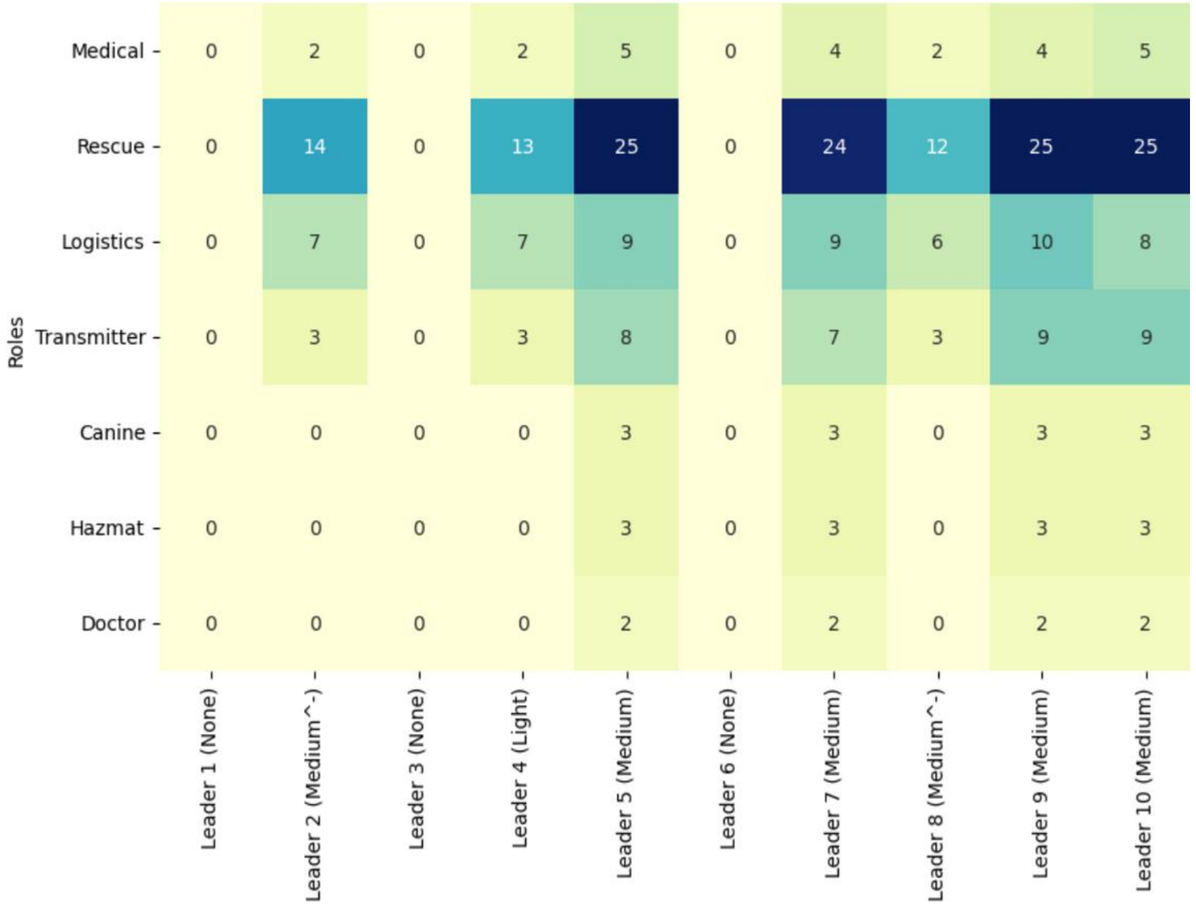
Medium

Medium-

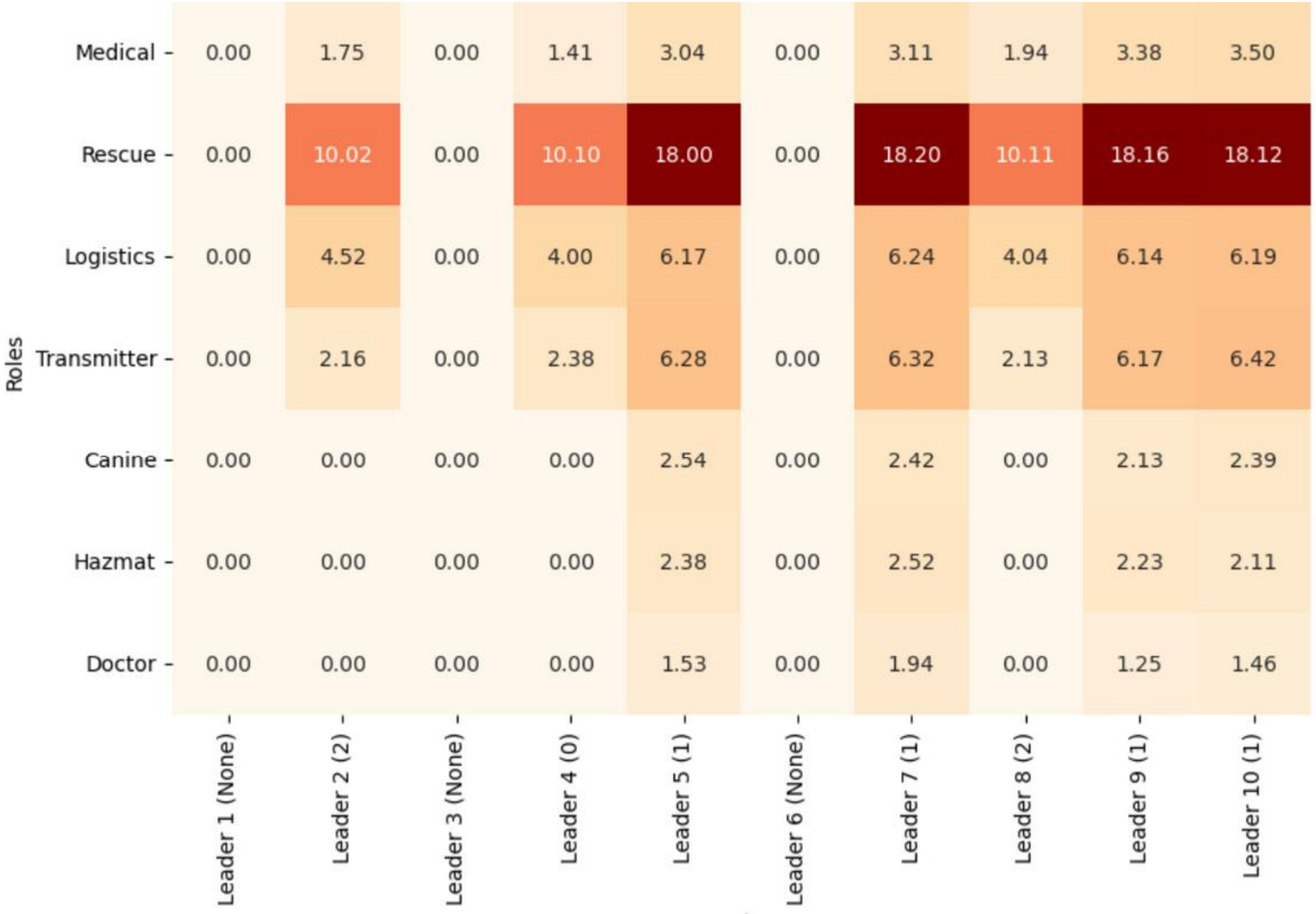
Medium
Medium-

Computational Results

Assigned Volunteer Numbers



Total Proficiency in Teams



$$\sum_i \sum_r x_{ilr} \leq 59$$

$$c_r = \begin{cases} 1 & \text{for roles Medical, Rescue, Canine and Doctor} \\ 0 & \text{for roles Transmitter, Logistics and Hazmat} \end{cases}$$

Computational Results

Debris assignments

Team	Debris	Team Type
Team2	Debris3	Medium^-
Team4	Debris0	Light
Team5	Debris1	Medium
Team7	Debris4	Medium
Team8	Debris3	Medium^-
Team9	Debris4	Medium
Team10	Debris2	Medium

Table 6: Table of debris assignments

Number of missing staff

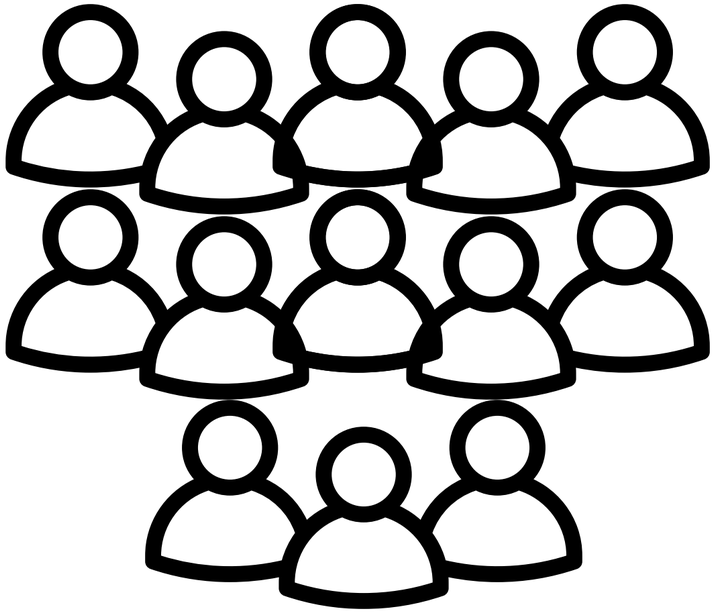
Medium^- Team Staff Summary:
Total Medium^- teams formed: 2

Role	Assigned Staff	Needed to Upgrade to Medium
Medical	4	2
Rescue	26	10
Logistics	13	0
Transmitter	6	6
Canine	0	4
Hazmat	0	4
Doctor	0	2

Table 7: Table of medium- team details

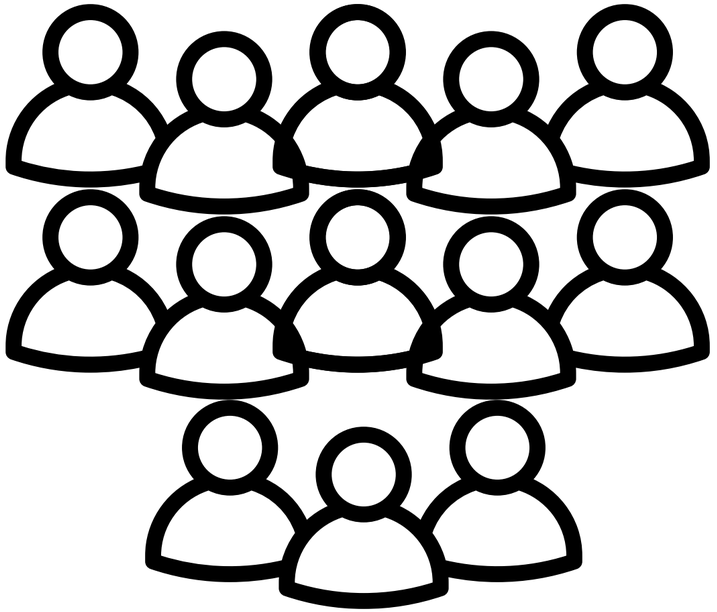
Computation Time
5.64 sec

Up to now

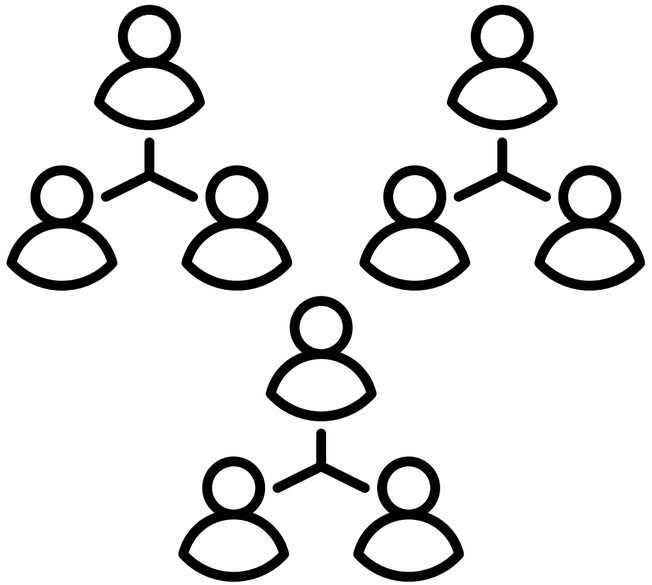


Volunteer Convergence

Up to now

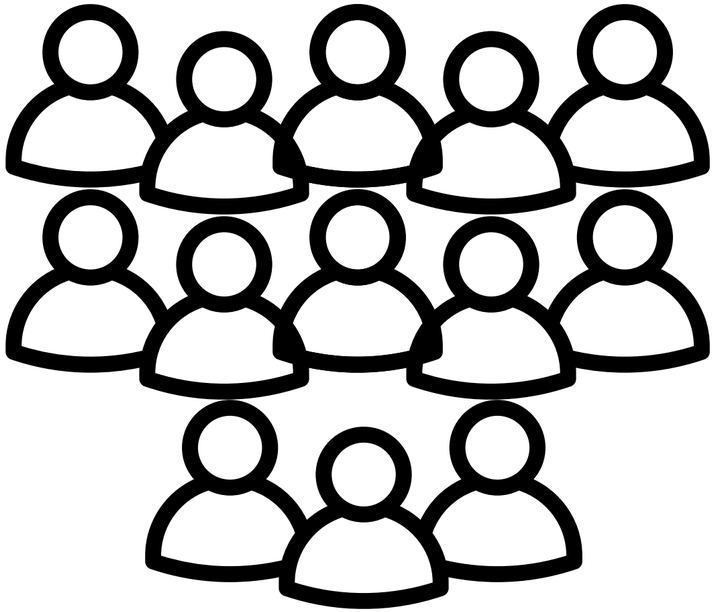


Volunteer Convergence

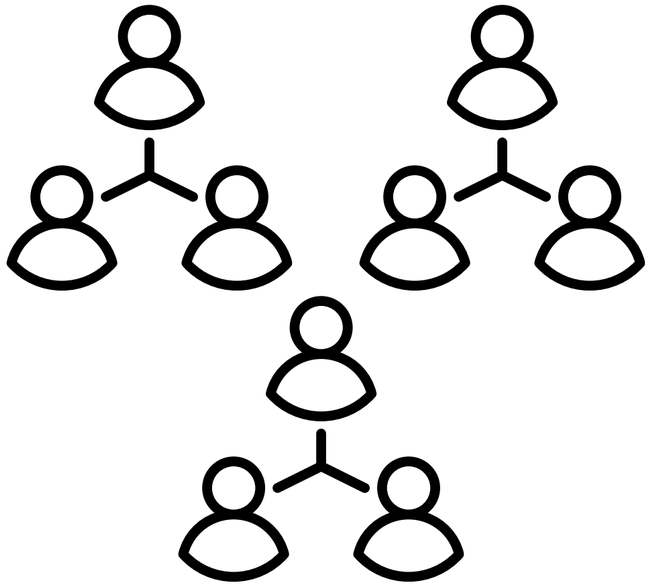


Team Formation

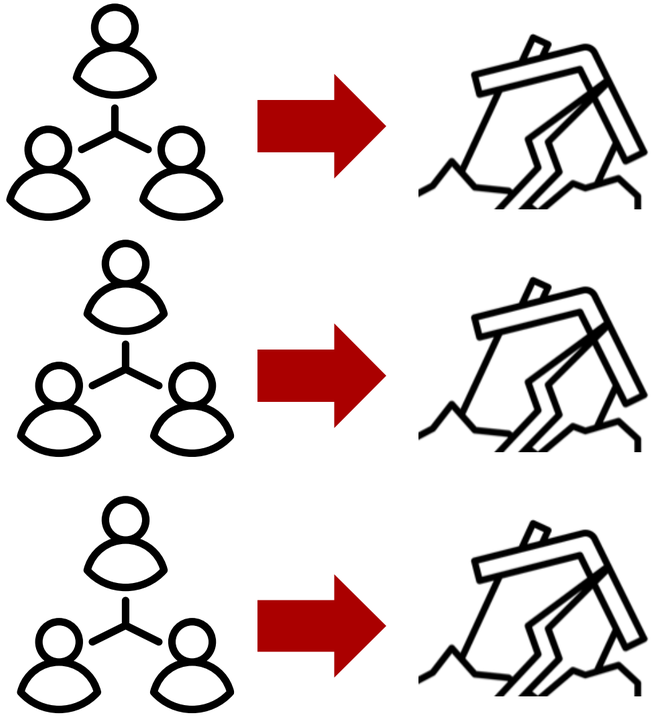
Up to now



Volunteer Convergence



Team Formation



Debris Assignment