



Effect of Medical System Size on Predicted Medical Risk and Medical System Design Considerations for an Extended Duration Lunar Mission

Exploration Medical Capability, NASA Human Research Program

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“Expanding the Boundaries of Space Medicine and Technology”

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**Thank you to the entire team from
Med Ops, JSC, GRC, ARC, LaRC
and of course ExMC!**



Disclosure Information

94th Annual Scientific Meeting

We have no financial relationships to disclose.

We will not discuss off-label use and/or investigational use in presentations.



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- **So, about that backpack...**

Med System parameters can be set:

- **Target mass or volume**
(e.g. 50 kg and 150 L)
- **Optimize a single parameter or a weighting of multiple parameters**
- **Fully Treated Kit**
- 445 kg (not feasible)

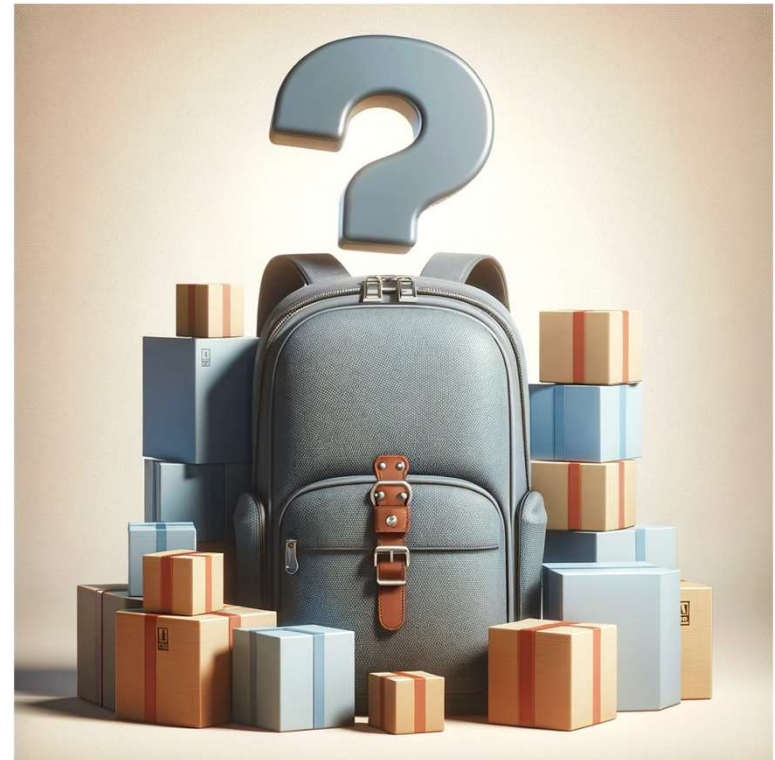
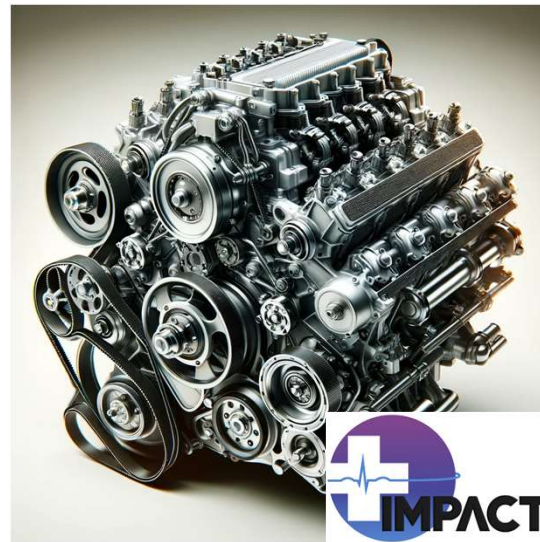


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Capabilities/Resources

Medical system:

- Mass
- Volume
- Power



Risk Metrics:

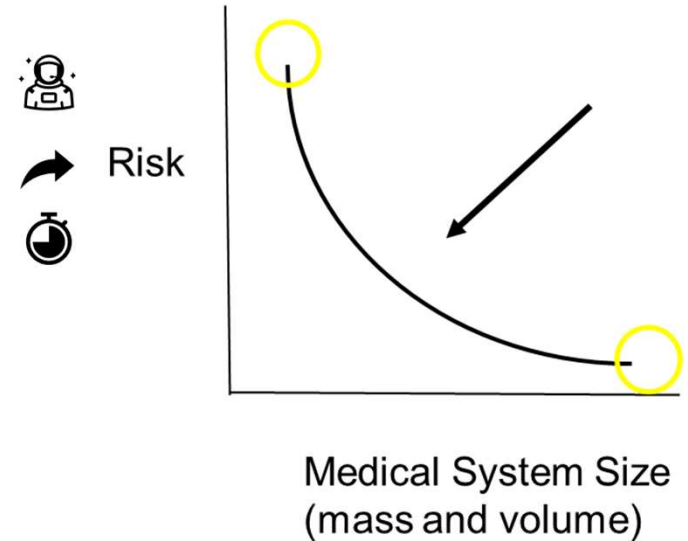
- Loss of Crew Life
- RTDC
- TTL

- We determined outcomes for each weight target
 - **LOCL** – Loss of crew life
 - **RTDC** – Return to definitive care (medical evacuation)
 - **TTL** – Task time lost (crew task impairment)
- We also determined the ranked contribution of medical conditions likely to occur that drive these risks
- We then explored the differences in the proposed resourcing for different size medical systems

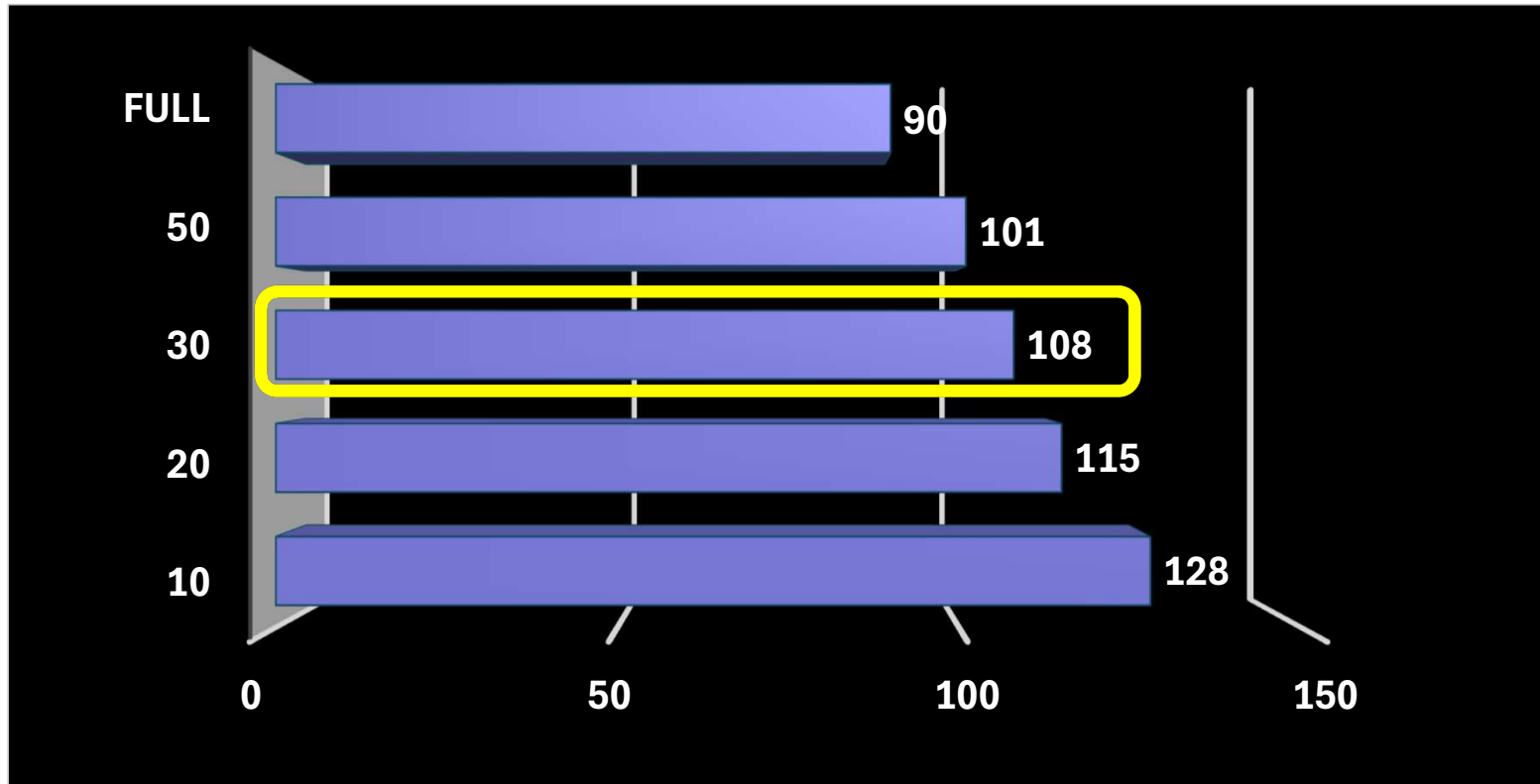


- **Medical System Size?**

- Identify inflection points in medical risk
- Mass reasonable for the desired mission
- Did not want to choose clinical threshold
 - What is an acceptable risk of LOCL?

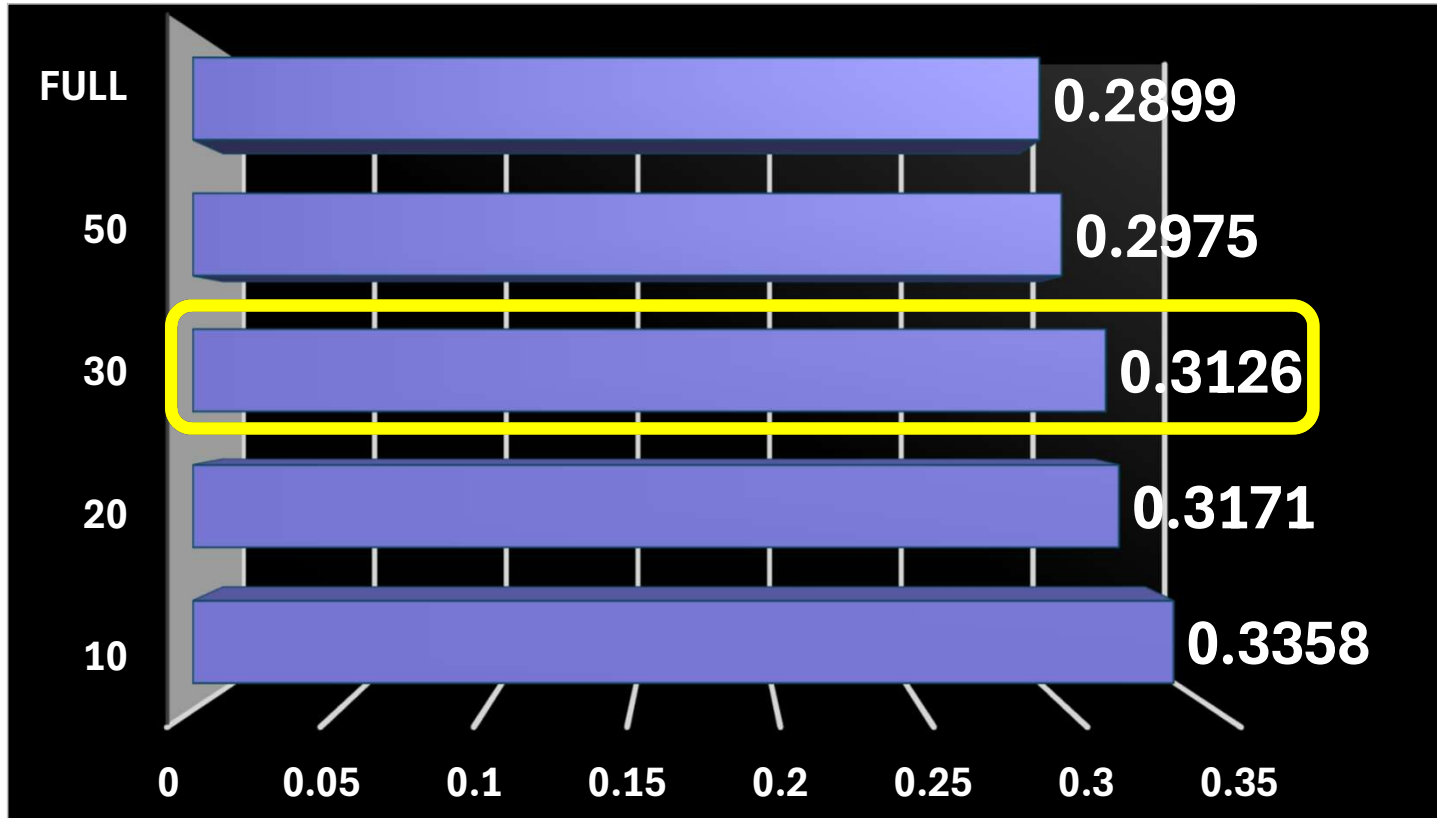


Medical System Physical Mass



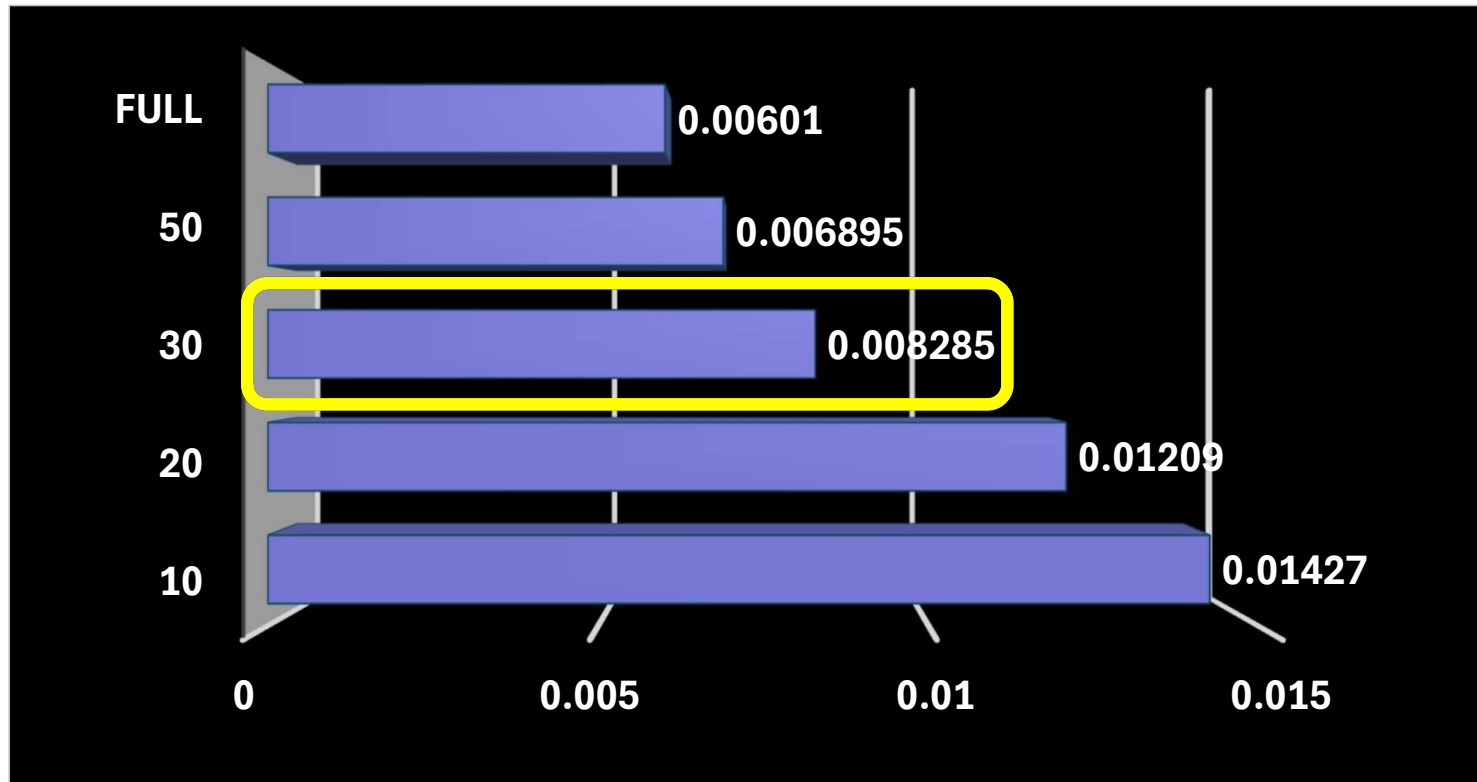
Estimated Task Time Lost - Person Days

Medical System Physical Mass



Risk of Consideration of RTDC - Events Per Mission

Medical System Physical Mass



Risk of Loss of Crew Life - Events per Mission



CONDITIONS INFLUENCING RISK

TOP 10 CONDITIONS – 30 Kg – LOCL

TOP 10	LOCL
EVA-related Decompression Sickness	0.0029
Traumatic Hypovolemic Shock	0.0011
Respiratory Failure	0.0007
UTI/Pyelonephritis	0.0007
Ebullism	0.0005
Abnormal Uterine Bleeding	0.0004
Dental Abscess	0.0002
Trauma - Severe Head	0.0002
Toxic Inhalation Exposure - Combustion Products	0.0002
Skin Infection - Bacterial	0.0002

Top 10 conditions contributing to the risk for crew loss of life in events per mission

TOP 10 CONDITIONS – 30 Kg – RTDC

TOP 10	RTDC
Fracture - Wrist	0.1413
Eye Foreign Body	0.0479
Barotrauma (Ear/Sinus Block)	0.0213
EVA-related Decompression Sickness	0.0210
Corneal Abrasion/Ulceration	0.0109
Burn - Chemical Eye	0.0099
Pregnancy, Risk For	0.0094
Pregnancy	0.0067
Skin Infection - Bacterial	0.0067
Gastroenteritis/Acute Diarrhea	0.0049

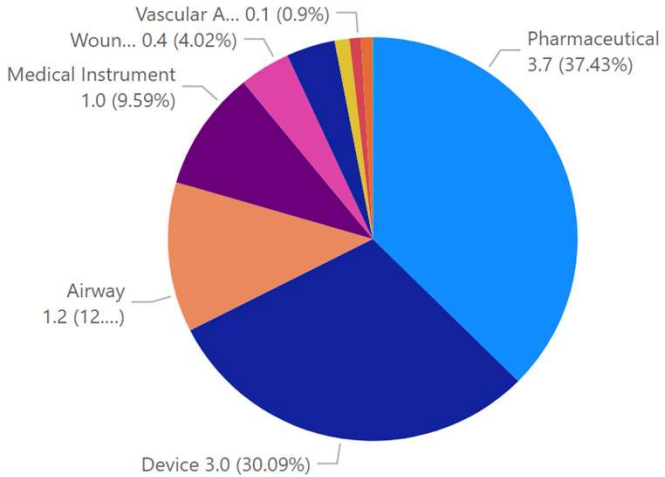
Top 10 conditions contributing to the risk for need for return to definitive care in events per mission

TOP 10 CONDITIONS – 30 Kg – TTL

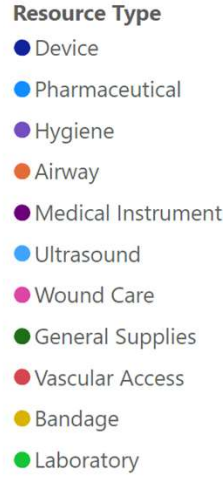
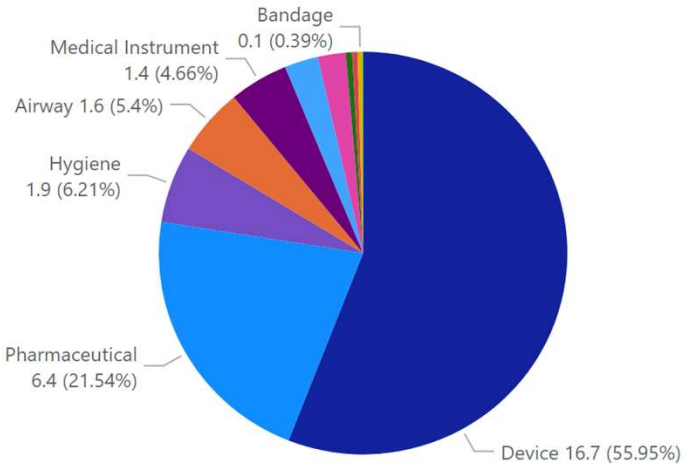
TOP 10	TTL
EVA-related Shoulder Injury	18.8977
Barotrauma (Ear/Sinus Block)	9.9344
EVA-related Suit Contact Injury	8.4271
EVA-related Hand Injury	5.7195
Sprain/Strain - Upper Extremity	5.5466
Sprain/Strain - Lower Extremity	5.1816
Rash, Spaceflight Associated	5.0890
Fracture - Wrist	4.7114
Sleep Disturbance/Insomnia	4.2666
Sprain/Strain - Back	4.1754

Top 10 conditions contributing to total crew task time lost in person days

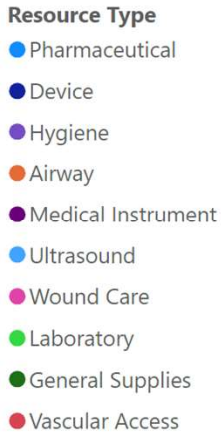
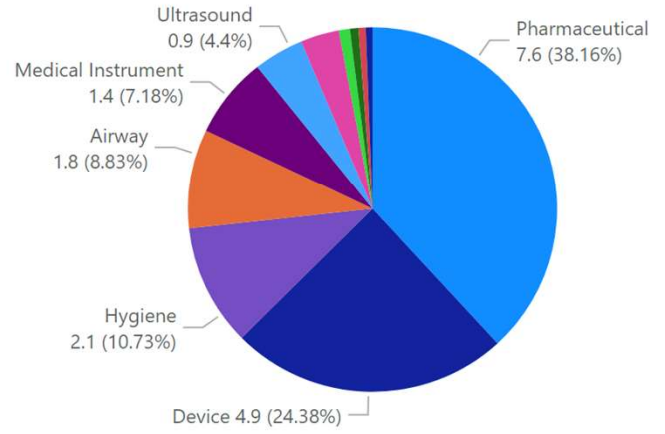
Total Resource Mass (kg), 10kg



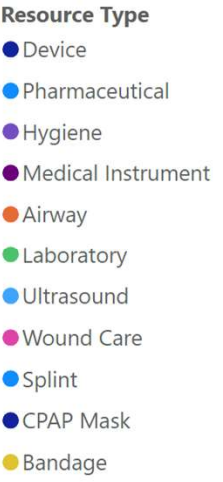
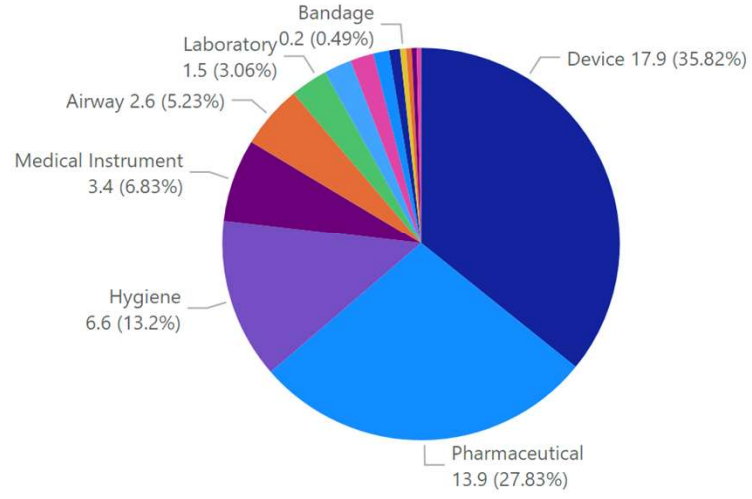
Total Resource Mass (kg), 30kg



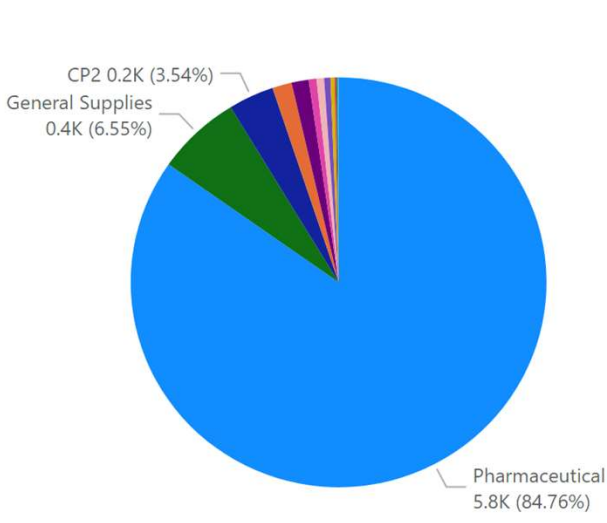
Total Resource Mass (kg), 20kg



Total Resource Mass (kg), 50kg

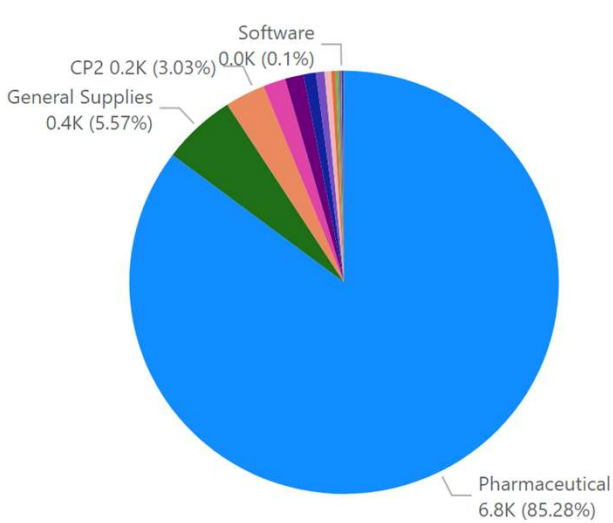


Total Resource Quantity, 10kg



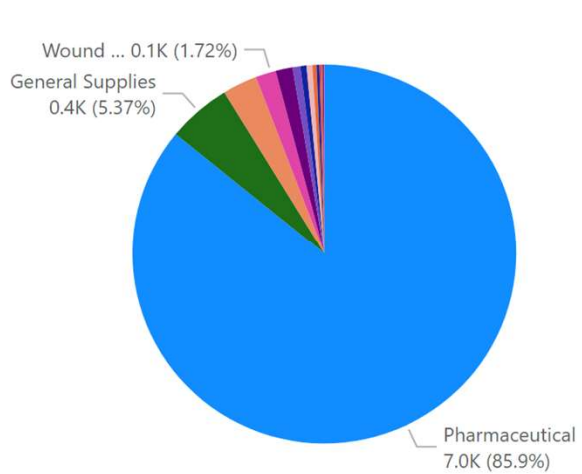
- Resource Type**
- Pharmaceutical
 - General Supplies
 - CP2
 - Wound Care
 - Medical Instrument
 - Hygiene
 - CP1
 - Device
 - Airway
 - Vascular Access
 - Software
 - Bandage

Total Resource Quantity, 30kg



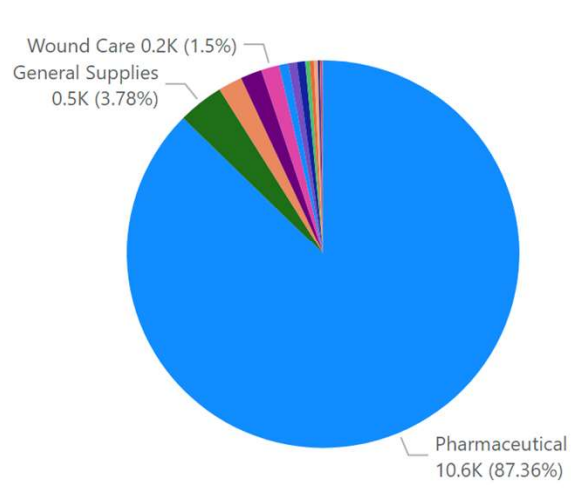
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 - Device
 - Hygiene
 - CP1
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 - Laboratory
 - Vascular Access
 - Software

Total Resource Quantity, 20kg



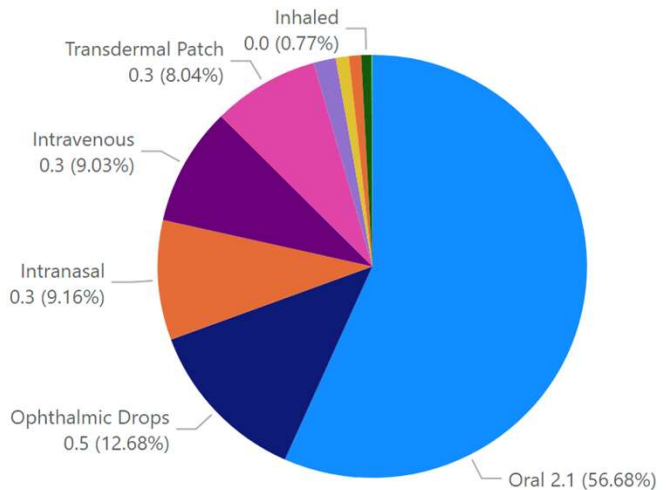
- Resource Type**
- Pharmaceutical
 - General Supplies
 - CP2
 - Wound Care
 - Medical Instrument
 - Hygiene
 - Device
 - CP1
 - Airway
 - Laboratory
 - Vascular Access

Total Resource Quantity, 50kg



- Resource Type**
- Pharmaceutical
 - General Supplies
 - CP2
 - Medical Instrument
 - Wound Care
 - Splint
 - Hygiene
 - Device
 - Laboratory
 - Airway
 - CP1

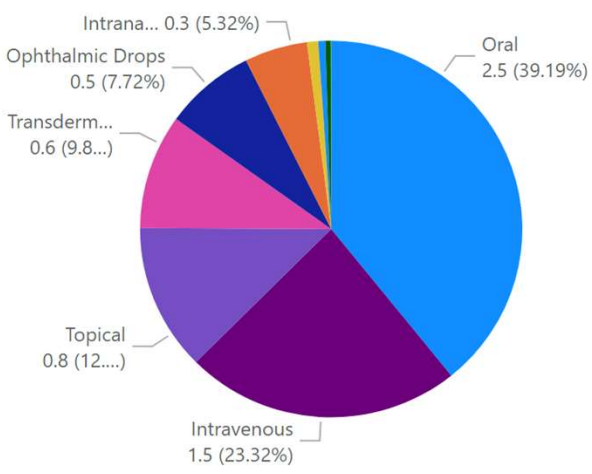
Pharmaceutical Masses (kg), 10kg



Resource Specification 1

- Oral
- Ophthalmic Drops
- Intranasal
- Intravenous
- Transdermal Patch
- Topical
- Subcutaneous
- Sterile Surgical Lubricant
- Inhaled
- Ophthalmic Strip
- Device
- Intramuscular

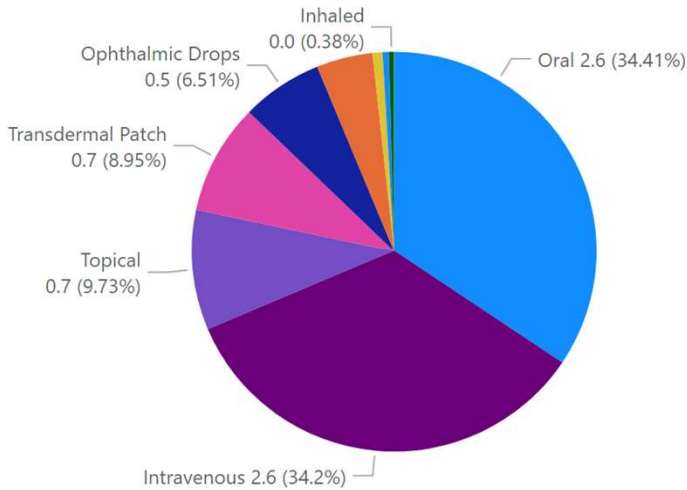
Pharmaceutical Masses (kg), 30kg



Spec1

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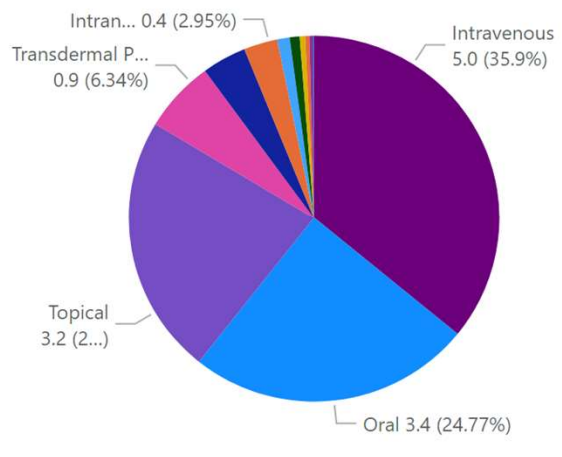
Pharmaceutical Masses (kg), 20kg



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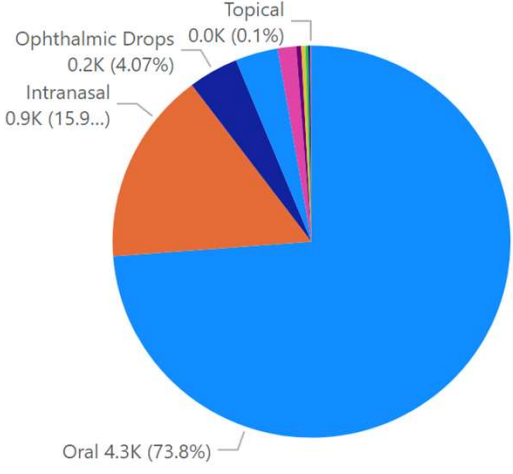
Pharmaceutical Masses (kg), 50kg



Resource Specification 1

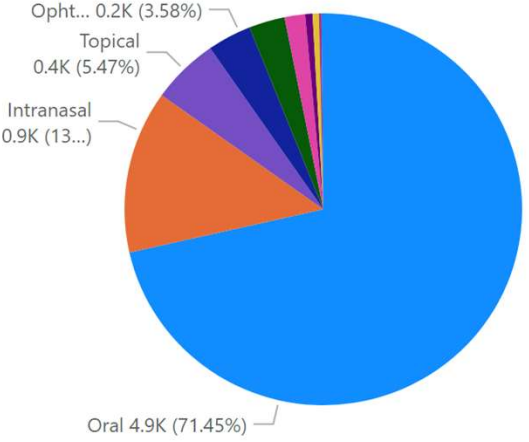
- Intravenous
- Oral
- Topical
- Transdermal Patch
- Ophthalmic Drops
- Intranasal
- Intramuscular
- Inhaled
- Subcutaneous
- Sterile Surgical Lubri...
- Device

Pharmaceutical Quantities, 10kg



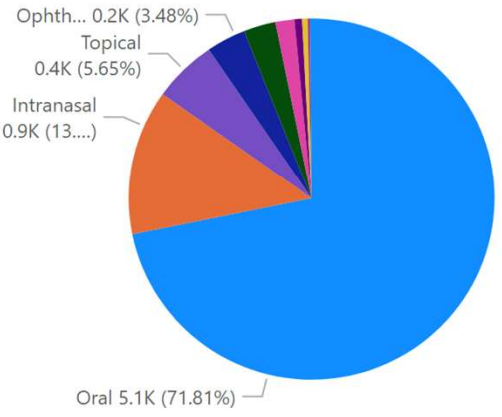
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Pharmaceutical Quantities, 30kg



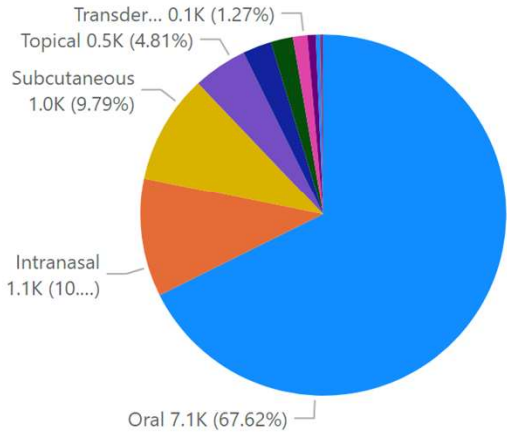
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Pharmaceutical Quantities, 20kg



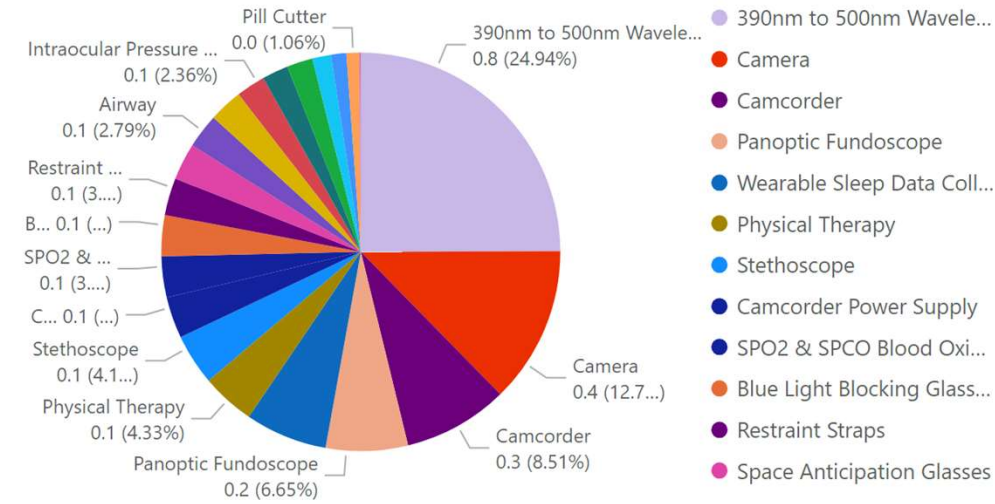
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 - Subcutaneous
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 - Sterile Surgical Lubricant

Pharmaceutical Quantities, 50kg

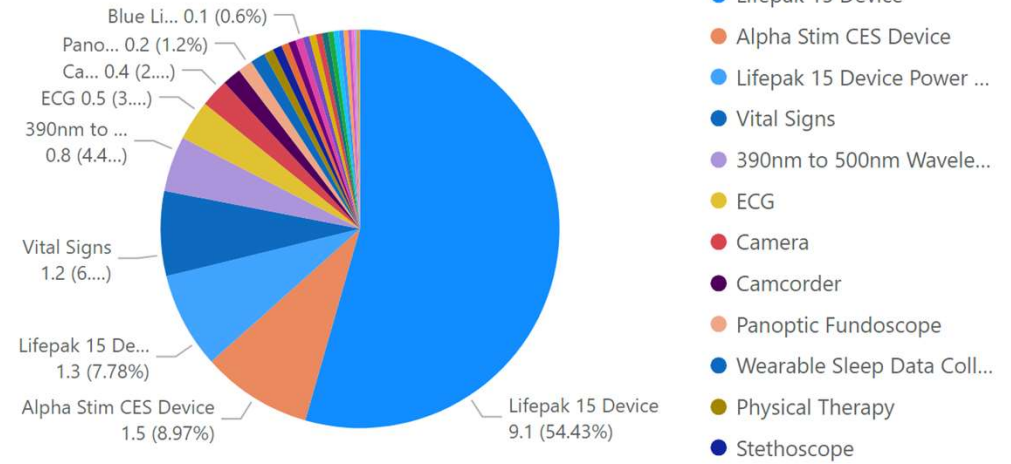


- Resource Specification 1**
- Oral
 - Intranasal
 - Subcutaneous
 - Topical
 - Ophthalmic Drops
 - Inhaled
 - Transdermal Patch
 - Intravenous
 - Otic Drops
 - Ophthalmic Strip

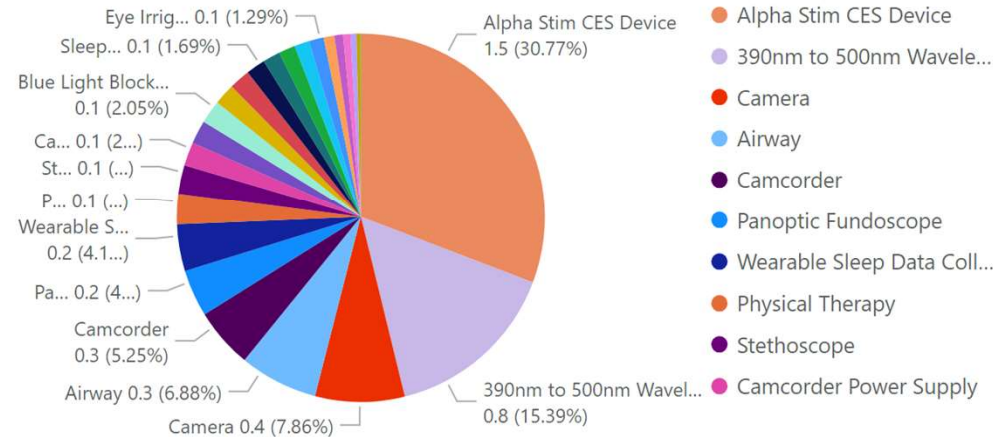
Device Masses (kg), 10kg



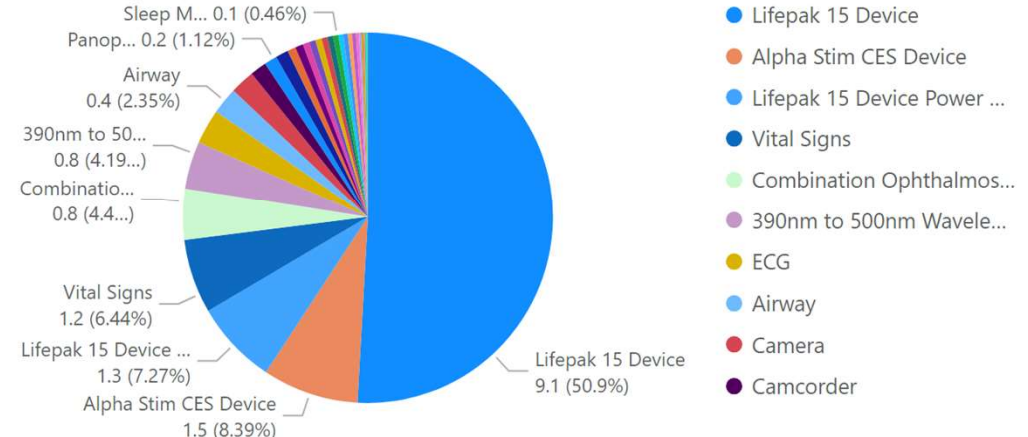
Device Masses (kg), 30kg



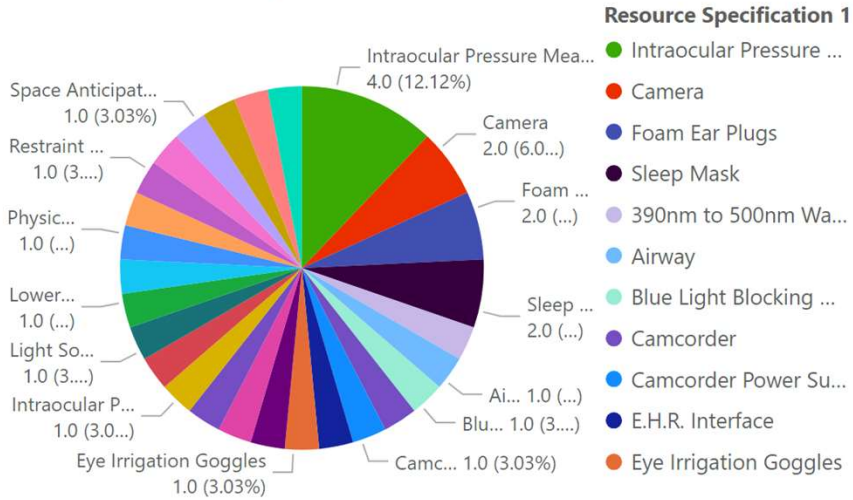
Device Masses (kg), 20kg



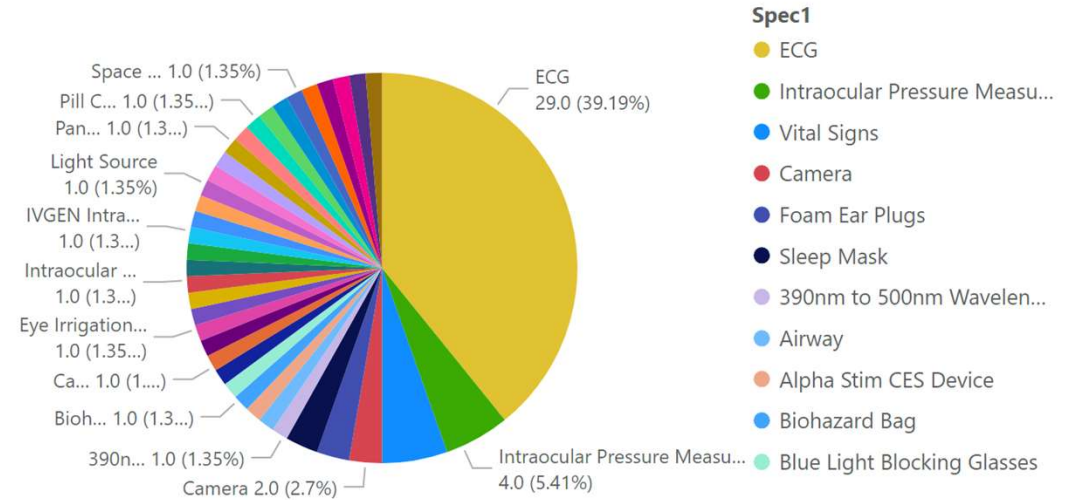
Device Masses (kg), 50kg



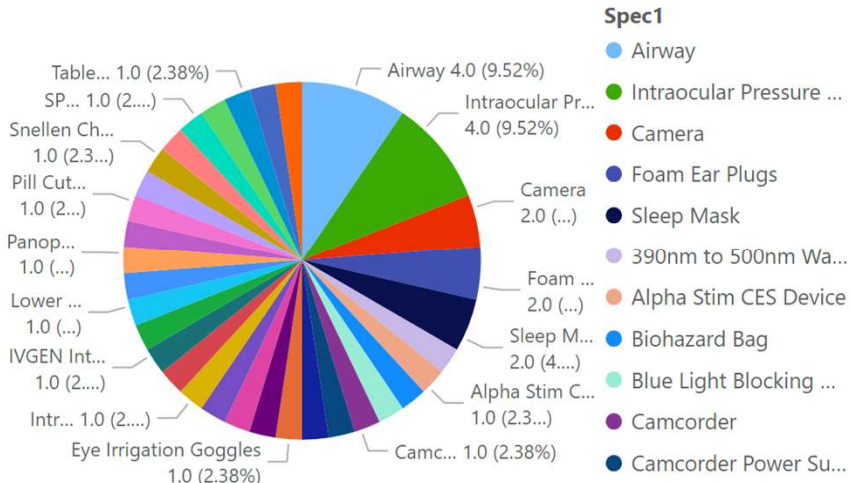
Device Quantities, 10kg



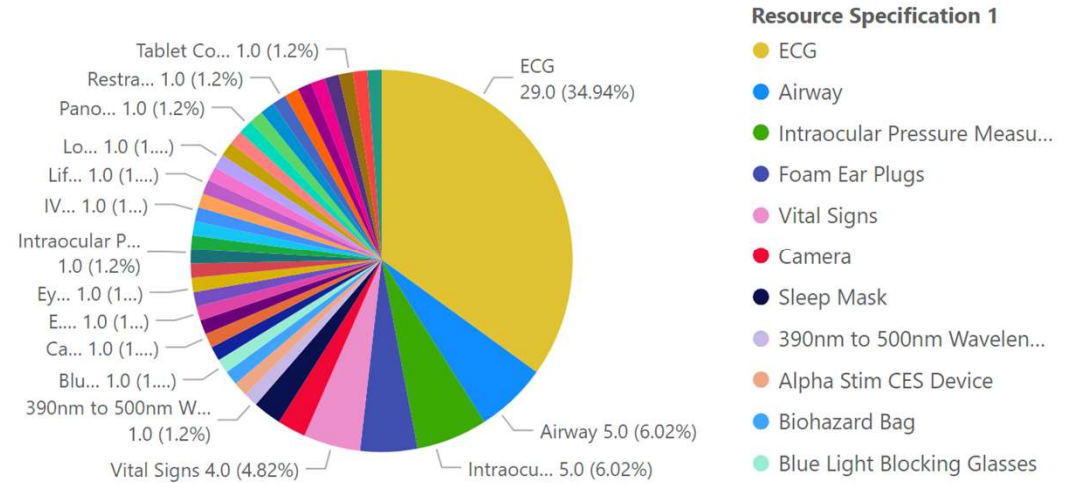
Device Quantities, 30kg



Device Quantities, 20kg



Device Quantities, 50kg



- As kg weight target increases – physical mass of system increases
- 30 kg is the inflection point for this DRM
- Systems engineers and mission planners will be able to select a kg target that is reasonable for a given mission and assess the **IMPACT** of that decision

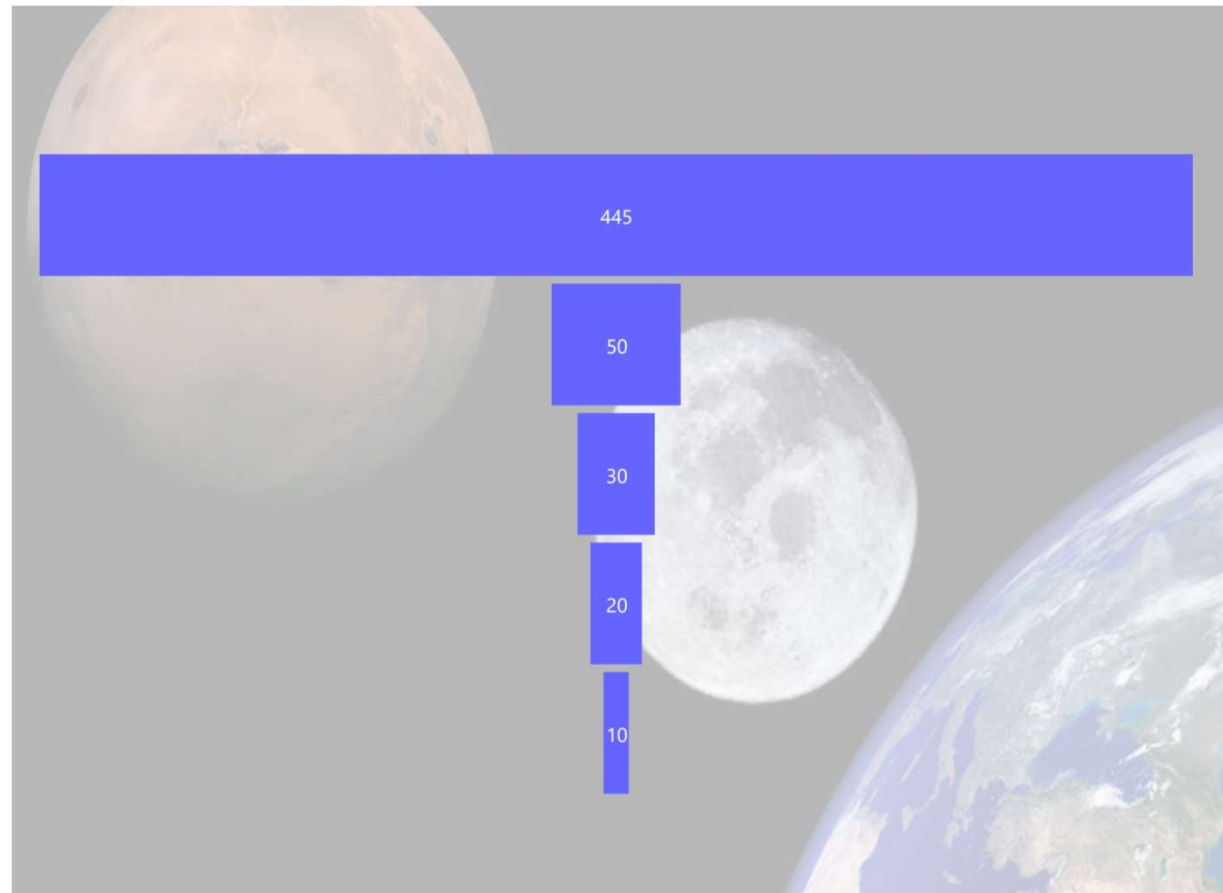


Image courtesy of: <https://www.space.com/artemis-1-moon-stepping-stone-mars>

- **Considerations:**
- **Ease of re-supply**
 - Smaller kit – risk of resupply not as concerning for LEO missions vs. Mars
- **Longevity of components**
 - E.g. IMPACT does not consider risk of Lifepak malfunction.
 - Pharmaceutical stability tests ongoing
- **IMPACT not yet modeling certain mission segments**



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**Please hold all questions until the end.
Thank you!**

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