# Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture

**Guiding question**

Concrete → vocabulary → diagram → calculation → limits → mission.

### Course map

The real phenomenon → Vocabulary and problem boundary → Course-specific system view → Mathematical relationship and reading the symbols → Worked calculations and interpretation

## 1 — The real phenomenon

Robotic Mars heritage demonstrates remarkable technologies, but human missions impose a different mass class. NASA EDL syntheses compare Mars robotic heritage, around the one-tonne landed class for Mars 2020, with human objectives around 20 tonnes and above, including studied concepts in the 26 to 36 tonne landed class. This is not one official final architecture: it is a problem scale motivating new entry systems, guidance, propulsion, surface sensing and test campaigns.
The guiding question is: What stops being a simple extrapolation when landed mass increases by more than a factor of twenty? Reasoning starts with the physical or operational function before introducing the mathematical relationship.
The goal is not to accumulate terminology, but to know which quantity changes, why it changes and what becomes hazardous when it leaves its domain. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, the first task here is therefore to identify the mechanism specific to this subject before searching for an equation or reference value.

## 2 — Vocabulary and problem boundary

In “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, distinguish the phenomenon, available measurement, any command, the margin and the success criterion. The calculation boundary states what is included and excluded; without that boundary, a percentage, mass or time may be mathematically correct but wrong as an engineering conclusion. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, the chosen boundary also states what would otherwise be double-counted or omitted from a mission budget.
velocity, kinetic energy, altitude, deceleration and state of each EDL event
a bad state estimate, an event triggered outside its window or insufficient braking reserve
six-degree-of-freedom simulation, dispersion Monte Carlo and sequence rehearsal with injected faults

### Equation - evidence - decision

**facteur = valeur_2 / valeur_1 ; A ∝ diamètre²**

Failure to test: The reference failure is not a vague “broken component.” For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, test in particular a bad state estimate, an event triggered outside its window or insufficient braking reserve. Diagnosis asks which symptoms appear first, which are only consequences and which action preserves the most options.

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## 3 — Course-specific system view

This lesson does not reuse one generic picture for every subject. The system view follows cause → measured quantity → decision or physical response → limit for “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”. The English text remains fully equivalent while large translated illustrations are intentionally deferred until their dedicated artwork is supplied. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, the system view must expose inputs, outputs, measured quantity and the consequence of drift without relying on a generic module diagram.

## 4 — Mathematical relationship and reading the symbols

Read aloud : scale factor is the ratio of two values; for similar shapes, characteristic area scales with diameter squared.

Before substituting numbers, write the unit of every term, state whether the relationship is a physical law, approximation or project indicator, and check dimensional consistency. This is especially important here because “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture” combines quantities that do not all have the same evidence status. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, this relationship is chosen because of the phenomenon under study; a different dominant quantity would require a different equation or model.

## 5 — Worked calculations and interpretation

30,000 kg ÷ 1,025 kg ≈ 29.27. The denominator is the published landed Perseverance rover mass; this calculation is not the mass of the complete Mars 2020 EDL chain.

If a hypothetical characteristic diameter changes from 4.52 m to 8.00 m, the ratio is 8.00 ÷ 4.52 ≈ 1.77 and similar-shape area scales as $1.77^2 \approx 3.13$. The 8 m value is a calculation scenario, not an announced NASA concept.

30,000 kg × 0.08 = 2,400 kg. The 8% reserve is an explicitly declared training assumption, not a universal NASA margin.

1. Landed rover mass and 30 t scenario 30,000 kg ÷ 1,025 kg ≈ 29.27. The denominator is the published landed Perseverance rover mass; this calculation is not the mass of the complete Mars 2020 EDL chain. Interpretation: keep flight heritage, geometry and mission assumptions distinct.

2. Geometry — training assumption If a hypothetical characteristic diameter changes from 4.52 m to 8.00 m, the ratio is 8.00 ÷ 4.52 ≈ 1.77 and similar-shape area scales as $1.77^2 \approx 3.13$. The 8 m value is a calculation scenario, not an announced NASA concept. Interpretation: keep flight heritage, geometry and

### Operational table

| | |
|---|---|
| **Phenomena / sections:** | 3 — Course-specific system view ; 4 — Mathematical relationship and reading the symbols ; 5 — Worked calculations and interpretation |
| **Relationship to revisit:** | facteur = valeur_2 / valeur_1 ; A ∝ diamètre² |
| **Expected decision:** | measure → compare with margin → choose nominal, degraded or stop |

### Check before continuing

Explain without rereading: 3 — Course-specific system view ; 4 — Mathematical relationship and reading the symbols ; 5 — Worked calculations and interpretation. State one measured quantity, one margin and one possible decision.

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3. Mass reserve — scenario 30,000 kg × 0.08 = 2,400 kg. The 8% reserve is an explicitly declared training assumption, not a universal NASA margin. Interpretation: keep flight heritage, geometry and mission assumptions distinct.

## 6 — What the formula does not contain

The relationship “facteur = valeur_2 / valeur_1 ; A ∝ diamètre²” does not by itself contain all of “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”. It does not automatically tell us whether a sensor is valid, a structure is aging, a resource is accessible, a command arrives in time or a secondary failure removes margin. The calculation 30,000 kg ÷ 1,025 kg ≈ 29.27 explicitly compares a 30 t landed-payload scenario with the landed Perseverance rover mass; it does not compare two complete EDL systems.

To make the model useful, explicitly add the quantities that dominate this subject: velocity, kinetic energy, altitude, deceleration and state of each EDL event. We can then ask which variation truly changes the result, which is negligible and which forces an architectural change. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, this model limitation states exactly what a correct calculation still cannot establish about the real system.

## 7 — Instrumentation, observability and data quality

For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, observability relies on velocity, kinetic energy, altitude, deceleration and state of each EDL event. Each datum has a unit, acquisition rate, uncertainty, timestamp and validity domain. A value arriving without context can be more dangerous than no measurement because it creates unjustified confidence.

Consistency is checked with at least one independent piece of information when the function is critical. A trend, physical balance or second measurement principle helps distinguish a real system change from a drifting sensor. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, the selected instrumentation must distinguish a real physical change from sensor drift or a bad state estimate.

## 8 — Phenomenon-specific failures and recovery

The reference failure is not a vague “broken component.” For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, test in particular a bad state estimate, an event triggered outside its window or insufficient braking reserve. Diagnosis asks which symptoms appear first, which are only consequences and which action preserves the most options.

The degraded mode must be defined before failure: minimum function, allowable duration, consumed stock,

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## 9 — NASA / reference case

The scale comparison is now labelled correctly: the published mass of about 1,025 kg refers to the landed Perseverance rover, not the complete Mars 2020 EDL stack. Human studies discuss landed payloads around 20 tonnes or more depending on concept; they do not define one universal “NASA future lander”.

The case is used only within what it actually demonstrates. Flight measurement, human-system standard, component test and architecture study are different kinds of evidence; the text therefore states what is observed, calculated, simulated or still prospective. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, the cited NASA case is used as targeted evidence for this phenomenon and is never turned into one universal Mars architecture.

## 10 — Architecture trade

The scaling trade cannot be reduced to one diameter. A larger vehicle simultaneously changes aerodynamic area, protection mass, stiffness, propulsion, control, landing-zone needs and plume interaction; every dimension must therefore be tied to a study or explicitly marked as a scenario.

The trade is recorded together with its assumptions. If environment data, mass or mission cadence changes, we know which conclusions must be recomputed instead of silently preserving an obsolete choice. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, the trade is evaluated against the interfaces actually touched by this subject rather than a generic list of desirable qualities.

## 11 — Demonstration, testing and success criteria

The evidence strategy for “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture” combines six-degree-of-freedom simulation, dispersion Monte Carlo and sequence rehearsal with injected faults. Every test records exact hardware, software, configuration, environment, tolerances and success criterion. A successful demonstration outside the mission domain does not replace qualification inside it.

Evidence grows by levels: analytical relationship, simulation, component, subsystem, integrated system, duration and failure. This hierarchy prevents one spectacular test from being presented as validation of the whole mission. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, demonstration must reproduce the constraints that make this phenomenon difficult; a spectacular test outside the mission domain is insufficient.

## 12 — Decision exercise

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| | |
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### Check before continuing

Explain without rereading: 9 — NASA / reference case ; 10 — Architecture trade ; 11 — Demonstration, testing and success criteria. State one measured quantity, one margin and one possible decision.

**Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture**

Situation: revisit “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture” with a 20% increase in the most penalizing quantity from the first worked example while one measurement or backup path is unavailable.

Situation: revisit “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture” with a 20% increase in the most penalizing quantity from the first worked example while one measurement or backup path is unavailable. Expected answer: recompute the relationship, identify remaining margin, check whether observability is still adequate, and decide whether degraded operation remains acceptable. Multiplying by 1.2 is not enough if the variation also changes interfaces or limits.

## 13 — What to retain without over-generalizing

## 14 — Topic-specific primary sources

These references directly document the phenomenon, technology or human constraint addressed in this lesson. They do not by themselves define an official Mars architecture. For “Heavy human EDL: why moving from 1 tonne to more than 20 tonnes changes the architecture”, the bibliography is deliberately targeted to this page so that readers can trace each claim back to the relevant primary document.

## Topic-specific primary sources

NASA NTRS — Human Mars Entry, Descent, and Landing Architecture Study - https://ntrs.nasa.gov/citations/20160011571

NASA NTRS — Mid Lift-to-Drag Ratio Vehicle Performance for Human Mars EDL - https://ntrs.nasa.gov/citations/20200000240

NASA NTRS — A Rigid Mid-Lift-to-Drag Ratio Approach to Human Mars EDL - https://ntrs.nasa.gov/citations/20160014035

JPL — Mars 2020 Launch Quick Facts - https://www.jpl.nasa.gov/news/press_kits/mars_2020/launch/quick_facts/

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Explain without rereading: 13 — What to retain without over-generalizing ; 14 — Topic-specific primary sources ; Topic-specific primary sources. State one measured quantity, one margin and one possible decision.