

CODY HILL | APRIL, 2024

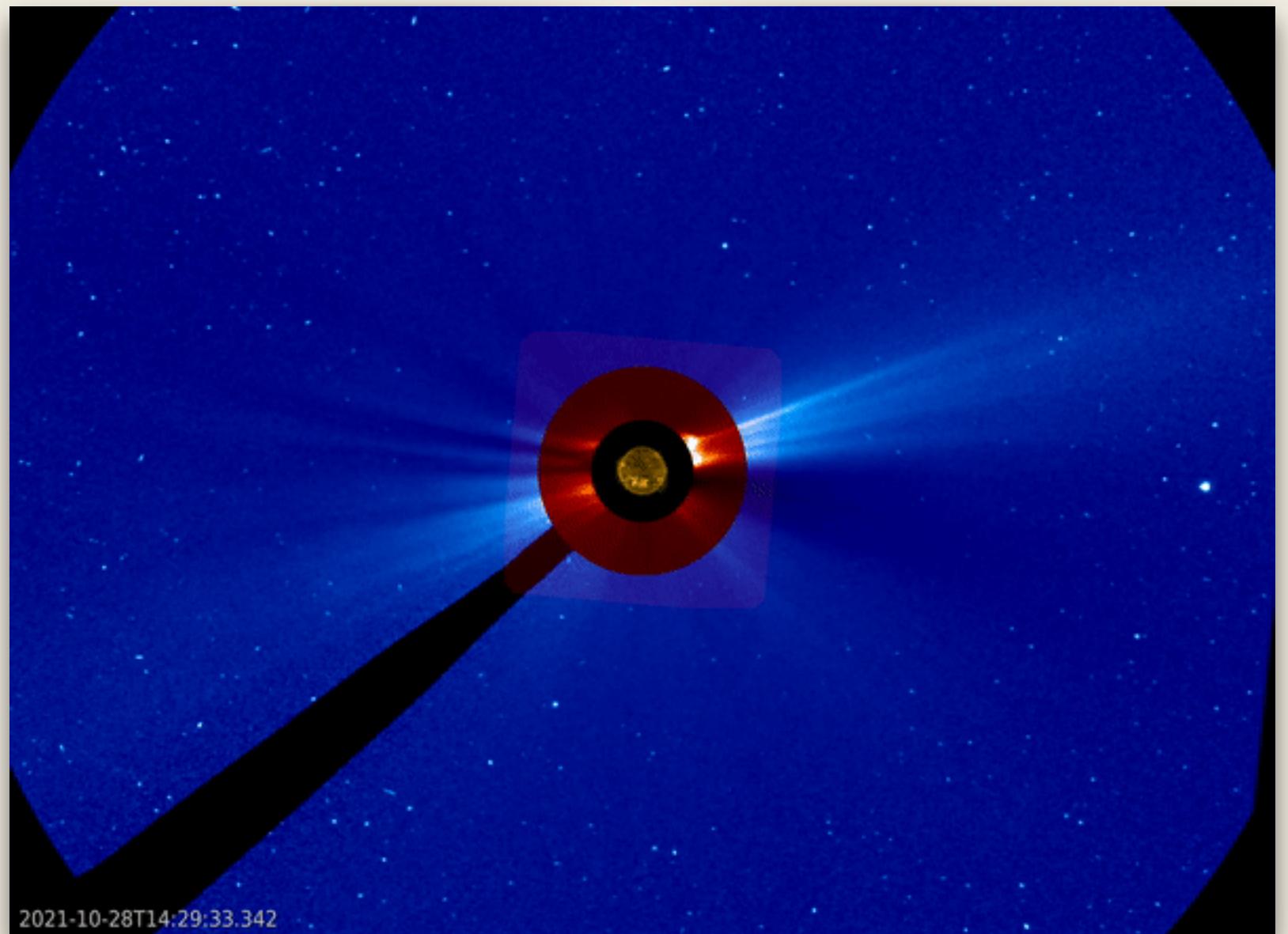
# NASA Astronaut and Mission Database

The Process of Relational Database Design

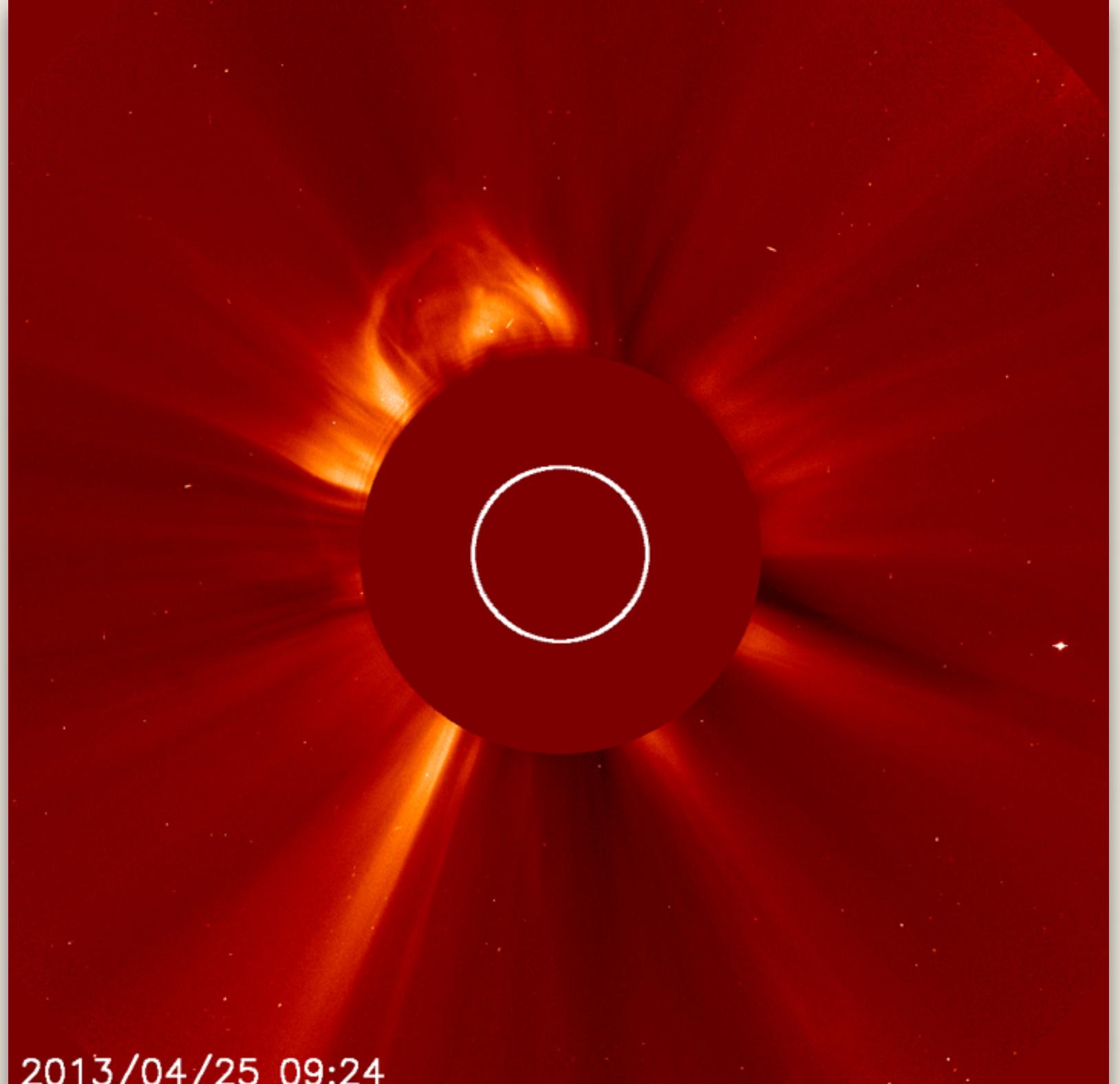
*With the predicted increase in solar activity this year, NASA is building contingency plans for all of their systems. An unfortunately timed coronal mass ejection (CME), that is aimed at Earth, with total ejected mass equal to or greater than the Carrington Event in 1859 has potential to devastate unprotected power transmission, communications, and electronics systems globally in a way we haven't seen since the adoption of modern technologies.*

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NASA has put out a contract to design a replacement database that stores all their previous and upcoming mission information. This database would include information on **Astronauts**, **Missions**, **Training**, **Rockets**, **Spacecraft**, and daily information about the **International Space Station (ISS)**.



2021-10-28T14:29:33.342



2013/04/25 09:24

# Building an Entity Relationship Model

## Entities:

- **Astronauts:** \*EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality
- **ISS:** \*Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitallInclination, OrbitalPeriod, SpacecraftDocked
- **Spacecraft:** \*CosparID, \*Callsign, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitallInclination, OrbitalPeriod
- **Rockets:** \*LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor
- **Missions:** \*MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew
- **Training:** \*TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission

*Note: An asterisk (\*) denotes a primary key or candidate key of the entity.*

# Building an Entity Relationship Model

## Entities:

- **Astronauts**
- **ISS**
- **Spacecraft**
- **Rockets**
- **Missions**
- **Training**

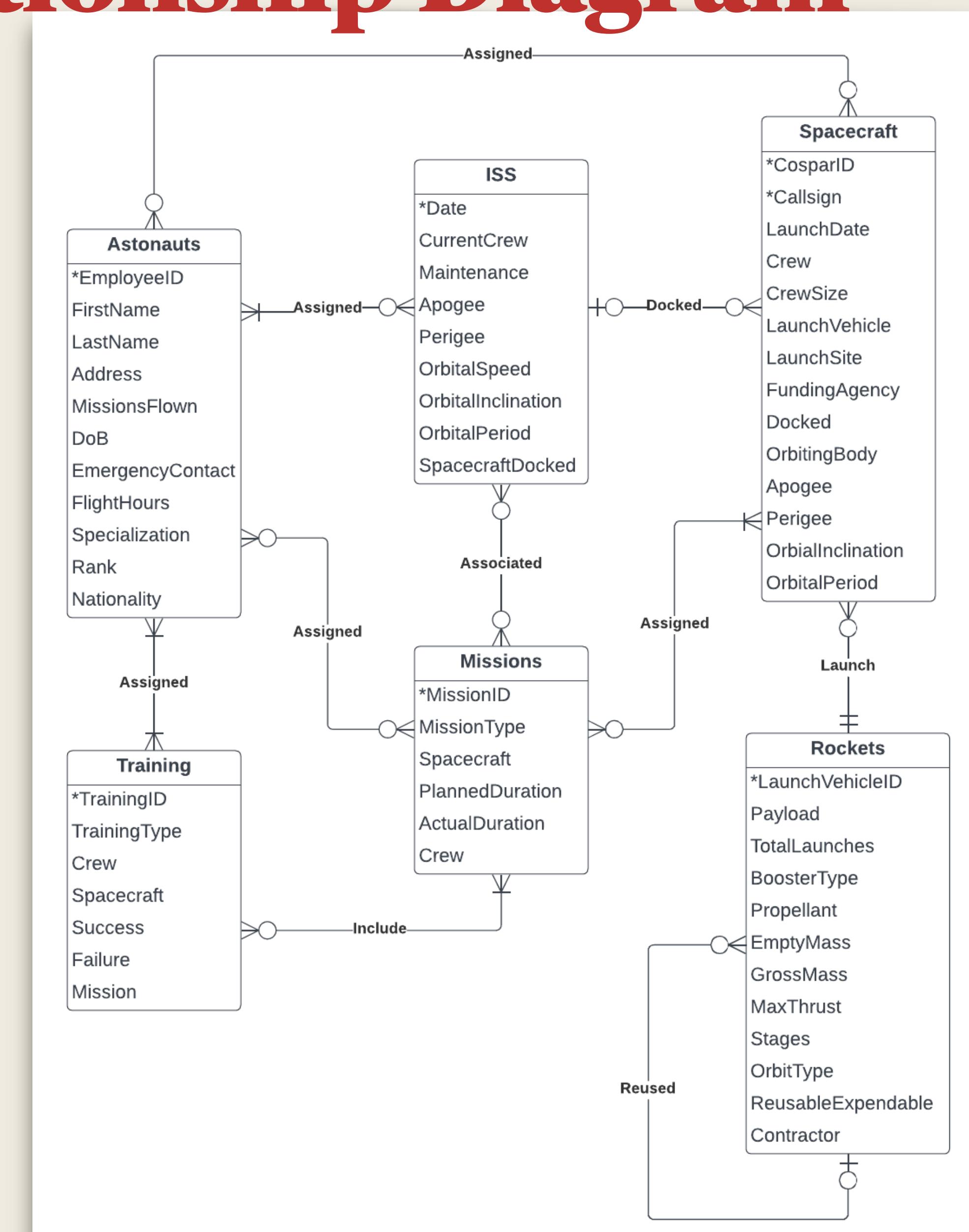
## Relationships:

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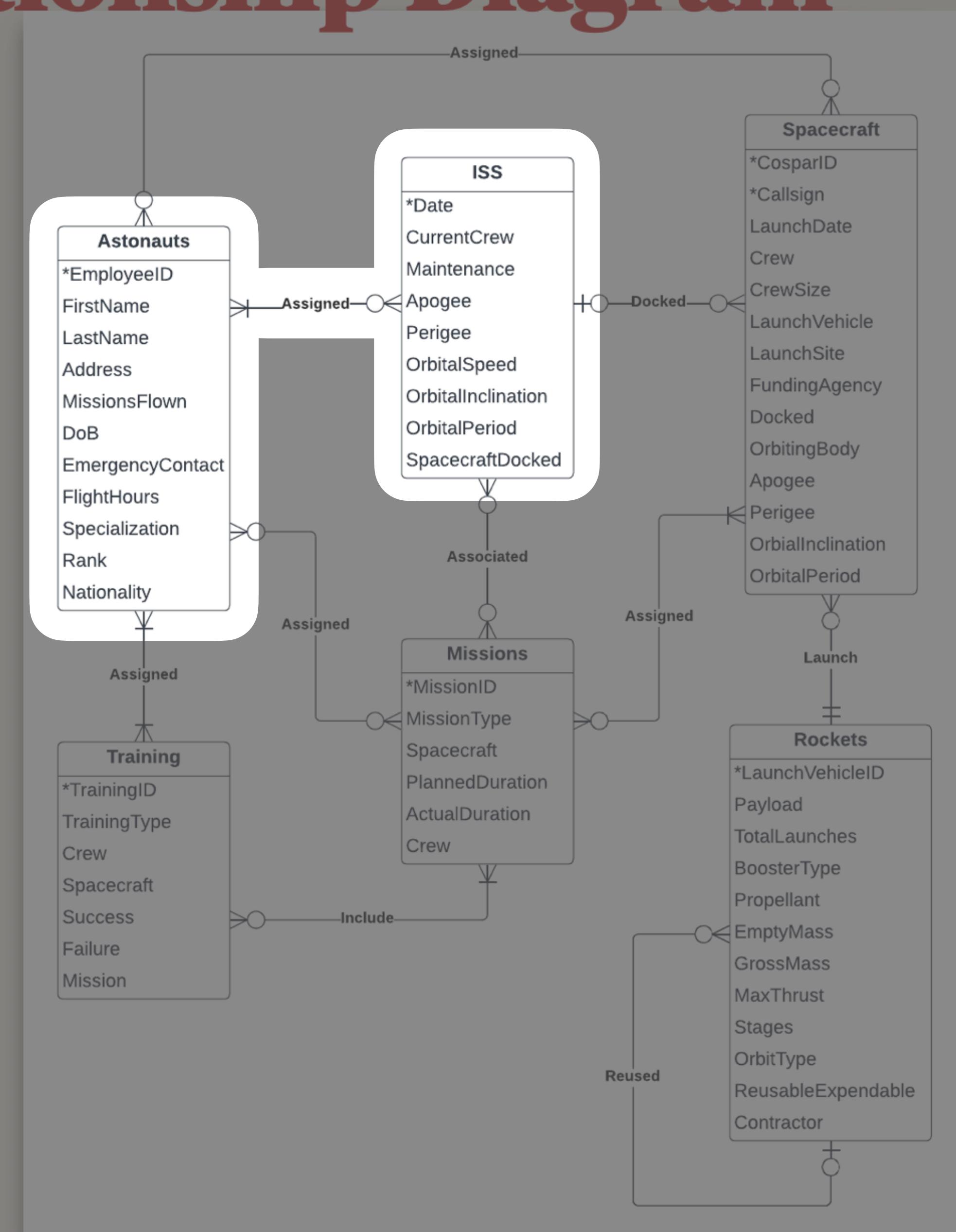
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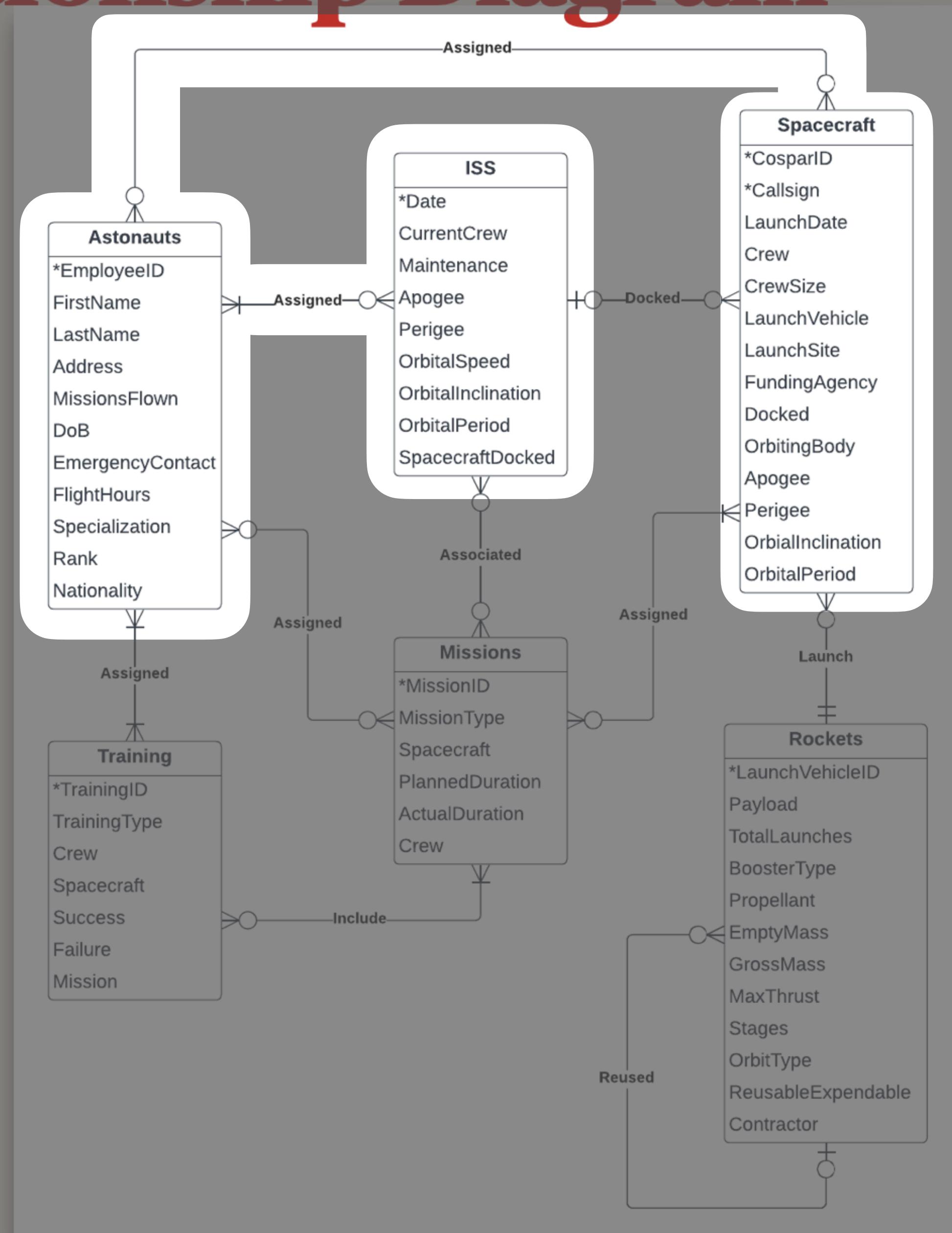
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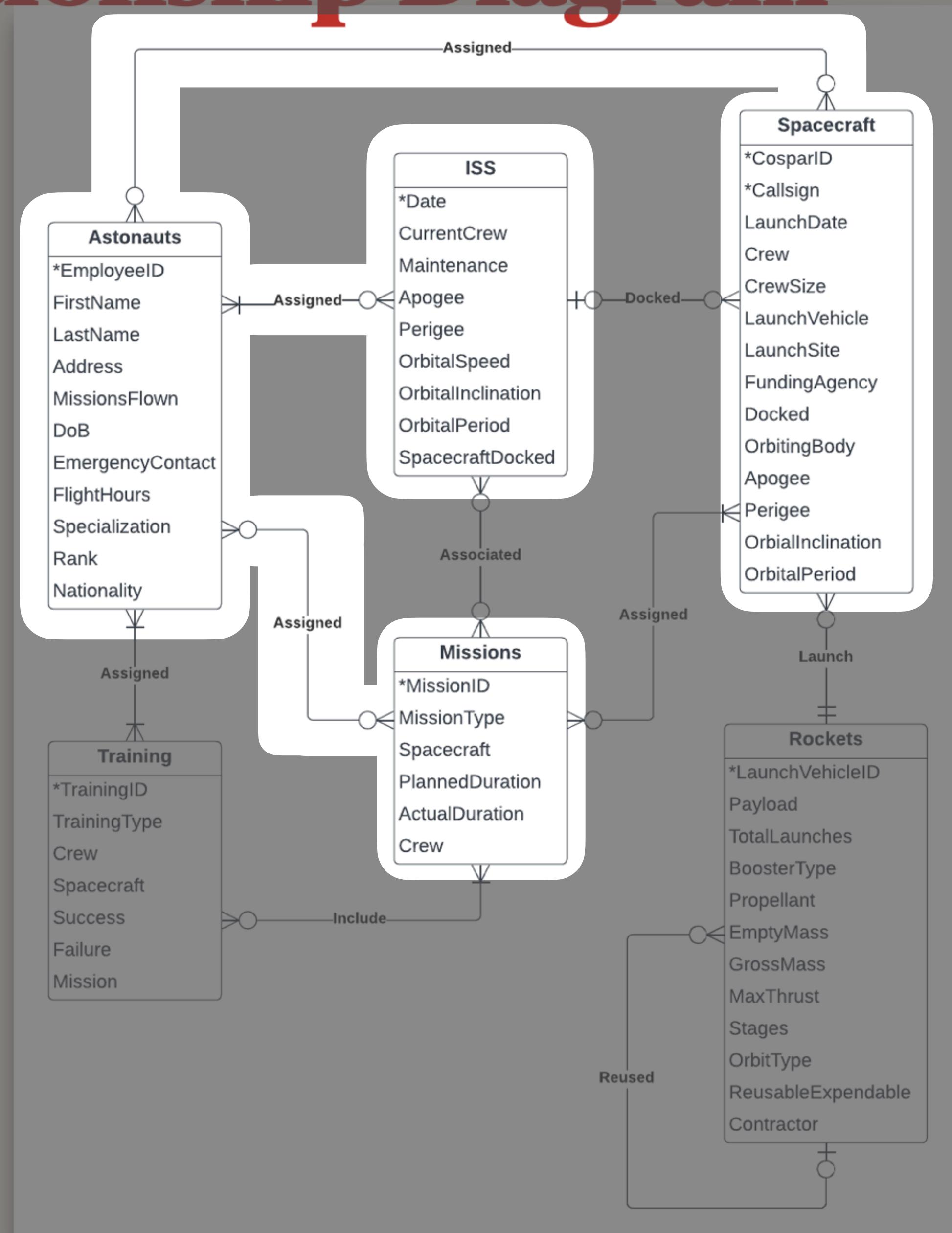
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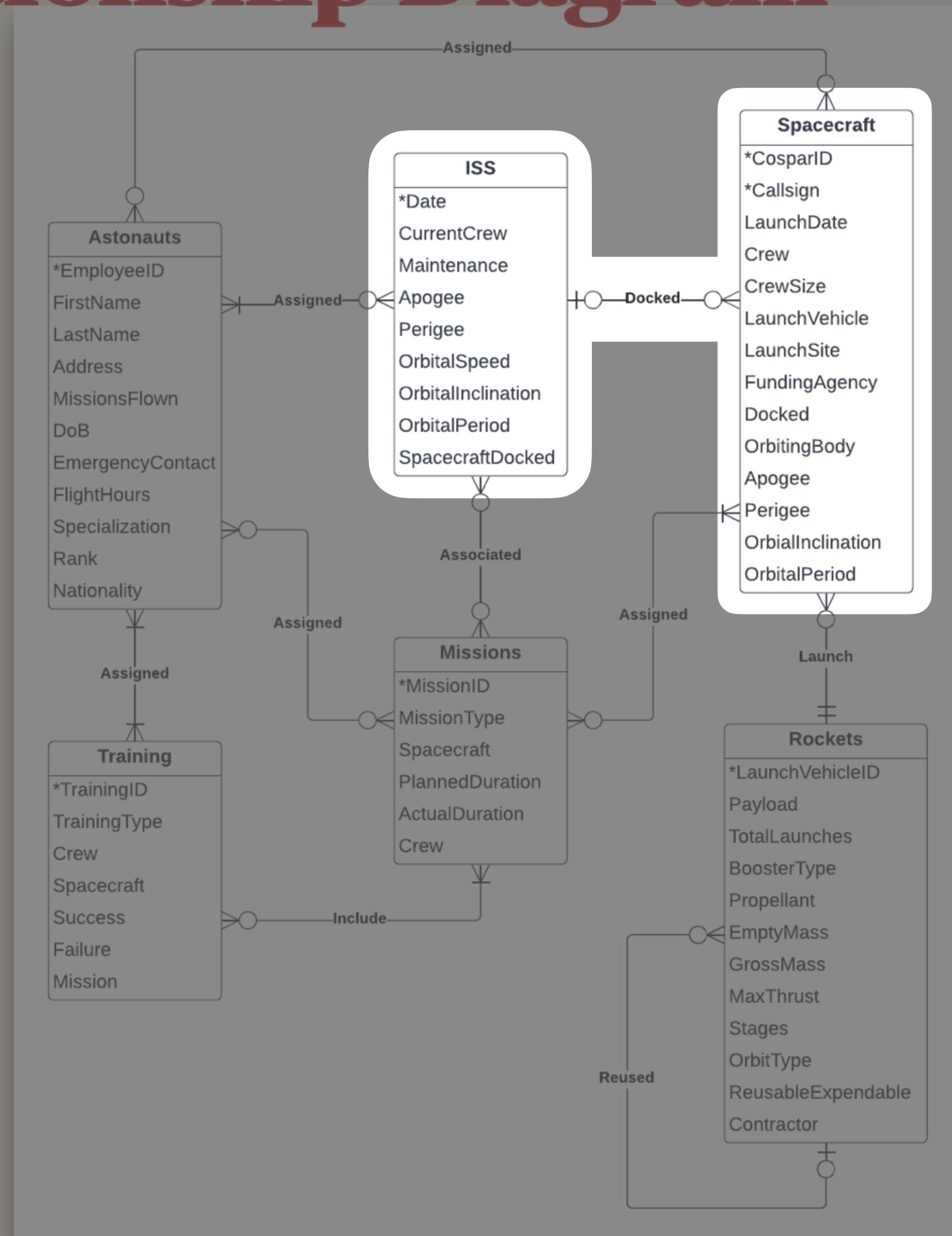
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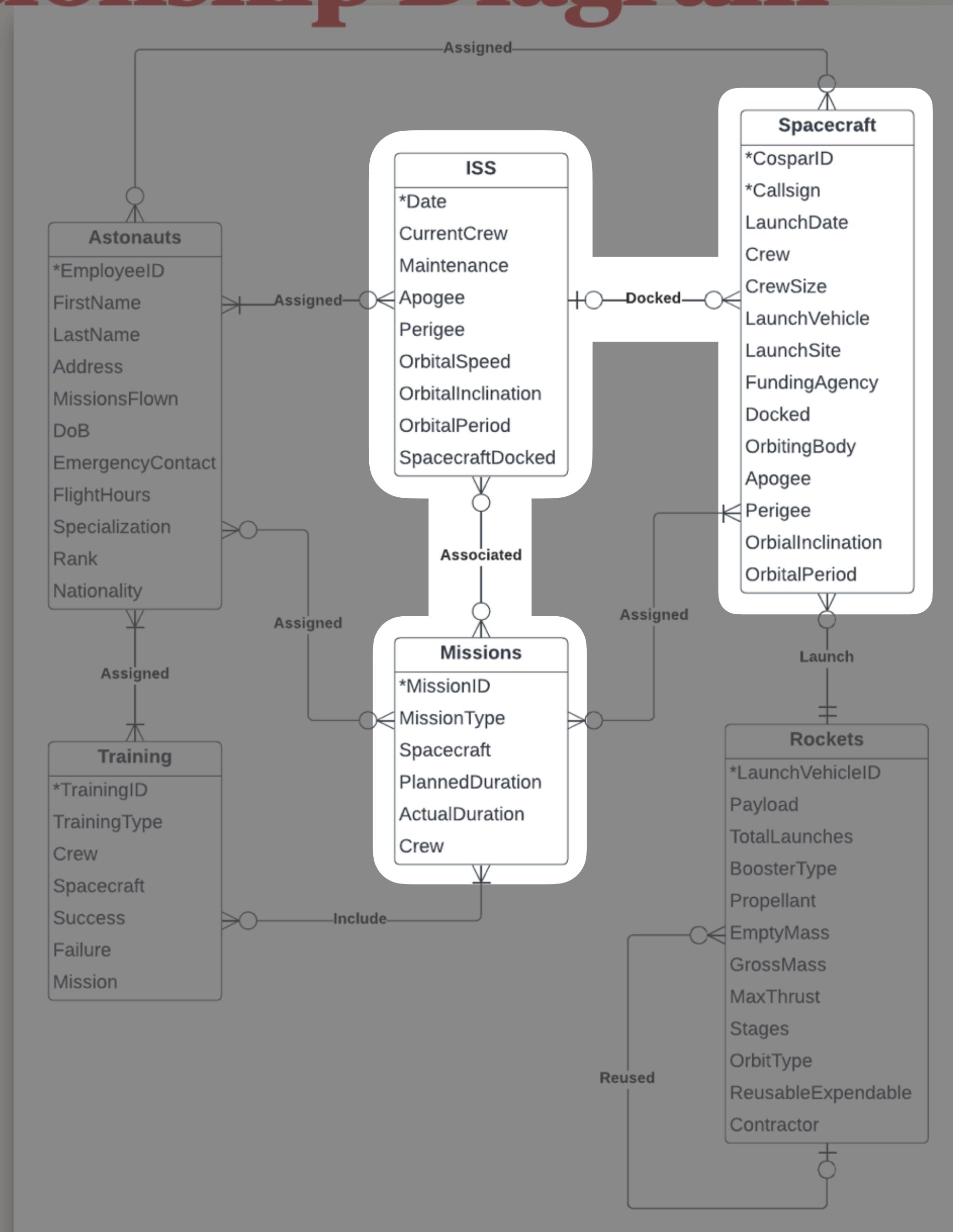
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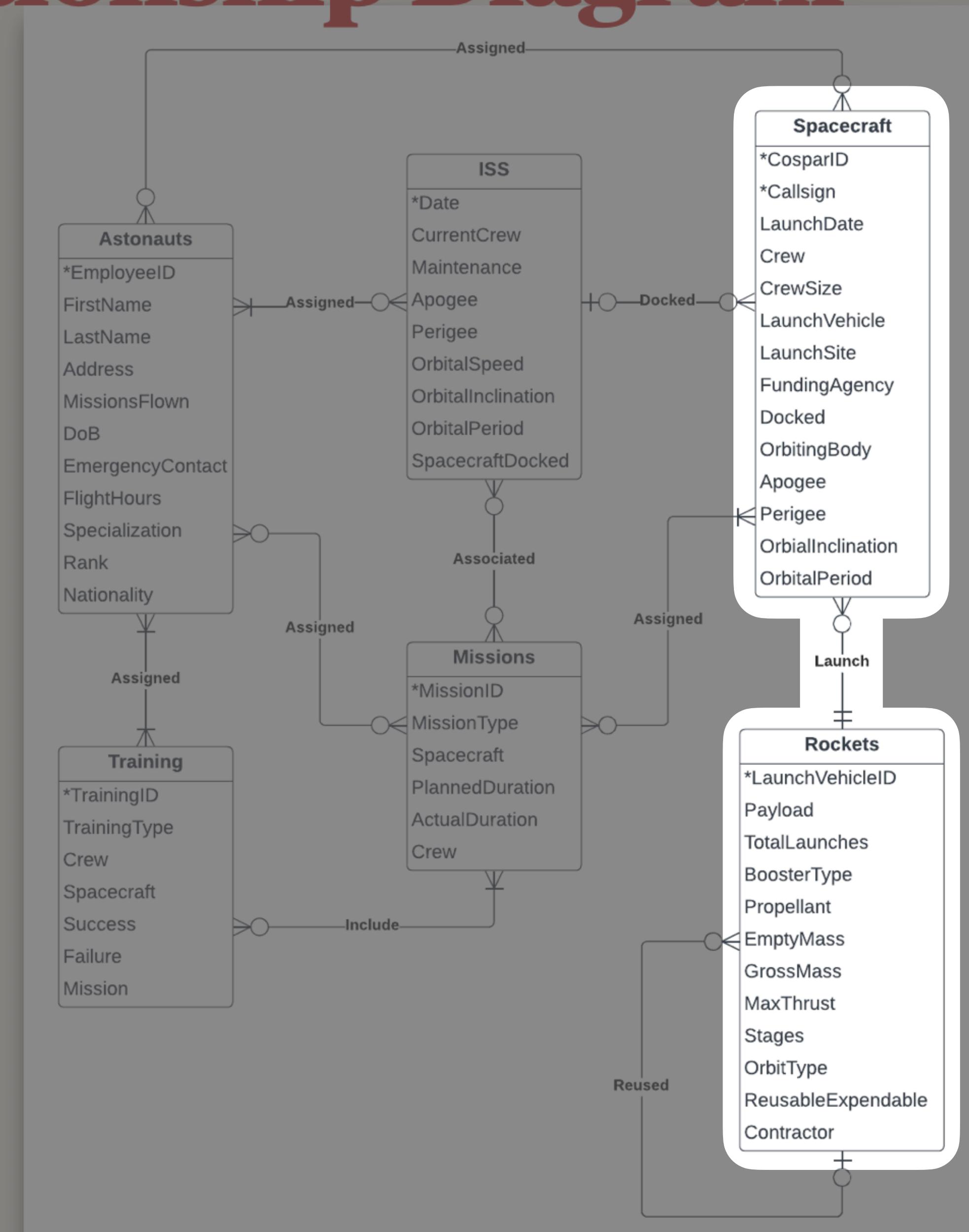
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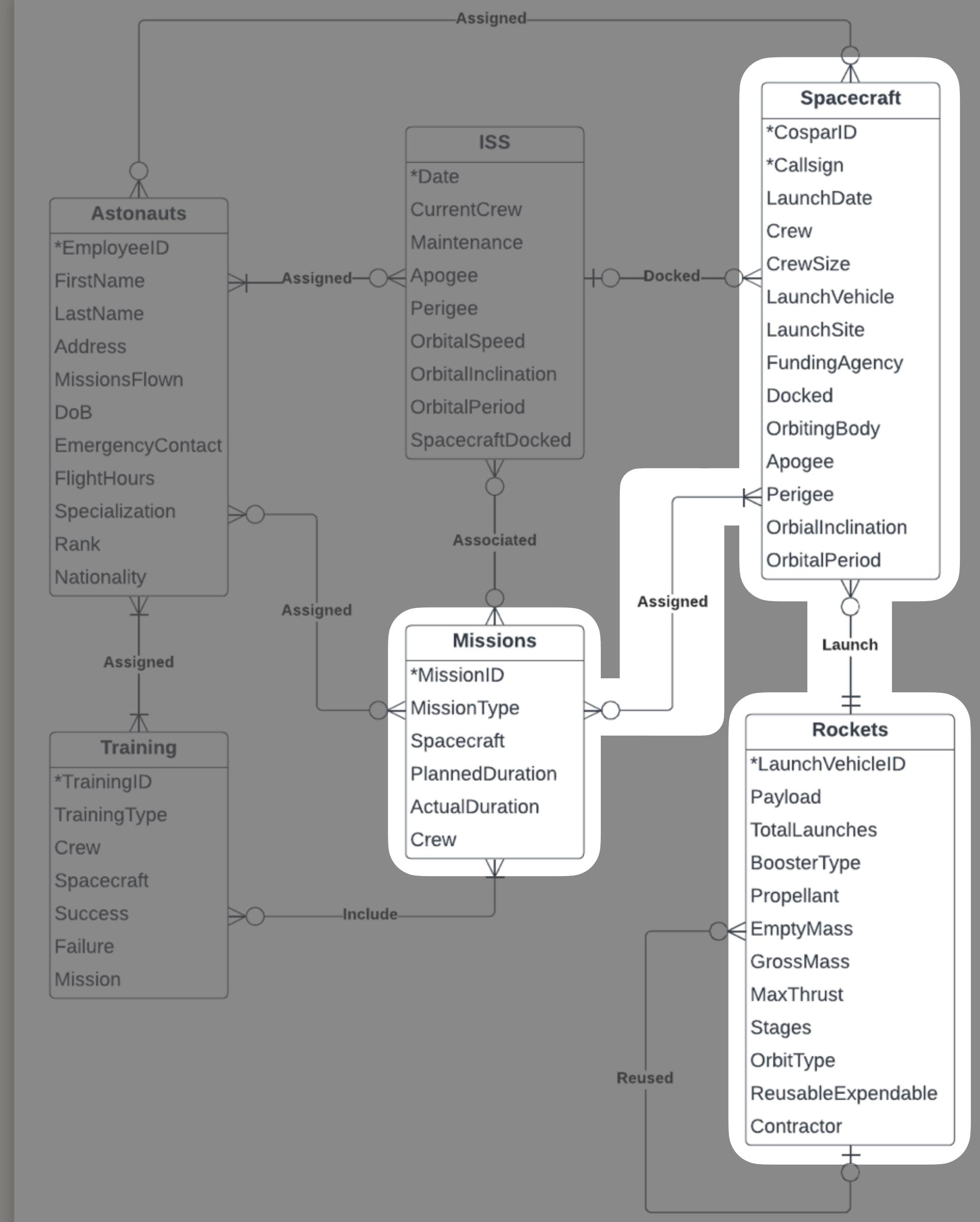
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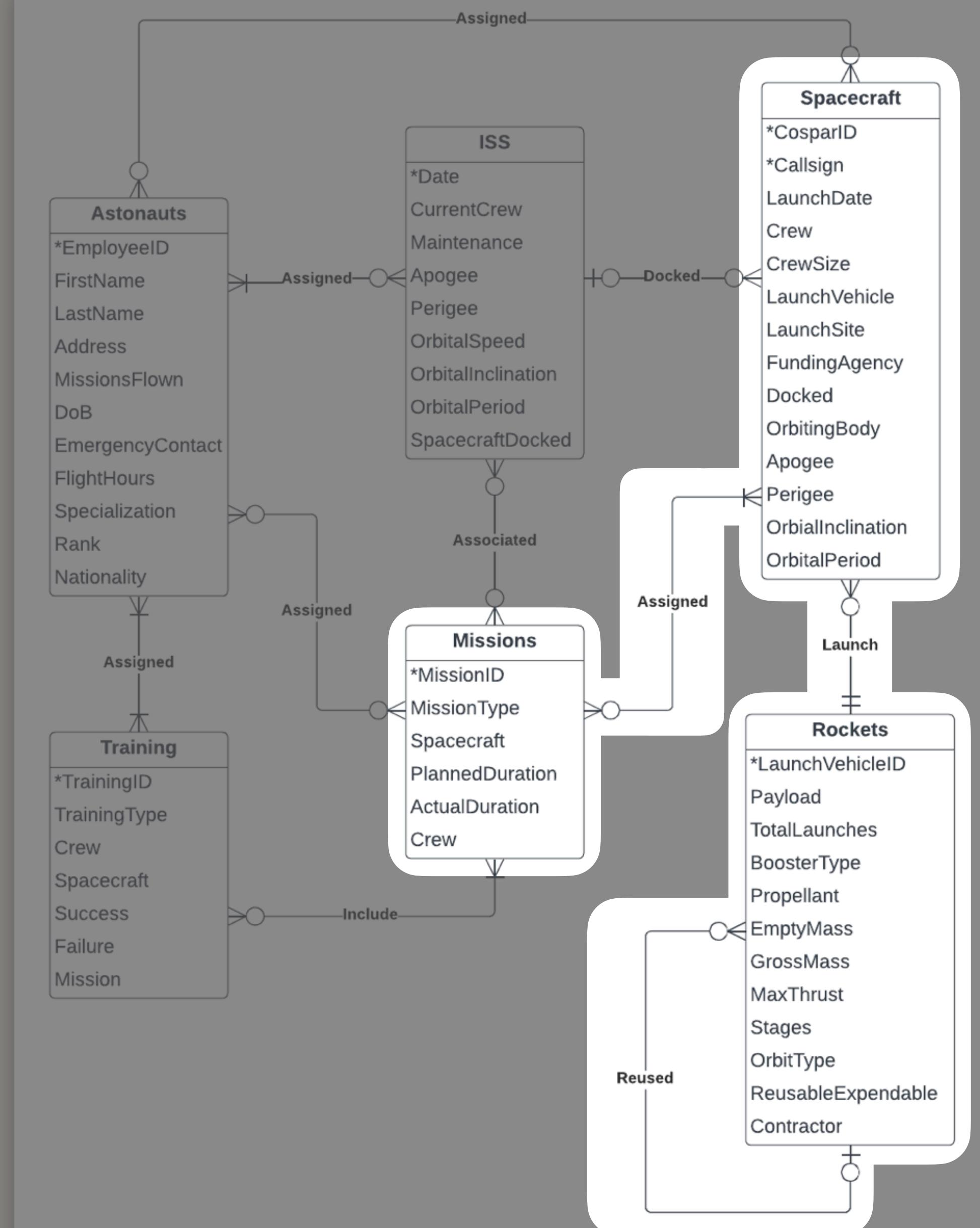
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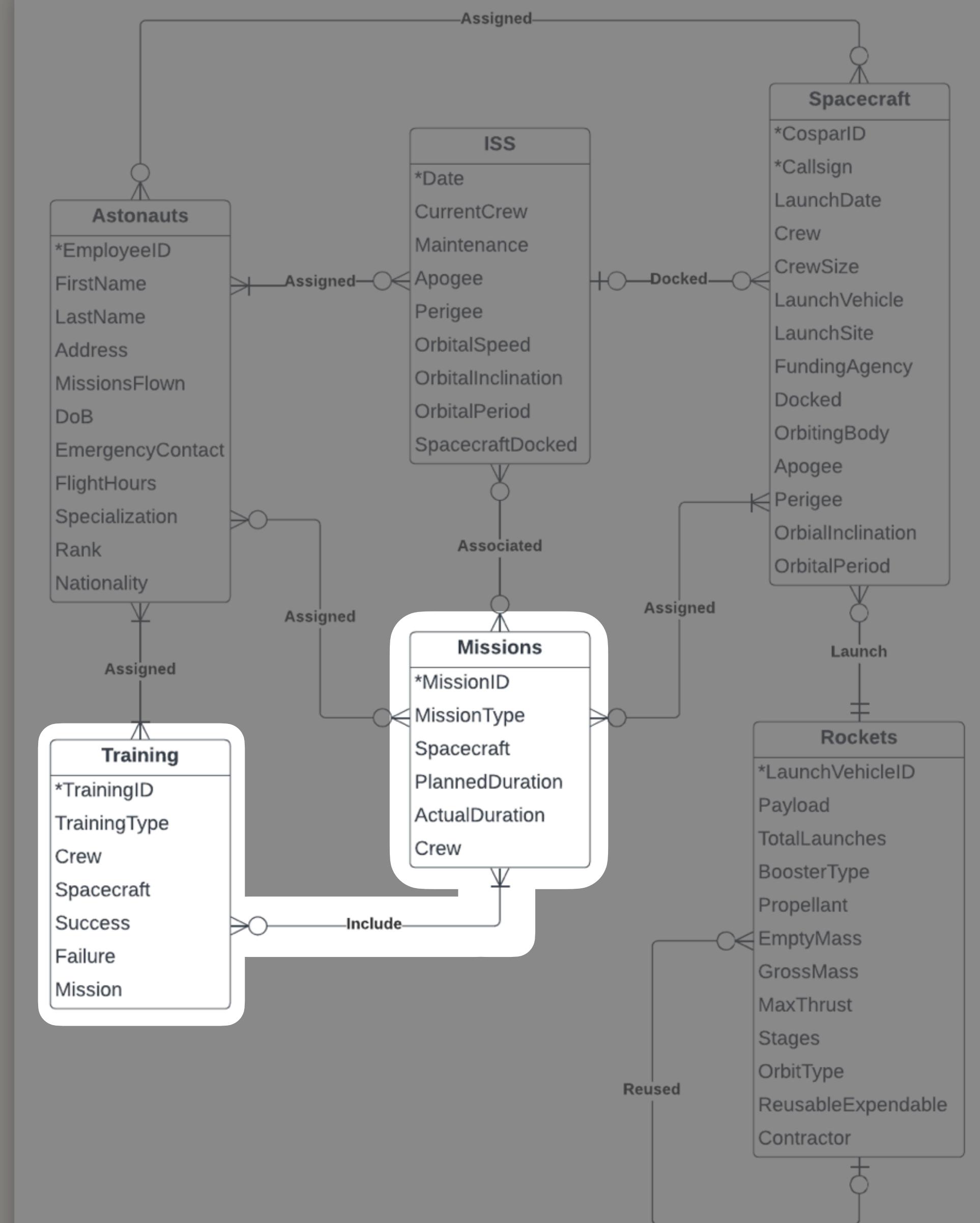
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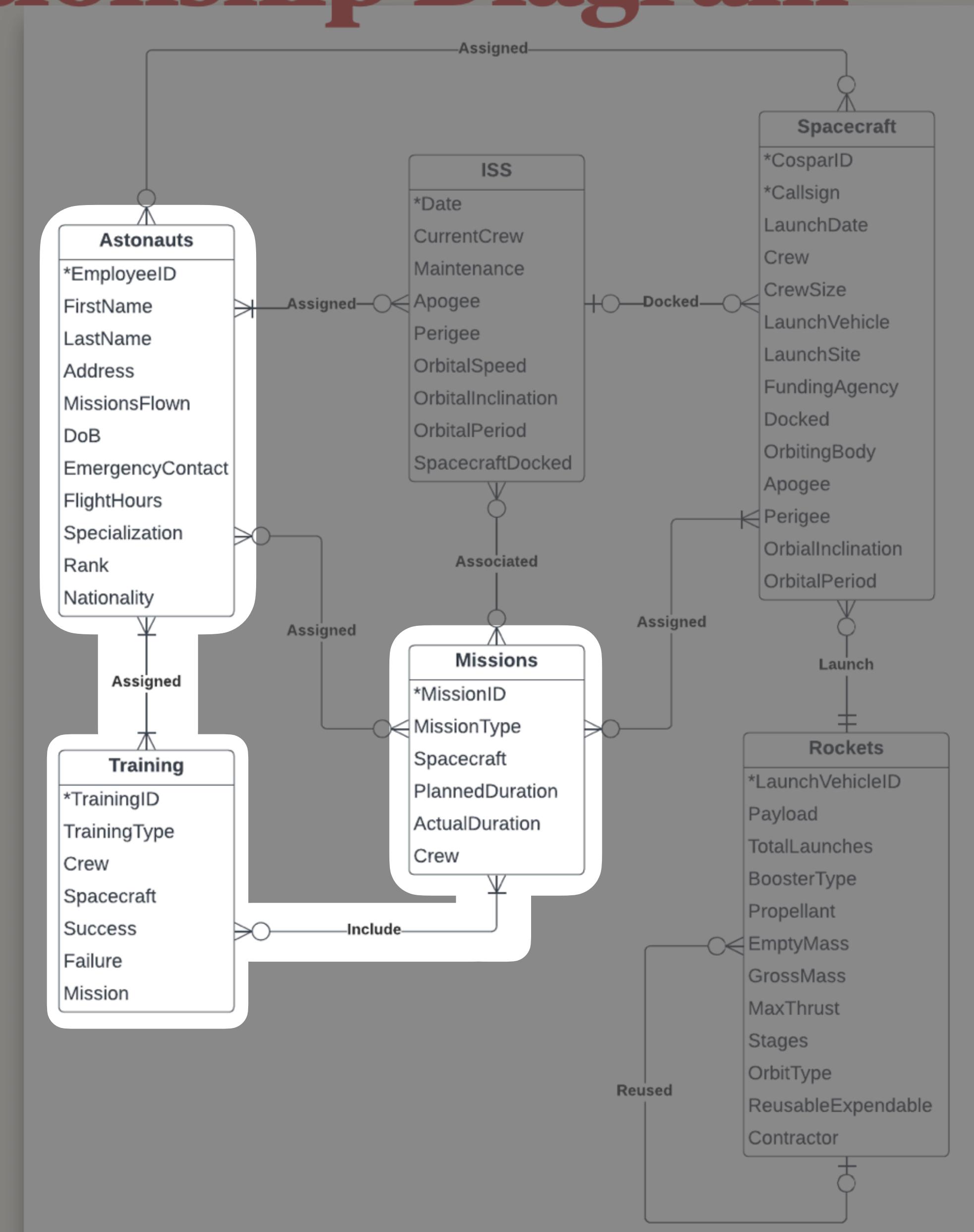
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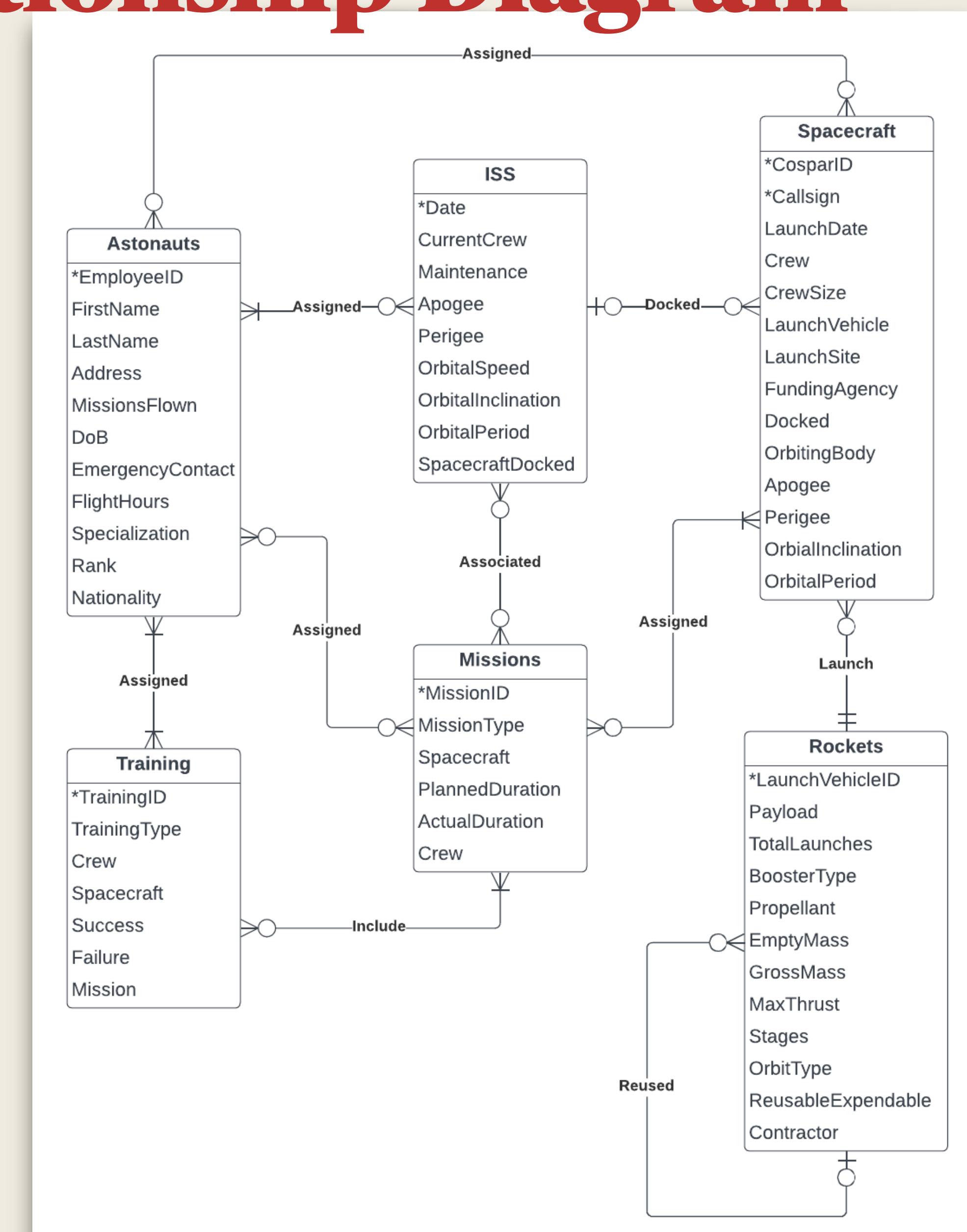
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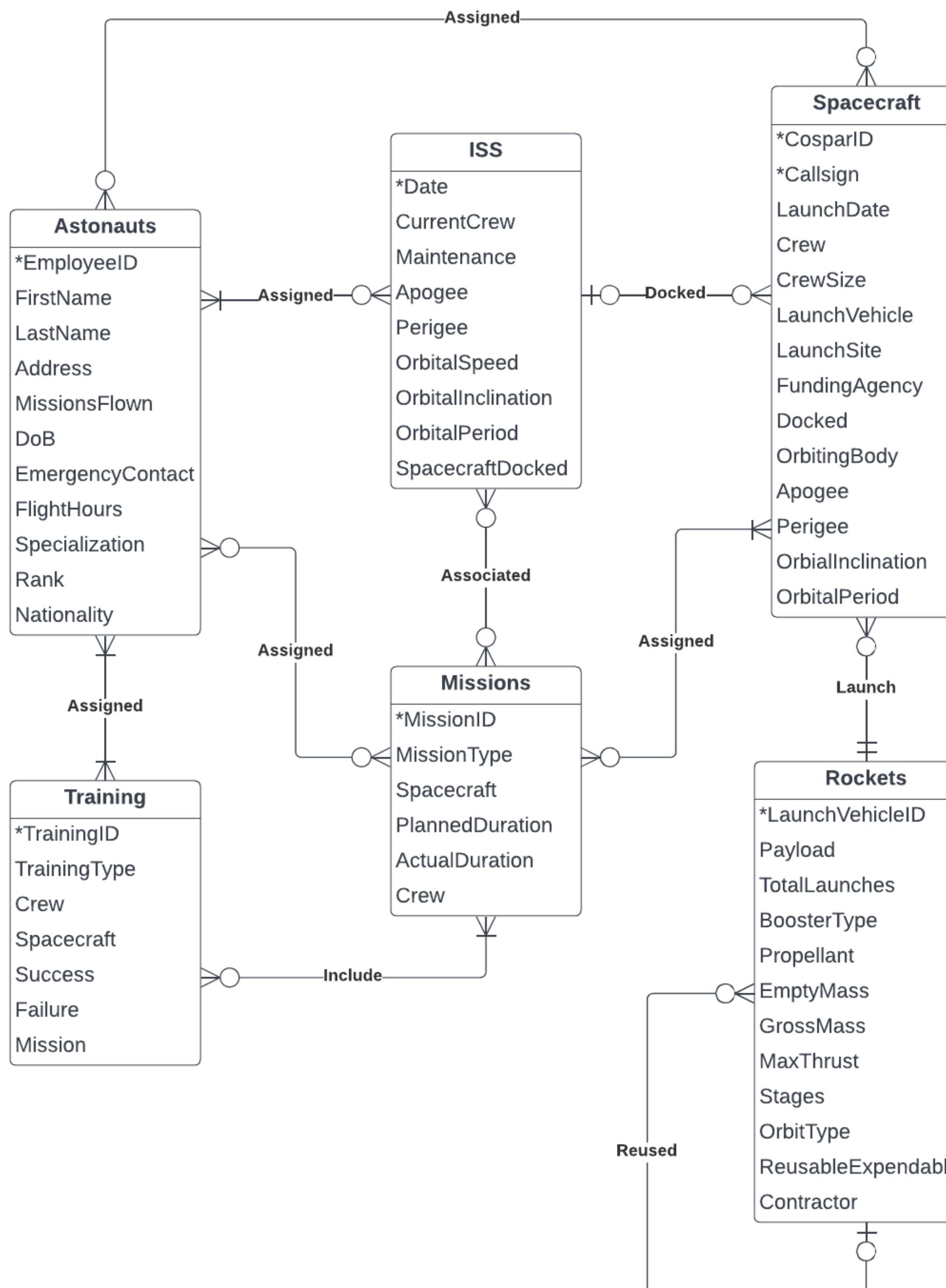
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# Converting to | Relational Model



## Relations:

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

**Spacecraft\_Crew** (EmployeeID(fk), CosparID(fk))

**Astronaut\_Training** (EmployeeID(fk), TrainingID(fk))

**ISS\_Crew** (EmployeeID(fk), Date(fk))

**Assigned\_Missions** (EmployeeID(fk), MissionID(fk))

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

**ISS\_Missions** (Date(fk), MissionID(fk))

**Spacecraft** (CosparID, Callsign, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

**Spacecraft\_Missions** (CosparID(fk), MissionID(fk))

**Spacecraft\_Rocket** (CosparID(fk), LaunchVehicleID(fk))

**Rocket** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

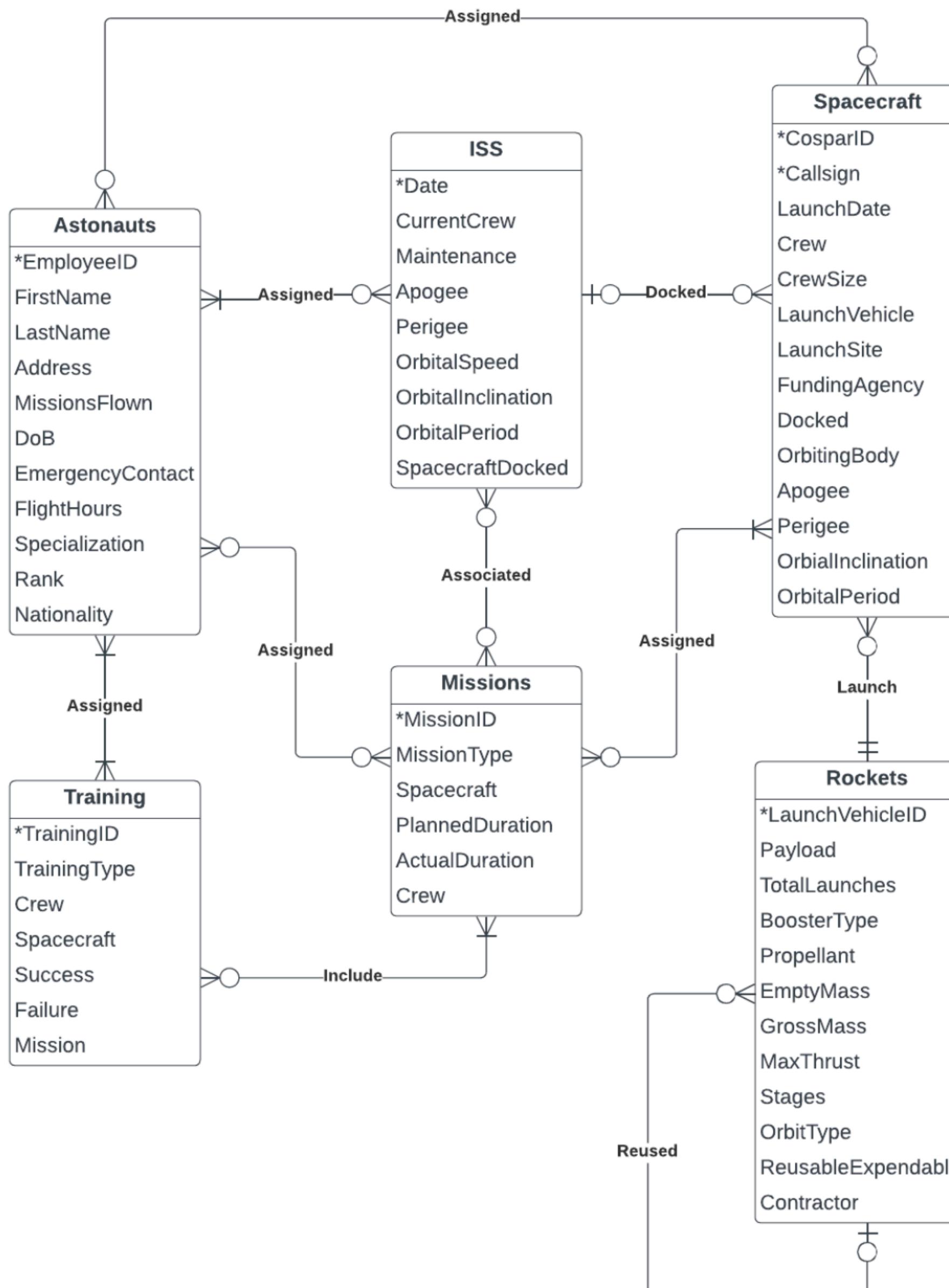
**Mission** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

**Training\_Missions** (MissionID(fk), TrainingID(fk))

Note: Underline and **Bold** denotes a primary key or candidate key of the relation, and (fk) denotes a foreign key.

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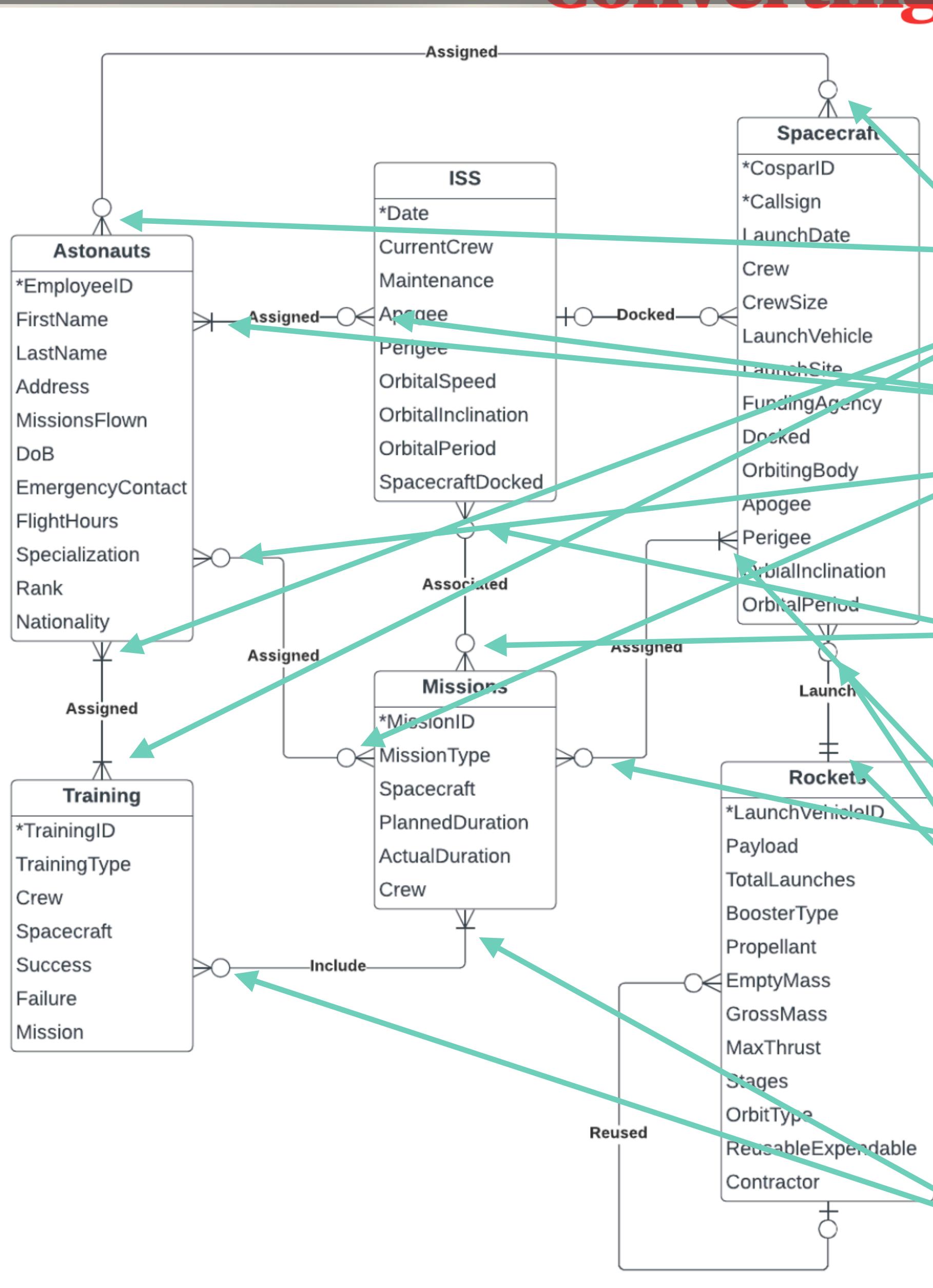
**Mission** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

**Training\_Missions** (MissionID(fk), TrainingID(fk))

Note: Underline and **Bold** denotes a primary key or candidate key of the relation, and (fk) denotes a foreign key.

# Converting to | Relational Model



Relations:

Two-Sided One or More Relationships

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

**Spacecraft\_Crew** (EmployeeID(fk), CosparID(fk))

**Astronaut\_Training** (EmployeeID(fk), TrainingID(fk))

**ISS\_Crew** (EmployeeID(fk), Date(fk))

**Assigned\_Missions** (EmployeeID(fk), MissionID(fk))

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

**ISS\_Missions** (Date(fk), MissionID(fk))

**Spacecraft** (CosparID, Callsign, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

**Spacecraft\_Missions** (CosparID(fk), MissionID(fk))

**Spacecraft\_Rocket** (CosparID(fk), LaunchVehicleID(fk))

**Rocket** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

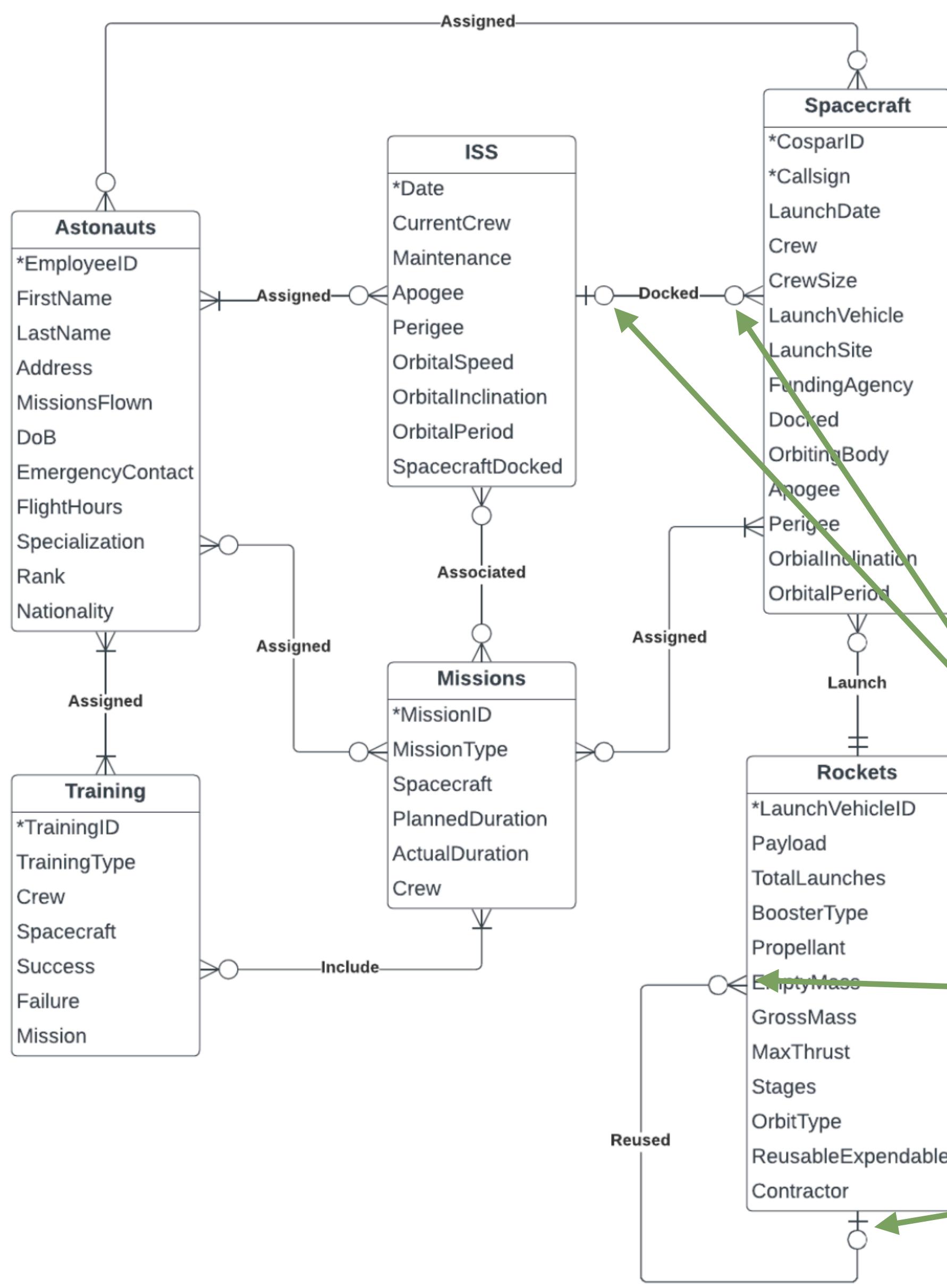
**Mission** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

**Training\_Missions** (MissionID(fk), TrainingID(fk))

Note: Underline and **Bold** denotes a primary key or candidate key of the relation, and (fk) denotes a foreign key.

# Converting to | Relational Model



Relations: **One-Sided One or More Relationships**

**Astronauts** (**EmployeeID**, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

**Spacecraft\_Crew** (**EmployeeID(fk)**, **CosparID(fk)**)

**Astronaut\_Training** (**EmployeeID(fk)**, **TrainingID(fk)**)

**ISS\_Crew** (**EmployeeID(fk)**, **Date(fk)**)

**Assigned\_Missions** (**EmployeeID(fk)**, **MissionID(fk)**)

**ISS** (**Date**, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

**ISS\_Missions** (**Date(fk)**, **MissionID(fk)**)

**Spacecraft** (**CosparID**, **Callsign**, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, **DockedDate(fk)**)

**Spacecraft\_Missions** (**CosparID(fk)**, **MissionID(fk)**)

**Spacecraft\_Rocket** (**CosparID(fk)**, **LaunchVehicleID(fk)**)

**Rocket** (**LaunchVehicleID**, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, **ReusableLaunchVehicleID(fk)**)

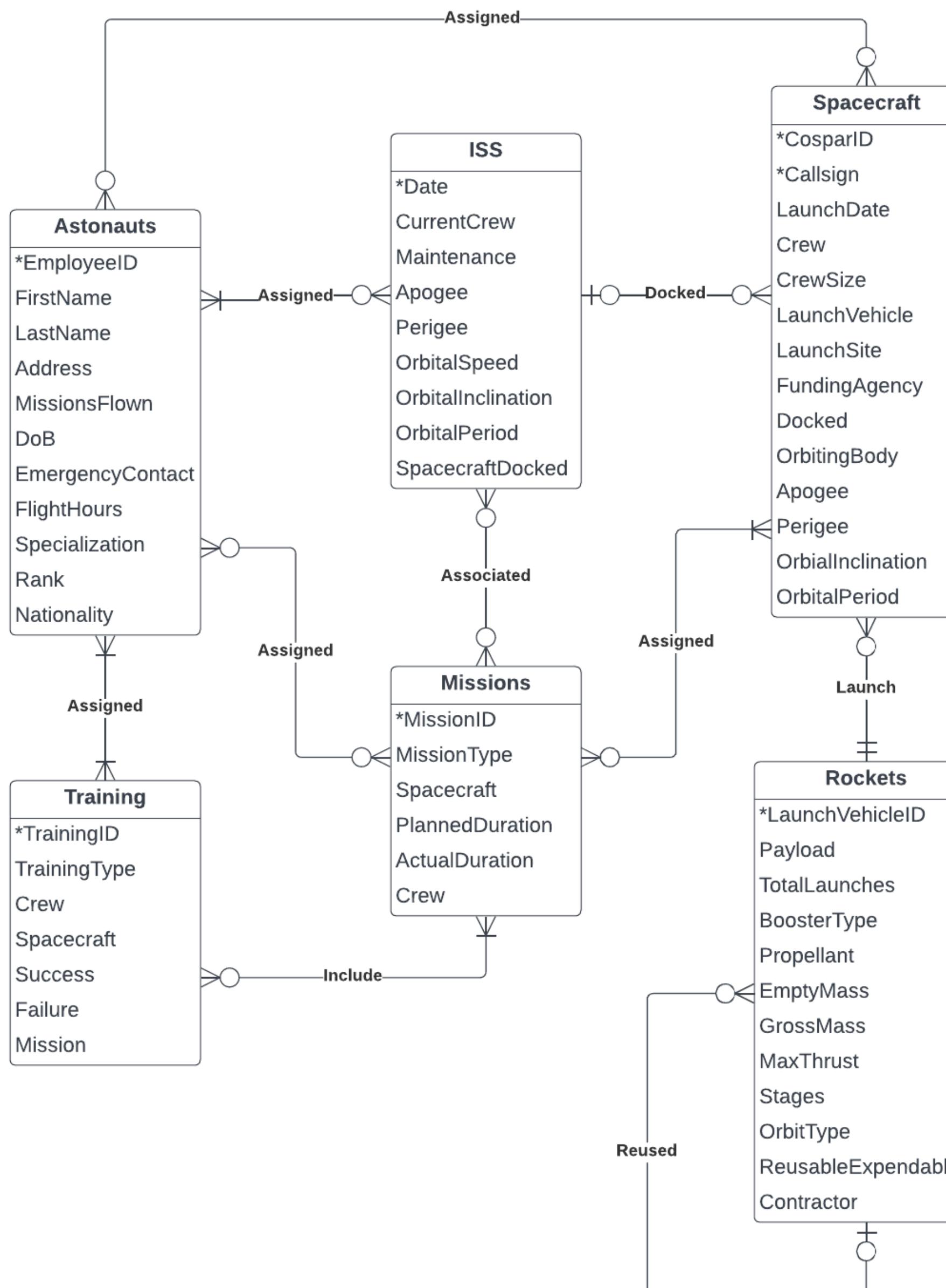
**Mission** (**MissionID**, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

**Training** (**TrainingID**, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

**Training\_Missions** (**MissionID(fk)**, **TrainingID(fk)**)

Note: **Underline** and **Bold** denotes a primary key or candidate key of the relation, and **(fk)** denotes a foreign key.

# Converting to | Relational Model



## Relations:

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

**Spacecraft\_Crew** (EmployeeID(fk), CosparID(fk))

**Astronaut\_Training** (EmployeeID(fk), TrainingID(fk))

**ISS\_Crew** (EmployeeID(fk), Date(fk))

**Assigned\_Missions** (EmployeeID(fk), MissionID(fk))

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

**ISS\_Missions** (Date(fk), MissionID(fk))

**Spacecraft** (CosparID, Callsign, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

**Spacecraft\_Missions** (CosparID(fk), MissionID(fk))

**Spacecraft\_Rocket** (CosparID(fk), LaunchVehicleID(fk))

**Rocket** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

**Mission** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

**Training\_Missions** (MissionID(fk), TrainingID(fk))

Note: Underline and **Bold** denotes a primary key or candidate key of the relation, and (fk) denotes a foreign key.

# Normalize | Relational Model | Functional Dependencies

## Relations:

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

**Spacecraft\_Crew** (EmployeeID(fk), CosparID(fk))

**Astronaut\_Training** (EmployeeID(fk), TrainingID(fk))

**ISS\_Crew** (EmployeeID(fk), Date(fk))

**Assigned\_Missions** (EmployeeID(fk), MissionID(fk))

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

**ISS\_Missions** (Date(fk), MissionID(fk))

**Spacecraft** (CosparID, Callsign, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

**Spacecraft\_Missions** (CosparID(fk), MissionID(fk))

**Spacecraft\_Rocket** (CosparID(fk), LaunchVehicleID(fk))

**Rocket** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

**Mission** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

**Training\_Missions** (MissionID(fk), TrainingID(fk))

Note: Underline and **Bold** denotes a primary key or candidate key of the relation, and (fk) denotes a foreign key.

## Functional Dependencies:

**Spacecraft\_Crew** (EmployeeID(fk), CosparID(fk))

- No non-primary-key attributes; no dependencies.

**Astronaut\_Training** (EmployeeID(fk), TrainingID(fk))

- No non-primary-key attributes; no dependencies.

**ISS\_Crew** (EmployeeID(fk), Date(fk))

- No non-primary-key attributes; no dependencies.

**Assigned\_Missions** (EmployeeID(fk), MissionID(fk))

- No non-primary-key attributes; no dependencies.

**ISS\_Missions** (Date(fk), MissionID(fk))

- No non-primary-key attributes; no dependencies.

**Spacecraft\_Missions** (CosparID(fk), MissionID(fk))

- No non-primary-key attributes; no dependencies.

**Spacecraft\_Rocket** (CosparID(fk), LaunchVehicleID(fk))

- No non-primary-key attributes; no dependencies.

**Training\_Missions** (MissionID(fk), TrainingID(fk))

- No non-primary-key attributes; no dependencies.

All relations without functional dependencies can be temporarily removed for convenience as they will not affect the normalization process.

MORE ON NEXT SLIDE...

Note: An arrow (→) denotes the attributes on the right are functionally dependent on the attributes/primary keys on the left.

# Normalize | Relational Model | Functional Dependencies

## Relations:

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

**Spacecraft\_Crew** (EmployeeID(fk), CosparID(fk))

**Astronaut\_Training** (EmployeeID(fk), TrainingID(fk))

**ISS\_Crew** (EmployeeID(fk), Date(fk))

**Assigned\_Missions** (EmployeeID(fk), MissionID(fk))

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

**ISS\_Missions** (Date(fk), MissionID(fk))

**Spacecraft** (CosparID, Callsign, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

**Spacecraft\_Missions** (CosparID(fk), MissionID(fk))

**Spacecraft\_Rocket** (CosparID(fk), LaunchVehicleID(fk))

**Rocket** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

**Mission** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

**Training\_Missions** (MissionID(fk), TrainingID(fk))

Note: Underline and **Bold** denotes a primary key or candidate key of the relation, and (fk) denotes a foreign key.

## Functional Dependencies - Continued:

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

- **FD1:** EmployeeID → FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

- **FD1:** Date → CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked

- **FD2:** Apogee, Perigee, OrbitalSpeed → OrbitalPeriod

**Spacecraft** (CosparID, Callsign, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

- **FD1:** CosparID, Callsign → LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk)

- **FD2:** Callsign → Crew, CrewSize

- **FD3:** Docked → DockedDate(fk)

**Rockets** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

- **FD1:** LaunchVehicleID → Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk)

- **FD2:** ReusableExpendable → TotalLaunches

**Missions** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

- **FD1:** MissionID → MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

- **FD1:** TrainingID → TrainingType, Crew, Spacecraft, Success, Failure, Mission

- **FD2:** TrainingType → Crew

Note: An arrow (→) denotes the attributes on the right are functionally dependent on the attributes/primary keys on the left.

# Normalize | Relational Model | 1st Normal Form (1NF)

## Functional Dependencies:

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

- **FD1:** EmployeeID → FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

- **FD1:** Date → CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked
- **FD2:** Apogee, Perigee, OrbitalSpeed → OrbitalPeriod

**Spacecraft** (CosparID, Callsign, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

- **FD1:** CosparID, Callsign → LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk)
- **FD2:** Callsign → Crew, CrewSize
- **FD3:** Docked → DockedDate(fk)

**Rockets** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

- **FD1:** LaunchVehicleID → Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk)
- **FD2:** ReusableExpendable → TotalLaunches

**Missions** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

- **FD1:** MissionID → MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

- **FD1:** TrainingID → TrainingType, Crew, Spacecraft, Success, Failure, Mission
- **FD2:** TrainingType → Crew

Changes Needed to be in **1NF**:

**NONE**

The relations are already in first normal form.

1. All relations have a primary key.
2. No columns are duplicated in any relation.
3. Each attribute will only have a single value per row.

# Normalize | Relational Model | 2nd Normal Form (2NF)

## Normalization in Progress | 1NF → 2NF

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

- **FD1:** EmployeeID → FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

- **FD1:** Date → CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked
- **FD2:** Apogee, Perigee, OrbitalSpeed → OrbitalPeriod

**Spacecraft** (CosparID, Callsign, LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

- **FD1:** CosparID, Callsign → LaunchDate, Crew, CrewSize, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk)
- **FD2:** Callsign → Crew, CrewSize
- **FD3:** Docked → DockedDate(fk)

**Rockets** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

- **FD1:** LaunchVehicleID → Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk)
- **FD2:** ReusableExpendable → TotalLaunches

**Missions** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

- **FD1:** MissionID → MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

- **FD1:** TrainingID → TrainingType, Crew, Spacecraft, Success, Failure, Mission
- **FD2:** TrainingType → Crew

Changes Needed to be in **2NF**:

Remove all **partial** functional dependencies by creating new relation and adding foreign keys.

# Normalize | Relational Model | 2nd Normal Form (2NF)

## Normalization in Progress | 1NF → 2NF

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

- **FD1:** EmployeeID → FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

- **FD1:** Date → CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked
- **FD2:** Apogee, Perigee, OrbitalSpeed → OrbitalPeriod

**Spacecraft** (CosparID, Callsign, LaunchDate, ~~Crew~~, ~~CrewSize~~, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

- **FD1:** CosparID, Callsign → LaunchDate, ~~Crew~~, ~~CrewSize~~, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk)
- **FD2:** ~~Callsign~~ → ~~Crew~~, ~~CrewSize~~
- **FD3:** Docked → DockedDate(fk)

**Rockets** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

- **FD1:** LaunchVehicleID → Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk)
- **FD2:** ReusableExpendable → TotalLaunches

**Missions** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

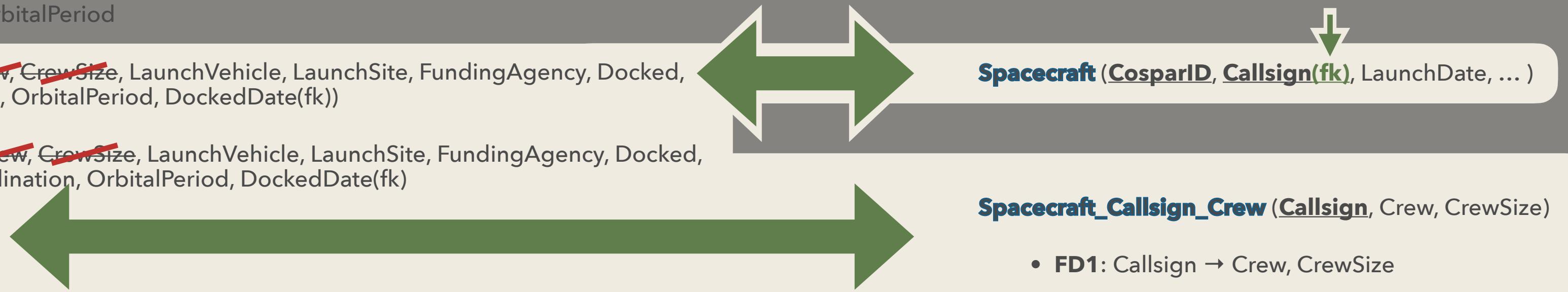
- **FD1:** MissionID → MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

- **FD1:** TrainingID → TrainingType, Crew, Spacecraft, Success, Failure, Mission
- **FD2:** TrainingType → Crew

Changes Needed to be in **2NF**:

Remove all **partial** functional dependencies by creating new relation and adding foreign keys.



# Normalize | Relational Model | 3rd Normal Form (3NF)

## Normalization in Progress | 2NF → 3NF

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

- **FD1:** EmployeeID → FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked)

- **FD1:** Date → CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, OrbitalPeriod, SpacecraftDocked
- **FD2:** Apogee, Perigee, OrbitalSpeed → OrbitalPeriod

**Spacecraft** (CosparID, Callsign(fk), LaunchDate, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

- **FD1:** CosparID, Callsign → LaunchDate, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk)
- **FD2:** Docked → DockedDate(fk)

**Spacecraft\_Callsign\_Crew** (Callsign, Crew, CrewSize)

- **FD1:** Callsign → Crew, CrewSize

**Rockets** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

- **FD1:** LaunchVehicleID → Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk)
- **FD2:** ReusableExpendable → TotalLaunches

**Missions** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

- **FD1:** MissionID → MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

- **FD1:** TrainingID → TrainingType, Crew, Spacecraft, Success, Failure, Mission
- **FD2:** TrainingType → Crew

Changes Needed to be in **3NF**:

Remove all **transitive** functional dependencies by creating new relation and adding foreign keys.

# Normalize | Relational Model | 3rd Normal Form (3NF)

## Normalization in Progress | 2NF → 3NF

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

- FD1: EmployeeID → FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, ~~OrbitalPeriod~~, SpacecraftDocked)

- FD1: Date → CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, ~~OrbitalPeriod~~, SpacecraftDocked
- FD2: ~~Apogee\_Perigee\_OrbitalSpeed~~ → ~~OrbitalPeriod~~

**Spacecraft** (CosparID, Callsign(fk), LaunchDate, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk))

- FD1: CosparID, Callsign → LaunchDate, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, DockedDate(fk)
- FD2: Docked → DockedDate(fk)

**Spacecraft\_Callsign\_Crew** (Callsign, Crew, CrewSize)

- FD1: Callsign → Crew, CrewSize

**Rockets** (LaunchVehicleID, Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

- FD1: LaunchVehicleID → Payload, TotalLaunches, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk)
- FD2: ReusableExpendable → TotalLaunches

**Missions** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

- FD1: MissionID → MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew

**Training** (TrainingID, TrainingType, Crew, Spacecraft, Success, Failure, Mission)

- FD1: TrainingID → TrainingType, Crew, Spacecraft, Success, Failure, Mission
- FD2: TrainingType → Crew

Changes Needed to be in **3NF**:

Remove all **transitive** functional dependencies by creating new relation and adding foreign keys.



**ISS** (Date, CurrentCrew, Maintenance, Apogee(**fk**), Perigee(**fk**), OrbitalSpeed(**fk**), OrbitalInclination, SpacecraftDocked)

**ISS\_OrbitalPeriod** (Apogee, Perigee, OrbitalSpeed, OrbitalPeriod)

- FD1: Apogee, Perigee, OrbitalSpeed → OrbitalPeriod

# Normalize | Relational Model | 3rd Normal Form (3NF)

## Normalization in Progress | 2NF → 3NF

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

- FD1: EmployeeID → FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality

**ISS** (Date, CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, ~~OrbitalPeriod~~, SpacecraftDocked)

- FD1: Date → CurrentCrew, Maintenance, Apogee, Perigee, OrbitalSpeed, OrbitalInclination, ~~OrbitalPeriod~~, SpacecraftDocked
- FD2: ~~Apogee, Perigee, OrbitalSpeed~~ → ~~OrbitalPeriod~~

**Spacecraft** (CosparID, Callsign(fk), LaunchDate, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, ~~DockedDate(fk)~~)

- FD1: CosparID, Callsign → LaunchDate, LaunchVehicle, LaunchSite, FundingAgency, Docked, OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod, ~~DockedDate(fk)~~
- FD2: ~~Docked~~ → ~~DockedDate(fk)~~

**Spacecraft\_Callsign\_Crew** (Callsign, Crew, CrewSize)

- FD1: Callsign → Crew, CrewSize

**Rockets** (LaunchVehicleID, Payload, ~~TotalLaunches~~, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk))

- FD1: LaunchVehicleID → Payload, ~~TotalLaunches~~, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable, Contractor, ReusedLaunchVehicleID(fk)
- FD2: ~~ReusableExpendable~~ → ~~TotalLaunches~~

**Missions** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

- FD1: MissionID → MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew

**Training** (TrainingID, TrainingType, ~~Crew~~, Spacecraft, Success, Failure, Mission)

- FD1: TrainingID → TrainingType, ~~Crew~~, Spacecraft, Success, Failure, Mission
- FD2: ~~TrainingType~~ → ~~Crew~~

Changes Needed to be in **3NF**:

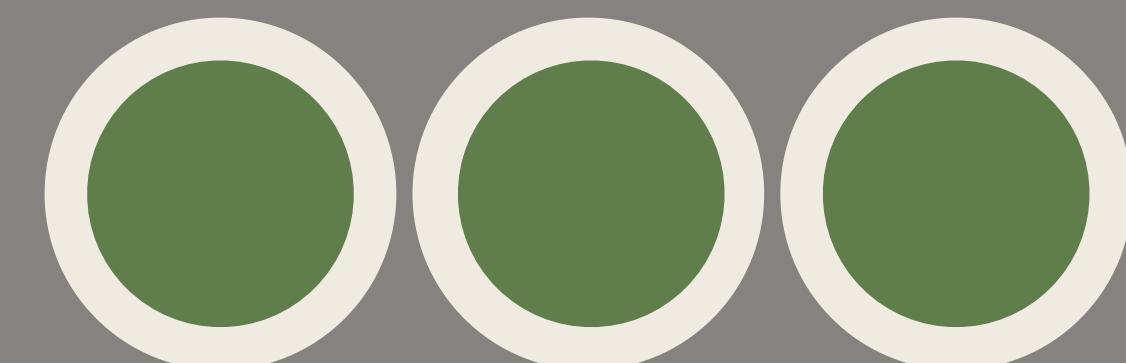
Remove all **transitive** functional dependencies by creating new relation and adding foreign keys.



**ISS** (Date, CurrentCrew, Maintenance, Apogee(**fk**), Perigee(**fk**), OrbitalSpeed(**fk**), OrbitalInclination, SpacecraftDocked)

**ISS\_OrbitalPeriod** (Apogee, Perigee, OrbitalSpeed, OrbitalPeriod)

- FD1: Apogee, Perigee, OrbitalSpeed → OrbitalPeriod



# FINAL | Relational Model | 3rd Normal Form (3NF)

## Final Model:

**Astronauts** (EmployeeID, FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality)

- **FD1:** EmployeeID → FirstName, LastName, Address, MissionsFlown, DoB, EmergencyContact, FlightHours, Specialization, Rank, Nationality

**Spacecraft\_Crew** (EmployeeID(fk), CosparID(fk))

- No non-primary-key attributes; no dependencies.

**Astronaut\_Training** (EmployeeID(fk), TrainingID(fk))

- No non-primary-key attributes; no dependencies.

**ISS\_Crew** (EmployeeID(fk), Date(fk))

- No non-primary-key attributes; no dependencies.

**Assigned\_Missions** (EmployeeID(fk), MissionID(fk))

- No non-primary-key attributes; no dependencies.

**ISS** (Date, CurrentCrew, Maintenance, Apogee(fk), Perigee(fk), OrbitalSpeed(fk), OrbitalInclination, SpacecraftDocked)

- **FD1:** Date → CurrentCrew, Maintenance, Apogee(fk), Perigee(fk), OrbitalSpeed(fk), OrbitalInclination, SpacecraftDocked

**ISS\_OrbitalPeriod** (Apogee, Perigee, OrbitalSpeed, OrbitalPeriod)

- **FD1:** Apogee, Perigee, OrbitalSpeed → OrbitalPeriod

**ISS\_Missions** (Date(fk), MissionID(fk))

- No non-primary-key attributes; no dependencies.

**Spacecraft** (CosparID, Callsign(fk), LaunchDate, LaunchVehicle, LaunchSite, FundingAgency, Docked(fk), OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod)

- **FD1:** CosparID, Callsign(fk) → LaunchDate, LaunchVehicle, LaunchSite, FundingAgency, Docked(fk), OrbitingBody, Apogee, Perigee, OrbitalInclination, OrbitalPeriod

**Spacecraft\_Docked** (Docked, DockedDate(fk))

- **FD1:** Docked → DockedDate(fk)

**Spacecraft\_Callsign\_Crew** (Callsign, Crew, CrewSize)

- **FD1:** Callsign → Crew, CrewSize

**Spacecraft\_Missions** (CosparID(fk), MissionID(fk))

- No non-primary-key attributes; no dependencies.

**Spacecraft\_Rocket** (CosparID(fk), LaunchVehicleID(fk))

- No non-primary-key attributes; no dependencies.

**Rockets** (LaunchVehicleID, Payload, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable(fk), Contractor, ReusedLaunchVehicleID(fk))

- **FD1:** LaunchVehicleID → Payload, BoosterType, Propellant, EmptyMass, GrossMass, MaxThrust, Stages, OrbitType, ReusableExpendable(fk), Contractor, ReusedLaunchVehicleID(fk)

**ReusableRockets** (ReusableExpendable, TotalLaunches)

- **FD1:** ReusableExpendable → TotalLaunches

**Missions** (MissionID, MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew)

- **FD1:** MissionID → MissionType, Spacecraft, PlannedDuration, ActualDuration, Crew

**Training** (TrainingID, TrainingType(fk), Spacecraft, Success, Failure, Mission)

- **FD1:** TrainingID → TrainingType(fk), Spacecraft, Success, Failure, Mission

**Crew\_Training** (TrainingType, Crew)

- **FD1:** TrainingType → Crew

**Training\_Missions** (MissionID(fk), TrainingID(fk))

- No non-primary-key attributes; no dependencies.



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**THANK YOU!**

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