Based on the surveyed literature, a novel system would involve multiple agents transporting a cable-suspended load, under distributed or decentralized control, with a unified controller and trajectory planner allowing for generation and tracking of feasible paths.

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| **Problem Aspect** | **Previous Model** | **Latest Model** |
| Agent configuration | Multiple agents, Quadrotor UAVs, self-sufficient localization. Leader-follower structure | Multiple agents, homogeneous quadrotor UAVs, self-sufficient localization. Leader-follower structure |
| Load configuration | Cable-suspended load, rigid and homogeneous composition.  Multiple operational modes: ascend, carry, descend | Cable-suspended load, **rigid** v. flexible, **homogeneous** v. heterogeneous composition.  Multiple operational modes: ascend, carry, descend, failure response |
| System dynamics | Assuming use of Pixhawk flight controller: ideal closed-loop linear system with 7 degrees of freedom [x, y, z, pitch, roll, yaw, thrust].  Point-mass model for forces on load, zero internal force, even weight distribution, rigid cables with constant tension.  No external disturbances, no obstacles to avoid. | **Using flight controller (i.e. ideal closed-loop linear system): easier to analyze mathematically, perhaps loss of maneuver speed, produces equation of motion compatible with LQR / MPC formulation.**  Linearizing the (nonlinear) quadrotor dynamics: mathematically more complex, produces equation of motion compatible with LQR / MPC formulation.  Handling of coupling effects and system non-idealities (non-zero internal force, uneven weight distribution, variations in cable tension).  No external disturbances. Possibility of obstacles to avoid. |
| Trajectory Planning | Follow preset geometrical trajectory | Incorporate real-time trajectory planner into optimal controller  Minimize flight duration  Constraints: bounds on load swing, load pose with respect to agents’ poses (to avoid agent-load collision), agent separation (to avoid inter-agent collision), agent velocity. |
| Agent Control Strategy | Decentralized control  For leader: PID controller, follow position setpoints  For follower: PID controller, measure cable angle and track a specific angle (0 rad) | If feasible: fast and aggressive maneuvers.  **Decentralized control: no communication between agents, computationally simpler.**  Collision avoidance: use potential field or make this as a constraint for the trajectory generator. **To localize other agents, will leader need to communicate with them? Consider use of zone contracts.**  Leader:  Optimal controller with trajectory planning and tracking; consider a variant of MPC. Active damping?  Follower:  Estimate the pose of self and load using Kalman filter, use PID controller to track a reference pose with respect to load. **Where would the follower reference pose come from? What measurements would be fed into the KF and where would they come from?**  Distributed control: direct implementation of collision avoidance, computationally more complex and requires communication between agents  Leader:  Optimal controller with trajectory planning and tracking; consider a variant of MPC. Active damping?  Followers:  Estimate the pose of self, neighbors and load. PID control: maintain distance from the load.  or  MPC: plan trajectory to maintain distance from the load and avoid collision with neighbors.  **Should agents maintain a single pose with respect to the load for each flight mode or change dynamically? When would the latter be desirable? Should followers impose zero or non-zero internal force on the load?** |
| Measurements | Self pose, cable angle | Self pose. Leader: start and end positions, self pose. Follower: self pose, load pose (via cable angle?), neighbor poses? |