CLAIMS

1. A method for creating a predictive model for structural repair during heavy maintenance in a fleet of aircraft that each include a structural component, the method comprising:

storing, on a memory accessible to a computerized system, first sensor data from one or more first aircraft sensors of a first aircraft of the fleet, the first sensor data including one or more of environmental conditions, aircraft operations, aircraft stresses, and overstress events experienced by one or more components of the first aircraft;

for the first aircraft of the fleet that experienced a replacement of the structural component of the first aircraft during heavy maintenance of the first aircraft:

calculating, by a processing unit of the computerized system and based on the first sensor data, a qualification dataset of fatigue-related parameters from a portion of the first sensor data collected during a first group of flights of the first aircraft, wherein each flight of the first group of flights occurred before the heavy maintenance of the first aircraft and wherein, during each flight of the first group of flights, the first aircraft experienced a corresponding overstress event for the first aircraft;

displaying, by the computerized system, the qualification dataset; and

receiving, by the computerized system, a selection of the fatigue-related parameters;

storing, on the memory accessible to the computerized system, second sensor data from one or more second aircraft sensors of a second aircraft of the fleet, the second sensor data including one or more of environmental conditions, aircraft operations, aircraft stresses, and overstress events experienced by one or more components of the second aircraft;

for the second aircraft of the fleet that experienced heavy maintenance without replacement of the structural component of the second aircraft:

calculating, by the processing unit and based on the second sensor data, a verification dataset of the selection of fatigue-related parameters from a portion of the second sensor data collected during a second group of flights of the second aircraft, wherein each flight of the second group of flights occurred before the heavy maintenance of the second aircraft and wherein, during each flight of the second group of flights, the second aircraft experienced a corresponding overstress event for the second aircraft;

displaying, by the computerized system, the verification dataset; and

receiving, by the computerized system, a set of the selection of the fatigue-related parameters, wherein the set of the selection of the fatigue-related parameters is less than all of the fatigue-related parameters;

calculating, by the processing unit, a training dataset of the set of the selection of the fatigue-related parameters from data collected during additional flights of respective aircraft of the fleet, wherein each of the respective aircraft experienced heavy maintenance, wherein each flight of the additional flights occurred before the heavy maintenance of the respective aircraft of that flight, and wherein each flight of the additional flights is a flight during which the respective aircraft experienced a corresponding overstress event for the respective aircraft;

training, by the processing unit, a predictive model for structural repair during heavy maintenance with the training dataset;

storing the predictive model on the memory accessible to the computerized system; and

deploying, by the computerized system, the predictive model for structural repair of a subject aircraft, wherein the deploying comprises:

receiving third sensor data from one or more third aircraft sensors of the subject aircraft of the fleet, the third sensor data including one or more of environmental conditions, aircraft operations, aircraft stresses, and overstress events experienced by one or more components of the subject aircraft;

extracting, by the processing unit, feature data from the third sensor data from the one or more third aircraft sensors to determine a statistic of sensor values for the subject aircraft;

determining, by the processing unit and based on the predictive model, a performance status of a subject structural component of the subject aircraft using the feature data from the third sensor; and

initiating, by the processing unit and based on the performance status, a signal to a health management system associated with the subject aircraft, the health management system being configured to update a maintenance of structural components of the subject aircraft based on the signal.

2. The method of claim 1, wherein the corresponding overstress events for the first aircraft, the corresponding overstress events for the second aircraft, and the corresponding overstress events

for the respective aircraft are each independently selected from the group consisting of a hard landing, a positive acceleration above a predetermined positive acceleration threshold, and a negative acceleration below a predetermined negative acceleration threshold.

3. The method of claim 1, wherein the fatigue-related parameters include at least one of a strain of an aerodynamic structure, a difference of strains, an acceleration, a pitch rate, a roll rate, a yaw rate, and a speed brake deployment event.

4. The method of claim 1, wherein the structural component of the first aircraft and the structural component of the second aircraft are the same type of structural component and selected from the group consisting of a frame member, a longeron, a stringer, a former, a strut, a beam, a web, a support, a linkage, a splice, and a panel.

5. The method of claim 1, wherein the displaying the qualification dataset includes visualizing the qualification dataset and wherein the displaying the verification dataset includes visualizing the verification dataset.

6. The method of claim 1, wherein the displaying the qualification dataset includes displaying responsive to user inputs and wherein the displaying the verification dataset includes displaying responsive to user inputs.

7. The method of claim 1, wherein training the predictive model includes applying machine learning to the training dataset.

8. The method of claim 1, wherein the selection of the fatigue-related parameters is less than all fatigue-related parameters.

9. The method of claim 1, wherein the set of the selection of the fatigue-related parameters is less than all of the selection of the fatigue-related parameters.

10. The method of claim 1, wherein the receiving the selection of the fatigue-related parameters includes receiving, from a user, the selection of the fatigue-related parameters based on the user's determination of a correlation between the replacement of the structural component of the first aircraft during heavy maintenance and the fatigue-related parameters, and wherein the receiving the set of the selection of the fatigue-related parameters includes receiving, from the user, the set of the selection of the fatigue-related parameters based on the user's determination of a lack of correlation between the selection of the fatigue-related parameters of the qualification dataset and the corresponding fatigue-related parameters of the verification dataset.

11. The method of claim 1, wherein the calculating the qualification dataset includes restricting the qualification dataset to the fatigue-related parameters from data collected during the corresponding overstress event for the first aircraft, wherein the calculating the verification dataset includes restricting the verification dataset to the fatigue-related parameters from data collected during the corresponding overstress event for the second aircraft, and wherein the calculating the training dataset includes restricting the training dataset to the fatigue-related parameters from data collected during the corresponding overstress event for the respective aircraft.

12. The method of claim 1, wherein the deploying the predictive model further comprises: determining a plurality of indicators by applying the predictive model to a plurality of indicator values to the third sensor data from one or more third aircraft sensors of the subject aircraft of the fleet; and aggregating the plurality of indicators to generate the performance status of the subject structural component of the subject aircraft.

13. A hybrid feature selection system to generate a predictive model for structural repair during heavy maintenance in a fleet of aircraft that each includes a structural component, the hybrid feature selection system comprising:

a flight database of data collected by one or more aircraft sensors during flights of aircraft of the fleet of aircraft, the data including one or more of environmental conditions, aircraft operations, aircraft stresses, and overstress events experienced by individual aircraft of the fleet of aircraft during flights;

at least one processing unit;

a computer-readable memory storing non-transitory computer-readable instructions that, when executed by the at least one processing unit, cause the hybrid feature selection system to:

retrieve qualification data from the flight database; calculate a qualification dataset by applying fatigue-related parameters to the qualification data;

display the qualification dataset;

receive, from a user, a selection of the fatigue-related parameters, wherein the qualification data is data collected during a first group of flights of a first aircraft of the fleet that experienced a replacement of the structural component during heavy maintenance of the first aircraft, wherein each flight of the first group of flights occurred before the heavy maintenance of the first aircraft, and wherein, during each flight of the first group of flights, the first aircraft experienced a corresponding overstress event for the first aircraft;

retrieve verification data from the flight database;

calculate a verification dataset by applying the selection of the fatigue-related parameters to the verification data;

display the verification dataset;

receive, from the user, a set of the selection of the fatigue-related parameters that is less than all of the fatigue-related parameters, wherein the verification data is data collected during a second group of flights of a second aircraft of the fleet that experienced heavy maintenance without replacement of the structural component of the second aircraft, wherein each flight of the second group of flights occurred before the heavy maintenance of the second aircraft, and wherein, during each flight of the second group of flights, the second aircraft experienced a corresponding overstress event for the second aircraft;

retrieve training data from the flight database;

calculate a training dataset by applying the set of the selection of the fatigue-related parameters to the training data;

train a predictive model for structural repair during heavy maintenance with the training dataset; and

provide the predictive model to the user.

14. A method of determining a performance status of a structural component of an aircraft, the method comprising:

storing first sensor data from one or more first aircraft sensors of the aircraft, the first sensor data including one or more of environmental conditions, aircraft operations, aircraft stresses, and overstress events experienced by one or more components of the aircraft;

selecting a group of flights of the aircraft, wherein, during each flight, the aircraft experienced an overstress event;

extracting feature data from a portion of the first sensor data flight data collected by the one or more first aircraft sensors during the group of flights, wherein the feature data relates to fatigue of the structural component;

applying an ensemble of classifiers configured to identify categories to which the feature data belong to produce a classifier indicator for each classifier of the ensemble of classifiers of a predictive model, wherein each classifier is configured to indicate a category of the structural component of the aircraft based upon the feature data, and wherein the predictive model is trained using:

a first data set from second sensor data collected by one or more third aircraft sensors of a second aircraft during a first group of flights of the first aircraft that experienced a replacement of the structural component during heavy maintenance of the first aircraft, wherein each flight of the first group of flights occurred before the heavy maintenance of the first aircraft and wherein, during each flight of the first group of flights, the first aircraft experienced a corresponding overstress event for the first aircraft, and

a second data set from third sensor data collected by one or more third aircraft sensors of a second aircraft during a second group of flights of the second aircraft that experienced heavy maintenance without replacement of the structural component, wherein each flight of the second group of flights occurred before the heavy maintenance of the second aircraft and wherein, during each flight of the second group of flights, the second aircraft experienced a corresponding overstress event for the second aircraft;

aggregating the classifier indicators to produce an aggregate indicator that indicates an aggregate category of the structural component;

determining the performance status of the structural component based on the aggregate indicator; and

initiating, based on the performance status, a signal to a health management system associated with the aircraft, the health management system being configured to update a maintenance schedule of the structural component based on the signal.

15. The method of claim 14, wherein the overstress events of the flights of the aircraft are selected from the group consisting of a hard landing, a positive acceleration above a predetermined threshold, and a negative acceleration below a predetermined threshold.

16. The method of claim 14, wherein the feature data include at least one of a strain of an aerodynamic structure, a difference of strains, an acceleration, a pitch rate, a roll rate, a yaw rate, and a speed brake deployment event.

17. The method of claim 14, wherein the feature data include at least one of a sum, a difference, a count, a value, and a statistical measure of selected flight data collected during a duration of the overstress event of one of the flights of the group of flights of the aircraft.

18. The method of claim 14, wherein the structural component of the aircraft is selected from the group consisting of a frame member, a longeron, a stringer, a former, a strut, a beam, a web, a support, a linkage, a splice, and a panel.

19. The method of claim 14, further comprising performing heavy maintenance on the aircraft based upon the performance status.